Eurasian Journal of Agricultural Research

Volume 5, Issue 2, December 2021

ISSN: 2636 – 8226

https://dergipark.org.tr/en/pub/ejar

INTERNATIONAL INDEXING

CONTENTS

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:66-83

Analysis of The Impact of Agricultural Policies on Food Security in Kenya

Benson NJORA[1*], Hasan YILMAZ[2]

[1]*Department of Agricultural Economics, Isparta University of Applied Sciences, Isparta, Turkey*

[2]*Department of Agricultural Economics, Isparta University of Applied Sciences, Isparta, Turkey*

[*]*Corresponding author: wanduben12@gmail.com*

ORCID: 0000-0001-7082-488X[1] , 0000-0002-0487-8449[2]

Abstract

Agricultural policies consist of laws and regulations set by the government to control both domestic and foreign agricultural activities and the trade of agricultural and related products. The policies set by the government have both direct and indirect effects on the agricultural sector which affects the food security state. Kenya has been on the frontline in fighting food insecurity but it is far from becoming a food secure country. To help improve the agricultural sector towards fighting food insecurity, there has been an establishment of various key policies over time. Economic Recovery Strategy (ERS), Agriculture Sector Development Strategy (ASDS), Strategy for Revitalizing Agriculture (SRA), Poverty Reduction Strategy Paper (PRSP), and Vision 2030 are some of the key policies put in motion to help fight against food insecurity. Despite the effort put in place by government and private organizations, Kenya is still facing a lot of challenges in the agricultural sector such as land pressure due to increasing population, the inadequacy of agricultural research and agricultural extension services, climate change, insufficient stewardship of fishing grounds, pests and diseases, public expenditure, and infrastructure leading to high rate of food insecurity. The study uses secondary data to analyze the effects of various agricultural policies implemented over time on Kenya's food security. Also, the paper provides key recommendations that can help fight against food insecurity in Kenya.

Keywords: Kenya, Agricultural policies, Food security, Trade and consumption

Research article
Received Date:29 June 2021
Accepted Date:3 September 2021

INTRODUCTION

Kenya is a developing country with a GDP of $95.5 billion. The agricultural sector plays a key role in Kenya's economy contributing 51 percent to the total GDP; 26% directly and around 26% indirectly (World Bank, 2019). The agricultural sector employs the highest number of Kenyans accounting for 60 percent of employed and 65 percent of Kenya's total exports. Despite of the agricultural sector being the largest employer, it is dominated by small-scale farmers who owns an average of between 0.2 and 3 hectares. In comparison with large-scale producers, small scale farmers' production is around 78 percent of the total agricultural production. Kenya's agricultural GDP is driven by cash crops and horticulture as compared to food crops such as cereals. The sector is dominated by mostly poor people trying to make a living and not necessarily for commercial productions.

Kenya's agricultural sector has been classified to six major subsectors; food crops, horticulture, industrial crops, livestock, fisheries, and forestry. According to Government of Kenya Report (2017), horticulture is the largest subsect contributing around 33%, industrial crops 17%, food crops contribute 32%, the livestock subsector contributes 17% of Agricultural GDP. In terms of export share, horticulture subsector takes the largest share of 33$, livestock 7% while food crops contribute 0.5% of the agricultural GDP. The government has been in the frontline to fight against food insecurity through establishment of different types of policies but due to poor implementation methods most of these polices do not achieve the expected results. To introduce stability in agricultural production, advancement of marketing structures, commercialization of agriculture through agribusiness and to promote environment sustainability, several policies have been implemented over time. There are more than 130 legislation pieces in Kenya that affect the agricultural sector both directly and indirectly (Faling, 2020). On top of this, other draft policies such as the National Land Use Policy, National Irrigation Policy, National Seed Policy, National Agriculture Research Policy and National Horticultural Policy among others have been established (Government of Kenya Report, 2010).

METHODOLOGY

This study employed descriptive research designs. This design helps to answer the questions of who, what, when, where, and how a phenomenon is related to a specific research problem. Descriptive research also helps to get information on the existing problem under study and to describe "what exists" with regards to the study variables. The reason for this design is that the study used secondary data which is hard to manipulate, unlike primary data that can be manipulated easily. The data was collected by reviewing policy documents, journals, articles, and other relevant materials. The data was also obtained from Government of Kenya database, the Ministry of Agriculture, Fishery and Livestock, Planning and National Development Ministry, the Ministry of Agriculture and Rural Development, and the Food and Agriculture Organization of the United Nations.

RESULTS AND DISCUSSIONS

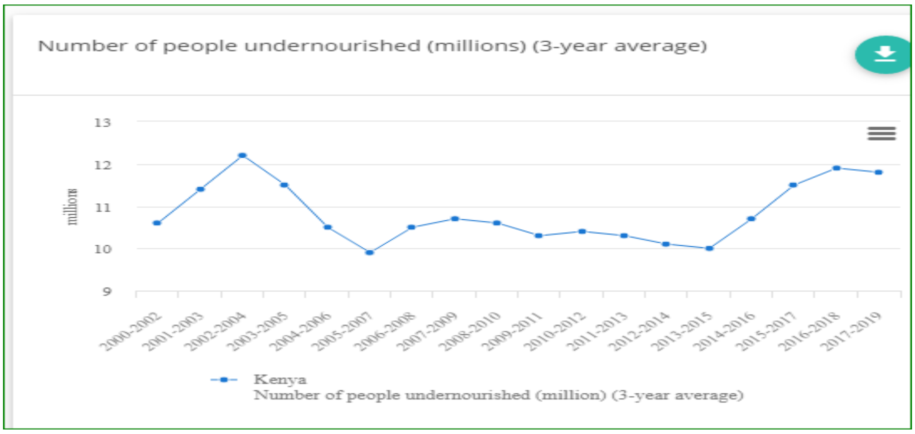
This section presents findings on economic impact of agriculture, food security state in Kenya and other East Africa countries, agricultural policies, agricultural production, trade and consumption, challenges as well as policy recommendations to achieving food security.

The State of Food Security in Kenya

Agriculture remains the highest economic earner in Kenya. 75% of the population makes their income from Agriculture related activities (U.S Agency for International Development,2020). However, food security in Kenya is far from being sufficient. Poor access to financial services, current technology, and crises such as dry weather and foods make many families vulnerable. Despite having a large population involved in the agricultural sector, Kenya is far from attaining food security for all Kenyans. With a population of 50 million, 25% of this live in underdeveloped housing and suffer a lot from food insecurity and diseases. Kenyans who are most vulnerable to food insecurity live in Arid and Semi-Arid areas.

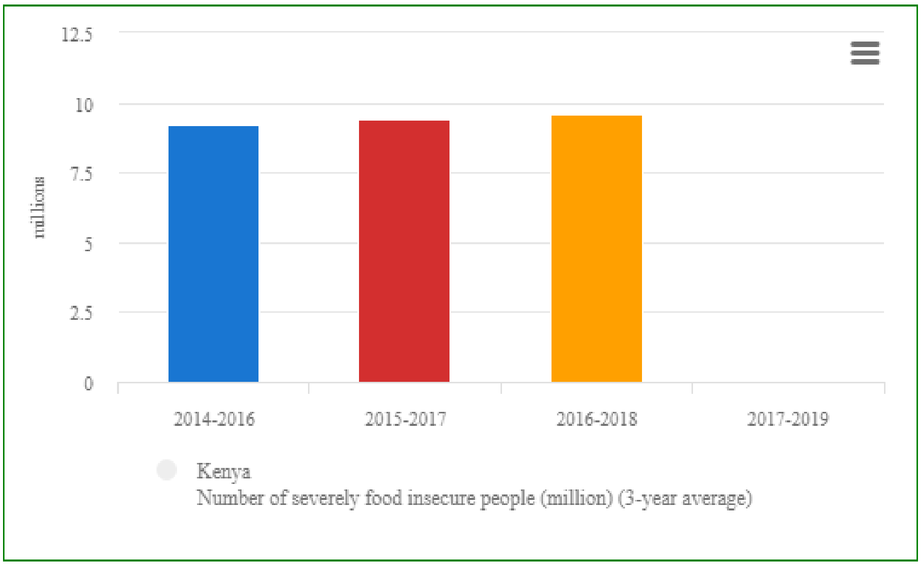
Kenya has a landmass of approximately 592,000 km^2 of which 80% is semi-arid and 20% is arable land. Kenya has a huge potential to improve agricultural productivity and move towards achieving food security.

The state of food Security in Kenya can be evaluated by looking at the number of undernourished people, as revealed in figure 1 and 2. Undernourished people do not have access to sufficient nutritious foods for the proper sustenance of their bodies. The three year average on the number of people malnourished has been fluctuating according to the data above. Between 2000 and 2005, this figure reached 12 million markets; however, between 2005 and 2014, and specifically during the 2006 and 2007 period, there was an improvement (FAO, 2020). However, data from 2015 through to 2019 point to a worrying trend of an increase in the number of undernourished people. Also, in the other graph presented above, the number of people who face acute food security has been on the rise between 2016 and 2018, almost reaching 10 million people (FAO, 2020).



Source:(FAOSTAT, 2020)

Figure 1. Kenya's Three Year Average of the Number of Undernourished People



Source:(FAOSTAT, 2020)

Figure 2. The Graph Showing the Number of People that Facing Severe Food Security Challenges

Lack of nutritionally differentiated food supplements and poor value addition processes in Kenya, which had failed to reach the levels it had reached in 2006, also contributes to low food security levels in the country. In 2020, delayed planting was occasioned by the fall of heavy rains in the country in February, leading to a potential delay in harvesting (FEWS.NET, 2020).

When harvesting is delayed, the country's existing food reserves are depleted, leading to a potential lack of food security as prices of basic staple food commodities like maize soar. The occurrence of heavy rains in April also leads to flooding. Flooding destroyed some crops that had reached knee height. The price of maize and other flours has been increasing, and the increase in the price of maize in 2020 has been higher than the overall increase in other years(FEWS.NET, 2020). As a subsistence farmer, if he cannot access the right market for his agricultural goods, he can be discouraged and shift to another economic activity. Kenyan farmers face unfavorable terms of trade and the loss of a major chunk of their revenue by selling food substances to the middlemen instead of urban centers.

Food lost and wastage is a key factor contributing to food insecurity not only in Kenya but also in the whole world. Graph 3 shows the percentage of the food commodity lost throughout the value chain is so high at production and so low at consumption. Among the Kenyan farmers, the losses attributed to the crop after the harvesting activities reduces the number of foods and the quality of food substances that reach the market. Reduced storage facilities and increased harvest causing an oversupply in the market, contribute to the post-harvest losses. Lack of technologies to ensure that the foods are available in periods of plenty and periods of plenty affects food security (Ridolfi, Hoffman & Siddharta,2018). According to FAO, 2020, about 14% of world's food is lost even before reaching to market. The total food loss and wastage is valued at around $400 billion annually. The World Food Programme (WFP), Food and Agriculture Organization and the UN Environment Programme (UNEP), have been leading the fight against food loss and wastage as it is a key contributor of food insecurity world. During the first international day of awareness of food loss and waste on 29 September 2020, FAO Director- General QU Dongyu, urged for strong partnerships between public and private investments to help fight food loss and waste with the main goal of improving food security and protecting the environment. According to QU Dongyu 2020, there is urgent need to train small-scale farmers, more application of technology and innovation to step up the fight against food loss and waste. In 2020, delayed planting was occasioned by the fall of heavy rains in the country in February, leading to a potential delay in harvesting (FEWS.NET,2020). When harvesting is delayed, the country's existing food reserves are depleted, leading to a potential lack of food security as prices of basic staple food commodities like maize soar. The occurrence of heavy rains in April also leads to flooding. Flooding destroyed some crops that had reached knee height. The price of maize and other flours has been increasing, and the increase in the price of maize in 2020 has been higher than the overall increase in other years(FEWS.NET,2020). As a subsistence farmer, if he cannot access the right market for his agricultural goods, he can be discouraged and shift to another economic activity. Kenyan farmers face unfavorable terms of trade and the loss of a major chunk of their revenue by selling food substances to the middlemen instead of urban centers. Among the Kenyan farmers, the losses attributed to the crop after the harvesting activities reduces the number of foods and the quality of food substances that reach the market. Reduced storage facilities and increased harvest causing an oversupply in the market, contribute to the post-harvest losses. Lack of technologies to ensure that the foods are available in periods of plenty and periods of plenty affects food security (Ridolfi et al., 2018).

General View of Food Security in Kenya and other East African Countries

Across East Africa, there are acute cases of food insecurity. In 2019, over 18.7 million people in East Africa were facing malnutrition. This is a rise from 16.9 million people in 2018. 12.5 million people in Kenya, Somalia, South Sudan, and Ethiopia face food shortages (World Food Programme, 2019). The main cause of food insecurity has been the extreme weather conditions, i.e., too much flooding in some areas and too many dry conditions in other areas. Within the region, at least 2.5 million people face severe food shortages as a result of the floods (World Food Programme, 2019). As indicated in the table below, Eastern Africa countries have high rate of food insecurity and it keep on increasing. The reasons that have contributed to food insecurity in East Africa can be classified into three; Climate shocks, economic shocks, political instability, and conflicts and insecurity. In Eastern Africa countries, despite having high percentage of their population living in Rural areas, participating in agriculture, there is no correlation with agricultural productivity. Agriculture productivity is still low and food produced is not able to meet food demand thus leading to food insecurity. Eastern Africa countries are still relying on agriculture as a major source of livelihood but the full potential of the agricultural sector in terms productivity and revenue generation. Also, the support offered to the agricultural sector by these countries is not much thus lack of enabling and conducive environment for agricultural activities and related businesses have contributed a lot to food insecurity.

Table 1. Food Crisis Levels in Eastern Africa

Country	Population (Millions)	% of people living in Rural and Urban Areas	Food-Insecure People In Need Of Assistance (Millions)	Food Insecurity Levels
Djibouti	0.927	22% Rural, 78% Urban	0.157 1	Crisis And Emergency
Ethiopia	112.1	80% Rural, 20% Urban	8.1	Crisis And Emergency
Kenya	46.3	73% Rural, 27% Urban	2.6	Crisis And Emergency
Somali	13.9	56% Rural, 44% Urban	2.7	2.2m Crisis 496 000 Emergency
South Sudan	11	81% Rural, 19% Urban	6.1	4.3m Crisis 1.7m Emergency 47 000 Catastrophe
The Sudan	43.9	66% Rural, 34% Urban	6.2	5.6m Crisis 601 000 Emergency
Uganda	44.2	77% Rural, 23% Urban	1.1	Crisis And Emergency
Rwanda	12.63	80% Rural, 20% Urban	1.8	Crisis And Emergency
Tanzania	53.5	70% Rural, 30% Urban	2.1	Crisis And Emergency
Burundi	11.53	87% Rural, 13% Urban	1.7	Crisis And Emergency

Source: Regional Focus on the Intergovernmental Authority On Development (IGAD) Global Report on Food Crises 2019

Agricultural Policies in Kenya

Agricultural policies play a critical role in the development of the agricultural sector, empowering farmers, promoting marketing and trade of agricultural products, developing public investments supporting agriculture, and assisting in the accessibility of farm inputs and related services. In 2017, President Uhuru Kenyatta launched the “Big Four Agenda” that aimed at steering Kenya’s economy. The big four agendas; food security and nutrition, affordable housing, universal healthcare, and manufacturing. According to the President, the food security agenda objective is to ensure the country moves towards becoming a food secure country; all Kenyans to have access to physical, social, and economic access to safe, nutritious, and sufficient food that meets their dietary needs at all time. Food security and nutrition aim at enhancing large-scale agricultural production and at the same time empowering smallholders to improve and commercialize their products. To achieve this, the government has embarked on reforming the old policies, formulation, and implementation of new policies and strategies (Government of Kenya, Big Four Agenda Report, 2017). The government’s Food and Nutrition Agenda is a ten-year Agricultural Sector Growth and Transformation Strategy (ASGTS) plan aiming at achieving low agricultural product prices and empowering farmers by increasing accessibility to farm inputs, improving extension services, and investing more in research and technology. Since the establishment of ASGTS, government priorities have been shifting the key objective of fighting food insecurity to more politics which have even worsened food security states in Kenya (Government of Kenya, Big Four Agenda Report, 2017). In the 2020/2021 budget, the Government of Kenya increased finance allocation from 1.57 % of the total budget in 2019/2020 to 2.09% of the total budget. As indicated on the table 2, budget allocation to the agricultural sector is way too low hence contributing to poor performance of the agricultural sector in Kenya. Despite the effort Kenya is making, it continues to default the commitment made by the African Union in July 2003 in Maputo; The Maputo Declaration for country members to spend at least 10% of the total yearly budget on agriculture (Research Institute (IFPRI), 2013). Despite the important role the agricultural sector plays in Kenya’s economy, the total amount allocated to the agricultural sector in Kenya is less than 3% of the total budget as shown on table 2. This continues to hinder growth in the agricultural sector hence contributing to the increasing food insecurity rate in the country.

Table 2. Budget Allocation to the Agricultural Sector

Financial Years	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021
Total Budget (Billion)	$20.5	$24.9	$22.9	$25.0	$32.0	$29.10
Total Allocated to the Agricultural Sector (Million)	$461	$452	$440	$450	$501	$607
Allocation Percentage	2.25%	1.82%	1.92%	1.80%	1.57%	2.09%

Source: The National Treasury https://www.treasury.go.ke/budget.html

The Economic Recovery Strategy (ERS) 2003-2007 was a draft strategy that was implement to develop both agriculture and manufacturing sectors. The strategy involved interventions such as enabling legislation of agricultural institutions, development of irrigation schemes, provision of more extension services and increasing credit accessibility by small scale farmers (Alila and Atieno, 2006).

The implementation of ERS 2003-2007, led to increment of agricultural production as many farmers could access credit. Registered institutions working toward provision of better agricultural services all over the country also plays a key role in ensuring easier accessibility of agricultural services by farmers which in the long run increases production. Kenya is known for overdependence on rainfed agriculture, introduction of policies supporting irrigation development schemes ensure sustainability in agricultural production during the dry season. Policies that were established under this strategy led to an increase of milk and maize production as farmers took credits to increase their dairy farming whereas others could access high quality inputs such as certified maize seeds and subsidized fertilizers which led to higher productivity. The Strategy for Revitalizing Agriculture (SRA) was drafted and endorsed by the government in 2004 spanning up to year 2014 with the objective of creating vibrant and a business oriented agricultural sector to increase employment rate in the sector and also boost participation in regional and international agricultural trades (Bazeley, 2005). The implementation of this strategy led to increment of agribusinesses and most people started appreciating agriculture as a business as policies under this strategy created an enabling environment for conducting businesses, reduction in tax rates, improved transport sector also helps in reducing transportation costs thus adding more profits to farmers. At the same time, youths started to embrace agriculture as a commercial activity as compared to early days, currently the number of youths inclusive of those holding university degrees venturing in agribusiness keeps on increasing. In 2010, this policy was replaced with Agriculture Sector Development Strategy (ASDS) even before its full objectives were attained as expected by year 2014. However, Agriculture Sector Development Strategy (ASDS) was a 2010-2020 policy plan objective was to empower agricultural sector to be able to achieve a 10 % annual economic growth which is envisaged under Vision 2030 economic pillar. Kenya Vision 2030 foresees a food secure country where no person will be left behind in terms of development. The strategy has been working even though not as expected to help small scale farmers to shift from subsistence farming to commercial agriculture (Muraya and Ruigu, 2017). To promote productivity and growth and lowering production costs by reducing agricultural inputs prices, the government of Kenya with collaboration with the World Bank launched a Poverty Reduction Strategy Paper (PRSP in 2005. The objective was to empower small scale farmers who contribute about 70% of marketed agricultural production. The collaboration with the World Bank has led not only to the improvement of agricultural research and extension services provided to farmers but also easier access of credits without requirements of collaterals. This strategy has led to development of insurance covers relating to agricultural sector such as crop and animal insurance covers against natural disasters like floods, drought, etc. Recently, there have been development of insurance covers against lower crop or animal production which have played key role in protecting farmers against great losses that used to occur (World Bank, 2015). Maize is the most consumed agricultural product in Kenya, its Kenyans' staple food. To protect maize production sector, the Government of Kenya established National Cereals and Produce Board (NCPB) to help pursue maize marketing policy objectives. The organization procure maize from farmers, store it and also sell at administratively determined prices while trying to fight against maize shortage in Kenya. NCPB also provides certified seeds to farmers and help in the distribution of subsidized fertilizers to farmers (Onono, et al., 2013). NCPB has been playing a key role to increase maize productivity in Kenya as it not only provide ready market for farmers but also helps in maize distribution across the country. On the negative side, the organization seems to benefit large scale farmers as compared to the benefits small scale farmers gain.

For small-scale farmers, it is very challenging to sell their produce to the board and also to obtain the subsidized fertilizers. Large scale farmers find it very easy to access all services provided by NCPB without much struggle. This has made it hard for NCPB to achieve its objectives and appropriate policies to control corruption in this board are yet to be implemented.

The coffee sector has been negatively affected due to implementation of poor policies. Despite high potential to produce coffee in Kenya, coffee farmers have been forced to uproot coffee plantations to venture into other income generating activities. Policies such as high taxes imposed on farm inputs and withdrawal of farm inputs loan schemes have led to high coffee production costs. To add on poor policies, corruption and impunity in coffee cooperatives have contributed to low coffee prices leading to poor performance in the coffee sector (Kuguru 2016). Tea sector has been performing very well under the organization of Kenya Tea Development Authority (KTDA). The organization was established by the government to help boost tea productivity and also to expand international market for Kenya's tea. KTDA provides ready market for tea farmers thus eliminating lack of market challenges in the sector. Policies such as bonus incentives, fertilizer subsidies and provision of extension services educating farmers on best tea practices, profit maximization and importance of crop diversification has been put in place under KTDA. Despite of all the benefits offered by the organization and boosting Kenya's tea international markets, tea prices in Kenya remains low and farmers do not get good returns as from their efforts (Kirui, 2014). Potato farming occupies a huge part of agriculture in Kenya. To improve potato productivity, the government of Kenya developed the National Potato Industry Policy 2015 focusing on provision of appropriate research services, provision of certified seeds and marketing services for potato farmers. Through the National Government's Ministry of Agriculture and Irrigation 2019, they gazette new regulations requiring all potato packaging to be capped at 50kg. This has helped to reduced potato farmers' exploitation by middlemen and brokers (AGRA, 2019). Dairy Sector in Kenya has been growing over time but still there is a huge opportunity for growth as Kenya has high dairy farming potential. There are many players in the sector such as inputs and services providers, industries, development partners and consumers. However, dairy farming is more dominated by smallholder farmers. To protect the interest of all players involved, Kenya Dairy Board (KDB) was developed to ensure effectiveness in dairy sector. Under the organization, there have been establishment of different market agents, research and development organizations focusing on dairy farming, farmers group organizations, community based and non-government organizations. Other government ministries such us Ministry of Health, Agriculture, Trade, Industry, Cooperative Development, Kenya Agricultural Research Institute (KARI) and Veterinary Vaccine Production Centre(VVPC) have been working in collaboration to ensure high quality and health productivity in the sector (FAO. 2011). To further development of the livestock sector contributing about 2% of total country's earnings, National Livestock Policy was developed. The policy objective is to transform dairy farmers from subsistence to commercial dairy farmers aiming at improving their livelihoods. The policy also in in compliance with Kenya Vision 2030 as it focus on enhancing food and nutrition security for all Kenyans. On the other hand, the policy is working toward boosting industries dealing with livestock product processing which in return creates more employment opportunities. Agricultural Finance Corporation is a development financial institution fully owned by the government of Kenya. It has been in existence since 1963 with one key objective; helping in the development of agriculture as well as agricultural related industries. The organization has been providing credit and loans to farmers and agriculture related companies and provision of technical and managerial assistance to the loan beneficiaries. The agriculture, fisheries, and livestock sector account for a significant share of GDP and export. On the other hand, cereals such as maize, wheat, and rice are imported to meet the country's demand.

The major proportion of marketed agricultural and livestock production consists of horticultural produce and permanent industrial crops with 30.7% and 29.3% of the share to the total production, respectively. Some major crops and products and their recent years are as shown in Table 1 below. The horticulture sector has the largest share of total growth of gross marketed production (2012-2018) with a value of 71% in 2018, livestock and products (66.1%), permanent crops (23.4%), cereals (18.4%), and temporary crops (6.2%) respectively. Wheat (109.2%) and fruits (174.2%) experienced great growth whereas pyrethrum (54.1%) and sisal (30.2%) also lead to the growth of the crop categories. Other key agricultural products have been recording negative growth in the market. They include maize (-24.1%), sugarcane (-5.2%), coffee (-3.5), and sheep, goats, and lambs for slaughter (22.6). This shows that while some agricultural products have been recording positive growth in terms of quantity marketed locally and internationally, others have been recording negative growth.

Table 3. Kenya's Marketed Agricultural Production and Growth

Sectors	**Products**	**Gross Marketed Production (Million in dollar)**		**Share (%)**		**Growth of gross marketed production (2012-2018)**
		2012	**2018**	**2012 (%)**	**2018 (%)**	
Cereals	Wheat	56.13	117.44	1.6	2.3	109.2
	Maize	131.53	99.87	3.8	2.0	-24.1
	Rice (paddy)	23.23	27.11	0.6	0.5	16.7
	Barley	10.81	9.08	0.3	0.1	-16
	Other Cereals	23.16	36.48	0.6	0.7	57.5
	Cereal total	**244.87**	**290.00**	**6.9**	**5.6**	**18.4**
Horticultural	Cut flowers	649.63	1131.65	18.8	22.7	74.2
	Vegetables	202.25	276.85	5.8	5.5	36.9
	Fruits	46.80	128.31	1.3	2.5	174.2
	Horticultural total	**898.68**	**1536.81**	**25.9**	**30.7**	**71.0**
Temporary crops	Pyrethrum	0.17	0.26	0.0	0.0	54.1
	Sugar-cane	216.76	205.50	6.3	4.1	-5.2
	Tobacco	47.0	2.73	0.1	0.0	-42.1
	Cotton	12.35	12.36	0.3	0.2	0.2
	Other temporary crops	7.13	5.32	0.2	0.1	-25.4
	Temporary crops total	**241.12**	**22,6.17**	**6.9**	**4.4**	**6.2**
Permanent Crops	Coffee	153.75	14,8.38	4.45	3.0	-3.5
	Sisal	29.15	37.94	0.8	0.7	30.2
	Tea	1002.62	1276.69	29.0	25.6	27.4
	Permanent crops total	**1185.52**	**1463.01**	**34.2**	**29.3**	**23.4%**
Livestock & Products	Cattle and Calves for slaughter	541.41	1002.49	16.7	20.1	85.2
	Sheep, goats and lambs for slaughter	100.25	77.59	3.0	1.5	-22.6
	Pigs for slaughter	10.79	23.24	0.3	0.4	115.4
	Poultry and eggs	64.82	120.69	1.8	2.4	86.2
	Wool	0.03	0.0029	0.0	0.0	-90.0
	Hides and skins	15.25	17.16	0.4	0.3	12.5
	Dairy products	151.44	227.05	4.4	4.5	49.9
	Livestock and products total	**88,4.01**	**146,8.22**	**26.6%**	**29.2%**	**66.1%**

Source: FAOSTAT (2018)

Major Trading Agricultural Goods

Kenya relies most of its exports on commodity trade. The value-addition to commodity has not been seen extensively. The value of tea export is the highest in Kenya and its value is also the fourth highest in the world (FAOSTAT 2018). The cut flowers and coffee are also ranked among the highest in their trading volumes in the world. Kenya's top 10 exports accounted for around 83.6% of the overall value of its total exports. The oil seeds subsector recorded the fastest growing rate of up to 24-% from 2018 exports (Daniel W. 2020)

Table 4. Kenya's Top 10 Exports in 2019

Products	**Value (**million)	**% of the total exports**
Live trees, plants, cut flowers	US$779.4	22.6%
Coffee, tea, spices	$612	17.8%
Clothing, accessories (not knit or crochet	$303.7	8.8%)
Ores, slag, ash	$272.6	7.9%
Fruits, nuts	$241.3	7%
Vegetables	$225	6.5%
Knit or crochet clothing, accessories	$191.4	5.6%
Vegetable/fruit/nut preparations	$116.4	3.4%
Tobacco, manufactured substitutes	$70.6	2%
Oil seeds: $65.2 million	$65.2	1.9%

Trade and Consumption

Consumption and trade of agricultural productions in Kenya varies due to seasonal nature of agricultural production and over reliance on rainfed agriculture. Maize is Kenyan's staple food but its productivity have been lagging behind Kenya's population growth rate. Increasing urban population has led to increment in maize demand but domestically produced maize has not been able to meet the demand. Since 2000, there has been deficit in maize production in Kenya which forces importation of maize from neighboring countries like Uganda and Tanzania. In year 2017, due to drought and political instability in the country, there was a huge deficit in maize production. In response, the government of Kenya issued permits lowering maize import to increase maize importation to 6 million 90kg bags to increase maize supply in the market. To ensure all people had access, the government provided a subsidy on maize flour stabilizing prices at Ksh.45 per/kilogram (Kiptanui, 2019). Since then, the government has been implementing policies such as provision of subsidies on fertilizers and certified maize seed to help boost maize production.

Wheat is a key component of Kenya's domestic food production and it constitutes a large part of Kenya's diet. In 2019, wheat production was at 320,000 tonnes compared to domestic wheat consumption of 2,450,000 tones (FAOSTAT, 2019). There is a huge deficit in the sector which is substituted by importing wheat from Russia, Ukraine, the United States and Argentina (Kamwaga et al., 2016).

Rice farming is a key agricultural activity that most small scale farmers depend on to meet their basic needs. Most urban dwellers consume more rice as compared to Kenyans living in rural areas. For low-income consumers, rice accounts 3.9% of the total food expenditure compared to 10.7% of wheat and 11.5% of maize of their total expenditure on food. Rice consumption rate as of 2019 was at 949,000 metric tons per year. Annual rice production in Kenya in 2019 was recorded at 180,000 metric tons making Kenya to have a huge rice deficit. To meet the rice demand, Kenya import most of the rice from Far East Pakistan accounting for the highest percentage of the total rice imports, other countries included Vietnam, Thailand, India, and Egypt. To develop rice production in Kenya, there have been development of different policies and strategies such as National Rice Strategy-1, 2008 – 2018 and as National Rice Strategy-2- 2019-2030. With collaboration with other private organizations like International Rice Research Institute (IRRI) there have been introduction to high quality rice, subsidies on inputs and also provision of certified seeds and market by National Cereals and Produce Board of Kenya (Atera et al., 2018).

The sugar industry in Kenya plays a significant role in the economy; income generation to many small scale farmers, creating employment opportunities and generating revenue for the government. Sugar consumption has been growing steadily due to increasing population growth and growing standards of living. Despite high potential for Kenya to be sugar self-reliance producing country, high cost of production leads to lower productivity. To meet sugar demand, Kenya is forced to import sugar from COMESA countries. Higher production cost is associated with high inputs' cost and higher electricity cost in sugar milling companies. The regional trade and multi-lateral treaties associated with East Africa Communities (EAC), COMESA and World Trade Organization (WTO) has made it easier for Kenya to import sugar from member countries at a minimal or zero tariffs. Imported sugar goes at a lower cost as compared to locally produced sugar, this pause a huge threat to sugar industry in Kenya. For example, Mumias Sugar Company Limited used to be the largest sugar company but due to high production costs, it has failed and gone into huge debts.

The coffee industry for the past years has been a key pillar of Kenya's economy unlike today where the sector performance is not as before. The coffee sector has been a source of livelihoods for many Kenyans, provision of jobs and earning foreign exchange. The government of Kenya (GOK) has, with the support of its development partners, initiated new programs to revamp the sector. Increasing yields, modernization of processing plants, and streamlining of governance in marketing cooperatives, remain crucial to the recovery of Kenya's once key export commodity sector. Domestic coffee consumption is still low compared to other coffee producing countries like Ethiopia. Despite production of high quality coffee, Kenyans prefer tea to coffee, out of the total coffee produced in Kenya, only about 4% of it is consumed locally, therefore, Kenya's coffee relies heavily on export markets. To protect coffee industry, the government of Kenya has placed a 25% tariff on imported coffee thus encouraging consumption of locally produced coffee. Kenya Coffee Producers Association (KCPA) was developed to presented farmers' interests to Coffee Board of Kenya as there have been a lot of exploitation to coffee farmers. Policies in the sector have been all through using top-bottom approach where policies are made without even consulting famers. Therefore, KCPA campaigns for a bottom-top approach where farmers being the key stakeholders in the sector will be included in the development of government interventions in the sector. To promote coffee consumption in Kenya, Coffee Directorate has partnered with Kenya's universities aiming at promoting coffee-drinking culture among youths (International Coffee Organization 2019).

Tea is one of the most popular beverages consumed not only in Kenya but also in the whole world. Kenya is the leading tea exporter in Africa and according to the latest tea export report, Kenya is ranked 3rd tea exporter worldwide after China and India (Kiprotich et al., 2019). Tea coverage are in Kenya is 157,720 hectares, with an average production of 345,817 metric tons per year of which over 325,533 metric tons is are exported. Tea sector has a huge contribution to Kenya's economy as it constitute about 26% of total foreign exchange and contribute around 4% GDP. The growth of the tea sector is associated with different initiatives and policies by the government and Kenya Tea Development authority (KTDA).

Kenya's dairy sector is key to development of agriculture in Kenya contributing around %8 of GDP with an annual milk production of 3.43 billion litres. Kenya is the largest milk produced in Sub-Saharan Africa. The dairy sector plays an important role of enhancing food security especially for those communities living arid and semi-arid regions in Kenya. On the other hand, red meat is highly consumed in Kenya constituting of 80% of domestic meat consumption. Cattle and sheep are Kenya's main source of red meat. Over the past two decade, Kenya has recorded high increase in meat consumption, from 1990 to 2015, beef consumption has increased from 200,000 tons to 500,000 tons. White meat consumption includes pig meats and poultry accounts for 20% of total meat consumed in Kenya. According to FAO (2019), milk consumption is averaging 121 litres, 16kg of meat and 45 eggs per person per year. In 2018, meat, milk and dairy sector recorded a higher turnover of ksh.146 billion from ksh.135.6 billon because of support provided by the National Government, County Government and by private organizations.

Cash Transfer Policy is an intervening policy implemented since 2017 that aims to enable the older adults to receive cash in their pockets as they lack the youthful energy that enabled them to carry out farming. Although this policy is intended to increase food availability to older adults, it is riddled with accountability issues.

Challenges Contributing to Food Insecurity in Kenya

Land and population pressures

Population growth is driving a steady fall in the average farm size in Kenya. Average farm size is falling and land distribution is becoming more concentrated, leading to significant constraints on production, particularly for smallholders. Limited land for agricultural activities have will with no time led to lower agricultural productivity. Also, land degradation have been increasing overtime lowering land productivity rate (Olwande et al., 2015).

Agricultural research and development and agricultural extension

Agricultural extension services are yet to be fully implemented in Kenya. The proportion of farmers accessing extension services is not only low but also accessible to people who are able to afford their services. Extension service officers tend to favor the rich farmers as compared to poor farmers. Budget allocation on agricultural research and extension has been decreasing over time. In a survey conducted in 38 out of 47 counties in Kenya, only 21 % of sampled households accessed extension services, and 59% used the public extension system (Beintema et al., 2018).

Climate change

Climate change has been a great threat to agriculture not only in Kenya but also in the whole world. Kenya agriculture depend on rainfall, thus, due to variability of rainfall which recently rainfall patterns have been changing due to climate change. Lower rainfall lead to shortage in agricultural production whereas during rainfall seasons, floods caused due to higher rainfall also destroy crop plantations.

Insufficient Stewardship of Fishing Grounds

Fishing sector is yet to be fully exploited in Kenya. Illegal, unlicensed and unregulated fishing has been a major challenge. Fish farming volumes have been decreasing for the past few years due to competition from imported cheaper fishes. According to Kenya Marine and Fisheries Research Institute, Kenya has a potential to produce between 150,000 and 300,000 metric tons per year. However, in 2015, total fish production was just 9,000 metric tons. Poor policies have led to insufficient stewardship of fishing grounds. Also, pollution from industries and household wastes to water sources have been observed to affect fishing volumes negatively.

Pests and Diseases

Lack of information, inputs, technology and finance access makes it hard for small scale farmers to manage crops and livestock pest and diseases. Majoring of pest and diseases are manageable but most farmers fail to practice the required control measures. Pest and diseases cause crop loss, lower quality and quantity of crops and livestock which in return leads to lower income. For example, in December 2019, there was invasion of desert locust in many parts of Kenya destroying crops that could have feed thousands of people. According a findings by (FAO, 2020) about 175,000 hectares of crop and pastureland were affected by these locusts which affected almost 164,000 households.

Public Expenditure

The public expenditure allocated in agriculture has been low despite huge contribute of agricultural sector to total GDP. According to 2019/2020 financial year budget, there was an increase in budget allocation in agriculture from Ksh.45 billion to Ksh.52 billion which is 2.9% of the total budget. Kenya is a member of Malabo declaration compromising African Heads of States which requires every country member to commit at least 10% of its total budget to Agriculture with an objective to achieve a 6% growth in agricultural sector.

Infrastructure

Poor and inadequate infrastructure is a major problem facing the agricultural sector in Kenya for a long time. The poor state of transportation, communication, irrigation, markets and storage facilities affect agricultural productivity negatively. Poor infrastructures affects service delivery such as access to extension services, markings, information, education, financial services and education.

CONCLUSION AND RECOMMENDATIONS

The agricultural policies set by the government have both direct and indirect effects on the agricultural sector which in return affects the food security state in a country. The food security agenda established in 2017 by President Uhuru Kenyatta aims at ensuring that the country moves towards becoming a food secure country; all Kenyans have access to physical, social, and economic access to safe, nutritious, and sufficient food that meets their dietary needs at all time. In combination with previously implemented policies and strategies, there has been the development of new policies working toward achieving a food secure country by 2030 in line with Kenya Vision 2030 strategy. Policies such as high taxes on farm inputs (fertilizers, pesticides), and withdrawal of the Farm Inputs Loans Scheme, higher requirements for securing agriculture base loans has led to low productivity in the agricultural sector. The key challenges facing the agricultural sector in Kenya include; land and population pressures, climate change, pests and diseases, inadequate agricultural research and agricultural extension, lower public expenditure, poor infrastructure.

To achieve a food secure country by 2030 as per Kenya Vision 2030's plan policies and incentives need to be implemented to help small scale farmers to shift from subsistence farming to commercial farming. More financial institutions providing agricultural loans and credits by the government need to be put in place, thus, farmers who have not been able to shift to commercial farming due to lack of funds will be in a position to. Kenya has a big potential to produce all the imported agricultural products if efficient policies can be implemented. For instance, there is much potential to produce sugar but due to higher production costs which are caused by higher taxation on inputs, higher electricity costs, and poor transport infrastructures. Reduction of tax on inputs, provision of subsidies on inputs, and purchase support will help in improving all agricultural sectors. The government should work more on the implementation side to increase this policy's effectiveness in low-income areas. For instance, more expansion of the cash transfer program to all areas of the country and increased accountability will benefit more people from the program. The food product subsidies policy, which aims to reduce maize prices for the low-income earners, should be implemented strictly. Its application should be made in consultation with the budget allocation, amount of taxes collected so that the program is sustainable.

Over-reliance on rainfed agriculture is a major issue contributing to food insecurity in Kenya. Irrigation systems need to be developed to boost productivity all year long, offering education to farmers on how to go about it, provision of required facilities will improve agricultural productivity. There should be the introduction of technologies that will contribute to water harvesting which will make other farming practices like irrigation possible.

Promotion of crop diversity and sensitizing the populace on the importance will reduce the reliance people have on maize. One way of promoting other crops' consumption is by adding value and encouraging farmers to grow these crops by paying them promptly once these farmers have delivered this product to the factory for processing. To improve maize's food quality, fortify maize with other nutrients, and develop better seed varieties is a strategy that should be explored.

The government needs to provide subsidies and cut taxation costs on basic food products. This will lower the costs of these products thus making them accessible to people. Also, despite curfew and lockdown, the government agencies should put in place measures ensuring agricultural products are transported to markets at the right time. Market accessibility will create markets for farmers' produce thus sustaining their earnings and at the same time making food available to the people.

Another way the government will help in improving food security is by setting urgent policies that will keep in check the price of agricultural produces as most businesses in the food supply chain are taking advantage of high demand and low supply to overprice basic agricultural products.

Achieving a food secure country will require more than the current budget allocation in the agricultural sector. The government needs to increase money allocations to the agriculture and food sectors. Also, there should be the development of bottom-top-based policies where members of the public especially those participating in agriculture and related activities have a say as it creates critical opportunities to push for the creating of a fair and sustainable food system.

Acknowledgement

There was no funding involved.

Author Contributions

Both authors contributed substantially to the research design, data collection, data analysis, write-up and editing of the manuscript. The submitted version is checked and approved by both authors.

Conflict of Interest

The authors confirm that there are no conflicts of interest.

REFERENCES

AGRA 2019. Potato regulations: A new dawn for farmers | AGRA news center. (2019, August 1). Retrieved from https://agra.org/news/2019-potato-regulations-a-new-dawn-for-farmers/

Alila P. & Atieno R. 2006. Agricultural Policy in Kenya: Issues and Processes.

Among R. (n.d.). *Food Price Crisis and Food Insecurity in Kenya*. Virtual Library on Capacity Development. https://elibrary.acbfpact.org/acbf/collect/acbf/index/assoc/HASH01b5/cd96f147/6ca2937f/79e1.dir/Food%20crisis%20and%20food%20insecurity%20in%20Kenya.pdf.

Atera E., Onyancha F. & Majiwa E. 2018. Production and marketing of rice in Kenya: challenges and opportunities. Journal of Development and Agricultural Economics. *Journal of Development and Agricultural Economics*, 10(3), 64-70.

Atieno R. & K. Kanyinga 2008. The Revitalisation of Kenya Cooperative Creameries: The Politics of Policy Reforms in the Dairy Sector in Kenya. Report for Future Agricultures Consortium, Institute of Development Studies, University of Nairobi, Nairobi.

Bazeley P. 2005. Kenya: Strategy for Revitalizing Agriculture; October 2005 Visit Report & Further Issues and Options, Peter Bazeley Development Consulting, Dorset, UK.

Beintema N., Mose L., Kibet T., Emongor R., Murithi F., Kimani I., Ndungu V. & Mwangi P. 2018. Kenya: Agricultural R&D Indicators Factsheet Update. Washington, D.C.: International Food Policy Research Institute (IFPRI); and Kenya Agricultural and Livestock Research Organisation (KALRO).

Budget. (n.d.). The National Treasury. https://www.treasury.go.ke/budget.html

Charlotte S. & Mazhar M. 2018. From Maputo to Malabo: Public Agricultural Spending and Food Security in Africa. hal-01844094.

Daniel W. 2020. *Kenya's top 10 exports*. (2020, June 14). World's Top Exports. https://www.worldstopexports.com/kenyas-top-10-exports/

Faling M. 2020. Framing agriculture and climate in Kenyan policies: a longitudinal perspective. *Environmental Science & Policy*, *106*, 228-239.

FAO 2020. *Food loss and waste must be reduced for greater food security and environmental sustainability*. (n.d.).Home |Food and Agriculture Organization of the United Nations. https://www.fao.org/news/story/en/item/1310271/icode/.

FAO. 2011. Dairy development in Kenya, by H.G. Muriuki. Rome.

FAO. 2019. *The future of livestock in Kenya. Opportunities and challenges in the face of uncertainty*. Rome. 56 pp. Licence: CC BY-NC-SA 3.0 IGO.

Fao, Eca And Auc. 2020. Africa Regional Overview of Food Security And Nutrition 2019. Accra. Https://Doi.Org/10.4060/Ca7343en.

FEWS.NET. 2020. *Kenya - Food security outlook: Wed, 2020-06-10 to sun, 2021-01-10 | Famine early warning systems network*. Famine Early Warning Systems Network. https://fews.net/east-africa/kenya/food-security-outlook/june-2020.

Food and Agricultural Organization of the United States. (2020). *Fast*. Home | Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/en/#country/114.

Government of Kenya 2010. Agricultural Sector Development Strategy 2010–2020, Nairobi

Government of Kenya. 2011. National Food and Nutrition Security Policy. Available at: https://extranet.who.int/nutrition/gina/en/node/11501 http://www.teaboard.or.ke/opencms/export/sites/tbk/about/reports/TEA_BOARD_MAG_FINAL_BITMAP.pdf

International Coffee Organization, (2019). Retrieved Online From: http://www.ico.org/documents/cy2018-19/icc-124-7e-profile-kenya.pdf.

Kamwaga J., Macharia G., Boyd L., Chiurugwi T., Midgley I., Canales C., Marcheselli M. & Maina I. 2016. Kenya Wheat Production Handbook. Kenya Agricultural and Livestock Research Organization, Nairobi, Kenya.

Kenya Ministry of Agriculture, Livestock, Fisheries and Irrigation. (2018). Agricultural Sector Transformation and Growth Strategy 2019–2029 (ASTGS), abridged version. Kenya: Government of Kenya. Pg 3.

Kenya National Bureau of Statistics. 2019. Enhanced Food Balance Sheets for Kenya. African Development Bank-Building today, a better Africa tomorrow. https://www.afdb.org/sites/default/files/documents/publications/food_balance_sheets_kenya_full_report.pdf.

Kiprotich et al. 2019. Influence of Organic Enriched Manure and Inorganic Fertilizers on Plant Physiological Processes of Kenyan Tea Clone. *Asian Journal of Soil Science and Plant Nutrition* 5(3): 1-7, 2019; Article no. AJSSPN.52680 ISSN: 2456-9682.

Kiptanui T. 2019. Maize Crisis: A Position Paper on Strategies for Addressing Challenges Facing Maize Farming In Kenya. East African Scholars Journal of Education, Humanities and Literature, 2(3), 149-158.

Kirui K. 2014. Socio-Economic Effects of Liberalization of Small Scale Tea Sector in Kenya: Evidence from Tea Farmers in Konoin District. *Research Journal of Finance and Accounting* 5(24),148-160

Kuguru N. 2016. Effects of Government Policies on Performance of Coffee Industry in Kenya. IOSR Journal of Business and Management, 18(6),53-60.

Makoye K. 2020. *Tanzania draws up plans to quell malnutrition*. Anadolu Ajansı. https://www.aa.com.tr/en/africa/tanzania-draws-up-plans-to-quell-malnutrition/2041130

Ministry of Livestock Development. 2008. Sessional paper no. 2 of 2008 on national livestock policy. Nairobi: Republic of Kenya, Ministry of Livestock Development

Mutua J. 2019. Foods that Kenyans eat the most. Business Daily. https://www.businessdailyafrica.com/bd/data-hub/foods-that-kenyans-eat-the-most-2249422

Muatha I.T., Otieno D.J. & Nyikal R.A. 2017. Determinants of smallholder farmers' awareness of agricultural extension devolution in Kenya, *African Journal of Agricultural Research(AJAR),* 12 (51), pp 3549-3555, 21 December, ISSN 1991-637X

Ochieng J., Kirimi L. & Mathenge M. 2016. Effects of climate variability and change on agricultural production: the case of small scale farmers in Kenya. NJAS - Wageningen *Journal of Life Sciences,* 77, 71-78.

Olwande J., Smale M., Mathenge M. K., Place F. & Mithöfer D. 2015. Agricultural marketing by smallholders in Kenya*:* A comparison of maize, kale and dairy. *Food Policy,* 52, 22-32.

Onono P.A., Wawire N.W.H. & Ombuki C. 2013, The response of maize production in Kenya to economic incentives, *International Journal of Development and Sustainability,* Vol. 2 No. 2 (in Press).

Owiye O., Naibei K. & Momanyi G. 2016. Effect of Trade Liberalization on Performance of Sugar Firms in Kenya: The Case of Government Owned Firms. *European Scientific Journal,* 12(13), 306-320.

Phoebe S. 2020. *Food security declines in East Africa following economic, climate and conflict shocks*. (2020, October 8). Future Directions International. https://www.futuredirections.org.au/publication/food-security-declines-in-east-africa-following-economic-climate-and-conflict-shocks/

Rapsomanikis G. 2015. The economic lives of smallholder farmers. Rome: Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/3/a-i5251e.pdf

Rapsomanikis G. 2015. The economic lives of smallholder farmers.

Research Institute (IFPRI), I. F. (2013). Complying with the Maputo declaration target. https://doi.org/10.2499/9780896298415

Ridolfi C. Hoffman V. & Siddhartha B. 2018. Post-Harvest Losses in Fruits and Vegetables. *Institute of Food Policy Research Institute*, 1- http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/132325/filename/132536.pdf

Susan MacMillan 2019. Kenyan livestock sector to grow 'exponentially'—Kenya national bureau of statistics. Retrieved from https://www.ilri.org/news/kenyan-livestock-sector-grow-%E2%80%98exponentially%E2%80%99%E2%80%94kenya-national-bureau-statistics

TBK 2011. Annual Report and Accounts 2010/2011.

U.S. Agency for International Development. (2020, May 15). *Agriculture and food security*. https://www.usaid.gov/kenya/agriculture-and-food-security

Unicef 2018.UNICEF. https://www.unicef.org/uganda/media/3886/file/KNP%20launch%20Booklet.pdf

Wang'ombe J. 2008. The potato value chain in Kenya and Uganda. Maastricht School of Management,Netherlands.http://www.roundtableafrica.net/media/uploads/File/oseph%20 Gichuru%20WangombeThe%20Potato%20Value%20Chain%20in%20 Kenya%20and%20Uganda.pdf

World Bank Group 2018. Kenya Economic Update, April 2018, No. 17: Policy options to advance the Big 4. World Bank, Nairobi. Retrieved from: https://openknowledge.worldbank.org/handle/10986/29676

World Bank 2019. Retrieved from https://data.worldbank.org/country/KE

World Bank. 2019. *Kenya economic update: Transforming agricultural productivity to achieve food security for all*. https://www.worldbank.org/en/country/kenya/publication/kenya-economic-update-transforming-agricultural-productivity-to-achieve-food-security-for-all.

World Food Programme. 2019. *East Africa regional food security & nutrition update (November 2019) - Ethiopia*. ReliefWeb. https://reliefweb.int/report/ethiopia/east-africa-regional-food-security-nutrition-update-november-2019.

Assessment on the Performance of Income Generating Project of Visayas State University: Pangasugan-Marcos Rice Production

Ulysses A. CAGASAN

Visayas State University, Visca, Baybay City, Leyte, Philippines

Corresponding Author: ulycagasan@vsu.edu.ph

Abstract

This study was conducted to assess the impact and contribution of VSU Income-Generating. Project on rice production conducted at Barangay Pangasugan and Marcos. The project will cater to the four core functions of the Visayas State University, instruction, research, extension, and production. It served as the site of the Agronomy students' field activities. This site served as the research and extension project of the Department of Agronomy. Moreover, it is one of the income-generating projects of Visayas State University. The project generated a total net income of PhP280,000 for the four-year operations. The project served 45 students, five faculties and 25 farmers conducted their extension project on low-cost rice production technology.

Keywords: Lowland rice, income-generating, cultivators, and management

Research article
Received Date: 10 June 2021
Accepted Date: 9 November 2021

INTRODUCTION

The emergence of income-generating projects (IGPs) in State Colleges and Universities (SCUs) has been conceived to augment the University's resources and fill in the budget gap for any relevant expenditure items that the University may incur (Miranda et al. 2016). One of the IGP proposed by the Visayas State University-Income Generating Project personnel and supervised by the Department of Agronomy (VSU-IGP 2018). The project on rice production is located in Barangay Pangasugan and Barangay Marcos in Baybay City, Leyte, Philippines. The total land area occupied by the project was approximately 1.5 hectares with ten cultivators. The project on rice production is guided by the modern rice production technologies adopted by the farmer cultivators.

The rice production project in VSU decreased in 2017 and 2020 due to typhoons and the problems on COVID 19 Pandemic, respectively. Thus we need to adopt modern technologies in rice production (Beronio et al. 2020). Planting is usually done two (2) times a year. The sharing of harvest is 2/3 for the cultivator and 1/3 for VSU. No project expenses were incurred in this project since the cultivators provided all the inputs except for the hauling of VSU share from the farm up to the roadside where the palay is sold.

This project will serve the four core functions of the University for Instruction, Research, Extension, and Production. To study will try to assess the project's performance and examine the challenges experienced by the rice farmer cultivators that may hinder them from achieving the maximum productivity and income.

METHODOLOGY

The project on rice production is located in Barangay Pangasugan and Barangay Marcos in Baybay City, Leyte, Philippines. The area is lowland irrigated with plain elevation. Previously, the total land area occupied was approximately 2.5 hectares with 12 cultivators. However, now it only had approximately 1.65 hectares because PhilRootcrops took an approximately 0.75-hectare area of 2 cultivators for their research activities. The project dealt on one commodity only, specifically on rice production as the area is only suited for rice. Planting is usually done two times a year. During harvest, the cultivators informed the project leader of any activities in the field, especially during harvest time. The project leader will also inform the person in charge of the IASSO. Implementation of the project was based on the premise of the University's general objectives.

The harvest sharing is 2/3 for the cultivator and 1/3 for VSU. No project expenses were incurred since all inputs were provided by the cultivators except for the hauling of VSU share from the farm up to the roadside where the VSU vehicle will pick the palay harvest. The VSU shared will be sold to the palay buyer with the highest price per kilo of fresh palay. Income generated from sales was recorded correctly and remitted to the treasury of the University. The sales report was supported by sales receipts from the commercial buyers and checked by the IASSO personnel.

The project's organizational structure follows the guidelines of the Visayas State University Income Generating Project of VSU (VSU-IGP 2018).

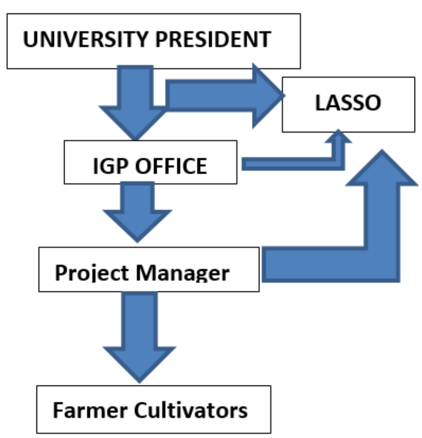


Figure 1. Organizational structure of the VSU-IGP

RESULT and DISCUSSION

Table 1. The farmer cultivators with their corresponding farm size

Cultivators	Name of farmers	Age	Area (Ha) Cultivated	Number of Cropping
1	Almario Halasan	57	0.10	Wet season only
2	Melquiades Bagarinao	62	0.02	Wet and dry season
3	Eleno Bagarinao	60	0.30*	terminated
4	Eduardo Leal	56	0.02	Wet and dry season
5	Isidro Fernandez	65	0.35	Wet season only
6	Jimmy Caballero	53	0.30	Wet and dry season
7	Isidro Bagarinao	71	0.45*	terminated
8	Enrique Alcober	68	0.10*	terminated
9	Faustino Bagarinao	6	0.30	Wet and dry season
10	Evelyn Frances	48	0.35	Wet and dry season
11	Jesus Vega	50	0.25	The wet and dry season
12	Pedro Bagarinao		0.15	The wet and dry season
Total			1.65 has	
Mean		69		

* Terminated because Philrootcrops used the area for their research activities

Contribution to the University's four-fold functions

The project goal followed the four-fold function of the University's instruction, research, extension, and production. (VSU-IGP 2020)

University's four-fold functions	Project's Contribution
1. Instruction	The project will serve as the demonstration area for rice production that will cater to agriculture students to observe their farm activities from land preparation up to harvesting and collecting pests in the rice field for the pest management majors.
2. Research	The project will also cater to some research activities of the students and faculty as learning sites such as farmer's field school and others.
3. Extension	The project will serve as sites for the extension project of the Department of Agronomy, such as technical assistance to the farmer cultivators for the improvement of rice yield.
4. Production	This is one of the purposes why this project was implemented to support the income-generating projects of VSU.

Inventory of Equipment and Supplies

This project was purely supervision by the rice cultivators during harvesting. The farmer cultivators will provide the needed farm equipment and capital such as inputs and other expenses during the farm operation. Thus the VSU will not provide equipment and field supplies to the cultivator.

Problems Met and Action Taken

Problems Encountered	Actions Taken
1. LOW PRODUCTION- caused by the following factors: a. Weather Conditions Continuous rains and frequent visit of typhoons which affected field operations and cultural management practices like application of fertilizer and pesticides b. Lack of Inputs	• Adjusted activity schedule and implementation • Timing of planting to minimize damage/sterility of grains caused by strong wind (habagat). • Proposed support on the credit of fertilizer and other chemical inputs to the cultivator
2. Conflict of work schedule to monitor the project operations, especially during harvesting	• Prioritized scheduling of work activities through an advance notice on the activity schedule like harvesting.
3. Harvesting Schedule	• Imposed harvesting is scheduled to be done during weekdays to facilitate the presence of the authorized personnel for monitoring purposes.

Recommendation for Improvement

a. Financial Target income to P50,000.00 per year	• Conduct meeting with the cultivators before planting to facilitate the preparation of seeds and inputs needed in each farm. • Promote low-cost cultural management practices for rice production • Promote the use of hybrid rice variety and other high yielding inbreed rice varieties
b. Non-financial • Closely supervise the cultivators under the project and • Increase the production of rice and income per unit area • Provide technical and financial assistance to the cultivators	• Frequent visit to the area/farm • Promote the use of certified rice seeds • The efficiency of using inputs (pesticides and fertilizers) • Provide certified seeds and some inputs (thru credit) to the farmers/tenants

	• Promote the use of hybrid rice variety, and other high-yielding inbreed rice varieties.

Income Statement (2016 to 2020)

Income Statement	Net Income Remitted to VSU	Reasons
CY 2016	PhP 51,548.50	The project still achieved the projected income.
CY 2017	PhP 42,396.00	Most of the cultivators experienced meager harvest due to severe damage on their rice field brought about by the typhoons and other natural calamities.
CY 2018	PhP 58,430.00	This is the regular income and yield harvest yield for the two cropping season, wet and dry seasons.
CY 2019	PhP 68,430.00	Surplus of target income was achieved due to improvements in the management. Thus, they can get a good harvest.
CY 2020	PhP 48,430.00	Due to the Pandemic, some farmer cultivators were not able to plant their fields.
TOTAL		

Assessment of the Project (VSU-IGP 2018)

Overall Management

Items	Last Year's Performance Rating (1-10 scale), NA not applicable	Details or justifications for the rating provided
1. Able to sustain the gains of the project carried over from the previous administration	5	The year 2017 was considered a failure for the cropping season due to severe damage of the crop due to typhoons
2. Able to manage and improve the efficiency of workers	6	Due to the heavy workload of the project manager on instruction and research
3. Able to implement initiatives to improve the productivity of workers	7	Implemented initiatives to improve the productivity of workers
4. The project falls within the mandate of the unit	10	This is part of the department and university goal to provide the four-fold functions (instruction, research, extension, and production) of the University
5. Maintenance of peaceful environment in the project	8	No requests of mediation to settle disputes within the project
6. Worker turn-over degree	7	Some cultivator did not produce a good harvest due to late planting
7. Worker retrenchment	NA	NA

8. Frequency of requests of mediation to settle disputes within the project	8	No requests of mediation to settle disputes within the project
9. Adherence to BOR/ CHED/DBM policies/guidelines	NA	NA
10. Practicing transparency in all transaction	10	All harvesting activities up to the sale of shares were attended by IASSO personnel. The sales were remitted directly to the cash division office

Research Management

Items	Last Year's Performance Rating (1-10 scale), NA not applicable	Details or justifications for the rating provided
1. Have made improvements/innovations in the project based on research results	6	No proper research/interventions were done in the farm sites. Still, the project proposal was submitted to VSU Extension Office.
2. Extended support to research community to improve research capability	6	No proper research/interventions were done in the farm sites. Still, the project proposal was submitted to VSU Extension Office.
3. Provided infrastructure to improve research capability	6	The farmer cultivators only maintained irrigation canal for their use No other infrastructure was established
4. Adoption of relevant technologies	7	Not all farmer cultivators follow the modern technology for rice, such as certified seeds and proper use of inputs (chemical fertilizers and pesticides). Timing of planting / synchronous planting to all rice farmers.

Extension Management

Items	Last Year's Performance Rating (1-10 scale), NA not applicable	Details or justifications for the rating provided
1. Alignment of the project with instruction and extension	7	Caters primary agronomy students' for their laboratory classes and demonstration for extension
2. Formulated and implemented creative outputs to bring project output to intended clientele	7	The project serves as training sites for the department’s extension activities.

3. Provided mentoring services and established partnership arrangement with clientele or interested parties	7	Cater's primary agronomy students' for their laboratory classes and any interested clientele
4. Sustainability of implementing the project	8	Sustainability of production system for the farmer
5. Transfer of knowledge and expertise to interested parties	7	Caters primary agronomy students' for their laboratory classes and researches
6. Technologies extended or demonstrated	8	Provides training program on the production and management of the different cultural management practices for rice to agronomy primary students specifically for their skills development (practicum) and interested farmers/technicians on their NC II and III in Crop Production.
7. The extent to which the project is used for the University's extension function	7	The project serves as a laboratory facility for instruction, research, and the training area for the department's extension activities.

Production Management (Miranda et al., 2016)

Items	**Last Year's Performance Rating (1-10 scale) NA not applicable**	**Details or justifications for the rating provided**
1. Level of revenue /yield generated from the project	6	The yield of rice is low because of erratic climatic condition that affects the operations.
2. Number of other potential marketable products of the project	5	No other crop has been planted because the area is intended only for lowland crops like rice
3. Employed strategies or technologies to increase income generation or production	5	Cultivators need skills training specifically for modern cultural management practices for rice. Adoption of low-cost land preparation and proper/efficient use of inputs need to be observed
4. Level of income generated from the commercialization of products generated from technology developed	6	They introduced technology to the cultivators are to be verified and tested.

Financial Management

Items	Last Year's Performance Rating (1-10 scale) NA not applicable	Details or justifications for the rating provided
1. On-time payment of salaries and benefits	NA	No salaries for workers because the farmer cultivators shouldered it
2. On-time payment to suppliers	NA	No salaries for workers because the farmer cultivators shouldered it
3. Adherence to COA policies	8	Cultivators informed the project leader of any activities in the field, especially during harvest time. The project leader will also inform the person in charge at IASSO for proper monitoring.
4. Efficiency in the utilization of GOP budget	NA	No GOP needed
5. Efficiency in the utilization of income	NA	No project expenses were noted because the cultivators shouldered all production inputs except for the hauling of VSU share from the farm up to the roadside where VSU vehicles will pick/get the palay harvest.
6. Amount of annual savings	NA	The money was deposited in the cash division office under the general fund
8. Practice record keeping	10	Income generated from sales was recorded correctly and remitted to the treasury of the University.
9. On-time submission of financial reports	9	The sales report was supported by sales receipts from the commercial buyers and checked by the IASSO personnel. Financial reports were submitted to IASSO.

Plans for Improvement in the Project Operation

This project needs intervention to improve the efficiency of production. The pool of experts from the Department of Agronomy submits an extension project proposal to the VSU Extension Office for funding support. The project aims to promote the low-cost rice production technology to the interested farmers in the neighboring barangays, including our rice farmer cultivator.

CONCLUSION

The project's success depends on the people who are handling the operations (Florendo, 2005). Hence, continuous farmer/cultivator education is necessary to make them understand scientific principles of crop and resource management; adjust various inputs to temporal and spatial variability of rice fields; adopt integrated nutrient, water, weed, and pest management; and increase farm income through efficient post-harvest processing and utilization of byproducts.

The project served as the demonstration area for rice production that will cater to agriculture students to observe their farm activities from land preparation up to harvesting the project generated a total net income of PhP280,000 for the four-year operations. Served 15 students, five faculty and 25 farmers conducted their extension project on low-cost rice production technology.

RECOMMENDATION

1. Cultivators need skills training specifically for modern cultural management practices for rice. Adoption of low-cost land preparation and proper/efficient use of inputs need to be observed.
2. To increase income generation, the development/cultivation of some idol areas was done to increase the area for rice production. Proper maintenance of irrigation and drainage was done to efficiently control and maintain the water supply for rice production. Use of modern rice cultural management practices was adopted like certified rice seed varieties and application of inputs efficiency.
3. Farmer/cultivators need adequate training and technical support to improve their decision-making capacity and adequately utilize the new techniques.

LESSONS LEARNED

1. The project is solely income-generating, which is also followed the COA rules and regulations.
2. A cultivator should be provided with trainings on modern rice production technologies to increase the production per unit area per unit time.
3. An integrated crop management approach (water, soil fertility/nutrients, weeds/pests/diseases, and post-harvest processing) is vital to maximize the productivity and profitability of rice farmers/cultivators.
4. All technologies and practices should be used synergistically to help farmers increase and/or maintain grain yields at the same or reduced cost.
5. Improving the quality of milled rice and increasing the recovery of head-rice will enhance farmers' profitability.
6. We need to train the extension staff and equip them with adequate tools to educate their farmer-clients on modern rice farming.

REFERENCES

Beronio R., Bordey F., Eligio A., Barroga K., Malasa R., Mariano M. & Castaneda A. 2020. Is the household income of rice farmers getting better over time? Rice Science for Better Decision-Makers, Issue 1, (Munoz, Philippines: Department of Agriculture- Philippine Rice Research Institute).

Florendo F.S. 2005. Income generating projects and institutional development of selected State Universities and Colleges in Luzon: implications to policy formulation, Unpublished Doctoral Dissertation, Technological University of the Philippines, Manila, March, p. 64.

Income Generating Project 2020. An accomplishment report of Visayas State University, available at: www.vsu.edu.ph/accomplishments (Accessed 9 June 2020).

Miranda A.T., Tenedero L.E., Fiel-Miranda J.L. & Celestino E.R. 2016. The income-generating projects of a government academic institution in The Philippines: The case of the University of Eastern Philippines, Asia Pacific Journal of Innovation and Entrepreneurship, Vol. 10 No. 1, pp. 5-16. https://doi.org/10.1108/APJIE-12-2016-006

Orgaya N. 2007. Productivity through income generating projects: camarines Sur Polytechnic College experience, Unpublished Master's Thesis, School of Graduate Studies and Research, Naga College Foundation, Naga City.

Visayas State University 2018. Consolidated implementing guidelines for the VSU income generating program.

Eurasian Journal of Agricultural Research 2021; Vol: 5, Issue:2, pp: 94-109

Effect of water stress on crop coefficient of irrigated Soybeans (*Glycine max L merr.)* under sub-humid conditions

Omotayo B. ADEBOYE[1*], Bart SCHULTZ[2], Kenneth O. ADEKALU[1] and Krishna C. PRASAD[3]

[1]*Department of Agricultural and Environmental Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria*
[2]*Land and Water Development IHE Delft, Delft, the Netherlands*
[3]*Freelance Irrigation and Water Resources Management Consultant, Lalitpur, Nepal*

**Corresponding author: adeboyeob@oauife.edu.ng*

ORCID: 0000-0002-2428-4226

Abstract

In order to manage irrigation systems effectively and sustainably for food production, it is important to estimate crop evapotranspiration with high precision and understand the relationship between functional parameters in the soil-water-plant-atmosphere system. Soybean was drip irrigated for two seasons in Ile-Ife, Nigeria. The experimental factor was the timing of irrigation. The treatments consisted of full irrigation (T_{1111}); skipping of irrigation every other week during flowering (T_{0111}); pod initiation (T_{1011}); seed filling (T_{1101}) and maturity (T_{1110}). The treatments were arranged in a randomized complete block design with three replicates. Leaf area index (*LAI*), canopy cover (*CC*) and crop coefficient (k_c) were measured and the single crop coefficient approach was used to determine evapotranspiration (ET_c). The *crop coefficient* (k_c) during flowering and maturity ranged from 1.14-1.29 and 0.49-1.19 respectively, while during pod initiation and seed filling, it was 1.29 in the seasons. The actual crop coefficient (k_{ci}) when irrigation was skipped during flowering, pod initiation, seed filling and maturity ranged from 1.04-1.46; 1.30-1.48; 0.82-1.48 and 0.77-1.17 respectively in the seasons. The k_{ci} when irrigation was skipped during flowering, pod initiation, seed filling and maturity reduced by 13.4, 11; 26 and 17% respectively compared with the fully irrigated soybeans. Exponential equations described excellently the relationship between k_{ci} and green leaf area index (*LAI)* ($0.87 \leq r^2 \leq 0.97$; $p < 0.0001$). There was strong linear correlation between k_{ci} *and* daily actual evapotranspiration (ET_c) ($0.73 \leq r^2 \leq 0.84$; $p < 0.0001$) in the seasons. The k_{ci} and canopy cover (CC) are highly and significantly linearly related ($0.89 \leq r^2 \leq 0.97$; $p < 0.0001$) and intercept very close to zero. Skipping of irrigation during the reproductive stages of soybeans reduced the crop coefficient and evapotranspiration.

Keywords: Drip irrigation, soybeans, crop coefficient, full and deficit irrigation

Research article
Received Date: 13 July 2021
Accepted Date: 24 September 2021

INTRODUCTION

The crop coefficient plays a key role in many agricultural practices and it has been widely used to estimate actual evapotranspiration in irrigation scheduling (Pereira *et al.*, 1999). Crop coefficients are properties of plants used in predicting evapotranspiration (ET). Characteristics that distinguish a cropped surface from the reference surface are integrated into the crop coefficient when computing crop evapotranspiration.

The crop coefficient depends on the type of crop, stage of crop growth, soil moisture, health, and height of the plants, canopy cover and orientation in space (Allen *et al.*, 1998). Two major approaches are used in estimating the crop coefficient and these are the single and dual crop coefficient approaches. In the single crop coefficient method, the difference in evapotranspiration between reference grass and cropped field is combined into a coefficient. Evapotranspiration from a reference surface is also called reference evapotranspiration (ET_o) and is determined from weather data such as air temperature, humidity, solar radiation and wind speed at a location. The crop coefficient is computed from the ratio of crop water use to the ET_o. This method has been widely used in the planning and design of less frequent irrigation systems such as drip irrigation (Kang *et al.*, 2003; Hanson and May, 2006; Marin *et al.*, 2016). However, in the dual crop coefficient method, the crop coefficient is sectioned into evaporation (k_e) and transpiration (basal crop coefficient, k_{cb}) between the crop and the reference surface (Allen *et al.*, 1998). The crop coefficient curve is a description of the pattern of seasonal distribution of k_c. It can be related to time, thermal unit called growing degree-days or other agronomic parameters. The k_c for most of the agricultural crops increases from the lowest values at emergence or transplantation depending on canopy development until it reaches the peak value at maximum canopy cover. The k_c reduces shortly after reaching the maximum canopy cover in a cropping season. Growth characteristics and irrigation management influence the degree of declination of K_c during the late season (Kamble and Irmak, 2008). Crop coefficients depend largely on roughness of canopy, age of leaf and wetness of the surface (Justice and Townshend, 2002). As a crop canopy develops the ratio of transpiration to evapotranspiration increases, until transpiration constitutes a larger proportion of evapotranspiration compared to evaporation of water from soil. During this stage, plant canopy intercepts most of the radiant energy before a very small proportion reaches the soil surface. This occurs because the interception of radiant energy by the foliage increases until most light is intercepted before it reaches the soil. Researches show that the crop coefficient is highly correlated with the area of leafs (Williams *et al.*, 2003), leaf area index (*LAI*) of vegetables (Pereira *et al.*, 2011), canopy cover (de Medeiros *et al.*, 2001); and the fraction of light intercepted by the crop canopy (Williams and Ayars, 2005; Marsal *et al.*, 2014). However, the degree of correlation has not yet been generated for all tropical crops. There is variability in k_c in space and in time. This is due to variability in varieties, date of emergence, land use pattern, density of vegetation, rainfall and environmental conditions, such as air temperature, wind speed and vapour pressure deficit. For instance, k_c of soybeans varied from 0.54 to 1.11, 0.80 to 1.04 and 0.41 to 1.09 in 2002, 2003 and 2005 respectively (Payero and Irmak, 2013). They found that differences in weather conditions affected the crop coefficient of soybeans and cumulative growing degree-days. In addition, they found that the frequency of the wetting event affected the crop coefficient of soybeans. Doorenbos and Pruitt (1977) presented k_c for a large number of crops under varying climatic conditions, which could be used in places where local data is not available. The k_c was updated by Allen et al., (1998).

There have been criticisms on the applications of empirical crop coefficients because their values vary according to the conditions of climate and crop stages. Suyker and Verma (2009) found that the midseason k_c for irrigated soybeans was 0.98±0.02. The k_c for irrigated soybeans during early season, mid-season and later season were 0.27±0.17, 0.98±0.02, and 0.32±0.12 respectively (Suyker and Verma, 2009). The k_c found in literatures are for surface or sprinkler irrigation. The crop coefficients under localised irrigation systems are very scarce. Drip irrigation systems have been proven very efficient in saving water and improving water productivity. These systems are gaining acceptance even among the smallholders and commercial farmers in sub-Saharan Africa (Rai et al., 2017).

Therefore, in order to increase accuracy of evapotranspiration for an area or region, there is a need to compute and study the trend and dynamics of k_c under irrigated conditions in order to schedule water allocation accurately, calibrate crop yield models for local, regional, and global applications (Kashyap and Panda, 2001).

The development of simple techniques for estimating the crop coefficient at each stage of crop growth using a fraction of intercepted light by plant canopy would be very useful for computation of crop evapotranspiration and water management for crop production in the tropics and temperate regions.

The cost of operating other irrigation methods such as sprinkler irrigation is very high coupled with non-availability of energy for continuous use. In the recent times, interest in drip irrigation is increasing because of fluctuations in rainfall, limited water supply and the cost of pumping water for crop production. Drip irrigation can double or triple water productivity and thereby boosting crop per drop (Rai et al., 2017). The area under drip and other 'micro' irrigation methods has risen by more than 1000%, from 1.03 million ha in 1986 to more than 11 million ha at present over the last 30 years (Reinders and Niekerk, 2018).

Drip irrigation is highly efficient water application system because water is applied to the immediate vicinity of plant and therefore, less water is lost due to evaporation. Virtually all the water that is diverted under drip irrigation is consumptively used (Richter, 2014). The main challenge of adopting drip irrigation is its capital cost, which is up to US$ 2470 ha^{-1} (Hanson and May, 2006) and US$ 5700-6010 ha^{-1} (Adeboye *et al.*, 2015). The objectives of the study are to determine the effects of skipping irrigation every other week during vegetative and reproductive stages of growth on crop coefficients of drip-irrigated soybeans and to generate dynamic regression models between parameters that could be used to predict development of crops under application of full and deficit irrigation.

MATERIAL and METHOD

Study area

The fieldwork was carried at the teaching and research farms of Obafemi Awolowo University, Ile-Ife, Nigeria during the dry seasons of 2013 and 2014. The experimental field is located at latitude 7°28′0″N and longitude 4°34′0″E, 271 m+MSL (mean sea level). It is in the sub-humid area of Nigeria. The dry season extends from November to March, and the climate is conducive for the cultivation of grains and legumes under total and supplementary irrigation. In the recent times, there is variability in monthly distribution of rainfall, and time of occurrence.

These fluctuations in the daily rainfall often make it risky to grow crops during the rainy season or difficult to make a precise prediction of rainfall contributions to crop water use during the dry season. The first season was warmer than the second was. The upper 50 cm was sandy loam while the lower 50 cm contained more clay. The upper 50 cm was richer in organic matter than the lower 50 cm. The pH, phosphorus, and iron were higher in the upper 50 cm than in the lower 50 cm of the soil profile. However, the average total nitrogen, sodium, and potassium in the upper and lower 50 cm of the soil profile were uniform (Table 1).

The experimental factor was the timing of the irrigation. The treatments were arranged in a randomised complete block design (Table 2).

Table 1. Physical and chemical properties of the soil at the experimental field in the growing seasons

Soil depth (cm)	**00 - 20**	**20 - 40**	**40 - 60**	**60 -80**	**80 - 100**
Sand (%)	75	71	59	57	63
Clay (%)	15	19	21	30	18
Silt (%)	10	10	20	13	19
Texture class*	Sandy loam	Sandy loam	Sandy clay loam	Sandy clay loam	Sandy loam
BD (g cm^{-3})	1.49	1.56	1.58	1.57	1.62
OM (%)	1.28	0.74	0.61	0.44	0.34
FC (m^3 m^{-3})	0.18	0.27	0.2	0.31	0.29
PWP (m^3 m^{-3})	0.08	0.13	0.09	0.21	0.19
TAW (m^3 m^{-3})	0.10	0.10	0.12	0.10	0.10
K_{sat} (mm day^{-1})	880	570	415	350	580

BD, Bulk density; FC, Field capacity; PWP, permanent wilting point; TAW, Total available water; OM, Organic matter; *USDA Classification

Table 2. Experimental treatments and their descriptions in the seasons

Experimental label	**Description**
TT_{1111}	Irrigation was maintained weekly without stopping at any of the reproductive growth stage: flowering (R1 and R2 growth stages), pod initiation (R3 and R4 growth stages), seed filling (R5 and R6 growth stages) and maturity stage (R7 and R8 stages) (FI treatment);
TT_{0111}	Irrigation was skipped every other week during flowering
TT_{1011}	Irrigation was skipped every other week during pod initiation
TT_{1101}	Irrigation was skipped every other week during seed filling
TT_{1110}	Irrigation was skipped every other week during maturity

Field layout, cultivation, and measurement

At the commencement of the fieldwork in both seasons, the experimental field was harrowed and the stumps were removed manually. Perennial and spear grasses were controlled by using Force up^{TM}, Isopropylamine salt at 3 litres ha^{-1}. The field was pre-irrigated to a depth of 20 mm in order to initiate germination of the seeds. An indeterminate variety "TGX 1448 2^E", was planted on the 2nd of February (DOY 33) (day of the year) in 2013 (first season) and 8th of November 2013 (DOY 312), second season. The year 2012 was a wet year in the study area and much rainfall was recorded at the end of the year and early parts of 2013. The researchers experienced delay in the procurement of irrigation equipment in the first season coupled with logistic challenges. These were responsible for the late commencement of the experiment in the stated time. Three seeds were sown 4 cm below the soil surface and the plant spacing was 0.6 by 0.3 m, resulting in 166,668 plants ha^{-1}. Each plot occupied 12 m^2 and an alleyway of 1 m was used in separating the plots from one another.

The area of the experimental field was 19 by 15 m (285 m^2). After sowing of the seeds, defoliating beetles and aphids on the field were controlled by using Magic Force™ (Lambda-Cyhalothrin 15 g/L+Dimethoate 300 g/LEC) (Jubaili Agro Chemicals, Ibadan, Nigeria) at 1.5 litre ha^{-1} at intervals of two weeks. After physiological maturity of the crop on 25th May, 2013 (DOY 145) in 112 DAP (days after planting) and 25th February, 2014 (DOY 56), 110 DAP an area of 5.37 m^2 (central rows) was harvested from each plot and the grain yields per ha were estimated.

Design of drip irrigation system

The daily crop water use was estimated using the Penman-Monteith approach described in Allen *et al.,* (1998). The estimated peak evapotranspiration during the initial, and development stages was 1.13 and 6.53 mm day^{-1} respectively while at mid and late stages, it was 6.69 and 3.83 mm day^{-1} respectively. The pressure compensating inline-drip line (Dripworks, Inc., USA), 2.2 l h^{-1} and pressure of 1 bar was used to apply water to the crop throughout the growing seasons. The length of each lateral was 5 m and contained 17 point in-line emitters, which were pre-spaced at intervals of 0.3 m. The pressure compensating mechanism ensured even distribution of pressure along the laterals even in hilly and undulating areas. At the beginning of the experiments, the coefficient of variation of the discharges from the emitters was 0.03, which was described as excellent for a point source emitter (Michael, 2008). The statistical uniformity indicator U_s, a measure of the uniformity achieved by each emitter was 95%. Emission uniformity of the inline-drip system was 90.7% based on the approach in Ghinassi (2008). Volume of water required per plant per day at the initial stage was determined from the ratio of the product of peak evapotranspiration (1.13 mm day^{-1}) and wetted area of each plant to the emission uniformity. The initial stage lasted 25 days under the environmental conditions in Ile-Ife and estimated field water requirement for the entire experimental field was 1,530 litres. The daily water requirement during the mid (40 days) and late (18 days) seasons were 6.69 and 3.83 mm day^{-1} respectively and using the same procedure, the estimated daily water needs per plant during these stages were 0.36 and 0.21 litres respectively.

Similarly, the total amount of water budgeted during these periods were 14,688 and 3,860 litres respectively. At the initial stage, the readily accessible soil moisture was 5.5 mm. Irrigation frequency was determined from the ratio of the readily available moisture to the peak water use of 1.13 mm day^{-1} and this gave an average of 5 days. Details of the experimental layout can be found in Adeboye *et al*. (2015).

Soil moisture

A 53 mm diameter steel core sampler set was used to collect soil samples at intervals of 10 cm from 0 to 60 cm at 7:00 am during each measurement (Ali, 2010). The samples were weighed immediately on the field, kept in sealed polythene bags before they were taken to the laboratory. The samples were oven-dried at 105 ºC for about 48 hrs. The volumetric water content was determined by multiplying soil moisture content (%) by bulk density of each layer (Gardner, 1986). The volumetric soil moisture was converted to linear depth (mm) of water by multiplying it with the depth of each layer. There was rainfall in a few days during the fieldwork and this was built into the irrigation schedule by adding the effective rainfall to the plant available water and computing the number of days it would take the plant to use it. The same amount of water was applied until flowering when skipping of irrigation began. After 50% of the available water had been depleted, the crop was irrigated. The soil within the root zone was filled up to field capacity during irrigation.

The total available water was 110 mm m^{-1}. The irrigation requirement of the crop was determined using Eqn. 2 (Ali, 2010):

$$d = R - \sum_{i=1}^{n} \frac{(M_{fci} - M_{bi})}{100} \times A_i \times D_i \tag{2}$$

where:

d = net amount of irrigation applied (mm)
R = rainfall (mm)
M_{fci} = field capacity in the ith soil layer ($m^3 m^{-3}$)
M_{bi} = moisture content prior to irrigation in the ith soil layer ($m^3 m^{-3}$)
A_i = bulk density soil in the ith soil layer (g cm^{-3})
D_i = soil depth within the root zone (mm)
n = number of soil layers within the root zone

Irrigation frequency at each stage was determined from the ratio of the net water requirement to the peak water use (mm day^{-1}). The area irrigated by each dripper was determined from the ratio of the product of plant spacing and percentage of the cropped area irrigated to the number of the drippers at each emission. Only 30% of the cropped area was irrigated.

Crop water use

The soil water balance approach was used to determine the actual crop evapotranspiration (Ali, 2010). The moisture content was measured before irrigation in order to refill the soil at the root zone to field capacity. Runoff was measured by placing metallic boxes around plants within an area of 0.716 m^2 in replicates of each treatment.

The runoff within the area was directed towards a graduated plastic container and measured after each rainfall event. Daily effective rainfall was determined from the difference between daily rainfall and runoff (Ali, 2010). The contribution of the groundwater was ignored because the groundwater table was deeper than 10 m. The drainage below the root zone was not detected during the cropping seasons and therefore considered negligible under drip irrigation (Lovelli *et al.*, 2007). The change in the moisture in the root zone was determined from measurements of the soil moisture at the beginning and end of each stage of growth. Therefore, the seasonal crop water use was determined using Eq. 3 (Zhang *et al.*, 2017):

$$ET_c = I + R \pm \Delta S \tag{3}$$

where:
ET_c = seasonal crop water use (mm)
I = irrigation (mm)
R = rainfall (mm)
$\pm\Delta s$ = change in the soil moisture (mm)

Seasonal crop water use was determined by adding the water use at different stages together. The results of the effects of skipping of irrigation in the seasons can be found in Adeboye et al., (2015).

Leaf area index and crop coefficient

At average intervals of 7 days from 14 DAP in both irrigation seasons, the green LAI, above and below PARs were measured at 400 to 700 nm using AccuPAR LP 80 (Meter Group, USA) until maturity. Ten samples of the below and above PARs were taken from triplicates of each treatment by placing the probe (line sensor) perpendicularly to the rows above and below the plant canopy. Total of 14 consecutive measurements of LAIs were made in the two irrigation seasons. The canopy cover (CC) was determined by using the ratio of the PAR_{below} to the PAR_{above} (Eq. 4):

$$CC = 1 - \left(PAR_{below} / PAR_{above}\right) \times 100 \quad (4)$$

The daily *CC* was determined by interpolation of the measured values. The actual crop coefficient (k_{ci}) was determined from the combination of tau (τ) and *CC* by using the approaches of William and Ayar, Meter Group (Williams and Ayars, 2005; Decagon, 2015). In addition, *FAO* k_c was determined by using the FAO-56 approach. The *FAO* k_c during the **mid-season** and late stage were determined using Eqs. 5, and 6 (Allen *et al.*, 1998):

$$K_{c\ mid} = K_{c\ mid\ (Tab)} + \left[0.04(u_2 - 2) - 0.004(RH_{\min} - 45)\right]\left(\frac{h}{3}\right)^{0.3} \quad (5)$$

$$K_{c\ end} = K_{c\ end\,(Tab)} + \left[0.04(u_2 - 2) - 0.004(RH_{\min} - 45)\right]\left(\frac{h}{3}\right)^{0.3} \quad (6)$$

The k_c for other days within the growing seasons was determined by interpolation. Daily crop water use was determined from the product of k_c and reference evapotranspiration (ET_o). The ET_o was determined by FAO 56 method for grass using the Eq. 7.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T + 273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.3u_2)} \quad (7)$$

where:

ET_o = reference evapotranspiration (mm d^{-1})
R_n = net radiation at the crop surface (MJ m^{-2} d^{-1})
G = soil heat flux density (MJ m^{-2} d^{-1})
γ = psychometric constant (KPa $^oC^{-1}$)
T = mean of the monthly maximum and minimum air temperatures (^oC)
u_2 = wind speed at 2 m height (m s^{-1})
e_s = saturated vapour pressure (KPa)
e_s = actual vapour pressure (KPa)
e_s-e_a = saturated vapour pressure deficit (KPa)
Δ = slope vapour pressure curve (KPa $^oC^{-1}$)

Heat unit approach rather days after planting was used to determine the growing degree-days (GDD) because of the annual variability of the weather in the study area, and to allow transfer of the crop coefficients from one region to the other. The GDD was determined using Eq. 8 (McMaster and Wilhelm, 1997):

$$GDD_i = (t_{max} - t_{min})/\ 2 - THR \quad (8)$$

THR = lower threshold temperature at which plant growth stops (°C)
t_{max} = maximum temperature during the day (°C)
t_{min} = minimum temperature during the night (°C)
GDD_i = Growing degree-days on day i (°C day).

The crop coefficients were plotted against the cumulative GDD. Regression analysis was used to generate models for crop coefficients and evapotranspiration, LAI, and CC. In addition, comparisons were made between the actual crop coefficients and k_c estimated using the FAO approach.

Statistical analysis

SigmaPlot was used to do regression analysis of the data and generate relationships between parameters at 5% significance level.

RESULTS and DISCUSSION

Crop Coefficient

There was variability in the k_{ci} and *FAO* k_c during the seasons. During flowering, *FAO* k_c ranged from 1.14 to 1.29 and was lower than the k_{ci} (1.04-1.46) in the two seasons (Figs. 1 and 2). The peak *FAO* k_c was 1.29 during pod initiation and seed filling and was lower than k_{ci} when irrigation was skipped during pod initiation (1.30-1.48) and seed filling (0.82-1.48). At maturity, *FAO* k_c (0.49-1.19) was lower than k_{ci} when irrigation was skipped at maturity.

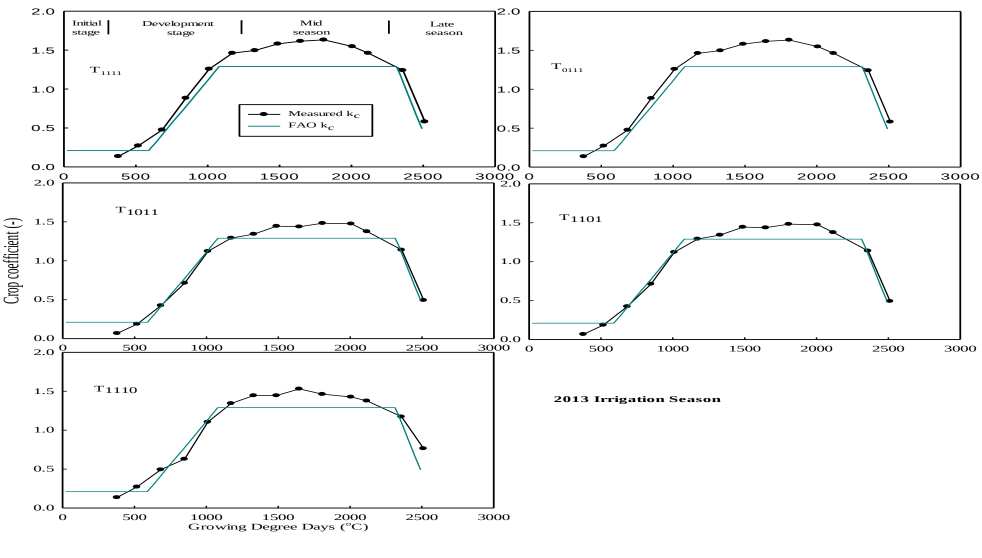


Figure 1. Crop coefficient of soybeans as a function of growing degree-day in the year 2013 irrigation season

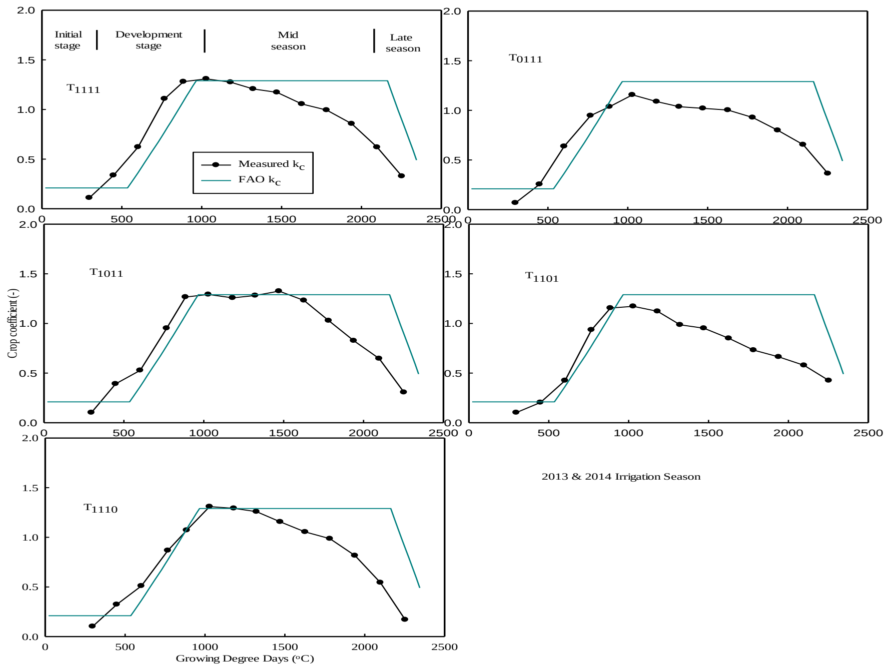


Figure 2. Crop coefficient of soybeans as a function of growing degree-day in the year 2013/2014 irrigation season

The k_{ci} was low in the early stages, but increased gradually until it reached the peak during mid-season and later descended at maturity (Fig. 1). In the first season, the k_{ci} during flowering ranged from 1.26-1.37 (43-55 DAP) while k_{ci} for the fully irrigated crop ranged from 1.15-1.45 and the peak k_{ci} for T_{0111} was higher than that of T_{1111} by 2.2%. However, the range of k_{ci} for T_{1011} and T_{1111} were the same. The k_{ci} during pod filling for T_{1101} ranged from 0.82-1.48 (35-101 DAP), while that of the fully irrigated ranged from 1.16-1.45 and the peak k_{ci} (1.50) was higher than the peak k_{ci} for the fully irrigated soybeans by 3.3%. However, the k_{ci} for T_{1110} ranged from 0.77-1.11 (102-109 DAP) while for T_{1111} ranged from 0.49-1.14 and the peak k_{ci} for T_{1110} was lower than that of T_{1111} by 2.6%.

In the second season, the k_{ci} ranged from 0.99-1.16 (38-49 DAP) for T_{0111} while k_{ci} for the fully irrigated crop during flowering ranged from 0.83-1.34 and this indicate that the peak k_{ci} for T_{0111} was lower than that of T_{1111} by 13.4% (Fig. 4). The k_{ci} when irrigation was skipped during pod initiation ranged from 1.29-1.45 (50-58 DAP) while k_{ci} during flowering for T_{1111} ranged from 1.36-1.45 and the peak k_{ci} for T_{1011} reduced by 11%. Similarly, the k_{ci} of the crop when irrigation was skipped during seed filling (0.59-1.08; 59-99 DAP) was lower by 26% from the k_{ci} for the fully irrigated (0.59-1.45) crop during seed filling. The k_{ci} when irrigation was skipped during maturity ranged from 0.23-0.45 (101-109 DAP) and its peak k_{ci} was lower than that of the fully irrigated (0.22-0.54) crop during seed filling by 17%. Reductions in the k_{ci} were more evident in the second season than the first season when irrigation was skipped during reproductive stages.

Evapotranspiration and grain yields

There was variability in the water used by the crop at different growth stages and seasons. In the two seasons, T_{1111} had the highest estimated seasonal ET_c as expected. In 2013, the estimated ET_c during flowering is 64 mm crop while in 2013/2014 season, it was 50 mm. During pod initiation, 58 mm and 31 mm of water were used in the two seasons (Fig. 5). There was variability in the ET_c due to the evaporating power of the atmosphere.

During pod filling, ET_c were 291 and 130 mm in 2013 and 2013/2014 seasons respectively. The average daily ET_o before flowering until 40 DAP was about 4.56 mm day^{-1} and was higher than the average ET_c of 2.00 mm day^{-1}. The ET_c increased considerably to 4.59 mm day^{-1} at DOY 76 and reduced to 3.34 (DOY 88) during the flowering in 2013. During pod initiation and filling, the ET_c ranged from 10.2 mm day^{-1} (DOY 110) to 3.31 mm day^{-1} (DOY 131) with an average ET_c of 7.69 mm day^{-1}. The trend in the second season was similar to that of the first season. The ET_o ranged from 1.70 mm day^{-1} (DOY 359) to 2.8 mm day^{-1} (DOY 2, 2014) during flowering with an average ET_o of 1.66 mm day^{-1}. The ET_c increased from 3.53 mm day^{-1} (DOY 354) to 5.29 mm day^{-1} (DOY 19, 2014). Towards the end of the cropping seasons, the ET_o was higher than the ET_c and the reason for this occurrence is not clear (Fig. 3).

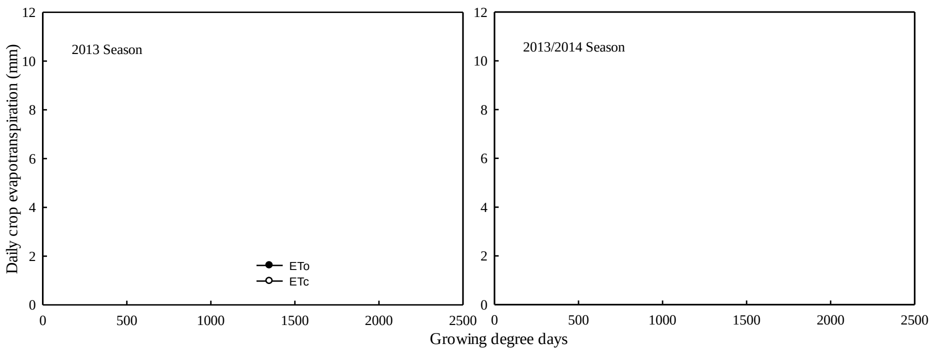


Figure 3. Estimated daily crop water use of drip irrigated soybeans without skipping the irrigation at any of the growth stages (T_{1111})

Crop coefficient and daily evapotranspiration

There were high coefficients of determination between crop coefficient and ET_c use in the seasons: ($0.73 \leq r^2 \leq 0.76$; 1.44 mm $\leq SEE \leq$ 1.53 mm; $p < 0.0001$) in the 2013 irrigation season and ($0.82 \leq r^2 \leq 0.84$; 0.42 mm $\leq SEE \leq$ 0.51 mm; $p < 0.0001$; Standard Error of Estimate) in 2013/2014 irrigation season (Fig. 4). These mean that k_c accounted for about at least 73% of the variability in the daily crop water use. The slopes and intercepts of the relationship were high and statistically similar in each season. The SEE was lower in the second season compared with the first.

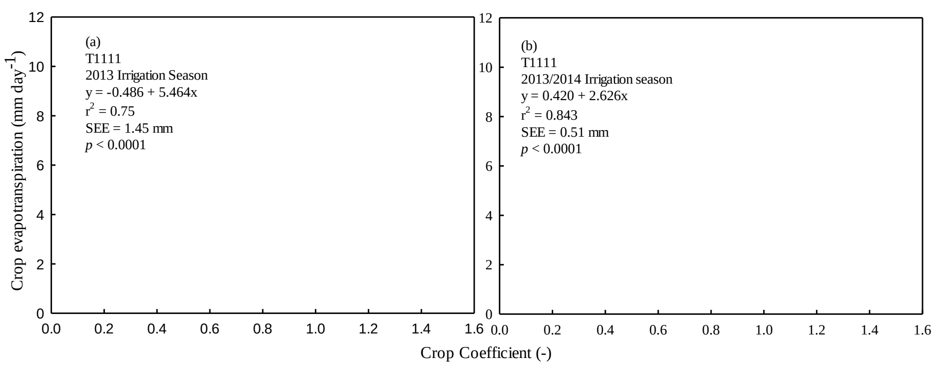


Figure 4. Estimated crop evapotranspiration and crop coefficients of fully irrigated soybeans in the two seasons

Leaf area index and crop coefficient

The exponential equations described excellently the relationship between crop coefficient and LAI in the two seasons (Figs. 5 and 6). The coefficients of determination ranged from 0.93 to 0.97 with $SEE \leq 0.69$ (Fig. 5) and from 0.87 to 0.94 with low $SEE \leq 0.31$ (Fig. 6). These imply that the LAI is responsible for about 97% variability in the crop coefficients of soybeans. The slopes ranged from 1.39 to 2.07 (Fig. 6) and the regression coefficients were highly significant with $p \leq 0.0001$ even when the data were pooled together. Many authors have shown that k_c is significantly correlated with LAI (Medeiros *et al.*, 2001) and leaf area (Williams and Ayars, 2005). This analysis indicates that equations reasonably describe the relationship of the crop coefficient and the LAI for the crop in the stated study area under the prevailing environmental conditions.

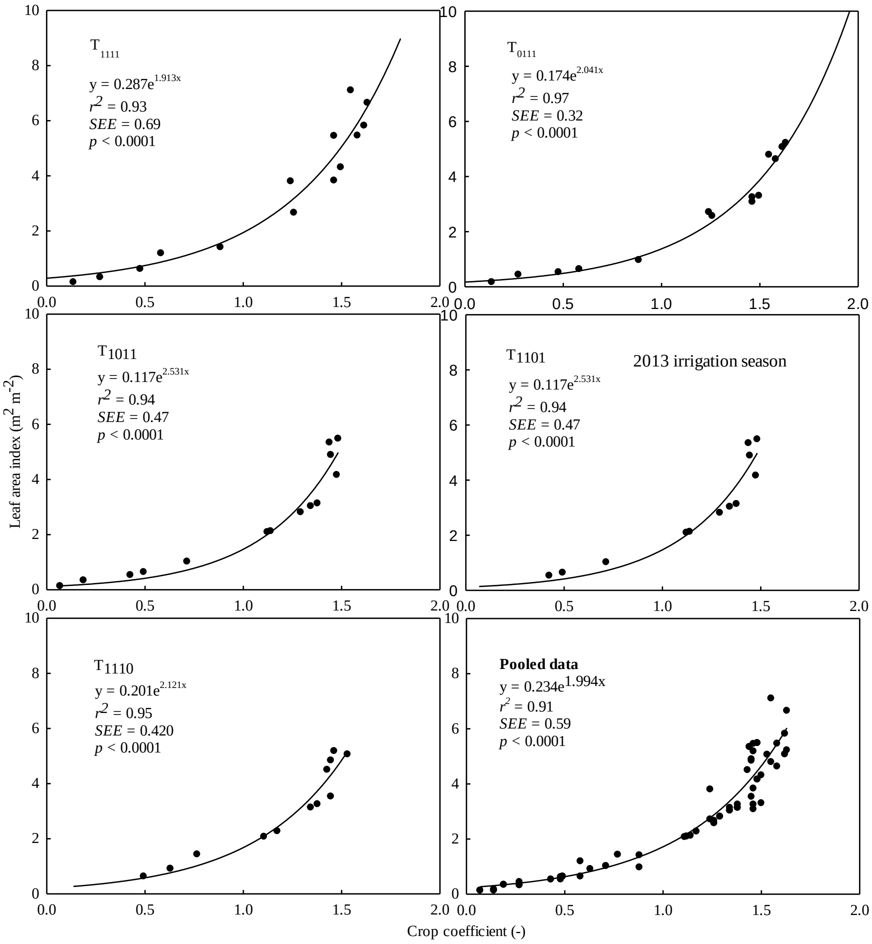


Figure 5. Leaf area index and crop coefficient of soybeans in the year 2013 irrigation season

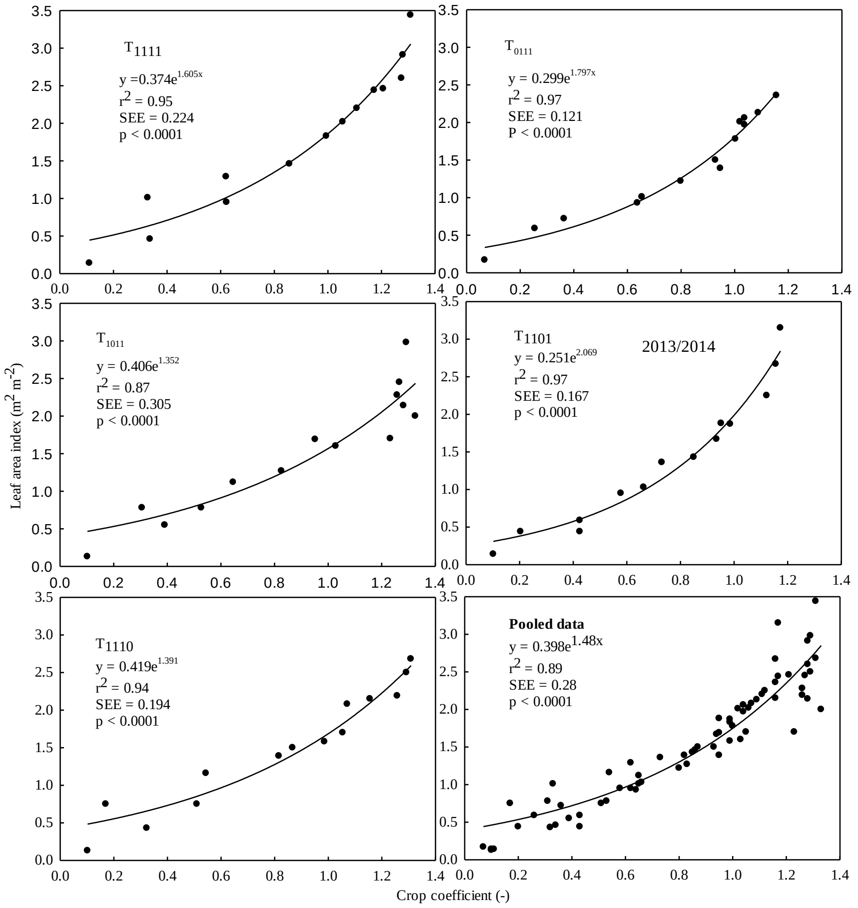


Figure 6. Leaf area index and crop coefficient of soybeans in the year 2013/2014 irrigation season

Crop coefficient and canopy cover

The *CC* increased rapidly after it reached 10% in the two seasons. The peak CC ranged from 87% for T_{1110} to 95% for T_{1111} in the 2013 irrigation season. However, it was low in the 2013/2014 season; it ranged from 67% for T_{1101} to 77% for T_{1111}. The CC decreased in the late season due to senescence, and the rate of decrease was very rapid in T_{1110}. The k_{ci} and LAI are highly and significantly linearly related ($0.89 \le r^2 \le 0.97$; $p < 0.0001$). The slope ranges from 0.017 to 0.17 with intercept very close to zero in the first season (Fig. 7). In the second season, the coefficient of determination varied from 0.93 to 0.96 with low *SEE* and the intercept very close to zero.

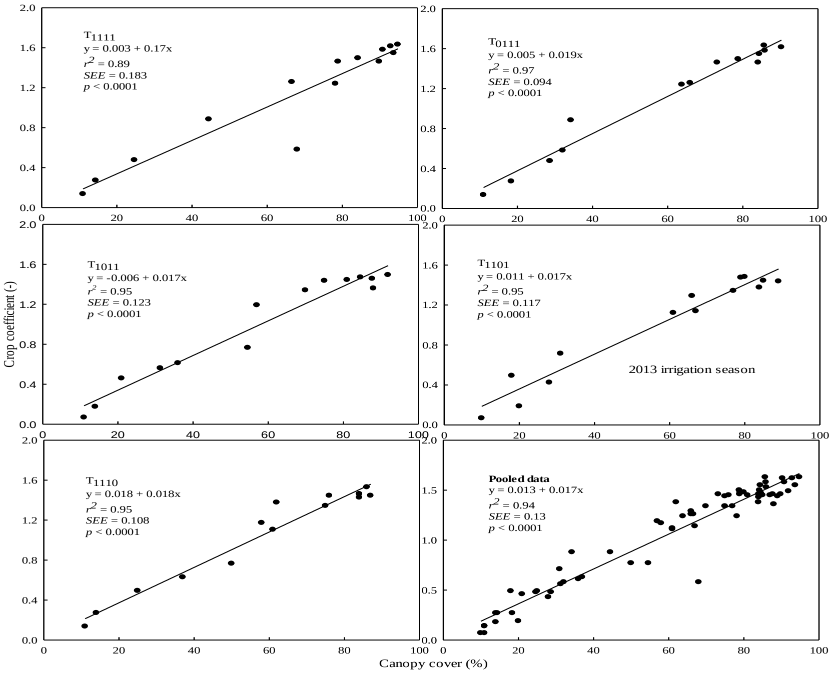


Figure 7. Crop coefficient and canopy cover of drip-irrigated soybeans in the year 2013 irrigation season

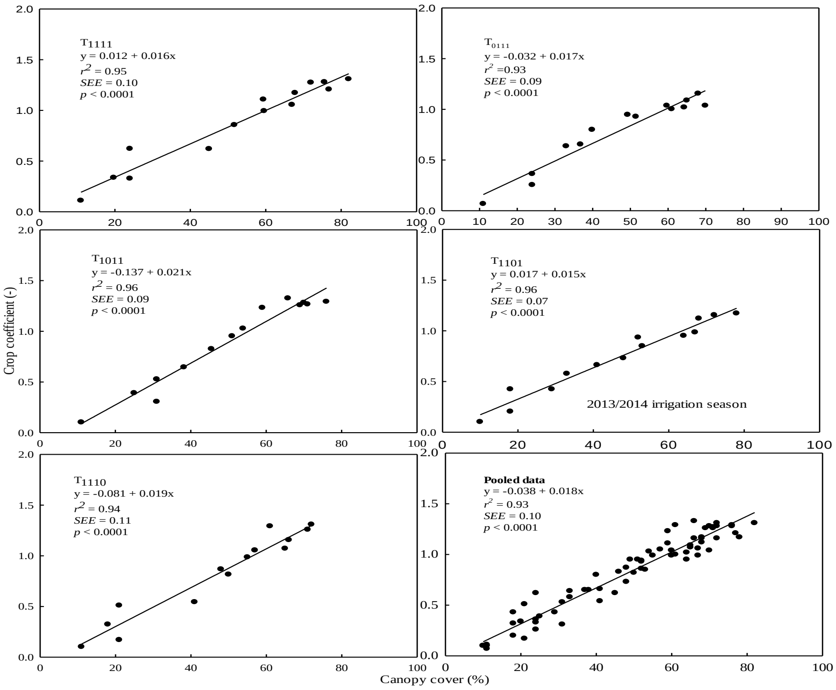


Figure 8. Crop coefficient and canopy cover of drip-irrigated soybeans for full irrigation and skipping of the irrigation during flowering, pod initiation, pod filling and maturity in the year 2013 irrigation season

The seasonal crop evapotranspiration using k_{ci} ranged from 497 mm for T_{1101} to 538 mm for T_{1111} in 2013. However, ET_c ranged from 221 mm for T_{1101} to 268 mm for T_{1111} in the 2013/2014 season. The seasonal ET_c was nearly the same for T_{1101} and T_{1110} in 2013. This is because the pod filling stage is very long, it overlaps into the maturity stage of the crop and a large amount of water is required by the crop to complete the process. The period of maturity was short and the crop used a small amount of water. The ET_c for T_{0111} during flowering reduced by 4.7, and 4.4% from ET_c of T_{1111} in 2013 and 2013/2014 irrigation seasons respectively. During pod initiation, ET_c for T_{1011} reduced by 0.42 and 9.8% compared with full irrigation in the two seasons. The ET_c during pod filling for T_{1101} in 2013 and 2013/3014 season reduced by 3.4 and 29.2% respectively. At maturity, the ET_c for T_{1110} was higher than that of full irrigation by 15.6% whereas in 2013/2014 irrigation season, the ET_c was almost the same. The variability in the ET_c indicates that ET_o plays a prominent role in determining the crop water use during each stage of growth. Therefore, during flowering and pod initiation, the recommended peak k_{ci} values are 1.46 and 1.48 respectively while during seed filling and maturity, peak k_{ci} values are 1.48 and 1.21 respectively to avoid water stress. Soybeans growers in the study area may find it challenging to use the k_{ci} and LAI relationship in managing their water resources for crop production. This is due to the challenges of instrumentations and time taken to take measurements, especially with variability in the weather conditions. However, the farmers may prefer the k_{ci} and CC relationship because it is more convenient to estimate visually the *CC* in the absence of sophisticated instrumentation. In order to ensure proper management of water for production of soybeans under full and deficit irrigation conditions in the dry seasons, a linear graph of crop water use versus k_{ci} was developed in this study. Care needs to be taken in the use and transfer of the linear curves because of the variability of the weather conditions from one location to the other and over the years.

CONCLUSION

Field experiments were carried out on soybeans for two dry seasons in order to determine the effects of water stress on the crop coefficient. The k_c when water was skipped for seven days during flowering reduced by 13.4% compared to fully irrigated soybeans. The k_c during pod initiation ranged from 1.30 to 1.48 in the two irrigation seasons and reduced from that of the fully irrigated treatment by 11%. The k_c during pod filling for T_{1111} ranged from 0.88 to 1.48 in the two seasons and reduced by 26% from that of full irrigation. During maturity, k_c ranged from 0.77 to 1.21 and reduced by 17% from that of full irrigation. The crop coefficient of soybeans reduced when irrigation was skipped during flowering, pod initiation, pod filling and maturity of the crop in the two irrigation seasons. Daily crop evapotranspiration reduced during skipping of water application. Daily crop water use increased progressively from 10% canopy cover and got to the peak during seed filling, after which it reduced to the minimum during maturity. There was strong linear correlation between the crop coefficient, and daily evapotranspiration and canopy cover.

ACKNOWLEDGMENT

The first author appreciates the financial assistance from the Dutch government through the Netherlands Fellowship Programme. He acknowledges the International Institute For Tropical Agriculture (IITA), Ibadan, Nigeria for the advisory services on the variety of soybeans used in the study. He appreciates technical assistance from the Institute of Agricultural Research and Training, Obafemi Awolowo University house station during the study. The authors appreciate the anonymous reviewers for their editorial comments.

REFERENCES

Adeboye O.B., Schultz B., Adekalu K.O. & Prasad K., 2015. Crop water productivity and economic evaluation of drip-irrigated soybeans (Glyxine max L. Merr.). *Agriculture & Food Security*, 4(1), 1-13. 10.1186/s40066-015-0030-8.

Ali M.H. 2010. Fundamentals of irrigation and on-farm water management. Springer, Berlin.

Allen, R.G., Pereira, L.S., Raes, D. Smith, M., 1998. Crop Evapotranspiration-Guidelines for computing crop water requirements. *Irrigation and Drainage Paper.* Food and Agriculture Organization, Rome, Italy.

de Medeiros G.A., Arruda F.B., Sakai E.l. & Fujiwara M. 2001. The influence of crop canopy on evapotranspiration and crop coefficient of beans (*Phaseolus vulgaris L.*). *Agricultural Water Management*, 49(3), 211-224. https://doi.org/10.1016/S0378-3774(00)00150-5.

Decagon D.I. 2015. Using AccuPAR to Find Crop Coefficients for Irrigated Grapevine Production.

Doorenbos J. Pruitt & W.O. 1977. Crop water requirements, Irrigation and Drainage No. 24. Food and Agriculture Organization, Rome, Italy.

Gardner W.H. 1986. Water Content. In: A. Klute (Editor), *Methods of Soil Analysis: Part 1-Physical and Mineralogical Methods.* Soil Science Society of America Book Series. Soil Science Society of America, American Society of Agronomy, Madison, WI, pp. 493-544.

Ghinassi G. 2008. Manual for performance evaluation of sprinkler and drip irrigation systems, ICID Publication No. 94. International Commission on Irrigation and Drainage, Delhi, India, 119 pp.

Hanson B.R. May D.M. 2006. Crop coefficients for drip-irrigated processing tomato. *Agricultural Water Management*, 81(3), 381-399. https://doi.org/10.10 16/j.ag wat.20 05.04.007.

Justice C.O. Townshend & J.R.G. 2002. Special issue on the Moderate Resolution Imaging Spectroradiometer (MODIS): A new generation of land surface monitoring. *Remote Sensing Environment*, 83, 1-12.

Kamble B. Irmak A. 2008. Assimilating Remote Sensing-Based ET into SWAP Model for Improved Estimation of Hydrological Predictions., Proceeding of the 2008 IEEE International Geoscience and Remote Sensing Symposium, Boston, USA.

Kang S., Gu B., Du T. & Zhang J. 2003. Crop coefficient and ratio of transpiration to evapotranspiration of winter wheat and maize in a semi-humid region. *Agricultural Water Management*, 59, 239–254.

Kashyap P.S. & Panda R.K. 2001. Evaluation of evapotranspiration estimation methods and development of crop-coefficients for potato crop in a sub-humid region. *Agricultural Water Management*, 50, 9-25.

Lovelli S., Perniola M., Ferrara A. & Di Tommaso T. 2007. Yield response factor to water (Ky) and water use efficiency of Carthamus tinctorius L. and Solanum melongena L. *Agricultural Water Management*, 92(1–2), 73-80. http://dx.doi.org/10. 1016/j.agwat.2 007.05.005.

Marin F.R. Angelocci L.R. Nassif D.S.P., Costa L.G., Vianna M.S. & Carvalho K.S., 2016. Crop coefficient changes with reference evapotranspiration for highly canopy-atmosphere coupled crops. *Agricultural Water Management*, 163 139–145. doi.org/10.1016/j.agwat.2015.09.010.

Marsal J., Johnson S., Casadesus J., Lopez G., Girona J. & Stöckle C. 2014. Fraction of canopy intercepted radiation relates differently with crop coefficient depending on the season and the fruit tree species. *Agricultural and Forest Meteorology,* 184(Supplement C), 1-11. doi.org/10.1016/j.agrformet.2013.08.008.

McMaster G.S., & Wilhelm W.W. 1997. Growing degree-days: one equation, two interpretations. *Agricultural and Forest Meteorology*, 87(4), 291-300. http://dx.doi.o rg/10.1016/S0168-1923(97)00027-0.

Medeiros G.A., Arruda F.B., Sakai E. & Fujiwars M. 2001. The influence of crop canopy on evapotranspiration and crop coefficient of beans (*Phaseolus vulgaris L.*). *Agricultural Water Management*, 49, 221-224.

Michael A.M. 2008. *Irrigation Theory and Practice,* Vikas Publishing House PVT, New Delhi, 768 pp.

Payero J.O. & Irmak S. 2013. Daily energy fluxes, evapotranspiration and crop coefficient of soybean. *Agricultural Water Management*, 129, 31– 43. http://dx.doi.org/10.1016/j.a gwat.2013.06.018.

Pereira A.R., Camargo M.B.P.d. & Villa Nova, N.A., 2011. Coffee crop coefficient for precision irrigation based on leaf area index. *Bragantia* 70, 946-951.

Pereira L.S. Perrier A. Allen F.G. & Alves I. 1999. Evapotranspiration: concepts and future trends. *Journal of Irrigation and Drainage Engineering*, 125, 45-51.

Rai R.K. Singh V.P. & Upadhyay A. 2017. *Way Forward to Improve Irrigation Efficiency, Planning and Evaluation of Irrigation Projects*. Academic Press, pp. 605-611.

Reinders F.B. & Niekerk A.S.V. 2018. Technology Smart Approach to Keep Drip Irrigation Systems Functional. *Irrigation & Drainage*, 67(1), 82-88. doi:10.1002/ird.2191.

Richter B. 2014. Taking Stock of Our Water Budgets, Chasing Water: A Guide for Moving from Scarcity to Sustainability. Island Press/Center for Resource Economics, Washington, DC, pp. 19-35.

Suyker A.E. & Verma S.B. 2009. Evapotranspiration of irrigated and rainfed maize–soybean cropping systems. *Agricultural & Forest Meteorology*, 149(3), 443-452. https://doi.org/10.1016/j.agrformet.2008.09.010.

Williams L.E. & Ayars J.E. 2005. Grapevine water use and the crop coefficient are linear functions of the shaded area measured beneath the canopy. *Agricultural & Forest Meteorology*, 132(3-4), 201-211.

Williams L.E., Phene C.J., Grimes D.W. & Trout T.J. 2003. Water use of young Thompson Seedless grapevines in California. *Irrigation Science*, 22, 1-9.

Zhang X., Qin W., Chen S., Shao L. & Sun H. 2017. Responses of yield and WUE of winter wheat to water stress during the past three decades-A case study in the North China Plain. *Agricultural Water Management*, 179, 47-54. http://dx.doi.org/10.1016/j.ag wa t.2016.05.004.

Enhancing Productivity and Quality of Parsley (*Petroselinum crispum* (Mill.) Nyman ex A. W. Hill) by Plant Growth Regulator Application

Leif Marvin R. Gonzales, Ph.D.

School of Agriculture
Northern Iloilo Polytechnic State College – Barotac Viejo Campus, Barotac Viejo, Iloilo, Philippines

Corresponding author: gleifmarvin@yahoo.com

ORCID: 0000-0002-4737-5577

Abstract

Plant growth regulators enhanced the growth and yield parameter of the most herbaceous plant. It was unknown how different plant growth regulators affected parsley growth, yield, and quality. As a result, a study was carried out to assess the effects of several plant growth regulators and identify which treatment had the best influence on parley growth, yield, and quality. The treatment includes the following plant growth regulator (100 ppm Ethrel, 100 ppm GA3, 100 ppm PBZ and 100 ppm GA3 + 100 ppm PBZ) and a control treatment without plant growth regulator. A Completely Randomized Design (CRD) comprising five treatments with three replicates was used to collect growth, yield, and quality data. The plant growth regulator greatly influenced the growth parameter of the parsley plant. It also influenced all yield parameters as well as the quality but except for pH. Thus, the application of GA3 best enhances the maximum plant height, whereas PBZ application best in increasing the maximum number of leaves and stem diameter. In terms of yield and yield components, PBZ revealed best in increasing the maximum yield in terms of root length, root fresh weight, and fresh weight of the plant. Furthermore, a combination of PBZ and GA3 best enhances the total soluble solid but not in pH of the parsley plant.

Keywords: Ethrel, gibberellic acid, paclobutrazol, parsley, plant growth regulator.

Research article
Received Date: 17 August 2021
Accepted Date: 24 September 2021

INTRODUCTION

The plant *(Petroselinum crispum* (Mill.) Nyman ex A. W. Hill) belongs to the Apiaceae family. It's a short-lived biennial or perennial plant with a short life cycle. Parsley is grown for its leaves, used as a garnish or condiment, either fresh or dried. Due to its essential oil content of 0.3 percent in the leaf and 2-7 percent in the fruit, parsley possesses antispasmodic, carminative, and diuretic properties. Additionally, parsley is a good source of carotene (pro-vitamin A), vitamins B1, B2, and C, as well as iron and other minerals (Osman and Abd El-Wahab, 2009).

Due to its large foliage and root mass, parsley generally requires a tremendous amount of fertilizer to grow. The yield acquired from overwintering plants may rely upon the applied cover and fertilization (Rumpel et al., 1995; Biesiada and Kolota, 1996). The utilization of PGRs helps overcome the ever-increasing demand for medicinal plants through increase production as expected. It is well-recognized that growth regulators are the best agricultural strategies for encouraging and increasing plant development in various plants.

Growth regulators are required to determine physiological processes, growth, differentiation, and development (Davies, 2010). The hormone is just viable within a certain amount. Too high concentrations can repress plant growth, even lethal, while less optimum concentration may bring ineffectiveness. Synthetic growth hormone can enhance crop yields, both through vegetative propagation and embryogenesis (Gana, 2011). The influence of PGRs on parsley growth, yields, and quality is not well documented in some literature. Henceforth, this study aimed to determine the impact of different growth regulators on the growth, yield, and quality of parsley and determine which treatment gave the best result concerning growth, yield, and quality of parsley.

MATERIAL and METHOD

Seed Preparation and Seedling Establishment

The study was conducted at the nursery area of the Department of Horticulture, College of Agriculture and Food Sciences, Visayas State University. Visca, Baybay City, Leyte. The seeds were sown directly in seedling tray and transplanted after 15 days to a plastic pot of 8-inches in diameter. The newly planted seeds were watered immediately to avoid wilting. However, replanting was done one week after transplanting. Each pot contained a media of carbonized rice hull and garden soil (1:1) and was placed in the site where the field trial was finally conducted. All recommended cultural management practices were carried out during the growing seasons.

Experimental Treatment and Design

A completely randomized design (CRD) with five treatments and three replications was used in this experiment. There were 75 pots used, with 15 pots for each treatment and 5 pots for each replication. To-control (no PGR), T1-100 ppm Ethrel, T2-100 ppm GA3, T3-100 ppm PBZ, and T4-100 ppm GA3 + 100 ppm PBZ are the treatments.

Application of Treatment

Different plant growth regulators were used after fifteen days of transplanting. The following concentration (100 ppm Ethrel, 100 ppm GA3, 100 ppm PBZ and 100 ppm GA3 + 100 ppm PBZ) and a control treatment without using a plant growth regulator were used. The application of ethrel and GA3 was done through foliar, whereas PBZ was applied by drenching.

Weeding and Cultivation

Cultivation was done using a hand trowel to loosen the soil and provide aeration in pots. During cultivation, the weeds were removed from the experimental pots to prevent competition for nutrients and sunlight. Weeding was done twice a week in the experimental pots.

Pest and Disease Control

The plant was closely monitored for possible infestation. Physical and mechanical measures were undertaken by picking and crushing the insects infecting parsley plants.

Harvesting

The plant was harvested after one month and two weeks after transplanting. Growth parameters were evaluated every week, and the yield was measured during the termination of the study.

Data Gathered

The data collection was done every week and during the termination of the study. The following parameters were gathered:

Plant height (cm) – was measured using a meter stake from the plant base up to the apical meristem weekly.

The number of leaves- was determined by counting the leaves per plant at weekly intervals.

Stalk diameter (cm) –was determined using a digital Vernier caliper per plant per replication, and the means were calculated.

Stem diameter (cm) –was measured using a digital Vernier caliper from the base of the plant up to 1 inch of the stem.

Stem length (cm) –was done by measuring the base of the stem up to the top using a ruler.

Root length (cm) –was determined by measuring the base of the root up to the tip of the root using a ruler.

Fresh weight of the roots (g) - The average weight of the individual roots was measured using a digital weighing scale in grams by weighting five randomly taken parley roots from each replication, and the means were calculated.

Fresh weight of the plant (g) - The average weight of the individual leaves was determined in grams using a digital weighing scale by weighing five randomly selected parsley stalks with leaves from each replication and calculating the means.

pH – 10 grams of parsley stalk with leaves from each replication were randomly taken and juice was extracted using a blender with the addition of 50 ml water. The pH was taken using the Hanna pH meter and was recorded.

Total Soluble Solid (^{0}Brix) – Total soluble solids (TSS) were measured using 10 g of parley stalk with leaves per replication in all treatments. This was extracted using a blender with 50 ml water and strain using a clean cloth to separate the juice. TSS in Brix% was measured by a hand refractometer standardized with distilled water by placing 3 drops of juice on the instrument's lens to take the reading.

Climatic Data

Climatic data such as temperature (maximum and minimum), relative humidity, day length, sunshine duration, and rainfall were gathered at the Philippine Atmospheric, Geophysical and Astronomical Services Administration, Visayas State University, Visca, Baybay City, Leyte.

Data Analysis

The data were analysed by Analysis of Variance (ANOVA) using Statistical Tool for Agricultural Research (STAR) software and treatment means were separated by the Least Significant Difference (LSD) test at a 0.05% level of significance.

RESULTS and DISCUSSION

Plant height

The plant height of parsley was significantly influenced by the application of the plant growth regulator at a weekly interval (Figure 1). There was a linear increase during the growth stages of the plant. The application of GA3 markedly increased the plant height of the plant from week one up to the harvesting. However, ethrel retard the growth during the first up to harvesting. The PBZ application followed this. The increase in plant height might be because of the effect of GA3 on cell division and cell enlargement, and GA3 stimulated the growth and expansion of cells by expanding the wall plasticity of cells (Saleh, 1990; Matlub et al., 1964). The promotive effect of gibberellins on growth possibly increases the auxin level of tissue or improves the conversion of tryptophan to IAA, which causes cell division and cell elongation (Kuraishi and Muir, 1964).

According to Kumar et al. (2010) that ethrel had dwarfing effect on plants. He further stated that a lower concentration of ethrel was less effective in reducing height, but a higher concentration (400 ppm) significantly reduced plant height (66.12 cm). The same result was also observed by Gautam et al. (2006) in chrysanthemum in the use of ethrel.

The plants with the paclobutrazol application were likely to have lower average height growth than the controlled plants. This was due to the effect that was caused by paclobutrazol, which delayed the production of gibberellin. The plant height was the result of apical meristem cells division and extension stimulated by (growth regulator) gibberellin, so the absence of gibberellin in plants might cause dwarf-plant growth. Gibberellin activities, stimulating meristematic cell division and growth, were prevented by paclobutrazol (Runtunuwu et al., 2011). This will reduce cell division and extension speed so that the growth of plant height was delayed (Nasrullah et al., 2012).

Number of leaves

The number of leaves was significantly affected by the application of different growth hormones (Figure 2). Plant treated with PBZ obtained the maximum number of leaves per replication as compared to other treatments. However, a minimum number of leaves were observed in the control treatment and the application of ethrel, the combination of PBZ and GA3 from the first week until harvesting. A linear increase in the number of leaves was observed on a weekly interval.

The result coincided with the study of Lolaei et al. (2012); their study demonstrated that the utilization of 60 and 90 mg L-1 of PBZ enhanced the number and area of the leaf yet reduced petiole length.

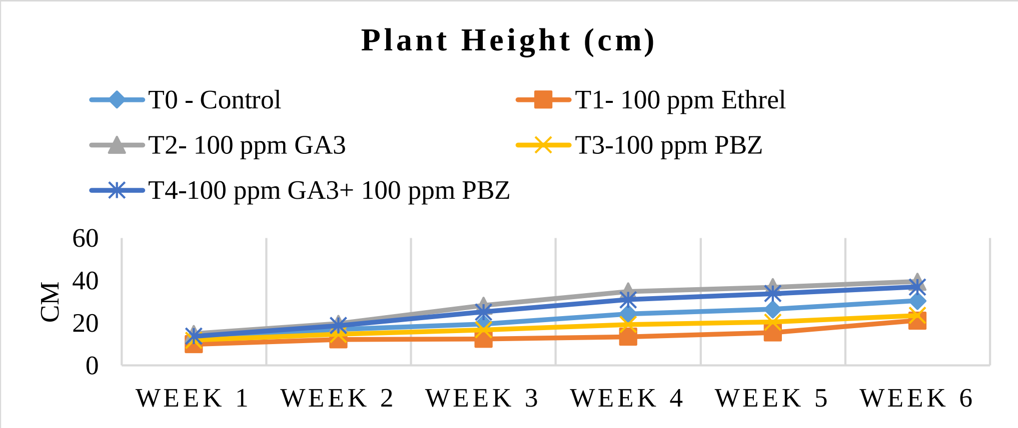


Figure 1. Plant height of parsley as affected by different plant growth regulators.

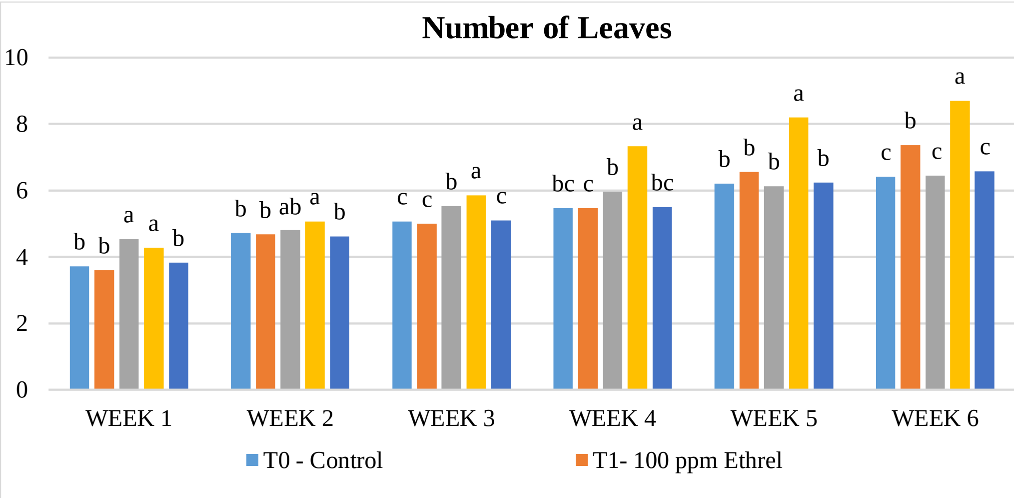


Figure 2. The number of leaves of parsley is affected by different plant growth regulators.

Stem Diameter

The stem diameter of parsley was significantly affected by applying different plant growth regulators from the first week up to the sixth week (Figure 3). Paclobutrazol consistently increased the stem diameter throughout the study as compared to control. Paclobutrazol treatment remarkably increases the thickness of the cortex, vascular bundles, and pith diameter resulting in thicker stems (Tsegaw et al., 2005). This modification might be attributed to the radial expansion of cells because of decreased endogenous activities in response to the treatment. On the other hand, GA limits the extent of radial expansion of plant organs, thereby increasing the stem diameter (Wenzel et al., 2000).

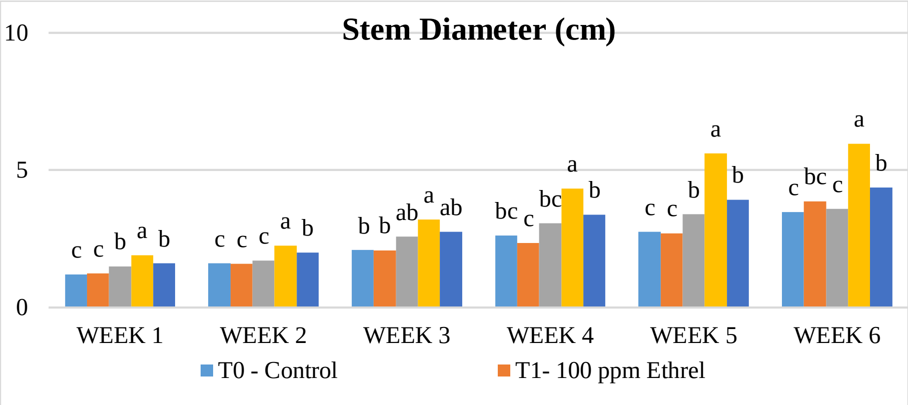


Figure 3. The stem diameter of parsley is affected by different plant growth regulators.

Yield and Yield Components

The yield and yield components parameter was significantly affected by applying different growth regulators (Figure 4-5). The application of PBZ and the combination of PBZ and GA3 significantly increased the diameter of the stalk compared to the control (Figure 4). Likewise, the application of ethrel, GA3, and control has a longer stem length while PBZ and combination treatment were obtained the shorter. The results are in agreement with the findings of Feucht and Watson (1958). They stated that the application of gibberellic acid increased the internode length of the seedlings and increased the number and size of cells. Cell elongation is predominantly responsible for the growth in internode length.

The reduction in stem length with the application of paclobutrazol may have been attributed to increases in stem diameter. Paclobutrazol contents of synthetic organic compounds could decrease the extension cell on sub-apical meristem and lessen the stem extension speed on responsive plants (Wattimena, 1989).

In the present study, the root diameter significantly increased by applying PBZ (Figure 6). PBZ increased the root diameter by inflating the cortex's width and enhancing the formation of more secondary xylem vessels (Tsegaw et al., 2005). According to Barnes et al. (1989), PBZ increased root diameter in soybean by increasing the size of cortical parenchyma cells.

PBZ also enhanced the root length of the study as compared to the control (Figure 8). Jaleel et al. (2007) reported that root growth might be connected to the increased partitioning of assimilates towards the roots because of decreased need on the shoot. On the other hand, increasing root growth by PBZ is additionally associated with the enhanced level of endogenous cytokinin (Fletcher and Arnold, 1986). In addition, inhibition of GA and increase of cytokinin and ABA might be the reason for the increased root length in the triadimefon treated plants. It might be related to larger parenchyma cells and the promotion of radial cell expansion (Jaleel et al., 2007).

The application of paclobutrazol enhanced the root's fresh weight, and the plant's weight also increased with PBZ alone and PBZ and GA3 combination (Figure 6). The highest increase was observed by paclobutrazol application. Paclobutrazol treatment improved the fresh weight in drought stress. A similar case of improvement in fresh weight was stated in Catharanthus plants in salt stress (Jaleel et al., 2007a).

The increase in yield characters caused by the use of PGRs could be attributed to the stimulatory effect of growth regulators. This induces many reproductive sinks, resulting in increased carboxylating enzymes and higher photosynthetic rates with greater translocation and accumulation of metabolites in the sink (Nehara et al., 2006).

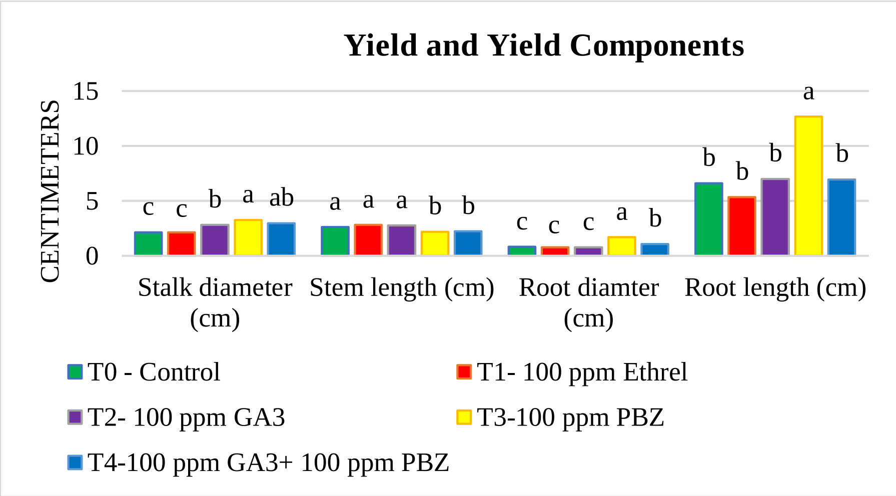


Figure 4. Yield and yield components of parsley as affected by different plant growth regulators.

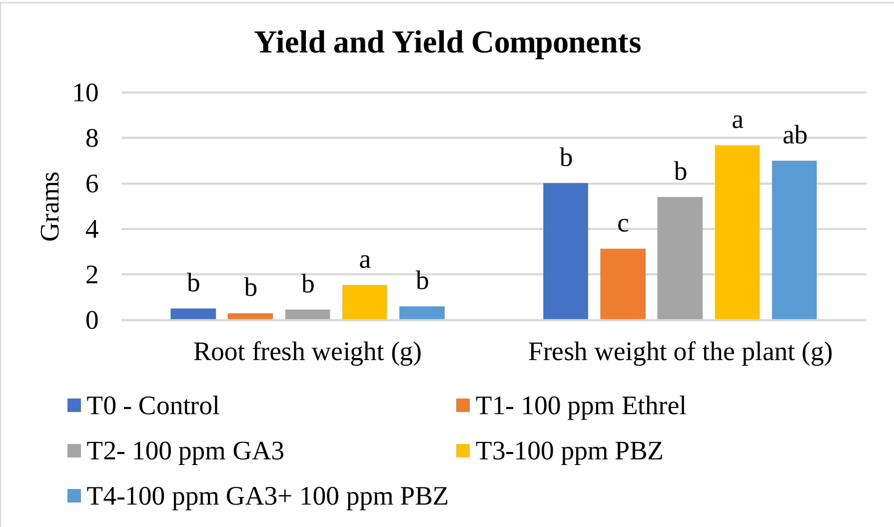


Figure 5. Yield and yield components of parsley as affected by different plant growth regulators.

Figure 6. Roots of Parsley as affected by different plant growth regulators.

pH and TSS

pH was not affected by the various plant growth regulator applications, but the TSS was influenced by the other treatments (Figure 7). All plants treated with PBZ increased the TSS of the plant as compared to control. Yeshitela et al. (2004) state that fruit quality improvements concerning TSS, TSS to acid ratio, total sugars, and reducing sugars in response to PBZ treatments can be related to assimilate partitioning of the plant. Assimilate demand is unidirectional to developing fruit. PBZ-treated trees had higher fruit quality attributes due to the significant suppression of vegetative growth. However, the result of this study was inconsistent with the result of Benjawan et al. (2007).

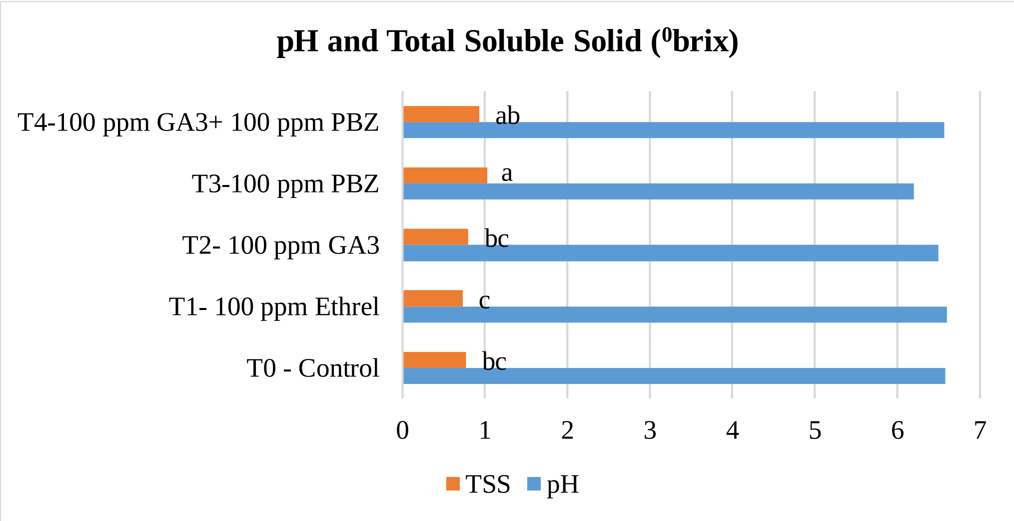


Figure 7. pH and total soluble solid of parsley as affected by different plant growth regulators.

Climatic Data

During the conduct of the study, there were fluctuating trends of temperature, sunshine duration, and relative humidity (Figure 8-9). On the other hand, there was a decreasing trend in rainfall (Figure 10). However, in terms of day length, there was an increasing linear growth observed throughout the growing period of the plant (Figure 11).

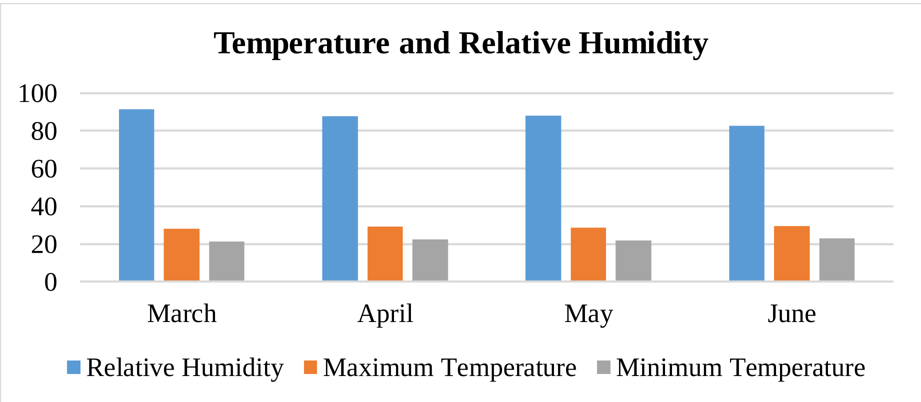


Figure 8. Data on maximum and minimum temperature and relative humidity during the conduct of the study.

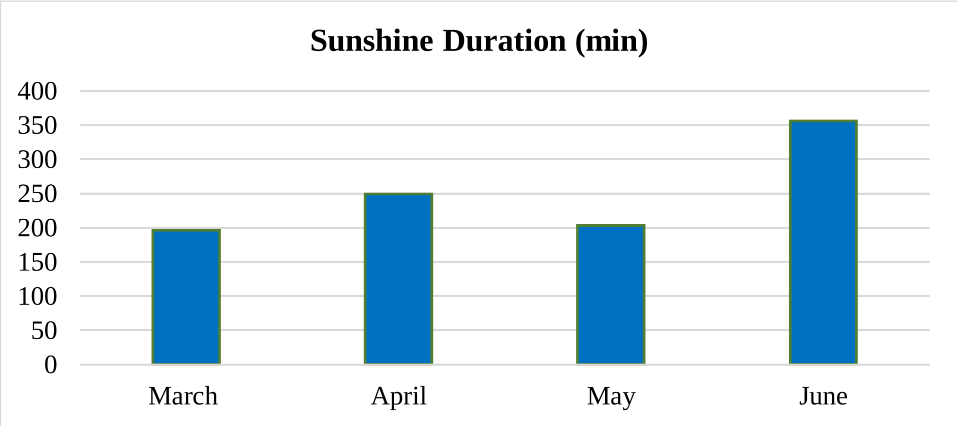


Figure 9. Data on sunshine duration during the conduct of the study.

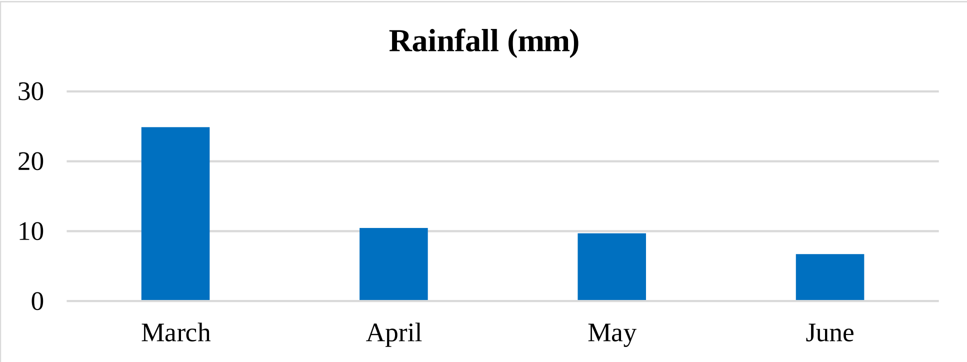


Figure 10. Data on rainfall during the conduct of the study.

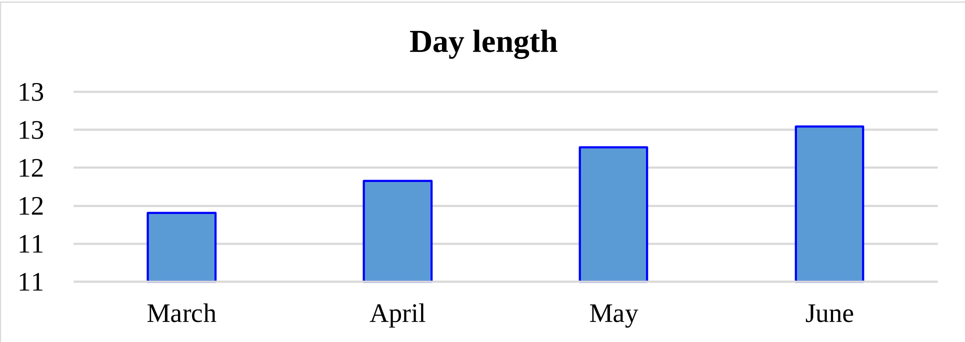


Figure 11. Data on day length during the conduct of the study.

CONCLUSION

The growth regulator greatly influenced the growth parameter of the parsley plant. It also influenced all yield parameters as well as the quality but except pH. Application of GA3 is best in increasing the plant height of the parsley, plant but in terms of the number of leaves and stem diameter, PBZ is the best treatment. However, in terms of yield and yield components, PBZ yielded the best result in terms of root length, root fresh weight, and fresh weight of the plant. On the other hand, PBZ and a combination of PBZ and GA3 show the best result in enhancing the TSS but not the pH.

REFERENCES

Barnes A.M., Walser R.H. & Davis T.D. 1989. Anatomy of *Zea mays* and *Glycine max* seedlings treated with triazole plant growth regulators. *Biologia plantarum,* 31(5), 370-375.

Benjawan C., Chutichudet P. & Chanaboon T. 2007. Effect of Chemical Paclobutrazol on Growth, Yield, and Quality of Okra (*Abelmoschus esculentus* L.) Har Lium Cultivar in Northeast Thailand, *Pakistan Journal of Biological Sciences,* 10 (3), 433-438.

Biesiada A. & Kołota E. 1996. Wpływ nawożenia mineralnego na plonowanie, trwałošc w przechowywaniu oraz przezimowanie w polu pietruszki korzeniowej. Mat. Konf. nt. „Przechowywanie i obrót produktami ogrodniczymi", Kraków, (in Polish), pp. 56–60.

Davies P.J. 2010. The plant hormones: their nature, occurrence, and functions. In-*Plant hormones* (pp. 1-15). Springer, Dordrecht.

Feucht J.R., & Watson D.P. 1958. The Effect of Gibberellins on Internodal Tissues of *Phaseolus vulgaris* L., *American Journal of Botany*, 45, 520-522.

Fletcher R. A., & Arnold V. 1986. Stimulation of cytokinins and chlorophyll synthesis in cucumber cotyledons by triadimefon. *Physiologia plantarum*, 66(2), 197-201.

Gana A.S. 2011. The role of synthetic growth hormones in crop multiplication and improvement, *African Journal of Biotechnology*, 10(50), 10330-10334.

Gautam S.K., Sen N.L., Jain M.C. & Dashora L.K. 2006. Effect of plant regulators on growth, flowering, and yield of *chrysanthemum morifolium* Ram, *Orissa J. Hort,* 34: 25-26.

Jaleel C. A., Manivannan P., Kishorekumar A., Sankar B., Gopi R., Somasundaram R. & Panneerselvam R. 2007. Alterations in osmoregulation, antioxidant enzymes and indole alkaloid levels in Catharanthus roseus exposed to water deficit. *Colloids and Surfaces B: Biointerfaces*, 59(2), 150-157.

Jaleel C.A., Gopi R., Manivannan P. & Panneerselvam R. 2007. Responses of the antioxidant defense system of *Catharanthus roseus* (L) G. Don. to paclobutrazol treatment under salinity. Acta Physiol Plant, 29: 205–209

Kumar R., Ram M. & Gaur G.S. 2010. Effect of GA3 and ethrel on growth and flowering of African marigold cv. Pusa Narangi Gainda, *Indian J. Hort,* 67: 362-366.

Kuraishi S. & Muir R.M. 1964. The mechanism of gibberellin action in the dwarf pea, *Pl. Cell. Physiol*., 5: 259.

Lolaei A., Rezaei M.A., Raad M.K. & Kaviani B. 2012. Effect of paclobutrazol and sulfate zinc on vegetative growth, yield and fruit quality of strawberry (Fragaria× ananassa Duch. cv. Camarosa), *Annals of Biological Research*, *3*(10), 4657-4662.

Matlub A. N., Al – Lus, H. F., Mustafa, M. & Al – Hafez, M. (1984). Effect of some treatments of GA3 on Potato's Dormancy and its effect on autumn yield. *Zanko Journal,* 2:49 – 69.

Nasrullah N., Wati Y.M. & Utami D.W. 2012. Induction of Bougainville flower (*Bougainvillea spectabilis* wild) with retardant and medium composition in a polluted environment, *Jurnal Lanskap Indonesia*, 4: 59-65.

Nehara K.C., Kumawat P.D. & Singh B.P. (2006). Response of fenugreek (*Trigonella foenum-graecum*) to phosphorus, sulfur, and plant growth regulators under semi-arid plains zone of Rajasthan, *Indian J. Agronomy,* 51(1), 73-76.

Osman Y.A.H. & Abd El-Wahab M. 2009 Economic evaluations for harvesting management of parsley (*Petroselinium sativum crispum* (Mill) Nym) and dill (*Anithum graveolens,* L.) plant under north Sinai, *J. Agric. Biol. Sci*. 5(3): 218-222.

Rumpel J., Grudzie K. & Borkowski J. 1995. Zimowanie warzyw pod osłona z włókniny. Mat. Konf. nt. „Nauka Praktyce Ogrodniczej”. *Lublin wrzešnia*, 14(15): 687–690.

Runtunuwu S.D., Mamarimbing R., Tumewu P. &Sondakh T. 2011. The concentration of paclobutrazol on the growth of seedling cloves height (*Syzygium aromaticum* (L.) Merryl & Perry), *Euginia*, 17: 135-141.

Saleh M.M.S. 1990. Physiology of plants growth hormones. 1st edition. Ministry of higher education – Salahaden University – Iraq. (From Arabic).

Tsegaw T., Hammes S. & Robbertse J. 2005. Paclobutrazol-induced leaf, stem, and root anatomical modification in potato, *Hortscience*, 40(5), 1343-1346.

Wattimena G.A., 1989. Zat pengatur tumbuh: Growth regulatory substances: The role of fisiologis and basic use laboratory of biotechnology crops. Department of Agriculture Cultivation. Faculty of Agriculture Bogor.

Wenzel C., Williamson R.E. & Wasteneys G.O. 2000. Gibberellin-induced changes in growth anisotropy precede gibberellin-dependent changes in cortical microtubule orientation in developing epidermal cells of barley leaves. Kinematic and cytological studies on a gibberellin-responsive dwarf mutant, M489, *Plant Physiology*, 124(2), 813-822.

Yeshitela T., Robbertse P. J. & Stassen P.J.C. 2004. Paclobutrazol suppressed vegetative growth and improved yield as well as fruit quality of ‘Tommy Atkins’ mango (*Mangifera indica)* in Ethiopia, *New Zealand Journal of Crop and Horticultural Science*, 32(3), 281-293.

Determination of Land Use Capabilities by GIS Analysis in Nigde Province, Turkey

M. Cüneyt BAĞDATLI[1*] M. Eren ÖZTEKİN[2]

[1]*Nevsehir Hacı Bektas Veli University, Engineering and Architecture Faculty, Department of Biosystem Engineering, Nevsehir, Turkey*
[2]*Çukurova University, Adana Organize Industrial Region of Vocational School Technical Sciences, Department of Architecture and Urban Planning, Adana, Turkey*

[*]*Corresponding author: cuneytbagdatli@gmail.com*

ORCID:0000-0003-0276-4437[1] , 0000-0003-2986-7049[2]

Abstract

This study was carried out with the aim of spatial evaluation of land use capabilities and subclasses by using 1/25.000 scaled digital soil maps of Niğde central district borders. For this purpose, spatial distribution maps of land use capabilities were created by using Arc GIS 10.3.1 which is one of the Geographical Information Systems (GIS) software. Within the scope of the research, it has been observed that the 7th class lands are in the majority compared to other land classes within the borders of the central district of Niğde and the ratio of these lands in the total area is 31.68% (864.62 km2). Class I lands in the research area cover 6.76% of the total area (184.47 km2) and II. class lands correspond to 16.61% of the total area with 453.19 km2. It was determined that the areas with slope and erosion damage and soil deficiency in the study area correspond to 39.60% of the total area and cover an area of 1080.63 km2. In the study, it will be inevitable that the spatial distribution maps of the land use capabilities will provide important contributions and basic bases to this and similar studies to be made for agricultural purposes in the center of Niğde in the future.

Keywords: Land Use Capabilities, GIS Mapping, Spatial Analysis, Nigde province, Turkey

Research article
Received Date: 25 August 2021
Accepted Date: 15 November 2021

INTRODUCTION

Soil is a natural entity that directly or indirectly constitutes the life source of many living things due to its functions. In this respect, the soil that covers the earth's surface in the form of a thin cover is the basis of life. Despite having such an important place for the life of living things, the quality of the soil, which is thought to be inexhaustible and can only renew itself in a very long period of time, continues to decrease due to reasons such as erosion, intensive tillage, overgrazing, salinity-alkalinity and desertification (Oldeman, 1994).

One of the main reasons for the deterioration of soil quality is that the lands are not used in a way that is not suitable for their ability classes. Mismanagement of land and water resources leads to a decrease in the productivity of these resources and to their being completely excluded from agricultural production over time (Arshad and Martin, 2002).

Land capability classification has been prepared in many developed countries such as America, England and France. Most of the land capability classification systems and mappings in the world in general are in the USA, which was published in 1961. It is an adaptation of the method of the Ministry of Agriculture. In Turkey, the first land capability classification was published by the “TOPRAKSU” Organization in 1978 as the "Turkey Land Presence" report within the framework of the criteria used in the USA. Accordingly, land capability was determined as eight classes (Atalay and Gökçe Gündüzoğlu, 2015; Atalay and Değeryurt, 2015; Atalay, 2016; Özşahin, Pektezel and Eroğlu, 2016).

Land use capabilities are a classification process made as an indicator of whether the land in an area is suitable for tillage agriculture. In this classification, the aforementioned lands can be classified into 8 different categories by revealing their suitability for agriculture. They are classified as areas that cannot even be used as meadows or forests, but can create an environment for natural life or can be used as resting places and national parks by people (Anonymous, 2005).

In recent years, land and soil classification studies have been carried out with the help of Geographical Information Systems and Remote Sensing techniques, with the development of more technological possibilities. “For example, in a study conducted on the advantages of using Quickbird satellite images in detailed soil survey studies in Adana, soil boundaries were tried to be determined by using combinations of aerial photographs, Quickbird satellite images and Landsat satellite imagery. It has been revealed that it is not appropriate to use Landsat images in detailed soil survey studies, but it has been concluded that due to the high resolution of Quickbird satellite images, survey studies can be carried out in half the time spent in survey studies conducted with classical methods” (Öztekin and Koca 2011).

In this study, land use capabilities and subclasses were spatially evaluated by using 1/25.000 scaled digital soil maps of Niğde central borders. In the research, digital soil maps were classified in the Arc GIS 10.3.1 environment, which is one of the Geographical Information Systems (GIS) software, and spatial distribution maps related to the land use of the borders of the central district of Niğde were produced. It is aimed that the results to be obtained from the study will form the basis for the investments to be made for agricultural purposes and be a guide.

MATERIALS and METHODS

This study was carried out within the boundaries of the central district of Niğde. The location and location of the Niğde Central district borders, which is the subject of the research, is shown in Figure 1.

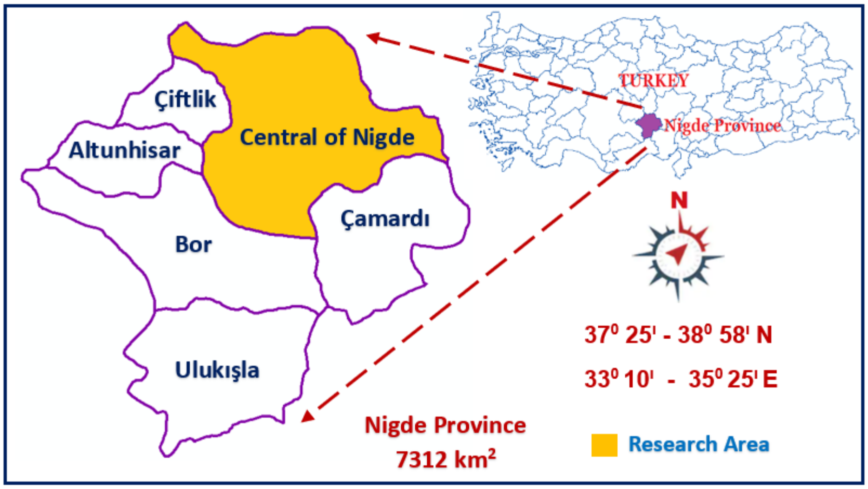


Figure 1. The location of research area

The study area is within the borders of the central district of Niğde province and is located between 37º 25' and 38º 58' north latitudes and 33º 10' and 35º 25' east longitudes. Niğde province has a total area of 7312 km^2 in the Central Anatolian Region, and the borders of the central district are spread over an area of 2699 km^2. Niğde province is adjacent to Nevşehir and Aksaray in the north, Konya in the west, Kayseri in the east and Adana and Mersin in the south. The province has 5 districts, 29 towns and 132 villages, including Altunhisar, Çiftlik, Bor, Çamardı, Ulukışla, excluding the Central district. Within the boundaries of Niğde Central district, which is the subject of the research, a total of 34 villages and 69 neighborhoods are scattered as settlements (Anonymous, 2021). Niğde province has an agricultural area of 2 million 758 thousand decares and approximately 38% of the province's surface area is agricultural lands. Pasture areas cover an area of 2,891,150 decares, and fallow areas cover an area of 676 thousand decares, which corresponds to 9% of the province's surface area. The forest area of Niğde province is 562,380 decares and the economically irrigable area in the province corresponds to 57% (1 million 200 thousand decares) of the province's surface area. The number of farmers who are interested in agricultural production throughout the province of Niğde is around 38 thousand, and 14 thousand of these farmers are active in the farmer registration system (Anonymous, 2020). In terms of climate characteristics, Niğde province has typical continental climate characteristics with hot and dry summers and cold and rainy winters. While the total annual precipitation was measured as 330.50 mm in the city center as of 2019, the average total precipitation value for many years was observed as 286.60 mm (Anonymous, 2019).

In a study evaluating the temperature changes for many years (1970-2019) in the Niğde region, the minimum temperature average was calculated as -1.2 ^{0}C and the maximum temperature average 24.5 ^{0}C. It has been determined that there is an increasing trend in the minimum temperature changes for many years, especially in spring, summer and autumn months. As a result of statistical analyzes, it has been revealed that there is a significant trend in the increasing direction in spring, summer, autumn and winter at maximum and average temperatures (Bağdatlı and Can, 2020).

In a study in which the maximum and total precipitation changes for many years (1970-2019) were evaluated by trend analysis within the borders of the central district of Niğde, it was determined that there was a significantly increasing trend in maximum precipitation in winter, summer and annual general average. It was concluded that there is no trend in total precipitation changes (Bağdatlı and Arslan, 2020). In the research, 1/25.000 scale digital soil maps obtained from the Ministry of Agriculture and Forestry were used (Anonymous, 2000). Arc GIS 10.3.1 software, which is one of the Geographical Information Systems software, was used for digital soil maps (Anonymous, 2010). The numerical data obtained were classified as spatial and the spatial distribution of the land use capabilities of the central district borders of Niğde and their subclasses were revealed. The classified soil maps obtained were evaluated according to the "Soil and Land Classification Standards Technical Instruction" published by the Ministry of Agriculture and Rural Affairs in 2005 (Anonymous, 2005). In the study, classification layers related to land use capabilities and subclasses are summarized in Tables 1 and 2.

Table 1. Land use capability classes (Anonymous, 2005)

Land Use Capability Classes	*Explanations*
I. Class Land	It is a land containing flat or nearly flat, deep, fertile and easily cultivable soils where conventional agricultural methods can be applied. First lands irrigated in places where there is little rainfall are those that have less than 1% slope, deep, loamy structure, good water holding capacity, moderately permeable soils.
II. Class Land	The differences of this from first-class terrain may be one or more of the limiting factors, such as mild inclination, moderate erosion exposure, moderately thick soil, occasional moderate flooding and moderate wetness that can be easily isolated.
III. Class Land	Moderate tendency, sensitivity to erosion, excessive wetness, shallow soil, presence of base stone, excess sandiness or graveliness, low water holding capacity and low productivity are the properties of this class.
IV. Class Land	Especially land suitable for permanent allocation to the meadow class is. Excessive slope, erosion, bad soil characteristics and climate are factors limiting agriculture to be made on this class of soils.
VI. Class Land	It is a land that requires moderate measures even when used as a forest or a meadow. It is very inclined and exposed to severe erosion.
VII. Class Land	It is very inclined, eroded, stony and defective, and includes shallow, dry, marshy or some other unfavorable soils. It can be used as a meadow or a forest provided that much attention is paid. If the vegetation on it decreases, erosion becomes very severe.
VIII. Class	It contains features that prevent cultivation and use as meadow or forest. These include marshland, desert, terrains containing very deep cavities, and high mountainous, overly defective, stony lands.

Table 2. Land use capability subclasses (Anonymous, 2005)

Symbols	**Explanations**
e	Slope and Erosion Damage
s	Soil Insufficiency (stoniness, salinity and alkalinity)
w	Age, Drainage disorder and Flood damage

RESEARCH FINDINGS

Spatial Analysis of Land Use Capabilities

Spatial distributions regarding the land use capabilities of the central district borders of Niğde, which is the study area, are given in Figure 2 and the spatial distributions related to this are given in detail in Table 3.

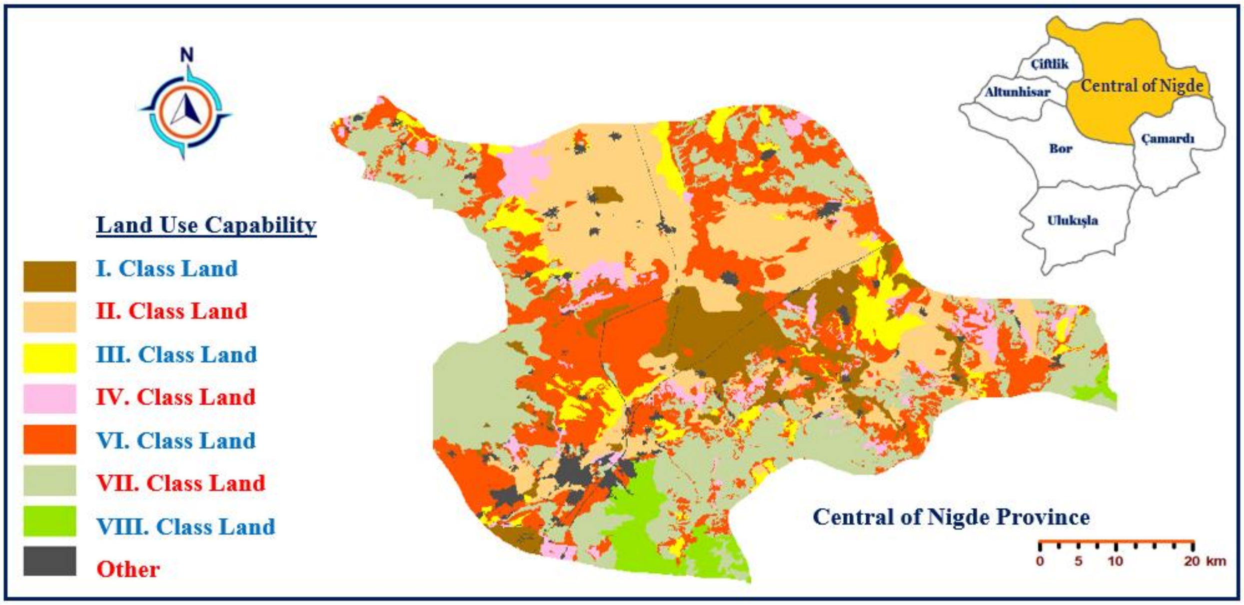


Figure 2. Spatial distribution of land use capabilities

Table 3. Areal distribution of land use capabilities

Land Use Capabilities	Area (km^2)	Total area ratio (%)
I. Class Land	184,47	6,76
II. Class Land	453,19	16,61
III. Class Land	142,43	5,22
IV. Class Land	117,66	4,31
VI. Class Land	671,26	24,60
VII. Class Land	864,62	31,68
VIII. Class Land	216,44	7,93
Other	78,90	2,89

Such lands have good water holding capacity and are known as areas with very good drainage. In contrast, VII. Class lands, on the other hand, are lands formed by areas that are very inclined and exposed to too much erosion and are not suitable for agriculture, and are characterized as lands that can be converted into suitable soil cultivation structures to meadow areas or evaluated as forest areas (Anonymous, 2005).

In the central of Niğde, VII. class lands dominate. IV. Class lands, on the other hand, cover a minimum area of 117.66 km^2 and correspond to 4.31% of the total area. IV. Class lands, on the other hand, are known as lands that restrict agricultural production due to insufficient soil and land conditions and unsuitable climatic conditions, but these areas are also known as areas suitable for allocation to meadow and pasture areas (Anonymous, 2005). The spatial distribution map obtained, spatially evaluated and classified in the subclasses of the land use capabilities classified within the scope of the study, is presented in Figure 3 and the calculated areal distributions for the groups classified accordingly are presented in detail in Table 4.

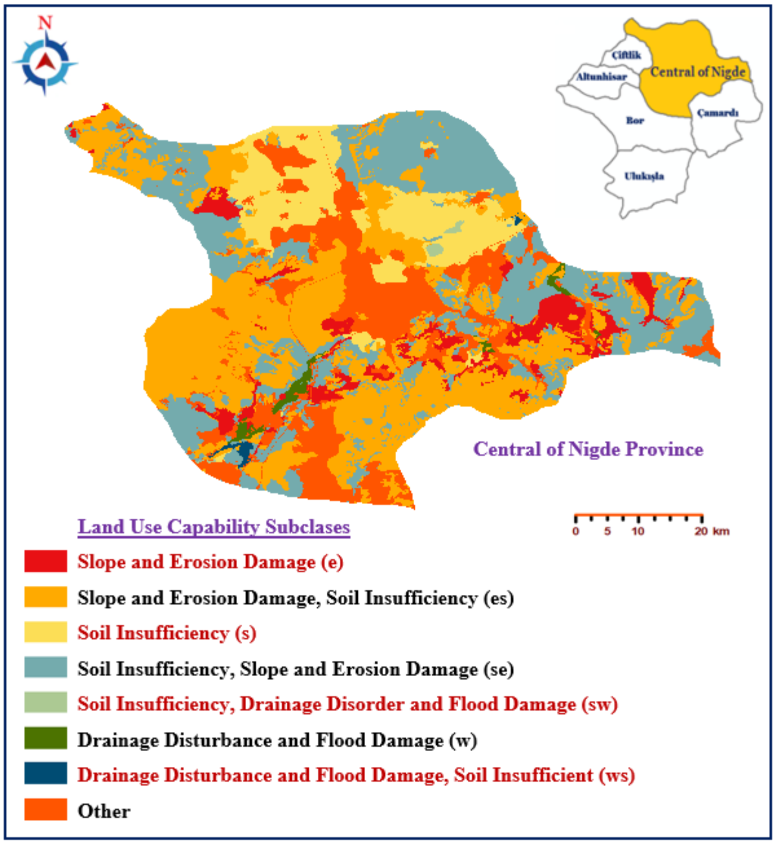


Figure 3. Spatial distribution of land use capability subclasses

Table 4. Areal distribution of land use capability subclasses

Land Use Capability Subclasses	Area (km^2)	Total area ratio (%)
Slope and Erosion Damage (e)	136,84	5,01
Slope and Erosion Damage, Soil Insufficiency (es)	1080,63	39,60
Soil Insufficiency (s)	253,82	9,30
Soil Insufficiency, Slope and Erosion Damage (se)	677,78	24,84
Soil Insufficiency, Drainage Disorder and Flood Damage (sw)	5,23	0,19
Drainage Disturbance and Flood Damage (w)	19,46	0,71
Drainage Disturbance and Flood Damage, Soil Insufficient (ws)	5,90	0,22
Other	549,30	20,13

It has been determined that the areas where slope and erosion damage and soil insufficiency are high in the research area are especially seen in 39.60% of the total area. It has been determined that drainage disorder and flood damage are seen in 0.71% of the total area in an area of 19.46 km^2. Soil insufficiency is also observed in the study area and it is seen that 9.30% of the total area is exposed to this situation.

CONCLUSION and RECOMMENDATIONS

In this study, spatial analyzes of land use capabilities and subclasses were carried out in the central district of Niğde. Accordingly, when we look at the distribution of land use capabilities based on 7 classes in the central of Niğde, it has been determined that Class I lands cover an area of 184.47 km^2 and correspond to approximately 6.76% of the total surface area of the study area. First class lands; It is a land containing flat or nearly flat, deep, fertile and easily cultivated soils where conventional agricultural methods can be applied. There may be little water and wind erosion on this grade of land. Soils have good drainage and are not subject to flood damage. They are suitable for hoe plants and other intensively grown crops. First class lands irrigated in places with low rainfall are lands with less than 1% inclination, deep, loamy structure, good water holding capacity, moderately permeable soils (Anonymous, 2005). In this context, it is seen that class I land assets in the study area are low compared to other land classes. In the research area II. Class land asset is 453.19 km^2, which corresponds to 16.61% of the total area. These lands, on the other hand, are good lands that can be easily cultivated only by taking some special precautions. Its differences from prime land may be one or more of the limiting factors such as light inclination, moderate erosion, moderately thick soil, occasional moderate flooding, and moderate wetness that can be easily isolated (Anonymous, 2005).

Areas with soil deficiency in the study area correspond to 9.30% of the total area (253.82 km^2). On the other hand, the areas where all components such as soil insufficiency, slope and erosion damage are seen constitute 24.84% of the total area. The areas where soil sufficiency is seen are not suitable for cultivated agriculture and can be characterized as mostly abandoned steppe and barren areas. In addition, the presence of water and wind erosion in the existing area causes the erosion of the existing soil surface and the transport of the fertile soil part. As can be seen in the classification of land use capabilities, I. and II. The scarcity of class land and the fact that it has a very low rate of 23.37% in the total area is an indicator that the slope, erosion, drainage and soil insufficiency problems that occur in the field are dominant.

Similar to this study conducted in Niğde province, other studies have been found in the literature using digital soil maps with Geography Information Systems (GIS) in Turkey. For example, in determining some land characteristics in Niğde province, in determining some soil resources potential in Thrace Region, in determining land slope, soil depths, erosion classes and large soil groups in Kayseri province, in determining land use and some soil properties in Kırşehir province, in determining some land and soil characteristics in Nevşehir province. Studies have been carried out to determine the large soil groups, current land uses, soil depths, land slope and erosion classes in Kırşehir province. In these studies, 1/25.000 scaled digital soil maps were used and some land and soil properties were analyzed spatially by using GIS (Bağdatlı and Arslan, 2020; Bağdatlı and Can, 2021a; Bağdatlı and Arslan, 2021; Bağdatlı and Ballı, 2021; Bağdatlı and Can; 2021b; Bağdatlı and Arıkan, 2021).

In this study, land use capabilities within the boundaries of the central district of Niğde province and accordingly its subclasses were spatially evaluated in the GIS method. As a result, the dimensions of the damages (soil deficiency, erosion, braking problem, slope) occurring in the lands of the region have been clearly revealed. The results obtained will make significant contributions to the agricultural investments to be made in the region. It will be inevitable that the spatial distribution maps of the land use capabilities will form the basis for different studies and will provide important bases for planning.

ACKNOWLEDGMENT

This study was carried out in Çukurova University, Institute of Science, Department of Remote Sensing and Geography Information Systems titled " Evaluation of The Time Change in the Usage of Agricultural and Urban Area in Niğde Province Using Sentinel-2 Satellite Images by Geography Information Systems (GIS) and Remote Sensing (RS) Integration". It has been prepared by making use of some results of the Master's Thesis.

REFERENCES

Anonymous 2000. Sayısal Toprak Haritaları, Mülga Köy Hizmetleri Genel Müdürlüğü, Ankara (in Turkish)

Anonymous 2005. Toprak ve Arazi Sınıflaması Standartları Teknik Talimatı, https://www.mevzuat.gov.tr/MevzuatMetin/1.5.5403.pdf (Access Date: 16.04.2020) (in Turkish)

Anonymous 2010. Arc GIS 10.3.1 software, ESRI Environmental System Research Institute. Redland, CA, USA

Anonymous 2019. Niğde İklim verileri, Meteoroloji Genel Müdürlüğü, Ankara (in Turkish)

Anonymous 2020. Niğde Tarımsal Üretim Verileri, Türkiye İstatistik Kurumu, Ankara (in Turkish)

Anonyomous 2021. Niğde ili idari yapısı, Niğde Valiliği, http://www.nigde.gov.tr/idari-yapi (Access Date: 07.08.2021) (in Turkish)

Arshad M.A. & Martin S. 2002. Identifying Critical Limits for Soil Quality Indicators in Agro-Ecosystems. Agriculture, Ecosys. and Environ. 88, 153-160.

Atalay İ. & Gökçe Gündüzoğlu A. 2015. Türkiye'nin Ekolojik Koşullarına Göre Arazi Kabiliyet Sınıflandırılması. (1. baskı). İzmir: Meta Basım Matbaacılık Hizmetleri. (in Turkish)

Atalay İ. & Değerliyurt M. 2015. Burdur Havzasında Arazi Kabiliyet Sınıflandırılması, *Ulusal Jeomorfoloji Sempozyumu, Bildiriler Kitabı* ss. 500- 520. Samsun Ondokuz Mayıs Üniversitesi (in Turkish)

Atalay İ. 2016. A New Approach To The Land Capability Classification: Case Study Of Turkey. International Conference – Environment at A Crossroads: Smart Approaches For A Sustainable Future. *Procedia Environmental Sciences,* 32: 264-274.

Bağdatlı M. C. & Can, E 2020. Temperature Changes of Niğde Province in Turkey: Trend analysis of 50 years data, *International Journal of Ecology and Development Research (IJEDR),* 6(2):62-71, ISSN: 2326-7204, doi:10.5281/zenodo.3903763

Bağdatlı M. C. & Arslan O. 2020. Trend Analysis of Precipitation Datas Observed for Many Years (1970-2019) in Niğde Center and Ulukisla District of Turkey, *International Journal of Recent Development in Engineering and Technology (IJRDET)*, 9(7):1-8

Bağdatlı M. C. & Arslan O. 2020. GIS Mapping of Large Soil Groups, Current Land Use, Soil Depths and Slopes, Soil Erosian in Kırsehir Province of Turkey, *World Research Journal of Agricultural Science (WRJAS), 8(1):265-277*

Bağdatlı M.C. & Can E. 2021a. Spatial Evaluation of Land and Soil Properties in the Example of Nevşehir Province, Turkey, *International Journal of Engineering Technologies and Management Research (IJETMR), 8(7):90-103*, doi:10.29121/ijetmr.v8.i7.2021.1007

Bağdatlı M.C. & Arslan O. *2021*. Classification and Mapping of Land Use and Some Soil Properties in Kırşehir Province, Turkey, *International Journal of Engineering Technologies and Management Research (IJETMR), 8(8):81-93*, doi: 10.29121/ijetmr.v8.i8.2021.1022

Bağdatlı M.C. & Ballı Y. 2021. GIS Mapping of Land Slopes, Soil Depths, Erosian Classes, Large Soil Groups and Some Soil Properties: A Case Study of Kayseri Province in Turkey, *Universal Journal of Agricultural Research, 9(5):166-175*, doi:10.13189/ujar.2021.090503

Bağdatlı M.C. & Can E. 2021b. Spatial Analysis of Soil Resources Potential by Using Geography Information Systems (GIS): A Case Study from Thrace Region, Turkey, *International Journal of Innovative Research and Reviews (INJIRR)*, 5(2): 45-50

Bağdatlı M.C. & Arıkan E.N. 2021. Assessment of Some Land Properties by Using GIS in Niğde Province of Turkey, *International Journal of Recent Development in Engineering and Technology (IJRDET), 10(11):1-9*

Oldeman L.R. 1994. The Global Extent of Soil Degredation. In: D.J. Greenland & Szabolics (eds.), *Soil Resilience and Sustainable Land Use*, pp. 99-118. CAB Inter., Wallingford, Oxon.

Öztekin M.E. & Koca Y.K. 2011. The advantages of Quickbird images for detailed soil survey Studies, *Journal of Food, Agriculture & Environment*, Vol.9 (3&4): 928-931.

Özşahin E. Pektezel H. & Eroğlu İ. 2016. Landuse Capability Classification for Tekirdağ (Thrace) Based on Atalay's Method. *4th International Geography Symposium* (23 – 26 May, 2016) Book of Abstracts (Edited by: Recep Efe & İsa Cürebal), p.:302, Kemer, Antalya.

A Review on the Status of Crop Production Innovations of the Philippines

Jincky D. DOGELLO[1], Ulysses A. CAGASAN[2*]

[1,2]Visayas State University, Visca, Baybay City, Leyte, Philippines

[*]Corresponding Author: ulycagasan@vsu.edu.ph

Abstract

The status of innovations strategies in crop production of the Philippines needs to be assessed to determine the country's ability to reach optimum productivity and income. Furthermore, the rising demands for food coming from a rapidly growing population have also heightened the significance of seeking a more productive and safer food. Thus, there is a need to identify and assess these innovations strategies of crop production in the Philippines. Thus, this paper aims to: identify innovative strategies in the field of crop production in the Philippines, assess current advances of technology in the field of crop production in the Philippines, and discuss the importance of innovations and advances in the field of crop production. The highlight of research findings on the innovative strategies that have been imposed by the researchers through practicing some smart farming innovations (SFI) and digital agriculture (DA). Advances, on the other hand, include the use of F1 seeds, solar power irrigation system, the website for crop planning (Farmers' Guide Map and Agri-information support portal), and the different applications that have been developed as well (Rice Crop Manager, AgriDOC, and KROPS). This improvement helped the farmers inefficient use of water, fertilizer, and other agricultural inputs in an environmentally friendly way to boost crop productivity while maintaining a safer environment for the farmers and the people. For instance, it is concluded that the innovations above and advances in technology in crop production of the Philippines will be one of the milestones in attaining a specific goal for everyone. And that is to increase the ability of the country to produce a sufficient amount of food for every Filipino family. At the same time, the approach will maintain sustainability and reduced the impact on the environment as long as these technologies are correctly managed.

Keywords: Farming innovation, efficiency, sustainable environment, and productivity

Review article
Received Date: 19 July 2021
Accepted Date: 24 November 2021

INTRODUCTION

Despite the plan to industrialize the economy in 2000, the Philippines is still primarily an agricultural country where most citizens still live in rural areas and support themselves through agriculture. The country's agriculture sector comprises four sub-sectors: farming, fisheries, livestock, and forestry (the latter two sectors are tiny), which together employ 39.8 percent of the labor force and contribute 20 percent of GDP (Nations Encyclopedia, n.d.).

Crop production mainly belongs to the farming sector. As of the second quarter of 2020, the agricultural production status in the Philippines managed to grow 0.5 percent. 5.0 percent growth in production. It shared 53.7 percent of the total agricultural output, where palay went up by 7.1 percent and corn by 15.4 percent. At current prices, the value of agricultural production amounted to Php. 439.8 billion. This was 4.6 percent higher than the previous year's level (PSA, 2020).

Currently, the Philippines faces many problems in the agricultural sector, which employs around 37 percent of people in the country, being a major source of income for many households. Yet, this sector's share in the country's GDP has gone down over the years, showing a decline. The Philippines government is also decreasing funding for agriculture. Starting in 2011, agriculture only makes up about 4 percent of the national budget. This makes agricultural development in the Philippines questionable. Worse, the Philippines is notoriously vulnerable to natural disasters, facing around 20 typhoons each year. For farmers, one typhoon or tropical storm could be enough to wipe out the entire crop. Starting over with the work can be expensive and time-consuming. For example, coconut farmers need up to 10 years for their crops to grow. The lack of financial support coupled with frequent natural disasters leaves farmers in a compromising state. As a result, 57 percent of agricultural households are impoverished. In comparison, non-agricultural households are three times less impoverished. This rate is even worse in agricultural-dependant areas and reaches up to 74 percent in Central Visayas (Massarath, 2018).

Philippine agriculture may be characterized, among others, by limited diversification and low productivity. The limitation in diversification and low productivity are considered the two most important challenges which constrain agricultural production and limit the capacity of the country to harness the full potentials of the growing local and international markets. Other ASEAN countries have generally prioritized diversification in the agriculture sector, exhibiting better agriculture performance than in the Philippines. For instance, crop yields are generally lower in the Philippines compared to other countries in the region. As a result, the country is growing behind in long-term total factor productivity in agriculture. Low agricultural productivity is an even bigger challenge. Long-standing challenges that hamper productivity include limited access to credit and Agricultural insurance, low farm mechanization, and inadequate postharvest facilities, inadequate irrigation, scant support for research and development (R & D), weak extension service, incomplete agrarian reform program implementation, and aging farmers and fisherfolks. There is also limited connectivity between production areas and markets and poor compliance with product standards resulting in low competitiveness of agriculture, forestry, and fisheries (FFTC-AP, 2018).

Furthermore, FFTC-AP described that to address the aforementioned constraints in agricultural production (specifically in crop productivity), investment in technology, innovation, and the necessary support services are the key factors that concerned agencies consider. Thus, the country's institutional framework or national agricultural development plan is embedded in the Philippine Development Plan 2017-2022, mainly on Chapter 8: Expanding Economic Opportunities in Agriculture, Forestry, and Fisheries had been formulated with an aim in expanding economic opportunity for those who are already engaged in producing agricultural products and increase access to economic opportunities for small farmers who are typically subsistence farmers with limited market participation.

The strategies stated in the plan include raising investments in R & D for production and postharvest technologies, enhancing the capacity of small farmers and fisherfolks to adapt better and new technologies, and innovative access financing. Therefore, this paper aims to identify recent innovations and advances in crop production in the Philippines with the previously mentioned strategic plan. Specifically; to identify the innovative strategies in the field of crop production in the Philippines, to assess current advances of technology in the field of crop production in the Philippines, to discuss the importance of innovations and advances in the field of crop production.

A REVIEW

Status of Philippine Agriculture

The agriculture sector mainly dominates the economy of the Philippines. Agricultural operations provide 40 to 45 percent of the total national income and about 75 to 80 percent of the country's exports. Food crops account for about two-thirds of the total production (tonnage) and about three-fourths of the cultivated acreage. The main crops usually cultivated for local consumption are rice, corn, and sweet potatoes. In keeping with the national emphasis on increased food production, there has been a consistent but not rapid increase in acreage devoted to these and other food crops. The increase in fruit and vegetable production has been quite significant. Double cropping of rice, corn, and some vegetables is practiced in many areas but is not general. Agricultural production, therefore, furnishes employment to about 3 million persons or about 60 percent of the gainfully employed workers where it provides 40 to 45 percent of the total national income and about 75 to 80 percent of the country's export (Cutshall, 1958)

The agriculture sector had loomed larger when it comes to employment, with nearly two-fifths (i.e. 37 percent) of the jobs are generated by the sector. Still, the services sector accounts for more or less half of both output and jobs in the economy. Unfortunately, the agriculture economy tends to fluctuate dramatically every quarter, manifesting similar volatility in its growth performance. The dramatic slowdown from various quarters had been caused mainly through unfavourable weather conditions. Notwithstanding these challenges, the agriculture sector is still recognized with incomparable value in overall economic development, first, as a source of raw materials and food for the rest of the economy. Second, it provides a significant market for the products of the non-agricultural economy. And third, as the sector grows and modernizes in the face of limited supplies of agricultural land. With 70 percent of the country's poor coming from the rural areas where agriculture is the dominant source of livelihood and employment, the importance of agriculture to the Philippine economy cannot be over-emphasized. Thus, the Medium Term Philippine Development Plans (MTPDPs) of successive administrations have consistently recognized the critical importance of energizing and modernizing the agricultural sector in the overall pursuit of vigorous and broad-based economic growth and development. But as we discuss below, success with this goal has continued to be elusive (Habito *et al.,* 2005).

RESULTS

Innovative strategies in the field of crop production in the Philippines

Use of Smart Farming Innovations (SFI)

SFI or Smart Farming Innovations is motivated by the 5th-agendas of the current Philippine President to increase agricultural and rural enterprise productivity. The study presents a strategy to lead research, development, and market of organic foods as medicine and build social entrepreneurs in using SFI. The researchers assumed the currently established protocols for micropropagation, cryopreservation, and management of vegetables, vertical farming and hydroponics, and monitoring in real-time of the climate, lighting, irrigation through the use of electronics, sensors, and automation in proposing the SFI to map the producers and market of organic foods, and finally build the cluster of social entrepreneurs in using the SFI smart technologies organic farm systems. It was found that scalable technology-driven products and services are an organic food production requires a certain radius to be effective and efficient. Therefore, it must consider setting up e-commerce, cloud computing, power and security, and utilizing big data analytics to aid in timely decision-making scaling up in the future (Matero *et al.*, 2020).

Digital Agriculture

Digital technology and innovations was a program introduced by the Department of Agriculture that includes e-Kadiwa and data analytics. These will be leveraged throughout the food value chain logistics, starting with the efficient distribution of inputs to farmers enrolled in the Registry System for Basic Sectors in Agriculture (RSBSA). The automated system will improve farm productivity and cut waste by using analytics to facilitate data-driven farming practices for small farmers. In addition, the status of crop production will be monitored using digital databases, strengthening the digitalization for "Agriculture 4.0" (D.A. n.d.). Thee-Kadiwa system was launched by the Department of Agriculture (DA) and private sectors on May 4, 2020, which is further described as an online marketing platform that can directly link producers, agripreneurs, and consumers. In his speech, DA secretary William Dar has said, "Through eKadiwa, we strengthen our commitment to providing every Filipino family a convenient and easier way to buy fresh, nutritious, and safe food products by simply using a mobile phone or computer". Customers only need to visit eKadiwa.da.gov.ph, where they can order a wide range of fresh and affordable farm and fishery products from three merchants: AgriNurture, Inc. (ANI); Zagana, Inc.; and Benjabi Ventures Corp. The ordered goods will be paid initially through cash-on-delivery (COD) or bank transfer. After that, the goods will be delivered initially via Mober, Inc. In addition, other transport and delivery service providers like Lalamove and Grab have signified joining the eKadiwa project.

The eKadiwa will initially cover Metro Manila and eventually expand to other major urban areas nationwide. ANI President and CEO Antonio Tiu said: "This is an opportunity for us to showcase our 'Bayanihan spirit and take part in the agriculture sector's paradigm shift towards modernization. This is a good example of a successful public-private partnership." "eKadiwa could be the biggest e-commerce site in the agriculture sector," he added.

Asked about the prospects of eKadiwa, Basil Bolinao of Mober Inc. said they are expecting a peak of 20,000 deliveries per day in Metro Manila. In all, the food supply chain will always be a part of 'essential services, with or without covid-19. The eKadiwa further expands ‘Kadiwa ni Ani at Kita,’ complementing regular outlets and rolling stores in Metro Manila and other areas nationwide (Bejarin, 2020).

Advances in technology in the field of crop production in the Philippines

Technology advancement had been the focal reform intended to Philippine agriculture. Aside from using F1 hybrid seeds in the year 2018, the country also had to make use of and completed the so-called "solar-powered irrigation system" in May. DA Secretary Manny Piñol has said that it has the ability to irrigates up to 500,000 hectares. Recorded in the same month are the Japanese-made drones that have been utilized in three Benguet towns to spray the fertilizer on mountain slopes to decrease the farmers' hours in the field. In addition to these, the government had created a website intended to help farmers in crop planning called Farmers Guide Map, with different applications that have developed. Such as Rice Crop Manager app, AgriDOC app, and KROPS with the main focus on assisting the farmers in identifying suitable crops to be planted on their lands, provide data on climate conditions and soil adaptability, provides recommendations to farmers in crop management based on their farm conditions, and to help them market their products at their prices and help potential buyers find sources of farm products within their area (Malasig, 2018).

On March 9, 2020, it was mentioned by AR that a web-based support system called "Agri-Information Support Portal" will be developed by the Department of Agriculture, headed by DA Secretary William Dar to link farmers and fisherfolks to aiding bodies that can address the commonly occurring issues efficiently for them as they move forward. This online portal is a nationwide initiative that will weave together regions of the DA, linked agencies, and bureaus to keep all parties in a single loop on agricultural advances and efforts. The system will encourage farmers and fishers to be more digitally aligned, technologically capable, and generally more innovative regarding how they carry out their processes. These will also provide improved sourcing of agriculture data and information to keep players consistently up-to-date at all times. In addition, it will enhance decision-support mechanisms that will be offered on the portal alongside speedy reporting of programs and projects. This initiative is a progressive step that will encourage other digital initiatives that DA has in-store. According to Secretary Dar, the development of the system will help industrialize the country's agriculture sector that will signify the establishment of a department-wide policy framework that focuses on the concept of "New Thinking for Agriculture" and for the Philippines to direct its efforts towards digitizing farming and agriculture businesses that will also involve the children of the farmers as infomediaries of the technologies they can get from this agri-information support portal. Furthermore, in the future, it is hoped that private bodies and digital players will also take part on the said digitization efforts to transform and bolster the Philippines' agriculture sectors as they will increase the importance and relevance to the economy as market demands jump and greater reliance on food security is attained.

Importance of innovations and advances in the field of crop production

Today's agriculture, inevitable innovations and advances in technology had routinely utilized high-end technologies such as robots, temperature and moisture sensors, aerial images, machines, information technology and GPS technology transformed farms and agricultural operations work far differently than those past few decades. Primarily, the advanced devices and precision agriculture and robotic system allow businesses to be more profitable, efficient, safer, and more environmentally friendly. Through these aforementioned technologies, farmers will no longer have to apply water, fertilizers, and pesticides manually across a huge field. Instead, they can use the minimum quantities required, target very specific areas, or treat individual plants differently. The advantages include higher crop productivity, decreased use of water, fertilizer, and pesticides, which in turn keeps food prices down, reduced impact on natural ecosystems, less runoff of chemicals into river and groundwater, increased worker safety. In addition, robotic technologies enable more reliable monitoring and management of natural resources, such as air and water quality. It will as well gives producers greater control over plant and animal production, processing, distribution, and storage which results in: greater efficiencies and lower prices, safer growing conditions and safer foods, and reduced environmental and ecological impact (NIFA-USDA, n.d.).

In most cases, current development and advances in technology had broadened the breadth, scale and immediacy of what these technologies can deliver. Advances *in situ* and remote sensing technologies have significantly increased the spatial and temporal resolution of physical measurements and allowed for low-cost, automated measurement of many aspects of agricultural production that were previously only able to be measured in a limited way – for example, at discrete points in time by a human observer conducting a field visit. Advances in massive data acquisition, storage, communication, and processing technologies have enabled the rapid transfer of vast quantities of data which would not have been possible even a decade ago. They have greatly magnified the ability to process large datasets and automate analytical processes with machine learning (OECD, 2019). Furthermore, advances in technology and farming practices have helped farmers become much more productive, growing crops efficiently in areas most suitable for agricultural production. Without these advances, far more land would need to be cultivated to produce the food we need today. For instance, it has been estimated that we could produce the same amount of total food grown fifty years ago on less than one-third the amount of land used back then. If yields had stayed the same since 1961, we'd need to cultivate more than double the amount of land to feed the population today – a shift from 12.2 billion acres to at least 26.3 billion acres. That's 82% of our total land area on earth (Farming First, n.d.).

CONCLUSION

Based on the condensed information from different researches, the following conclusions were drawn:

a. The innovative strategies in crop production in the Philippines include the use of smart farming innovations (SFI) and digital agriculture.

b. The current advances of technology in the field of crop production in the Philippines are the use of F1 seeds, solar power irrigation system, website for crop planning (Farmers' Guide Map and

Agri-information support portal), and the different applications that have developed as well (Rice Crop Manager, AgriDOC, and KROPS).

c. Innovations and advances in the field of crop production improved, continuously develop (as long as it is properly managed) and helped the farmers inefficient use of water, fertilizer, and other input in an environmentally friendly way to boost the crop productivity while maintaining a safer environment for the farmers and people as well.

For instance, it is concluded that the innovations mentioned above and advances in technology in cop production of the Philippines will be one of the milestones in attaining a specific goal for everyone. And that is to increase the ability of the country to produce a sufficient amount of food for every Filipino family. At the same time, the approach will maintain sustainability and reducing the impact on the environment.

REFERENCES

Ar A. 2020. How Philippines is empowering farmers with tech. Techwire Asia. https://techwireasia.com/2020/03/how-the-philippines-is-empowering-farmers-with-tech/

Benjamin G. 2020. Department of Agriculture Communications Group. Kadima goes online, bringing farmers' produce closer to more consumers. https://www.da.gov.ph/kadiwa-goes-online-bringing-farmers-produce-closer-to-more-consumers/

Cutshall A. 1998. Philippine Agriculture: Summary and Trends, The Professional Geographer, 10:5, Doi: 10.1111/j.0033-0124.1958.105 2.x

Department of Agriculture. N. D. Technology and Innovation Including Digital Agriculture. https://www.da.gov.ph/the-one-da-reform-agenda-eighteen-18-key-strategies/technology-and-innovation-including-digital-agriculture/

Farming First. N. D. Celebrating Science and Innovation in Agriculture. https://farmingfirst.org/science-and-innovation#home

Food and Fertilizer Technology Center for The Asian and Pacific Region, 2018. The Current State, Challenges, and Plans for Philippine Agriculture. https://ap.fftc.org.tw/article/500, November 21.

Habito C. & Briones R. 2005. Philippine Agriculture over the Years: Performance, Policies and Pitfalls 1

Massart F. 2018 December 8. Agricultural Development in the Philippines. The Borgen Project. Blog-Latest news. https://borgenproject.org/agricultural-development-in-the-philippines/

Matero C. & Jumawan-Matero M. 2020. Smart Farming Innovations for Philippines: Strategies and Recommendations. 10.2991/aebmr.k.200305.012.

National Institute of Food and Agriculture-United States Department of Agriculture. N. D. Agriculture Technology. https://nifa.usda.gov/topic/agriculture-technology

Nations Encyclopedia. N. D. Philippines-Agriculture. https://www.nationsencyclopedia.com/economies/Asia-and-the-Pacific/Philippines-Agriculture.html

Organization for Economic Cooperation and Development 2019. Chapter 2. Digital innovations and the growing importance of agricultural data. iLibrary for OECD. https://www.oecd-ilibrary.org/sites/367ac383-en/index.html?itemId=/content/component/367ac383-en

Philippine Statistics Authority. 2020. Performance of Philippine Agriculture (April-June 2020). http://www.psa.gov.ph/content/agricultural-production-increases-05-percent-second-quarter-2020.

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:137-145

Determination of the Amount of Land Area Required for Alternative Second-generation Feedstock to Replace First-generation Feedstock in Biodiesel Production in Turkey

Hülya KARABAŞ

Sakarya University, Faculty of Engineering, Department of Environmental Engineering, 54187, Sakarya, Turkey

Corresponding author: hkarabas@sakarya.edu.tr

ORCID: 0000-0002-2773-6160

Abstract

In this study, the amount of land area required for the replacement of sunflower and cottonseed plants, which are used as the first-generation feedstock source in the biodiesel production sector, which has the highest growing area as an oil plant in our country, with the second-generation vegetable oil feedstock was calculated. Safflower and rapeseed plants were selected as the second-generation vegetable oil feedstocks source. In this way, the required amount of land area and the amount of land saved to provide the same total potential biodiesel volume using second-generation feedstocks in the production sector has been determined. With the increase in the use of second-generation feedstock in biodiesel production, it is expected that land area use will be saved, our oil imports will decrease, and the pressure on the food sector will alleviation.

Keywords: Plantation area, biofuels, biodiesel, vegetable oil feedstocks, sustainability

Research article
Received Date: 16 October 2021
Accepted Date:25 November 2021

INTRODUCTION

In today's world, where conventional energy sources gradually decrease, energy is becoming one of the most expensive production inputs. Its importance is felt day by day with its polluting feature. Fossil fuels are unsustainable energy sources directly related to air pollution, soil pollution, water pollution, and climate changes. In this direction, governments, industrial organizations, non-governmental organizations, and agricultural unions struggling with global climate change always give privilege to the use of renewable energy sources, together with environmental awareness. Biofuels are seen as an attractive alternative to existing petroleum-based fuels. They can be used as transportation fuels with little change, are sustainable, provide energy security, and have significant potential to reduce greenhouse gas emissions (Ulukardeşler and Ulusoy, 2012; Göçer and Zaimoğlu, 2018). Biofuels are fuels of biological origin and are one of the energy sources that have come to the fore in recent years among renewable energy sources. Biofuels can be obtained from agricultural and forest products, animal and vegetable residues, and wastes, organic domestic, industrial, and urban wastes by thermochemical or biochemical methods. Biofuels can be in the form of solid, gas, or liquid. Solid biofuels include briquettes, pellets, biochar, and charcoal. Gaseous biofuels; consist of syngas, biogas, biohydrogen. Liquid biofuels include biodiesel, bioethanol, biomethanol, bio-dimethyl ether, and bio-oil (Avcıoğlu et al., 2011).

First-generation biofuels, whose production is commercial today, have a production of approximately 50 billion liters per year. First generation biofuels raise concerns in some scientists, especially on environmental and carbon balance issues. They argue that especially the increased production of first generation biofuels affects the food sector, which is the reason for the increase in food prices (Naik et al., 2010). Without the need for a design change in internal combustion engines biodiesel, defined as fatty acid methyl ester and bioethanol produced from sugary and starchy sources, constitute first-generation biofuels.

According to the International Energy Agency (IEA), second-generation biofuels are produced from cellulose, hemicellulose or lignin. Such biofuels can be blended with petroleum-based fuels or used in adapted vehicles (IEA, 2010). Navigant Research (2014) guess that global biofuel consumption in the road transportation sector will enlarge from more than 122.6 billion liters per year in 2013 to more than 193.41 billion liters per year in 2022, which will increase demand for advanced biofuels. In the last ten years, an increase in ethanol production capacity in the United States and Brazil, and biodiesel in Europe has resulted in biofuels gaining an important position in the global market for fuel. In the global liquid fuel market, biofuels have been particularly prominent in plenty countries and the production and consumption of biofuels like biodiesel and ethanol have been growing rapidly (UNCTAD, 2015).

Second-generation biofuel from locally available sources in each country can play a significant role in the economic development of that country's rural and developing regions. The production of 2nd generation biofuels is non-commercial, although pilot and demonstration facilities are being developed. Therefore it is anticipated that these 2nd generation biofuels could significantly reduce CO_2 production, do not compete with food crops, and some types can offer better engine performance. When commercialized, the cost of second-generation biofuels can be more comparable with standard petrol, diesel. It would be the most cost-effective route to renewable, low-carbon energy for road transport (Mofijur et al., 2021).

The two primary feedstocks for the production of second-generation biofuels are lignocellulosic and biodiesel feedstocks. Biodiesel, which has a biodegradable structure, is a second generation biofuel. . The main factor that creates the cost of biodiesel production is the oil feedstocks. Therefore, the way to reduce biodiesel production costs depends on the selection of the appropriate feedstock source. The main goal is to produce biodiesel at the lowest price and on a large scale. In general, oil raw materials used in biodiesel production can be classified into four groups. (i) edible vegetable oils (soybean, corn, sunflower, palm oil, etc.); (ii) inedible vegetable oils (camelina, karanja, mahua, jatropha, etc.); (iii) waste or recycled oils (cooking oils, vegetable oil soap stocks, etc.), (iv) animal fats (chicken fat, beef tallow, lard, fish oil, etc.).Inedible vegetable oils, waste or recycled oils, and animal fats are considered second-generation biodiesel raw materials. (Demirbaş, 2007; Lim and Teong, 2010; Balat 2011; Bhuiya et al., 2014; Silitonga et al., 2013).

Many countries in the world produce biodiesel from oil crops that are different and suitable for their ecological conditions. Figure 1 shows the most dominant biodiesel production feedstocks of different countries. Today, biodiesel has become more and more affordable due to the introduction of subsidies and tax exemptions (Mofijur et al., 2021).

Figure 1. Source of in different countries (Gardy et al, 2019)

According to the 1st Biodiesel Industry Report published in 2019, in the biodiesel sector in our country in 2018, as raw material sources, 32 000 tons of waste vegetable oil with a share of 30%, 35 000 tons of cotton oil with a share of 32%, 28 000 tons of canola with a share of 26%, 4200 tons of safflower oil with a share of 4%, and 8800 tons of other oils with a share of 8%. "Communique on Blending Biodiesel into Diesel Types" prepared by the Energy Market Regulatory Authority based on the Petroleum Market Law No. 5015 and the Regulation on Technical Criteria to be Applied in the Petroleum Market was published in the Official Gazette dated 16 June 2017 and numbered 30098 and entered into force. According to this communiqué, the blending ratio of biodiesel to diesel fuel was determined as 0.5%. In this way, it is aimed to reduce foreign dependency on energy, increase resource diversity, ensure efficient recovery of waste vegetable oils, reduce environmental pollution and adapt to the renewable energy policies of the European Union.

Considering our country's climate and soil characteristics, it has excellent potential for the production of oilseed plants. According to the data of the USDA report for the 2019-2020 growing season, total oilseed production in the world is approximately 577.15 million metric tons. Soybean ranks first with a production of 337.14 million metric tons, followed by rapeseed (canola) with 68.20 million metric tons and sunflower with 55.04 million metric tons (USDA, 2020).

Ranking first in oilseed production in Turkey in 2019, sunflower production is approximately 1.9 million tons, cotton production is 1.320 million tons, rapeseed production is 180 thousand tons, soybean production is 150 thousand tons, safflower production is 21.9 thousand tons, and sesame production is 16.9 thousand tons. The most cultivated area is a sunflower with 675.9 thousand ha, followed by cotton with 477.9 thousand ha, rapeseed with 52.5 thousand ha, soybean with 35.3 thousand ha, sesame with 24.9 thousand ha, and safflower with 15.9 thousand ha.

In our country, which has very different climate and soil characteristics ecologically, the production of oilseed plants cannot meet our consumption amount. The sustainability of biodiesel production, which has an important place among biofuels in providing energy diversity in our country, depends on the excellent display of vegetable oil raw materials. The production of oilseed plants will be brought to the desired levels, especially with the use of marginal and fallow areas in energy agriculture and specific agricultural regions.

According to the plant production data of the Ministry of Agriculture and Forestry in 2020, our total agricultural lands are 23 136 000 ha. While the area used for the cultivation of field crops is 15 615 000 ha, 3 173 000 ha has been left fallow. As a result of the increase in the population and the decrease in the total amount of agricultural land in Turkey, the amount of agricultural land per capita has decreased. In the 1990-2018 period, the population of Turkey increased by approximately 45.2%, and the shrinkage in agricultural areas per capita in the same period was 39.3%. The first generation feedstock in biodiesel production is edible oils used in the food industry. Second-generation feedstock, on the other hand, is non-preferred and inedible oils, especially in the food sector. The main alternative oil crops grown in our country are; rapeseed, safflower, camelina, sesame, and pelemir.

In this study, the amount of land area required to replace oilseed plants, which are used as a first-generation feedstock source in biodiesel production in our country, with second-generation oil raw materials that are not used in the food sector, were determined. In the study, sunflower and cottonseed were selected as first-generation biodiesel feedstocks. Rapeseed, which is harmful to human and animal health due to the high content of erucic acid and glucosinolate in its oil, was chosen as the second generationfeedstock, and safflower which is not preferred as edible oil. Camelina and pelemir plants, which are very suitable for use as second-generation feedstocks in biodiesel production, could not be used as a vegetable oil raw material source in this study because they have not reached sufficient production amount commercially in our country.

MATERIAL and METHOD

Materials

In this study, sunflower and cottonseeds were selected as the first-generation feedstock sources in the biodiesel production sector, while safflower and rapeseed were chosen as the second-generation feedstock sources. Data were taken from the public, online sources. Food and Agriculture Organization (FAO) of the United Nations Statistics Division (FAOSTAT) was used as the source for 2019 year. The crop yield data of each first and second generation feedstock which is obtained from FAOSTAT for Turkey.

Second-generation biodiesel feedstocks - replacement

Non-edible second-generation biodiesel feedstocks can be grown on non-arable land, although they can save lands for food production can be held. The potentially carbon-neutral feedstocks also do not raise food prices as they do not directly compete with agricultural food products for space and water. Food security can be correlated to plowland (Irabien and Darton, 2016). The land can be seen as a central to store, convert and provide energy for food production. By adjusting the preference to meet the local food demand and using the extra land to produce biofuel feedstocks, there could be a net improvement in food and energy security. But it still requires more study for feasibility and productivity for second-generation biodiesel feedstocks (Hasan and Avami, 2018).

At present, the total global renewable energy is 72.12×10^{12} MJ. By introducing the total potential biodiesel volume from all countries into the energy market, the value can be increased to 74.90×10^{12} MJ. Figure 2 shows the most dominant feedstock used in second-generation biodiesel production for each country in the world. Jatropha is a superior feedstock as it is the potential dominant feedstock in 62 out of 130 countries. Camelina is also an ideal feedstock in all European countries (Chong et al., 2021).

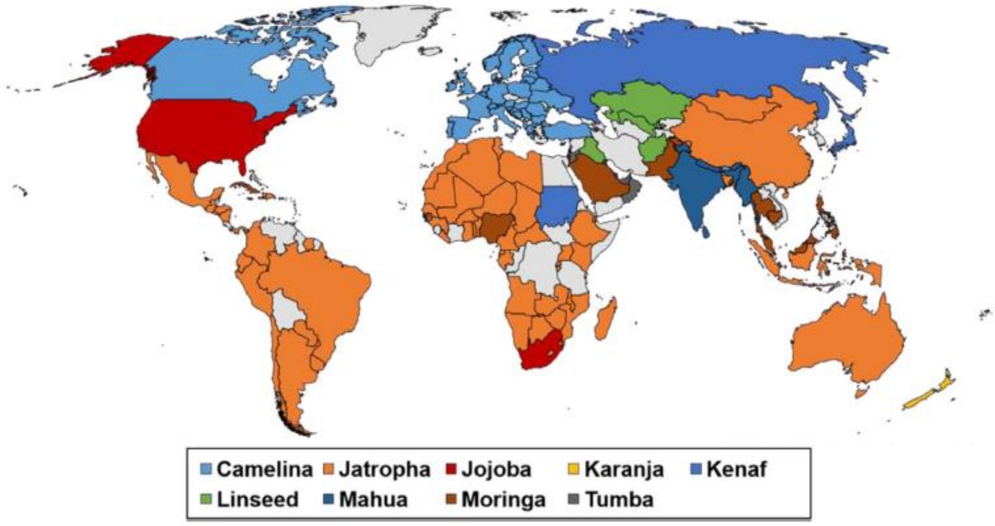


Figure 2. Potential dominant second-generation biodiesel feedstock of each country.

In this study, sunflower and cottonseed were selected as first-generationfeedstocks. These plants are the first two oilseed plants with the most planting area in our country. As seen in Figure 2, the second-generation feedstock foreseen for our country is camelina. However, since the cultivation areas of this plant are minimal, the data to be used in the calculations could not be reached, and safflower and rapeseed, which are our alternative oil crops, were taken into consideration in this context.

The safflower plant is a potential oil plant planted in large areas in our country with its comprehensive climate demands, high drought and heat tolerance, availability in summer/winter forms, and suitability for mechanization. Although its importance has increased rapidly globally, there has not been a significant development in agriculture until today, since it is not sufficiently known and its importance is not adequately understood in our country. 86% of biodiesel production in the world is provided from the rapeseed plant. However, when the TUIK 2019 data were examined, rapeseed agriculture could not reach the desired levels in our country. The oil content of rapeseed seeds is between 40-45%. Since the high erucic acid and glucosinolate in its oil are harmful to human and animal health, it is one of the most suitable oil plants for energy agriculture (Yıldırım, 2005; Bayramin, 2006; Gizlenci et al., 2012; Yılmaz et al., 2021).

Calculation of total plantation area of first-generation feedstocks

The total plantation area of first-generation feedstock (TPA_j) to produce the total potential biodiesel volume is calculated using the following equation 1:

$$TPA_j = \sum_i \frac{EQ_{ij} \times 1000}{CY_{ij} \times OC_i} \quad (1)$$

Equation 1 means CY_{ij} , OC_i and EQ_{ij} are the crop yield, oil content and export quantity of the feedstocks, respectively. The crop yield and export quantity of each first-generation feedstocks which is obtained from FAOSTAT varies for Turkey (FAO, 2014b). First-generation feedstocks with export quantity values below the threshold value of 10 000 tons are not considered in the calculation of potential biodiesel production (Chong et al., 2021).

Therefore, calculations were made by considering the data of sunflower and cotton seeds in the study since they have production values above the threshold value. Any export quantity of vegetable oils that is lower than the threshold is considered to be inadequate for the potential biodiesel production. The threshold value is based on a generic biodiesel plant with a capacity of 10 million litres per annum (USDA, 2017). The export quantity which reaches the threshold value is used in the calculation of the potential biodiesel production.

Calculation of total plantation area of second-generation feedstocks

The land area required by second-generation feedstocks (SPA_j) to produce the same volume of total potential biodiesel volume is calculated using the following equation 2:

$$\mathrm{SP}A_j = \frac{TPBV_j \times OD_i}{CY_i \times OC_i \times CR} \quad (2)$$

Equation 2 means total potential biodiesel volume, $TPBV_j$, OD is the oil density and CR (0.98) is the volumetric conversion ratio from oil to biodiesel. The land area saved by replacing first-generation feedstock with second-generation feedstock can be equated by deducting SPA from TPA (Chong et al., 2021; Johnston and Holloway, 2007).

RESULTS and DISCUSSION

Sunflower and cottonseed places as the first-generation dominant feedstocks sources in biodiesel production sector in our country. Table 1 contains the necessary data for calculating the plantation areas of first-generation biodiesel feedstocks. Table 1 shows the crop yield and export quantity information of sunflower, cotton seed, safflower and rapeseed oil crops for 2019 growing season according to FAOSTAT 2021 data.

Table 1. Properties of first and second generation vegetable oil feedstocks in Turkey

Feedstocks	**Oil content (wt%)**	**Crop yield (kg/ha)**	**Export quantity (tons)**	**Reference**
Sunflower	30	27937	544593	Altın et al. (2001), Karmakar et al. (2010)
Cottonseed	21.5	46044	9986	Agarwal (2007), Altın et al. (2001)
Rapeseed	42	34279	968	Agarwal (2007),
Safflower	40	13798	-	Altın et al. (2001)

Table 2 demonstrate the amount of plantation areas required for sunflower and cottonseeds, which are used as first-generation vegetable oil feedstocks in biodiesel production in our country. The TPBV value used in Equation 2 was calculated according to Chong et al. (2021).

Table 2. First-generation feedstocks plantation areas

Feedstocks	**TPA (ha)**
Sunflower	649787
Cottonseed	10087
Total	659874

Table 3 shows the amount of land area required by second-generation biodiesel feedstocks to produce the same of total potential biodiesel volume.

Table 3. The amount of land area required for second-generation vegetable oil feedstocks

Feedstocks	**SPA (ha)**
Rapeseed	383.525
Safflower	1002.643

The total potential biodiesel volume obtained by using all sunflower and cottonseeds grown in our country in the 2019 sowing period as a first-generation feedstock has been calculated as 593338554 liters. To achieve this production volume, the sunflower was grown in 649787 ha area, cottonseed was grown in 10087 ha area, and 659874 ha of land area was used for this cultivation in total. As can be seen from these results, if the rapeseed plant, which is not used in the food sector, were used as a feedstock biodiesel production, 383.525 ha would be needed to provide the same potential biodiesel volume, and 1002.643 ha would be required if safflower plant was used. In this way, 659490.4 hectares of land would be saved using rapeseed and 658871.3 hectares with the use of safflower.

CONCLUSION

As the population of Turkey increases, the amount of agricultural land area per capita decreases as a result of the decrease in the total amount of agricultural land. While the population increased by 45.2% between 1990 and 2018, there was a 39.3% contraction of farming areas. As a result of this shrinkage in agricultural regions, our energy resources, whose raw materials are based on agriculture and the food sector, are adversely affected by this situation. In this study, both the required land sizes and the saved land sizes were determined if the second-generation feedstocks are used instead of the first generation feedstocks in the biodiesel production sector. 659490.4 and 658871.3 hectares of plantation area can be saved in Turkey, by replacing sunflower and cottonseed as a first-generation feedstocks with rapeseed and safflower, recspectively. Second-generation biodiesel feedstocks can be planted in non-arable lands and do not compete for lands with food crops, making them good candidates to replace first-generation feedstocks. In 2020, 3173000 hectares of agricultural land was left fallow in our country. It is essential to use these areas and the areas we save thanks to using second-generation vegetable oil feedstock in energy agriculture. Ensuring energy security and the production of biodiesel, which is one of our renewable energy sources, depends on the sector throughout the year. To achieve it is crucial to evaluate these areas primarily for planting the necessary oilseed plants. There could be a net improvement in food and energy security by arranging the local food demand and using the extra land to produce biofuel feedstocks.

REFERENCES

Ulukardeşler A.H. & Ulusoy Y. 2012. 3. Nesil Biyoyakıt Teknolojisi olan Alglerin Türkiye de Üretilebilirlik Potansiyeli, *Onuncu Ulusal Kimya Mühendisliği Kongresi*, 3-6 Eylül 2012, Koç Üniversitesi, İstanbul.

Göçer S. & Zaimoğlu Z. 2018. Üçüncü ve dördüncü nesil biyoyakıtların araştırılması. *Uluslararası GAP Yenilenebilir Enerji Ve Enerji Verimliliği Kongresi*, 10-12 Mayıs 2018, pp: 71-75, Şanlıurfa, Türkiye. (Conference paper), GAP Yenilenebilir Enerji ve Enerji Verimliliği Merkezi (GAPYENEV-2018).

Avcıoğlu A.O., Türker U., Atasoy Z.D.& Koçtürk D. 2011. Tarımsal Kökenli Yenilenebilir Enerjiler-Biyoyakıtlar, *Nobel Yayıncılık*, Ankara.

Naik S.N., Goud V.V., Rout P.K. & Dalai A.K. 2010. Production of first and second generation biofuels: A comprehensive review, *Renewable and Sustainable Energy Reviews*, 14, 578-597.

IEA, (2010). Sustainable Production of second-generation Biofuels: Potential and perspectives in major economies and developing countries. https://www.iea.org/publications/freepublications/publication/second_generation_biofuels.pdf / (accessed 20 September 2021)

Navigant Research (2014) Biofuels demand for road transportation will surpass 51 billion gallons annually by 2022. https://www.navigantresearch.com/newsroom/ biofuels-demand-for-road-transportation-will-surpass-51-billion-gallons-annually-by-2022/ (accessed 15 September 2021)

UNCTAD, 2015. Second generation biofuel markets: State of play, trade and developing country perspectives. *United Nations Conference on Trade and Development (UNCTAD*). UNCTAD/DITC/TED/2015/8, United Nations Publication.

Mofijur M., Siddiki Y.A., Shuvho B.A., Djavanroodi F., Rizwanul Fattah I.M., Ong H.C., Chowdhury M.A. & Mahlia, T.M.I. 2021. Effect of nanocatalysts on the transesterification reaction of first, second and third generation biodiesel sources- A mini-review, *Chemosphere* 270, 128642.

Gardy J., Rehan M., Hassanpour A., Lai X. & Nizami, A.S. 2019. Advances in nanocatalysts based biodiesel production from non-food feedstocks, *J. Environ. Manag*. 249, 109316.

USDA (2020). Statistical data of USDA. Retrieved from: https://usda.library. cornell.edu/concern/publications/ tx31qh68h? locale=en./ (accessed 2 October 2021)

TÜİK (2019). Statistical data of TUIK. Retrieved from: https://biruni.tuik.gov.tr/ medas/?kn=104&locale=tr./ (accessed 2 October 2021)

TÜİK (2020). Statistical data of FAO. Retrieved from:https://biruni.tuik.gov.tr/ medas/?kn=92&locale=tr./ (accessed 2 October 2021)

Irabien A. & Darton R.C. 2016. Energy–water–food nexus in the spanish greenhouse tomato production, *Clean Technol. Environ. Policy* 18 (5), 1307–1316.

Hasan A.H. & Avami A. 2018. Water and emissions nexus for biodiesel in Iran. *Renew. Sustain. Energy Rev*. 93 (5), 354–363.

Yılmaz A., Yılmaz H., Arslan Y., Çiftçi V. & Baloch F.S. 2021. Ülkemizde Alternatif Yağ Bitkilerinin Durumu, *Avrupa Bilim ve Teknoloji Dergisi*, Özel Sayı 22, 93-100.

Gizlenci Ş., Acar M. & Şahin M. 2012. Türkiye'de yenilenebilir enerji kaynaklarının (Biyodizel, biyoetanol ve biyokütle) projeksiyonu, *Tarım Makinaları Bilimi Dergisi*, 8(3), 337-344.

Bayramin S. 2006. Aspir (*Carthamus tinctorius*L.) / Kolza (*Brassica napus*spp. oleifera L.) Tarımı ve Islahı, *Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi*,15(1-2), 74-85.

Yıldırım M. 2005. *Seçilmiş alternatif keten (Linum usitatissimumL.) hatlarının verimve verim öğeleri bakımından karşılaştırılması.* Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Ankara.

FAO 2014b. Crop Yield. FAOSTAT, http://www.fao.org/faostat/en/#data./ (accessed 25 September 2021).

Chong C.T., Loe T.Y., Wong K.Y., Ashokkumar V., Lam S.S, Chong W.T., Borrion A., Tian B. & Han N.G.J. 2021. Biodiesel sustainability: The global impact of potential biodiesel production on the energy–water–food (EWF) nexus, *Environmental Technology & Innovation*, 22, 101408.

USDA 2017. Foreign Agricultural Service, U.S. Department of Agriculture Gain Report. https://apps.fas.usda.gov/newgainapi/api/report/ (accessed 22 September 2021)

Johnston M. & Holloway T. 2007. Policy analysis a global comparison of national biodiesel production potentials, *Environ. Sci. Technol*, 41 (23), 7967–7973.

Agarwal A.K. 2007. Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines, *Prog. Energy Combust. Sci*, 33(3), 233–271.

Altın R., Cetinkaya S. & Yücesu H. 2001. Potential of using vegetable oil fuels as fuel for diesel engines, *Energy Convers. Manage*, 42, 529–538.

Karmakar A., Karmakar S. & Mukherjee S. 2010. Properties of various plants and animals feedstocks for biodiesel productio, *Bioresour. Technol*, 101(19), 7201-7210.

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:146-159

The Importance of Vermicompost in Agricultural Production and Economy

Ehlinaz TORUN KAYABASI[1], Orhan YILMAZ[2*]

[1]*University of Kocaeli, Faculty of Agriculture, Department of Agricultural Economics, Kocaeli, Turkey.*

[2]*Ardahan University, Faculty of Engineering, Department of Food Science, Ardahan, Turkey.*

[*]*Corresponding author: ehlinaz.torun@kocaeli.edu.tr*

ORCID: 0000-0001-9081-4734[1], 0000-0001-5237-2883[2]

Abstract

The aim of the study is to reveal the increase in agricultural production caused by the use of vermicompost in various agricultural productions compared to other fertilizers and its contribution to the economy of the farmer and the country depending on this increase. In order to achieve this aim, the results of previous studies and trials were investigated and analyzed. The study has shown that the results obtained with the application of vermicompost alone or in combination with other fertilizers provide an increase in both fruit rate, leaf development and dry matter rate. It has also been determined that it regulates the soil structure and PH value. The positive results of the use of vermicompost, the increase in the quality and quantity of the obtained product, the supply of the products needed by the market, the improvement of the soil structure, the more economical meeting of the plant nutrients that the plant needs are reflected both in the prices of the farmers and in the national economy. Therefore, the use of vermicompost is more economical than chemical fertilizers, the long-term effect on the soil and the increase in yield make a positive contribution to both the farmer and the country's economy

Keywords: Vermicompost, Economic Benefit, Soil PH, Inorganic Fertilizer, Product Quality

Review article
Received Date: 20 October 2021
Accepted Date: 25 November 2021

INTRODUCTION

The soil conditioner and plant feeding material produced by earthworm species such as red worm (Eisenia foetida) on the basis of changing the physical and chemical structures of bovine feces and organic plant materials is called vermicompost. The intensive use of agro-chemicals, which puts both human health and environmental safety at risk, reduces soil quality, and increases pathogen resistance, has caused serious concerns about the safety of natural resources. All this has led scientists to the development of sustainable agricultural production methods that target the use of effective organic products as biological fertilizers and pesticides. In this area, aerobic compost and vermicompost products, which increase soil quality in all respects, have gained great importance.

Vermicompost methods, which are a reliable, economical and sustainable method for the evaluation of various organic wastes, enable the production of products called “Vermicest”, which is thought to have a biological suppression effect on plant growth, plant nutrition and rot factors. Vermicompost (worm manure) enables a low-input production system, which is very important for small or medium-sized agricultural producers, and can compensate for the product decline initially observed in the transition from conventional agriculture to organic agriculture. Vermicompost methods are techniques that ensure food safety for humans and animals, support a sustainable agricultural production model that is reliable in terms of environmental health and has high economic value (Demir et al., 2010).

Vermicompost provides aggregate formation in the soil in order to increase productivity. It improves the structure of the soil, increases the porosity of the soil, and ensures that the air intake and water holding capacity are high. These also help the plant to complete root development better. Thus, the plant absorbs useful nutrients in the soil and causes an increase in plant characteristics and yield. In addition, due to the organic nature of the vermicompost applied to the soil, an increase in the nutrients in the soil is provided (Mısırlıoğlu, 2011). Worms significantly affect soil structure, fertility and plant production. Through their feeding and gallery opening activities, they improve the soil balance positively, increase the penetration of water into the soil, accelerate the mixing of organic matter, lime and fertilizers applied to the surface with the soil, and increase soil porosity. In addition, it has been proven by studies that they support plant root development; significantly reduce the rate of root diseases, increase meadow and crop yield and grain quality (Tomati and Gali, 1995).

Many vermicompost tests have been carried out on different plants throughout the world and Turkey. Most of the time, vermicompost was used together with other fertilizers in the experiments and the results were compared according to the control groups. Most of the studies on vermicompost are related to the effect of fertilizer on yield and diseases. Economic research is very limited. The results of some of the trials with different products and different fertilizers are presented below.

Vermicompost is a reliable organic fertilizer because it has a slow release (increasing agricultural production and reducing nutrient loss) feature and provides physical, chemical, biological and microbiological improvements in the soils it is used in. Among its widely known benefits are; It can be counted as having a soil conditioner feature, containing a sufficient amount of useful plant nutrients, controlling some pesticides and plant diseases, increasing the product yield by increasing the soil quality, being an environmentally friendly and economical fertilizer when used in the long term. All kinds of vegetable residues, farm manure, chicken manure, garbage compost and organic industrial wastes can be used to eliminate the lack of biological origin in the soil. These materials provide nutrients to the soil by improving the physical, chemical and biological properties of the soil, thus positively affecting the yield and quality in plant production (Sönmez et al., 2002; Entry et al., 1997; Pascual et al., 1997).

Vermiculture studies are involved in garbage treatment, soil detoxification and regeneration, and sustainable farming practices. Commercial vermiculture activities are concentrated in two areas. The first is vermicompost processing and the other is worm biomass production. Worm biomass production is made for the use of worms in poultry and fish farming as a protein source. On the other hand, vermistabilization is the vermicomposting of sewage, sewage sludge or other similar wastes (Edwards and Arancon, 2004). Earthworms increase plant growth (39%) and grain yield (35%), especially in grain production (Baker, 1994).

While compost applications obtained from various materials are rapidly becoming widespread in our country, vermicompost applications can be considered new for our country. In previous studies with vermicompost, it is emphasized that it improves the physical and biological structure of the soil and has positive effects on plant yield and quality. More recognition of vermicompost in our country and its effects on plant productivity should be revealed with further studies and studies. Studies have shown that organic fertilizers are beneficial for plants, soil, environment and economy. The most important studies are to increase the productivity of plants and to show that better results can be obtained in the long term compared to chemical fertilizers. Bio fertilizer and vermicompost applications to be made in the rhizosphere region, where microbiological activity is higher than other parts of the soil, provide an improvement in both the physicochemical properties of the soil and its biological productivity. Thus, the need for chemical fertilization decreases, and an increase in soil biodiversity and biomass occurs. In a study, worm compost created from waste helped to decrease the soil pH value, while it caused an increase in the amount of dry matter in the corn plant(Ferreira and Merchant, 1992).

(Fosgate and Babb, 1972) used vermicompost for plant nutrition. The researchers reported that vermicompost obtained using barnyard manure is the same as a "special greenhouse flower mix." In a study on rice plant, it was revealed that vermicompost increased the vegetative growth of the plant more than chemical fertilizers (Kale et al., 2013). (Edwards. , 1995) reported that vermicompost increased the germination rate and promoted growth.

(Buckerfield and Webster, 1998) in their study investigating the effect of vermicompost and sand mixtures on plant growth in radish, found that plant weight increased as the vermicompost ratio increased. It has been reported that spinach forms 16-17 leaves until flowering, however, the lower leaves turn yellow over time (Şalk, 1992).

In a study carried out in open field conditions, Matador and Spinoza varieties of spinach were grown in two different growing periods, such as autumn and spring. According to the results obtained, more yieldswere obtained from Matador variety and from sowing in March. In terms of earliness, Matador in autumn cultivation and Spinoza in spring cultivation came earlier to harvest (Deveci and Şalk, 1995).

A study was conducted in August 1992 at the Raichur District Research Institute for the Tompson seedless grape. The experiment was carried out on 2-year-old vines grown with a 1.8 x 1.2 m spacing system. In this study, the effects of different fertilizer applications on NPK uptake and yield were investigated. By applying vermicompost to two experimental plots, 100,000 and 200,000 worms were left. On the other parcels, 300:500:1000 NPK kg/ha was applied at the rates of 75%, 50%, and 25%, respectively. One parcel was left without any application as the control group. It was determined that the NPK level increased and the pH level decreased in the parcels with vermicompost application (Venkatesh et al., 1998).

In a study on sugar beet, the effects of nitrogen fertilizer, barn manure and vermicompost were investigated. According to the results obtained, it was observed that vermicompost used at the level of 10 t/ha formed biomass with more root and leaf growth in sugar beet (Zimny et al., 2001).

In an experiment, vermicompost was used as a fertilizer in tomato, pepper, potato and strawberry cultivation, and it was reported that leaf area, shoot length and market value of strawberries increased greatly in pepper and tomato (Arancon, et al., 2007); (Arancon, et al., 2004) investigated the effects of vermicompost on strawberries. It was concluded that vermicompost had a positive effect on growth and development when applied in different amounts. (Nurhidayati et al., 2016) in another study, lettuce and cabbage were grown by mixing compost and vermicompost in certain proportions. In an experiment, it was determined that vermicompost produced using sheep manure greatly increased the weight of tomatoes, lowered the pH in the soil and increased the solubility of plant nutrients (Gutiérrez-Miceli et al., 2007). As a result of studies on spinach, vermicompost application has been shown to increase nutrient intake (Nagavallemma et al., 2006; Peyvast et al., 2007).

Germination, fruit weight, amount of ascorbic acid and yield were investigated in different ratios of peat and vermicompost mixtures in tomato. According to the results obtained, it was observed that there was an increase in marketable yield with vermicompost application (Roberts et al., 2007). (Azarmi et al., 2008) stated that the application of vermicompost in tomato affects the physical structure of the soil, and there is an increase in the amounts of potassium (K), phosphorus (P), calcium (Ca), organic carbon (C), Manganese (Mn), Zinc (Zn).

(Arancon et al., 2007) demonstrated that vermicompost application partially controlled Meloidogyne incognita nematode in tomato-pumpkin rotation production. Again, (Arancon et al., 2007) stated that vermicompost reduced the number of egg masses and root tumors of Meloidogyne javanica (nematode). It was concluded that vermicompost suppressed fungivorous nematodes more effectively than baktivorous nematodes.

In a study by a group of scientists on tobacco plants, it was observed that worm castings applied in the form of 1 kg/m² suppressed Meloidogyne Incognita attacks. 5 tons/ha, 10 tons/ha and 20 tons/ha of vermicompost were applied to the plots planted with grapes, bell peppers, tomatoes and strawberries. Only inorganic fertilizer was applied to the control plots, and inorganic fertilizer was added to the vermicompost plots to equalize the N level. After these applications, a significant decrease in nematode growth was observed in 3 of the 4 plots where vermicompost was used compared to the one with inorganic fertilizer. On the other hand, it was observed that there was a continuous increase in nematodes in the plots where inorganic fertilizers were used (Arancon et al., 2007).

A study was carried out to observe the effects of various fertilizers on yield and quality parameters of Azarshahr variety of red onion in Azerbaijan. In this study, burnt barn manure, domestic waste compost and vermicompost were applied at different rates on the red onion cultivar. According to the results obtained, the highest yield was observed from the parcel where 6 tons of vermicompost was applied per 10 decares. The lowest deterioration rate with 12% deterioration rate was observed in the plot where burnt barnyard manure was applied. The lowest ascorbic acid concentration was observed in vermicompost with 13.5 mg per 100 g of fresh onions. The application with the highest protein content was observed in the application of 1.49% to 6 tons of vermicompost per 10 decares. The bitterness felt in onions was detected at the lowest rate in 20 tons of burned barn manure. It has been determined that vermicompost has a significant effect on growth and yield. Considering the effectiveness of inorganic macronutrients applied to all plants, it was observed that plant nutrient uptake became easier in plants with vermicompost applied (Bai and Malakout, 2007).

In a study carried out with 0, 10%, 20% and 30% doses of vermicompost in spinach plant under unheated greenhouse conditions, it was determined that vermicompost could significantly increase the number of leaves and leaf height in the plant (Peyvast et al., 2007).

In a study, in order to determine the effect of vermicompost application on yield and quality of strawberry plant, in addition to chemical fertilization, four different amounts of vermicompost, 2.5, 5, 7.5 and 10 t/ha, were applied.

According to the results obtained, dispersion, fiber content, dry matter content and total fruit amount increased in strawberry plant applied vermicompost (Singh et al., 2008). In another experiment, three different vermicompost tea and chemical fertilizers were used in Chinese Cabbage and its growth, nutrient content, mineral and antioxidant activity were analyzed. According to the results of the research, it was determined that there was an increase in the amount of mineral nutrients and phenolic substances (Pant et al., 2009).

According to the results of a study conducted with vermicompost and farm manure application in garlic, it was determined that 15 t/ha vermicompost and 50% NPK application had a greater effect on root, leaf and shoot length and fruit weight parameters than other applications (Suthar, 2009). In a trial investigating the effect of vermicompost on marigolds, it was determined that the largest flower diameter was formed at 40% vermicompost dose (Pritam et al., 2010). In another study, they determined that vermicompost increased the growth and development of chickpea and pea plants and increased the number of nitrogen-fixing bacteria (Sinha et al., 2009).

In order to see the effect of plant hormones on germination by a researcher, a laboratory study was carried out with liquid vermicompost containing Cyamophis tertagonoloba, and Trigonella foenum-graecum species. As a result of the experiment using 100% liquid vermicompost, 50% liquid vermicompost, 5% urea solution and distilled water, while the highest germination rate was observed in 50% liquid vermicompost application, when the growth parameters were examined, the best results were obtained from the 100% liquid vermicompost application group (Suthar, 2010).

In a trial, the effect of vermicompost and barn manure application on the growth and soil fertility of spinach (Spinicia oleracea var L.) plant was investigated. In this experiment, which was carried out during the winter months, the effects of various levels of vermicompost, barnyard manure and control applications without any fertilizer on the development and soil content of the spinach plant were investigated. As a result, barnyard manure gave better results on plant growth, yield, mineral content and soil fertility parameters. In addition, it was observed that there were significant increases in vermicompost applications compared to control plots, and that vermicompost application had a positive effect on the iron (Fe) content and calcium (Ca) content of the plant (Çıtak et al., 2011).

In a study carried out to determine the effect of vermicompost on growth and metabolic content of Chinese Cabbage (Brassica campestris ssp. chinensis), an increase was observed in nutrient content, water-soluble dry matter, vitamin C and total phenol (Wang et al., 2006).

(Çıtak et al., 2011) investigated the development of spinach, yield, mineral content and soil fertility criteria in a study conducted under open field conditions in winter to examine the effects of vermicompost and control application at different doses on the development and soil fertility of spinach. According to the results obtained, it was determined that the application of 3 tons of vermicompost per decare was significantly effective. In another study investigating the contribution of vermicompost to yield plant and soil nutrients in wheat, it was determined that the mixtures using vermicompost had a positive effect compared to the control group (Kızılkaya et al., 2012). In an experiment, the growth parameters of vermicompost on two different commercial lettuce varieties Brisa and Daguan were investigated. With the application of vermicompost, nitrate concentration increased significantly in Brisa cultivar, and significant differences were observed between the two cultivars in terms of leaf number and area, fresh and dry weight, and reducing sugar content (Leon et al., 2012).

In order to determine the effect of vermicompost on cauliflower in field conditions, 9 different doses of vermicompost were used in addition to chemical fertilization (6 kg/da N, 3 kg/da P_2O_5, 6 kg/da K_2O). As a result, it has been reported that 200 to 400 kg/da doses of vermicompost are appropriate in addition to chemical fertilization in cauliflower cultivation (Tavalı et al., 2013).

It has been observed that it increases the nutrient uptake in the plants applied with vermicompost (Yourtchi et al., 2013) investigated the effects of applying different amounts of vermicompost to potato plant on NPK uptake. It was determined that as the application amount of vermicompost increased, NPK intake also increased, accelerating plant growth and increasing yield. According to the results of the study, 15 kg/ha nitrogen and 12 tons/ha vermicompost application was recommended in order to obtain high yield and avoid environmental pollution.

In a trial study, the effects of 4 different doses of vermicompost, 0%, 10%, 20%, 40%, on the morphological properties and soil chemical properties of tomato (Solanum lycopersicum L.) were investigated. The highest yield level was reached at 20% and 30% vermicompost doses. Fresh and dry weight, plant height, yield were obtained from the application of maximum 20% vermicompost. The amount of P and K in the soil increased with the increase of the pH dose of vermicompost (Abafita et al., 2014).

A study was conducted to determine the effects of vermicompost and chicken manure on yield and quality as well as the chemical properties of the soil in summer squash. This trial was set up in open field conditions and different levels of both fertilizers were tested. According to the results, it was observed that the application of vermicompost at 400 kg/da had a more curative effect in terms of yield and quality of the zucchini plant and the chemical properties of the soil compared to other applications (Tavalı et al., 2014).

In a study carried out, the effects of mycorrhiza and vermicompost on the growth and mineral nutrition of pepper plants were investigated separately and together. In the trial, doses of 0, 1 and 2 g/pot for mycorrhiza and 0, 2.5, 5 and 10 g/pot for vermicompost were tried. While determining the fresh and dry weights of the pepper plant, the nutrient ratios it contains were examined. When the results were evaluated, it was determined that the application of mycorrhiza and vermicompost had a positive effect on the fresh weight, dry weight and nutrient content of the pepper plant. It has been reported that the highest improvement and the highest nutritional element contents are obtained at the highest doses (Küçükyumuk et al., 2014).

In an experiment conducted by a group of researchers using five different doses of vermicompost and NPK inorganic fertilizer on white head cabbage, it was observed that the yield and quality of cabbage increased as the vermicompost dose was increased (Tavalı et al., 2014). 12 different applications were made in the trials established by the Bangladesh Agricultural Research Institute between October 2008 and March 2009 on the 'snow white' variety of cauliflower. In these applications, in addition to a control plot where no fertilizer application was made, chemical fertilizers at different rates were used for 3 plots, worm manure was used at different rates for 3 plots, and more than one fertilizer combination at different rates was used for other plots. According to the findings obtained from the research, the best results in terms of product quality and productivity were obtained from the plots where vermicompost was used together with chemical fertilizers. It has been observed that vermicompost enables plants to take the nutrients carried by chemical fertilizers more easily (Jahan et al., 2014).

The effects of the use of vermicompost and inoculated seed (biostimulant) on the biomass and growth of the plants were investigated by Ran Agriculture Company in 2012 in the cultivation of the coriander plant. In the established experiment, 4 different levels of vermicompost were applied to the grafted and ungrafted seeds. As a result of the experiments, the highest biomass yield and fresh and dry plant weight were obtained from the plots where 9 tons/ha of vermicompost was applied (Shirkhodaei et al., 2014).

In a study conducted in Diyarbakır between 2010 and 2011, the effect and economic evaluation of 16 different nutrient sources on the yield of organic sweet corn plants. Efficiency, quality and net profitability criteria were evaluated in trials with different fertilizers and fertilizer combinations under the same conditions. According to the results obtained considering the quality and yield criteria, it was concluded that horse manure, horse manure + humic acid and cattle manure + humic acid applications are the most economically profitable fertilizers in organic corn cultivation. In the aforementioned study, damage was determined in peat, peat + humic acid applications, while vermicompost remained at the lowest profitability level (Cihangir and Öktem, 2015).

It has been observed that it has a positive effect on seedling quality and field performance in vegetables such as tomato (Lycopersicon esculentum Mill.), eggplant (Solanum melongena L.), pepper (Capsicum annuum L.). As a result of the research, an increase was observed in pepper and eggplant quality, while a decrease was observed in tomato quality (Ahirwar and Hussain, 2015).

In an experiment conducted with curly lettuce under unheated glass greenhouse conditions, different doses of liquid vermicompost and agrimol cover were used. As a result of the experiment, values such as head length and diameter, total acidity, pH were examined and it was observed that increasing doses of agrimol cover and vermicompost had a significant effect (Sağlam et al., 2015). In an experiment, the effects of different levels of vermicompost such as 0, 250, 500, 750, 1000 kg/da on yield and some soil properties in lettuce were investigated. As a result of this research, it was concluded that vermicompost applied at different doses was effective on the number of leaves (Özkan and Müftüoğlu, 2015). In an experiment investigating the effects of organic and inorganic fertilizers on yield and quality criteria in head cabbage (Brassica oleracea L. capitata), it was observed that vermicompost provided a significant increase in yield, vitamin C and sugar content compared to the control group (Nurhidayati et al., 2016).

A study was conducted to investigate the effect of vermicompost on the yield and soil of the spinach plant, in which doses of 0, 1, 2, 3, 4, 5 tons were given. As a result of this study, it was concluded that the yield and plant height increased with the dose of vermicompost, and the increase was statistically significant. In addition, it was stated that increasing amounts of vermicompost increased the number of leaves, but it was not statistically significant (Müftüoğlu, 2016). (Maltaş et al., 2017) in open field conditions vermicompost red the effect of the head cabbage plant on yield and quality parameters was investigated. Among the doses applied, 400 kg/da dose was found to be the most appropriate dose in red head cabbage cultivation.

The effect of different doses of vermicompost 0, 250, 500, 750, 1000 kg applied per decare on yield and quality of chard was investigated by a research group. In this study, it was determined that 1000 kg vermicompost application provided the highest plant fresh weight and number of leaves, and 750 kg application provided the widest leaf width (Aksu et al., 2017).

In a trial conducted under field conditions, different doses of chemical fertilizer and vermicompost were applied in the cultivation of red head cabbage (Brassica oleracea var. capitata f. rubra). According to the findings, it was determined that the application of vermicompost in increasing doses positively affected the yield, quality parameters and mineral nutrition values of cabbage, and it provided an increase of approximately 50% in yield and quality compared to the control group. In addition to chemical fertilization, a dose of 400 kg/da vermicompost has been suggested to producers in terms of economy (Maltaş et al., 2017).

In a trial conducted under field conditions, different doses of chemical fertilizer and vermicompost were applied in the cultivation of red head cabbage (Brassica oleracea var. capitata f. rubra). According to the findings, it was determined that the application of vermicompost in increasing doses positively affected the yield, quality parameters and mineral nutrition values of cabbage, and it provided an increase of approximately 50% in yield and quality compared to the control group. In addition to chemical fertilization, a dose of 400 kg/da vermicompost has been suggested to producers in terms of economy (Maltaş et al., 2017).

Five different doses of vermicompost (0, 250, 500, 750 and 1000 kg/da) were applied to chard (Beta vulgaris L. var. cicla) plant grown under greenhouse conditions by a group of researchers. According to the data obtained, it was observed that vermicompost positively affected plant growth parameters and it was stated that it could be an alternative to chemical fertilizers in terms of sustainability (Köksal et al., 2017).

In a trial study, a pea plant (Pisum sativum cv. Bonneville) was treated with vermicompost-HARV with 85% high humic acid content, a recommended dose of chemical fertilizer (NPK), and a vermicompost containing approximately 40% humic acid. Soil microbial structure was investigated by using DGGE (Denature Gradient Gel Electrophoresis) and PCR in soil samples taken at 0, 12, 30 and 60 days. As a result of the findings, it was seen that the bacterial and fungal diversity and rate of the vermicompost group containing high humic acid was the highest, and the microbial presence was lower in the samples with chemical fertilizer application compared to the control group. In addition, it was determined that organic fertilization increased the number of nodules and AMF amounts in the roots, and vermicompost with high humic acid content improved plant growth and soil structure (Maji et al., 2017).

In an experiment, organic cocktail tomato variety grown under greenhouse conditions was tested in negative and positive control groups. In this experiment, green parts and fruit yield characteristics were investigated. In the study, molasses-based liquid organic fertilizer (N 7%, P 7%, K 7%), synthetic fertilizer (N 10%, P 8%, K 5%), liquid vermicompost (N 1%, organic matter 5%, humic fertilizer) and fulvic acid (10%) were applied. Liquid organic fertilizer was applied twice during the seedling planting and flowering stages with mycorrhiza. As a result of the findings, no significant statistical difference was observed in fertilizer applications, but the highest tomato yield was with liquid organic fertilizer and vermicompost given with mycorrhiza obtained (Ulusu and Yavuzaslanoğlu, 2017).

In another study on cucumber, the effect of increasing doses of vermicompost such as 0%, 3%, 5%, and 7% on heavy metal concentration in cucumber was investigated. According to the results obtained, it was determined that increasing vermicompost doses caused a decrease in heavy metal concentration (Adiloğlu et al., 2018)

Kumar and Gupta, (2018) conducted a study on the effect of vermicompost and chemical fertilizer on the yield and quality of radish plants. The highest plant height, dry matter, tuber weight, root length were obtained from vermicompost application. It was determined that the yield increased more in vermicompost application compared to the control group. Vermicompost increases the organic matter content of the soil, allows the soil to breathe, increases the water holding capacity and facilitates the uptake of plant nutrients, as well as positively affects the yield in such factors. At the same time, since root development is one of the factors affecting yield, vermicompost increases soil porosity, spreads more easily on the roots, and root development is more, which leads to an increase in yield (Jackson, 1967).

In a study conducted by 2 scientists in Australia, vermicompost obtained from grape waste was used as fertilizer at the bottom of the same vine plants, and a 20-50% yield increase was achieved in the first harvest of the plants using vermicompost (Yağmur and Eşiyok, 2019). In the comparison of vermicompost and chemical fertilizers, the studies showed that although the effectiveness of the fertilizer disappeared after 1 month in the area where chemical fertilizers were used, the effectiveness of the vermicompost continued (Alam et al., 2007). It fights harmful bacteria in the soil (Demir et al., 2010). Vermicompost significantly improves the physical, chemical and biological properties of the soil as well as plant nutrition (Edwards & Bohlen, 1995). According to the research results of Rivasol, it is recommended to reduce the use of chemical fertilizers by up to 30%, provided that Liquid Vermicompost is used together (Rivasol, 2021).

CONCLUSIONS

Since vermicompost is included in the organic fertilizers group, is produced naturally and does not leave waste in the soil, it attracts the attention of many producers, institutions and organizations interested in sustainable and organic agriculture around the world.
Some features and benefits of worms and vermicompost can be listed as follows.

• Increases plant resistance and accelerates its development, providing early harvest. It provides about 15-20 days of earliness in approximately harvest.

• With its granular structure, it regulates the soil structure, increases the water holding capacity, and provides aeration of the soil.

• It makes the soil more productive by allowing the nitrogen in the air to be easily taken up by the plants and improved by the nitrogen fixing bacteria, thanks to the nitrogen fixing bacteria.
• It improves the soil and increases its productivity by giving mobility to the soil structure.
• As it facilitates the uptake of plant nutrients present in the soil that cannot be taken by plants, it increases the solid matter ratio of the products and ensures that they are of high quality.
• It contains substances such as enzymes, amino acids, growth hormones and vitamins in the fertilizer as a result of mixing with the excrement of the worm secretion and provides profitability by increasing the yield at a high rate.
• It does not contain weed seeds and it is more economical as the use of pesticides and fungicides in the products is reduced.
• It reduces fertilizer costs as it limits the use of chemical fertilizers.
• It reduces plant stress due to pesticide use.
• It increases the germination rate of seeds and prevents plant losses as it ensures healthy growth and becomes more profitable by increasing yield.
• Regulates the pH of the soil.
• It creates resistance against plant diseases and protects plants from frost thanks to the body fluids (coelom liquid) that worms pass into manure.

Due to the above benefits, the use of vermicompost in agricultural production is economically beneficial. According to the results, the use of vermicompost by farmers reduces production costs and increases profitability.

ACKNOWLEDGMENT

We would like to thank the reviewers, editors and all scientists who contributed to the processing of the article.

REFERENCES

Abafita R., Shimbir, T. & Kebede T. 2014. Effects of Different Rates of Vermicompost as Potting Media on Growth and Yield of Tomato (Solanum lycopersicum L.) and Soil Fertility Enhancement. *Sky Journal of Soil Science and Environmental Management*, 3(7), 73-77.

Adiloğlu S., Eryılmaz Açıkgöz F., Solmaz Y. & Çaktü E. 2018. Effect of Vermicompost on the Growth and Yield of Lettuce Plant (Lactuca sativa L. var. crispa). *International Journal of Plant & Soil Science*,, 21(1), 1-5.

Ahirwar C. S. & Hussain A. 2015. Effect of Vermicompost on Growth, Yield and Quality of Vegetable Crops . *International Journal of Applied and Pure Science and Agriculture*, 1(8), 49-56.

Aksu G., Köksal S. B. & Altay H. 2017. Vermikompostun Bazı Toprak Özellikleri ve Pazı Bitkisinde Verim Üzerine Etkisi. *ÇOMÜ Ziraat Fakültesi Dergisi*, 5 (2), 123-128.

Alam M. N., Jahan M. S., Ali M. K. & Ashraf M. K. 2007. Effect of Vermicompost and Chemical Fertilizers on Growth, Yield and Yield Compenents of Potato in Barind Soils of Bangladesh, *Journal of Applied Sciences Research*,, 3(12), 1879-1888.

Arancon N. Q., Edwards C. A. & Lee S. S. 2007. Management of Plant Parasitic Nematode Populations by Use of Vermicomposts. *1735 Neil Avenue, Columbus, USA*, 705-710 ref.11.

Arancon N. Q., Edwards C. A., Bierman P., Wlch C. & Metzger J. D. 2004. Influences of Vermicomposts on Field Strawberries. 1. Effects on Growth and Yields. *Bioresource Technology*, (93), 145 - 153.

Azarmi R., Giglou M. T. & Taleshmikail R. D. 2008. Influence of vermicompost on soil chemical and physical properties in tomato (Lycopersicum esculentum) field. *African Journal of Biotechnology*, 7(14).

Bai B. A. & Malakout M. J. 2007. The effect of different organic manures on some yield and yield quality parameters in onion. *Iran Soil and Water Sciences Journal*, 1(21), 33- 43.

Baker G. H. 1994. Earthworm, new discoveries, Rural Research. *A CSIRO Quarterly*, 163. 19–23.

Buckerfield J. & Webster K. A. 1998. Worm Worked Waste Boosts Grape Yields Prospects for Vermicompostuse in Vineyards. *Australia and New Zealand Wine Industry Journal*, 13, 73-76.

Cihangir H. & Öktem A. 2015. Diyarbakır Koşullarında Farklı Organik Bitki Besleme Uygulamalarının Tatlı Mısır Bitkisinin (Zea mays L. saccharata Sturt) Taze Koçan Verimi Üzerine Etkisi. *UÜ. Ziraat Fakültesi Dergisi*, 29(2), 69-81.

Çıtak S., Sönmez S., Koçak F. & Yasin S. 2011. Vermikompost ve Ahır Gübresi Uygulamalarının Ispanak Bitkisinin Gelişimi ve Toprak Verimliliği Üzerine Etkileri. *Derim*, 28(1), 56-69 ref:31.

Demir H., Polat E. & Sönmez İ. 2010. Ülkemiz İçin Yeni Bir Organik Gübre: Solucan Gübresi. *Tarım Aktüel*, (14), 54 - 60.

Deveci M. & Şalk A. 1995. Tekirdağ Şartlarında Ispanak Yetiştiriciliğinde Farklı Ekim Zamanı ve Bitki Sıklığının Gelişme ve Verim Üzerine Etkisi. *Tekirdağ Ziraat Fak. Dergisi*, 4(1-2), 1-11.

Edwards C. A. & Arancon N. Q. 2004. *The use of earthworms in the breakdown oforganic wastes to produce vermicomposts and animal feed protein. In Earthworm Ecology*. London, New York, Washington: 2nd Edition, Editor C.A. Edwards. C.R.C. Press, Boca Raton, Fl.,.

Edwards C. A. & Bohlen P. J. 1995. *Biology and Ecology of Earthworms.* (3 b.). New York,: Springer Hollanda. doi:978-0-412-56160-3

Edwards C. A. 1995. Commercial and environmental potential of vermicomposting: A historical overview. *BioCycle, June*, 62-63.

Entry J. A., Wood B. H., Edwards J. H. & Wood C. W. 1997. Influence of organic byproducts and nitrogen source on chemical and microbiological status of an agricultural soil. *Biology Fertilizer Soil*, 24, 196-204.

Ferreira L. D. & Merchant K. A. 1992. Field Research in Management Accounting and Control: A Review and Evaluation. *Accounting, Auditing & Accountability Journal*, Volume 5, Number 4, 0:0.

Fosgate O. T. & Babb M. R. 1972. Biodegradation of Animal Wastes by Lumbricus Terrestris. *J. Dairy Sci*, 55, 870-872.

Gutiérrez-Miceli F.A. Santiago-Bórraz J., Montes Molina J. A., Nafate C. C., Abdudarchila, M., Oliva LIven M.A. & Deendoven, L. 2007. Vermicompost as a Soil Supplement to Improve Growth, Yield and Fruit Quality of Tomato *(Lycopersicum esculentum). Bioresource Technology*, 98, 2781-2786. .

Jackson M. L. 1967. *Soil Chemical Analysis.* Yeni Delhi: Prentice Hall of India Pvt. Ltd. 8 .30, 2021 tarihinde https://books.google.com.tr/books?hl=tr&lr=&id= false adresinden alındı

Jahan F. N., Shahjalal A. M., Paul A. K. & Mehraj H. 2014. Efficacy of vermicompost and conventional compost on growth and yield of cauliflower. *Bangladesh Research Publications Journal*, 10(1), 33-38.

Kale R. D., Bano K., Vinayak K. & Bagyaraj D. J. 2013. Suitability Of Neem Cake As An Additive In Earthworm Feed And Its Influence On The Establishment Of Microflora. *Journal of Soil Biology & Ecology*, 6 (2), 98-103.

Kızılkaya R., Turkay F. H., Turkmen C. & Durmuş, K. 2012. Vermicompost Effects on Wheat Yield and Nutrient Contents in Soil Plant. *Archieves of Agronomy and Soil Science*, 58, 175-179.

Köksal S. B., Aksu G. & Altay H. 2017. Vermikompostun Bazı Toprak Özellikleri ve Pazı Bitkisinde Verim Üzerine Etkisi. *ÇOMÜ Zir. Fak. Derg. (COMU J. Agric. Fac.)*, 5 (2), 123–128.

Kumar A. A. & Gupta R. K. 2018. The Effects of Vermicompost on Growth and Yield Parametres of Vegetable Crop Radish (Raphanus sativus). *Journal of Pharmacognosy and Phytochemistry,*, 7(2), 589-592.

Küçükyumuk Z., Gültekin M. & Erdal G. 2014. Vermikompost ve Mikorizanın Biber Bitkisinin Gelişimi ile Mineral Beslenmesi Üzerine Etkisi. *Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi,*, 9 (1), 51-58.

Leon A. P., Martin J. P. & Chiesa A. 2012. Vermicompost Application and Growth Patterns of Lettuce (Lactuca sativa L.). *Agricultura Tropica et Subtropica*, 45(3), 134-139.

Maji D., Misra P., Singh S. & Kalra A. 2017. Humic Acid Rich Vermicompost Promotes Plant Growth by Improving Microbial Community Structure of Soil as Well as Root Nodulation and Mycorrhizal Colonization in the Roots of Pisum sativum. *Applied Soil Ecology* , 110, 97-108.

Maltaş A. Ş., Tavalı İ. E., Uz İ. & Kaplan M. 2017. Kırmızı Baş Lahana (Brassica oleracea var. capitata f. rubra) Yetiştiriciliğinde Vermikompost Uygulaması. *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi.*, 30(2), 155-161.

Mısırlıoğlu M. 2011. Toprak Solucanları Biyolojileri, Ekolojileri ve Türkiye Türleri,. Ankara: Nobel Akademik Yayıncılık.

Müftüoğlu N. M. 2016. Vermikompostun Ispanak Verimi ve Bazı Toprak Özellikleri Üzerine Etkisi. *ÇOMÜ Ziraat Fakültesi Dergisi (COMU J. Agric.Fac.)*, 4(1), 1-5.

Nagavallemma K. P., Wanı S. P., Lacroıx S., Padja V. V., Vıneela C., Rao B. & Sahrawat, K. L. 2006. Vermicomposting: Recycling Wastes into Valuable Organic Fertilizer. *Global Theme on Agroecosystems Report no. 8*, 2(1), 1-16.

Nurhidayati N., Ali U. & Murwani I. 2016. Yield and Quality of Cabbage (Brassica oleracea L. var. capitata) under Organic Growing Media Using Vermicompostand Earthworm Pontoscolex corethrurus Inoculation. *Agriculture and Agricultural Science Procedia*, 11, 5-13.

Özkan N. & Müftüoğlu N. M. 2015. Farklı Dozlardaki Vermikompostun Marul Verimi Ve Bazı Toprak Özellikleri Üzerine Etkisi. *Atatürk Bahçe Kültürleri Araştırma Enstitüsü Dergisi., 45* (Özel sayı), Cilt:2, 121-124. 2021 tarihinde alındı

Pant P. A., Theodore J. R., Hue N. V., Talcott S. T. & Krene K. 2009. Vermicompost Extracts Influence Growth, Mineral Nutrients, Phytonutrients and Antioxidant Activity in Pak Choi (Brassica rapa cv. Bonsai, Chiensis group) Grown Under Vermicompost and Chemical Fertiliser. *Journal of The Science of Food and Agriculture*, 89, 2383-2392.

Pascual J. A., Ayuso M., Hernández T. & García C. 1997. Phytotoxicity and fertilizer value of different organic materials. *Agrochemical*, 41, 50-62.

Peyvast G. H., Olfati J. A., Madeni S. & Forghani A. 2007. Effect of Vermicompost on the Growth and Yield of Spinach (Spinacia oleracea L.). *J. of Food, Agric. & Environ*, 6(1), 132-135.

Pritam. S., Garg V. K. & Kaushik C. P. 2010. Growth and Yield Response of Marigold to Potting Media Containing Vermicompost Produced from Different Wastes. *Environmentalist*, 30, 123-130.

Rivasol 2021. *Solucan Gübresinin Bilinmesi Gereken Faydaları.* rivasol.com.tr: https://www.rivasol.com.tr/solucan-gubresinin-bilinmesi-gereken-faydalari adresinden alındı

Roberts P., Ljones D. & Edward-Jones G. 2007. Yield and Vitamin C Content of Tomatoes Grown in Vermicomposted Wastes. *Journal Science Food Agriculture*, 87, 1957-1963.

Sağlam N., Doksöz S., Geboloğlu N., Şahin S. & Yılmaz E. 2015. Agrimol Örtü ve Sıvı Solucan Gübresinin Farklı Uygulama Sayısı ve Dozlarının Kıvırcık Yapraklı Salatada Verim, Kalite ve Bitki Gelişimine Etkileri. *Tarım Bilimleri Araştırma Dergisi*, 8(1), 59-61.

Shirkhodaei M., Darzi M. T. & Hadi M. H. 2014. Influence of Vermicompost and Biostimulant on The growth and Biomass of Coriander (Coriandrum sativum L.). *International Journal of Advanced Biological and Biomedical Research*, 2(3), 706 - 714.

Singh R., Sharma R. R., Kumar S., Gupta R. K. & Patil R. T. 2008. Vermicompost Substitution Influences Growth, Physiological Disorders, Fruit Yield and Quality of Strawberry (Fragaria x ananassa Duch). *Bioresource Technology*, 99, 8507-8511.

Sinha R. K., Herat S., Dalsukh V. & Kurunal C. 2009. The Concept of Sustainable Agriculture: An Issue of Food Safety and Security for People, Economic Prosperity for the Farmers and Ecological Security for the Nations. *American-Eurasian J. Agric & Environ. Sci*, 5 (S), 01-5.

Sönmez İ., Sönmez S. & Kaplan M. 2002. Çöp kompostunun bitki besim maddesi içerikleri ve bazı organik gübrelerle karşılaştırılması. *Selçuk Üniversitesi Ziraat Fakültesi Dergisi*, 16(29), 31-38.

Suthar S. 2009. Impact of Vermicompost and Composted Farmyard Manure on Growth and Yield of Garlic (Allium sativum L.) Field Crop. *International Journal of Plant Production*, 3(1), 27-38.

Suthar S. 2010. Evidence of Plant Hormone Like Substances in Vermiwash: An Ecologically Safe Option of Synthetic Chemicals for Sustainable Farming. *Ecological Engineering*, 36, 1089-1092.

Şalk A. 1992. Özel Sebzecilik 1. Ders Notları Tekirdağ Üniversitesi Ziraat Fakültesi. *Özel Sebzecilik 1. Ders Notları (Basılmamış) Tekirdağ*.

Tavalı İ. E., Maltaş A. Ş., Uz İ. & Kaplan M. 2013. Karnabaharın (Brassica oleracea var. botrytis) Verim, Kalite ve Mineral Beslenme Durumu Üzerine Vermikompostun Etkisi. *Akdeniz Üniv. Ziraat Fakültesi Dergisi*, 26(2), 115-120.

Tavalı İ. E., Maltaş A. Ş., Uz İ. & Kaplan M. 2014. Vermikompostun Beyaz Baş Lahananın (Brassica oleracea var. Alba) Verim, Kalite ve Mineral Beslenme Durumu Üzerine Etkisi. *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, 27*(1), 61-67.

Tomati U. & Gali E. 1995. Earthworms, soil fertility and plant productivity. *Acta Zoologica Fennica*, 196, 11-14.

Ulusu F. & Yavuzaslanoğlu E. 2017. Örtü Altı Organik Domates Yetiştiriciliğinde Farklı Gübre Uygulamalarının Bitki Yeşil Aksamı ve Meyve Verimine Etkisi. *Türk Tarım-Gıda Bilim ve Teknoloji Dergisi*, 5(13), 1757-1761.

Venkatesh P. B., Patil C. V. & Giraddi R. S. 1998. Effect of In situ Vermiculture and Vermicompost on Availability and Plant Concentration of Major Nutrients in Grapes. *Karnataka Journal Agricultural Science* , 11(1), 117 - 121.

Wang C., Sun Z. J. & Zheng D. 2006. Research advance in antibacterial immunity ecology of earthworm. *The Journal of Applied Ecology*, 17(3), 525.

Yağmur B. & Eşiyok D. 2019. *solucan-gubresi-vermikompost-iiivermikompostun-kullanim-alanlari*. 8 30, 2021 tarihinde www.dunyagida.com.tr: http://www.dunyagida.com.tr/haber/solucan-gubresi-vermikompost-iiivermikompostun-kullanim-alanlari/4341

Yourtchi M. S., Hadi M. & Darzi M. T. 2013. Effect of Nitrogen Fertilizer and Vermicompost on Vegetative Growth, Yield and NPK Uptake by Tuber of Potato. *International Journal of Agriculture and Crop Sciences*, 5(18), 2033-2040.

Zimny L., Malak D. & Sniady R. 2001. Yielding of Sugar Beet Cultivated After Manure and Vermicompost in the Background of Increasing Doses of Nitrogen Fertilization. *Archives of Agronomy and Soil Science*, (47), 473-480.

Change Trend of Electrical Conductivity (EC) Values of Water Resources in Trout Farms Operating in Niğde Province, Turkey

İlknur UÇAK[1*] M. Cüneyt BAĞDATLI[2]

[1]Nigde Ömer Halisdemir University, Faculty of Agricultural Sciences and Technologies, Nigde, Turkey
[2]Nevsehir Hacı Bektas Veli University, Engineering and Architecture Faculty,
Department of Biosystem Engineering, Nevsehir, Turkey

[*]Corresponding author: ilknurucak@ohu.edu.tr

ORCID: 0000-0002-9701-0824[1] , 0000-0003-0276-4437[2]

Abstract

In this research, the Electrical Conductivity (EC) values of the water resources in the trout farms in the Niğde Region (Turkey), which is located in the Central Anatolia Region, were periodically examined. Within the scope of the study, water samples were taken from four randomly selected trout farms in different periods (spring, summer, autumn and winter). Water samples were collected from the pond enterance and the pond exit. EC measurements were carried out in three replications using an EC meter in the laboratory conditions. The EC values of the water samples were interpreted within the scope of the "Water Pollution Control Regulation" standards published by the Ministry of Environment and Forestry in 2004. As a result of the study, the average EC values of the water saamples for four different trout farms (No1, No2, No3 and No4) were determined as 480, 320, 689 and 540 µS/cm, respectively. Considering the data obtained in the study, it can be concluded that the EC values in the region examined according to the Water Pollution Control Regulation do not pose any problem in terms of fish farming.

Keywords: Electrical Conductivity (EC), Trout Farms, Water Resources, Water Quality, Niğde Province, Turkey

Research article
Received Date: 19 October 2021
Accepted Date: 25 November 2021

INTRODUCTION

Water pollution is the pollution of clean water in nature directly by human hands or by organizations that produce for human life. Even though the fact that ¾ of the earth is covered with water gives the appearance of abundance of water in the world, the rate of drinkable water is only around 0.74%.

The world population, which was 1 billion at the beginning of the Industrial Revolution in the last quarter of the 18th century, reached 2.5 billion in 1950 and approximately 7 billion at the end of 2010. Reasons such as the rapid increase in the world population, the excessive development of industry and technology, and the inability to sufficiently establish or spread environmental awareness cause the amount of potable water in the world to decrease gradually. Studies show that water use worldwide has doubled in the last 40 years. In addition, the irresponsible pollution of potable water resources paves the way for problems that cannot be recycled. Estimates show that increasing water demand and decreasing clean water supply curves will intersect in 2030. This naturally means that there will be a universal crisis (Akın and Akın, 2007; Sağlam and Bellitürk, 2003).

The aquaculture sector has been a growing area in the world and in Turkey. In particular, the decrease in natural stocks due to global warming and environmental pollution has increased interest in aquaculture and has an increasing trend against products obtained from natural hunting (Anonymous, 1993; Çelikkale et al., 1994). World aquaculture production is 170 million tons in total, 80 million tons of which is obtained through aquaculture (Anonymous, 2018). The aquaculture sector is a growing and developing sector all over the world. According to the statistics of the Food and Agriculture Organization (FAO), Turkey is the third fastest growing country in aquaculture in the world (Coşkun et al., 2011). In Turkey, aquaculture, which started especially in the 1970s, is around 630 thousand tons in total, including 354 thousand tons of hunting and 276 thousand tons of aquaculture (Anonymous, 2018). With a production of approximately 110 thousand tons, trout ranks first among the species that are farmed in Turkey. The reason for this is the ease of production of trout farming compared to other fish, the better marketing network, the availability of fresh water resources with suitable characteristics for aquaculture in Turkey, the number of facilities and the amount of production (Emre and Kürüm, 1998).

There is a wide historical background for the natural life and cultural conditions of the trout. Trout are affected by various environmental factors (temperature, salinity (EC), pH, dissolved oxygen and ammonia), especially growth and reproduction activities, both in the natural environment and in the culture environment, and these have extreme and normal limits, and these environmental factors alone are effective. as well as it can make a folded effect together. These environmental conditions should be well known before aquaculture (Molony, 2001).The electrical conductivity (EC) of a water is the sum of the amounts of salts or soluble substances present in the water. The electrical conductivity of water depends on both geological factors and external influences. The conductivity increases in parallel with the increase in temperature and salinity (Özdemir et al., 2007; Dirican and Musul, 2008).

In this research, some of the trout farms operating in the Niğde region were investigated.This study was carried out to determine the seasonal change trend of Electrical Conductivity (EC) values in water resources. In this study, water samples were taken in four different periods (April, July, October, January) at the entrance and exit of the ponds from four trout farms selected by random sampling method. In the study, the EC values of the water samples collected from the trout farms were evaluated periodically and their suitability for trout farming was examined.

MATERIALS and METHODS

In this research, EC values of water resources of randomly selected trout farms in Niğde province were examined during four seasons (spring, summer, autumn and winter). Water samples were collected from the water sources in the pond enterance and from the pond exit. All samples were collected and transported to the laboratory. EC values were determined in laboratory conditions with digital display EC meters. The application regarding the EC measurements made in the laboratory environment is given in Picture 1.

Picture 1. EC measurements of water samples

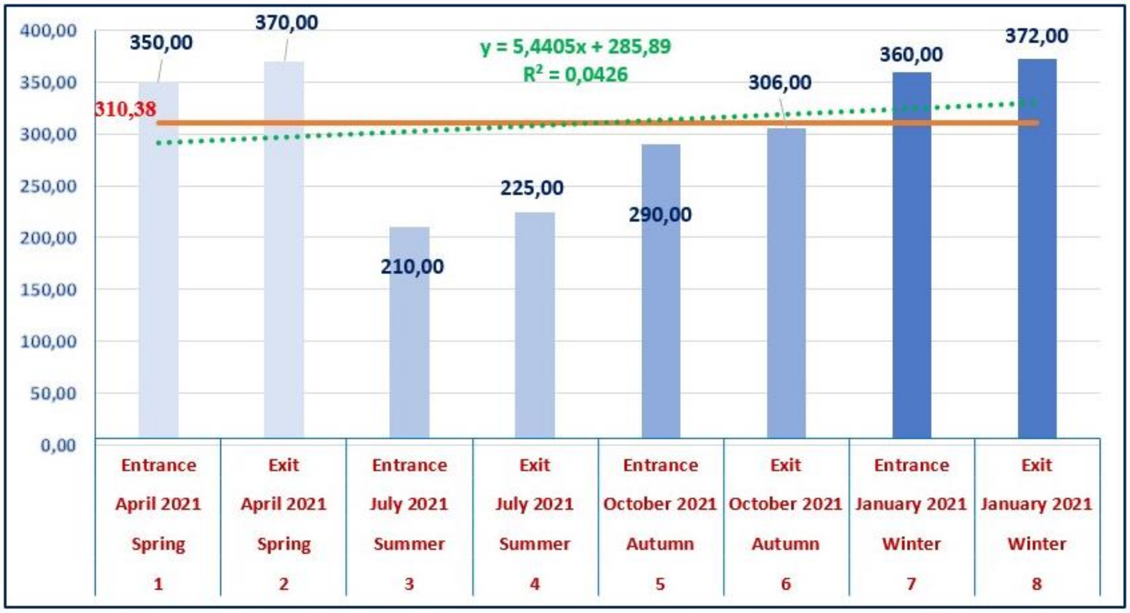
The EC values were evaluated according to the Water Pollution Control Regulation (Anonymous, 2004). Water samples were taken from the pool inlet and outlet waters from the designated areas for 4 periods. The periods during which water samples were taken are presented in Table 1.

Table 1. Dates and locations of water samples

Seasons	Dates	Locations
Spring	April 2021	Entrance of Pond
	April 2021	Exit of Pond
Summer	July 2021	Entrance of Pond
	July 2021	Exit of Pond
Autumn	October 2021	Entrance of Pond
	October 2021	Exit of Pond
Winter	January 2021	Entrance of Pond
	January 2021	Exit of Pond

RESEARCH FINDINGS

The EC changes of the pond entrance and pond exit in the No1 trout farm were periodically evaluated. As a result of the analysis, the periodic trend of the EC changes in the No1 trout farm is given in Figure 1.

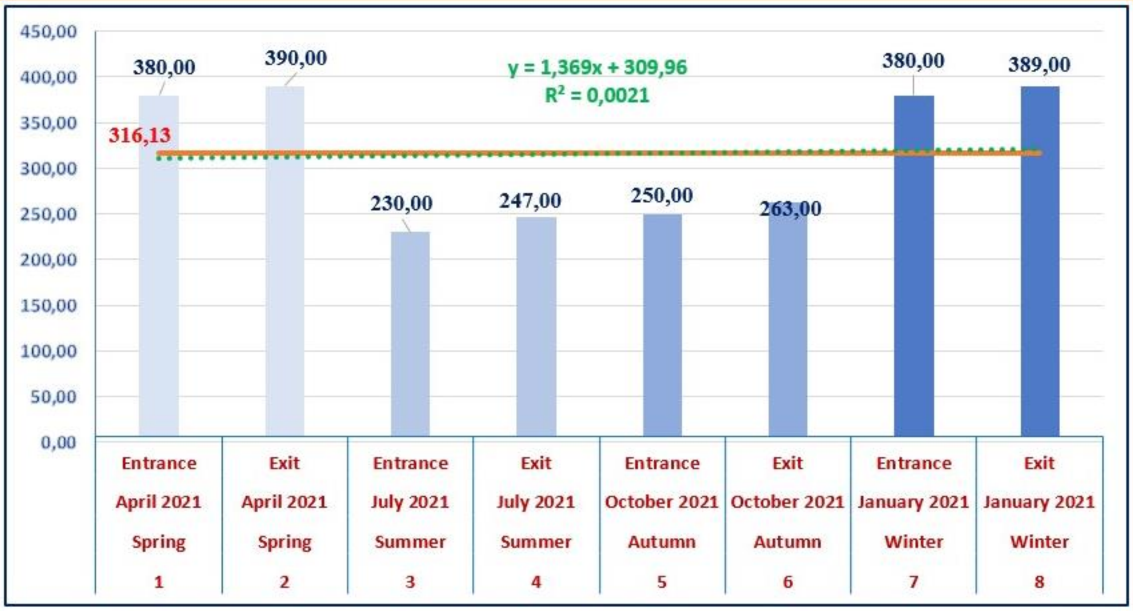


	Water Sample Periods	Dates	Sample Locations	EC (µS/cm)	Average
1	Spring	April 2021	Entrance	350,00	310,38
2	Spring	April 2021	Exit	370,00	310,38
3	Summer	July 2021	Entrance	210,00	310,38
4	Summer	July 2021	Exit	225,00	310,38
5	Autumn	October 2021	Entrance	290,00	310,38
6	Autumn	October 2021	Exit	306,00	310,38
7	Winter	January 2021	Entrance	360,00	310,38
8	Winter	January 2021	Exit	372,00	310,38
1st Trout Farm			Average	310,38	
			Maximum	372,00	
			Minimum	210,00	
			Standard deviation	64,57	

Figure 1. Periodic trend of EC changes in "No.1" trout farm

While the EC value measured from the water source at the entrance of the pond in April in the trout farm No. 1 was 350.0 µS/cm, the EC value at the pond outlet was determined as 370.0 µS/cm. In July, the EC value at the pond entrance was 210.0 µS/cm, while the EC value at the pond exit was measured as 225.0 µS/cm in the same month. In October, the EC of the pond entrance was 290.0 µS/cm, while it was determined as 306.0 µS/cm at the pond exit.

The EC value in January was determined as 360.0 µS/cm at the pond entrance and 372.0 µS/cm at the pond exit. The average EC value determined in the water samples collected during all periods in the No1 trout farm was determined as 310.38 µS/cm. The seasonal EC distribution of the water used in the No2 trout farm is presented graphically in Figure 2.

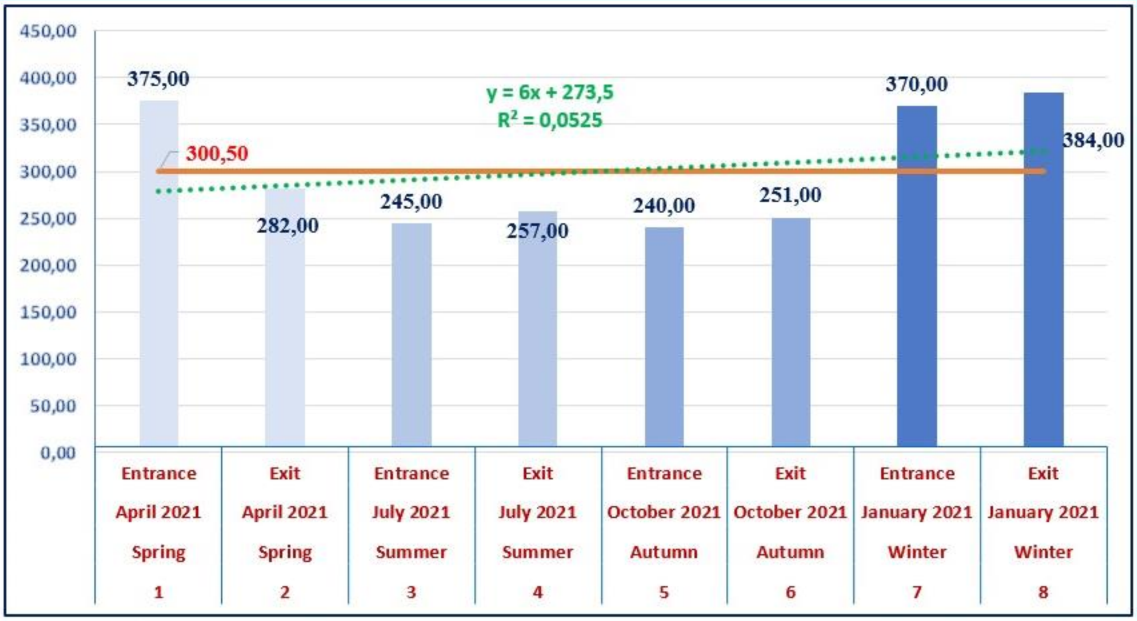


	Water Sample Periods	Dates	Sample Locations	EC (µS/cm)	Average
1	Spring	April 2021	Entrance	380,00	316,13
2	Spring	April 2021	Exit	390,00	316,13
5	Summer	July 2021	Entrance	230,00	316,13
6	Summer	July 2021	Exit	247,00	316,13
7	Autumn	October 2021	Entrance	250,00	316,13
8	Autumn	October 2021	Exit	263,00	316,13
3	Winter	January 2021	Entrance	380,00	316,13
4	Winter	January 2021	Exit	389,00	316,13
2nd Trout Farm			Average	316,13	
			Maximum	390,00	
			Minimum	230,00	
			Standard deviation	73,99	

Figure 2. Periodic trend of EC changes in "No.2" trout farm

Considering the periodic distribution of the EC value of the water in the No. 2 trout farm; the EC value at the pond entrance was 380.0 µS/cm in April, while the EC value at the pond exit was 390.0 µS/cm. In July, the EC value was determined as 230 µS/cm at the pond entrance and 247.0 µS/cm at the pond exit. In October, the EC value at the pond entrance was measured as 250.0 µS/cm and the EC value at the pond exit was measured as 263.0 µS/cm. In January, while the EC value at the pond entrance was 380.0 µS/cm, the EC value at the pond exit increased by 0.09 to 389.0 µS/cm. The mean EC value was determined as 316.13 µS/cm.

During the whole periods, the highest EC value was 390.0 µS/cm and the lowest EC value varied in the range of 230.0 µS/cm in the No. 2 trout farm. The standard deviation of all values was calculated as 73.99. The periodic distribution graph of the EC change in the trout farm No. 3 is presented in Figure 3.

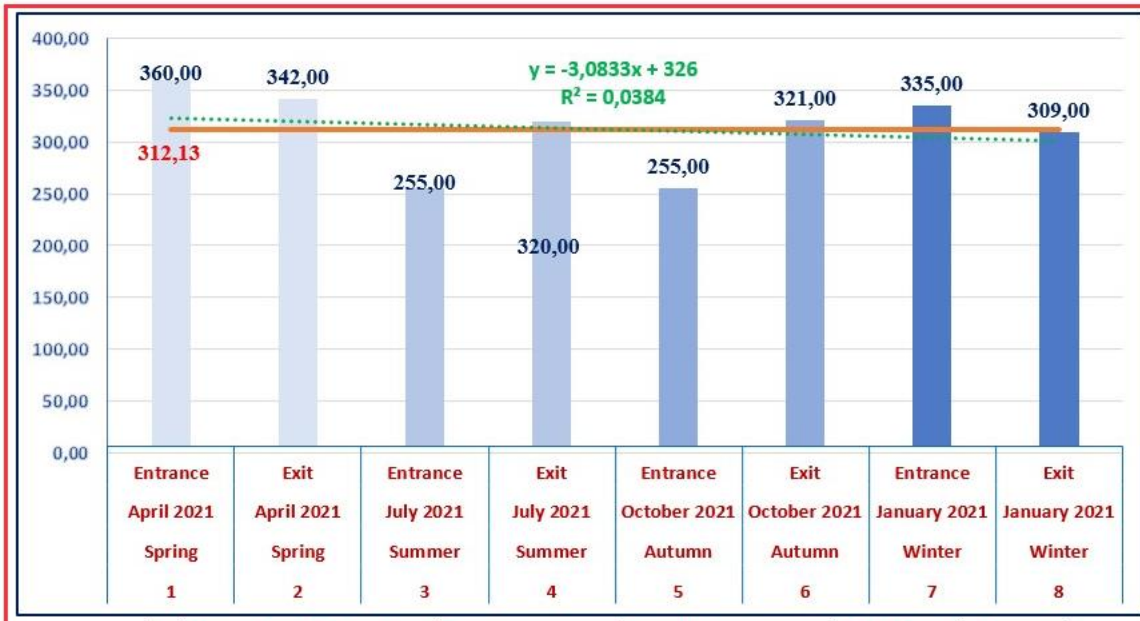


	Water Sample Periods	Dates	Sample Locations	EC (µS/cm)	Average
1	Spring	April 2021	Entrance	375,00	300,50
2	Spring	April 2021	Exit	282,00	300,50
3	Summer	July 2021	Entrance	245,00	300,50
4	Summer	July 2021	Exit	257,00	300,50
5	Autumn	October 2021	Entrance	240,00	300,50
6	Autumn	October 2021	Exit	251,00	300,50
7	Winter	January 2021	Entrance	370,00	300,50
8	Winter	January 2021	Exit	384,00	300,50
3rd Trout Farm			Average	300,50	
			Maximum	384,00	
			Minimum	240,00	
			Standard deviation	64,12	

Figure 3. Periodic trend of EC changes in “No.3” trout farm

Significant changes were detected between the EC values measured in the water samples taken from the pond entrance and pond exits in April, July, October and January in the No 3 trout farm. While the EC value of the water sample taken from the pond entrance was 375.0 µS/cm in April, the EC value measured from the same pond entrance was 245.0 µS/cm with a decrease of 130.0 µS/cm in January.

In general, the average EC values of the water samples taken from the pond entrance and exit during all periods were found to be 300.50 µS/cm. The seasonal distribution trend of EC changes in water samples taken in four different periods in trout farm No. 4 is summarized with the graph given in Figure 4.



	Water Sample Periods	Dates	Sample Locations	EC (µS/cm)	Average
1	Spring	April 2021	Entrance	360,00	312,13
2	Spring	April 2021	Exit	342,00	312,13
3	Summer	July 2021	Entrance	255,00	312,13
4	Summer	July 2021	Exit	320,00	312,13
5	Autumn	October 2021	Entrance	255,00	312,13
6	Autumn	October 2021	Exit	321,00	312,13
7	Winter	January 2021	Entrance	335,00	312,13
8	Winter	January 2021	Exit	309,00	312,13
4th Trout Farm			Average	312,13	
			Maximum	360,00	
			Minimum	255,00	
			Standard deviation	38,52	

Figure 4. Periodic trend of EC changes in "No.4" trout farm

Considering the periodic distribution of the EC change in the surface spring water used in the No 4 trout farm; It can be seen that there is a significant change between periods. EC values in April, July, October and January vary between 255.0-360.0 µS/cm. The average of the EC values measured in the water samples was 312.13 µS/cm.

CONCLUSION and RECOMMENDATIONS

EC values were determined in water samples of four different trout farms selected by random sampling method in Niğde region. Water samples were collected from pond inlets and pond outlets in trout farms. In general, the average EC values in the water samples were 310.38, 316.13, 300.50 and 312.13 µS/cm in trout farms 1, 2, 3 and 4 respectively;

However, when the EC distributions in the water samples of different periods are examined, the EC values in all the enterprises were higher in April and January compared to other months. The EC values in July were measured at a higher level compared to other months.

The electrical conductivity (EC) of water depends on both geological factors and external influences. As pollution increases in water, the electrical conductivity value exceeds 1000 µS/cm (Dirican and Mosul, 2008). Since the EC values of the water samples taken from the trout farms are below 1000 µS/cm, there is no risk in terms of salinity.

Cleanliness of water resources and keeping its chemical content below permissible limits are extremely important factors in trout farming. Sudden adverse changes in water quality will also significantly affect fish production. In particular, it is extremely important to constantly monitor the water source and to take measures against possible negativities. The increasing trend of fish farming in the Central Anatolian Region also increases the interest in this sector. It is among the preferred sectors especially in terms of incentives provided by the state and economic gain.

ACKNOWLEDGMENT

This study was supported by the Scientific Research Projects Unit of Niğde Ömer Halisdemir University with TGT 2019/12-HIDEP project number.

REFERENCES

Anonymous, 2004. Su Kirliliği Kontrolü Yönetmeliği, Çevre ve Orman Bakanlığı, Ankara http://web.deu.edu.tr/atiksu/ana39/skkypdf.pdf (Access Date: 04.08.2021) (in Turkish)

Anonymous 2018. Su Ürünler Verileri, Türkiye İstatistik Kurumu, Ankara (in Turkish)

Anonymous 1993. Türkiye'de Yetiştiriciliğin Çevresel Etkisi ve Bunun Turizm, Rekrasyon ve Özel Koruma Alanları ile İlişkisi , TÜGEM, 1-185, Ankara (in Turkish)

Akın M. & Akın G. 2007. Suyun Önemi, Türkiye'de Su Potansiyeli, Su Havzaları ve Su Kirliliği. *Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi,* 47 (2):105-118 (in Turkish)

Coşkun F. Gültek A. Patrona K. & Gür A. 2011. Su Ürünleri Yetiştiriciliği Sektör Raporu. Türkiye (in Turkish)

Çelikkale MS. 1994. İç Su Balıkları ve Yetiştiriciliği, Cilt I, Karadeniz Teknik Üniversitesi, Sürmene Deniz Bilimleri Fakültesi, Yayın No: 2, (in Turkish)

Dirican S. & Musul H. 2008. Çamlıgöze Baraj Gölü'nün (Sivas) bazı Fizikokimyasal özellikleri ve Cladocera Türleri Üzerine Bir Ön Çalışma, *Harran Üniversitesi Ziraat Fakültesi Dergisi,* 12(4):19-24. (in Turkish)

Emre Y. & Kürüm V. 1998. Alabalık Yetiştiriciliği, 2. Baskı, Posta Basım, s.272, İstanbul (in Turkish)

Molony B.W. 2001. Environmental requirements and tolerances of rainbow trout (Oncorhynchus mykiss) and brown trout (Salmo trutta) with special reference to Western Australia: a review. *Fish. Res. Rep. West.* Aust. 130 (28 pp.)

Özdemir N. Yılmaz F. & Yorulmaz B. 2007. Dalaman Çayı Üzerindeki Bereket Hidroelektrik Santrali Baraj Gölü Suyunun Bazı Fiziko-Kimyasal Parametrelerinin ve Balık Faunasının Araştırılması, *Ekoloji Dergisi,* V. 16(62):30-36 (in Turkish)

Sağlam M. T. & Bellitürk K. 2003. Su Kirliliği ve Toprak Üzerindeki Etkisi. *Alatarım,* 2 (1): 46-49 (in Turkish)

Composition and Sensory Properties of Wheat, Plantain and Cocoyam Flour Doughnuts

Adanse JOHN[1*], Antwi-Boasiako SUSSANA[2], Kate BIGSON[3], Kwakudua Ruth SITSOFE[4]

[1]*Department of Hospitality Management, Bolgatanga Technical University,*
P. O. Box 767, Bolgatanga-Ghana
[2]*Department of HCIM, Accra Technical University, Box GP 561, Barnes Road, Accra, Ghana*
[3]*Department of Hotel, Catering and Institutional Management, Dr. Hilla Limann Technical University,*
P. O. Box 553, Wa – Ghana
[4]*Home Economic Department, Presbyterian College of Education- Kibi, PMB Kibi, Eastern Region- Ghana*

[*]*Corresponding Author: johnadanse@bolgatu.edu.gh*

ORCID: 0000-0003-0582-6613

Abstract

This study was carried out to investigate proximate composition, functional properties and sensory evaluation of wheat, plantain and cocoyam flour blended doughnuts at different levels of plantain and cocoyam flour substitution for consumption. A whole wheat doughnuts and composite doughnuts were prepared in duplicates at 0, 12, 15, 30, 35% and 0, 8, 25, 25 and 50% levels of plantain and cocoyam flours substitution respectively and evaluated for proximate composition using AOAC Methods. The results reveal that moisture, ash, crude fiber and carbohydrate contents of the composite doughnuts increased significantly ($p<0.05$) while the protein and fat contents decreased significantly with progressive increase in the cocoyam and plantain flour substitution. The proximate composition of the various doughnut samples ranged from moisture, 16.29-20.15, ash, 1.49-2.6, protein, 4.54-9.36, fat, 38.35-46.35, fibre, 0.34-3.12 and carbohydrate, 42.20-49.18 g/100g. Results obtained from the functional properties of the composite flour revealed significant increase ($p < 0.05$) in water absorption capacity (118.78-135.61) and bulk density (0.58-0.70) as the levels of the plantain and cocoyam flours increased while the oil absorption capacity (68.21-96.44), emulsion ability (48.16-64.16) and foaming capacity (6.23-13.05) of the whole wheat flour increased. The sensory scores for the entire doughnut samples were above average, implying that the doughnut samples were highly acceptable based on the parameters assessed. The study concludes that Cocoyam and plantain flours could be blended with wheat flour up to 8% and 12% in doughnuts and other pastries preparation with no apparent difference in taste, aroma, or acceptability.

Keywords: Wheat flour, composite flour, doughnuts, functional properties, nutritional composition, sensory characteristics

Research article
Received Date: 15 November 2021
Accepted Date: 25 November 2021

INTRODUCTION

Dropped doughnuts are made from flour, water, egg, oil, sugar, and milk (Hatae et al., 2003). They are typically flour products that are ball-like shaped and are deep fried and can be garnished with sugar, chocolate, or maple glaze to create different varieties. Doughnut and other baked products consumption is increasing in Ghana and the entire continent as a result of urbanization (Adeyeye and Akingbala, 2015). Doughnuts are also one of the most popular foods, frequently consumed due to their ready-to-eat nature, high nutritional quality, high satisfaction and inexpensive nature (Adeleke and Odedeji, 2010; Adeyeye and Akingbala, 2015). People are becoming increasingly health-conscious and concerned about their diets because of that they require foods that are convenient, tasty, affordable, and have a positive nutritional image.

Wheat (*Triticum aestivum)* is an imported product in Africa and one of the most significant staple food crops in various countries throughout the world (Van iltersumet al., 2016). It provides more calories and proteins to the global diet than other commonly consumed grains (Kumar et al., 2011). Wheat grain is nutrient-dense, with protein levels ranging from less than 6% to more than 20% (Koehler and Wieser, 2013). It can be made into a variety of foods, such as semolina, bread, scones, noodles, and other confectionery goods (Kumar et al., 2011; Sramkovaet al., 2009). Wheat, because of the presence of gluten which is essential for given dough the ability to rise properly is a superior choice for baked goods than other cereals (Shewry and Hatford, 2002). Wheat is not a tropical crop, and only a few African countries have the climatic conditions to support its growth. As a result, significant sums of money are spent each year in Africa to import wheat to meet the expanding demand for wheat-based products (Ahmed et al., 2013). Wheat flour is the preferred flour for making doughnuts and other flour products; however, it is highly expensive when compared to flours made from underutilized crops like cocoyam and plantain. As a result, composite flours could be made from local crops, lowering the cost of doughnuts and other baked goods. According to Akobundu et al. (1998), while choosing components for composite flour blends, materials should be widely available, culturally acceptable, and have higher nutritious potential. According to the FAO (1995), composite flours made from grains and legumes have an advantage of boosting one's nutritional value. Chinma et al. (2007) also pointed out that composite flours made from legumes and tubers have high protein content as well as a high calorie value.

The herbaceous plants of the genus Musa are known as plantains. In Central and West Africa, plantain (*Musa paradisiaca*) is a common staple meal. It is a staple food crop and a low-cost energy source (Faturoti et al., 2007; Adeniyi et al., 2006). Plantain was listed as one of the key starchy staples in several Ghanaian and West African food consumption surveys (Odenigbo, 2012; Okeke et al., 2008; Ogechi et al., 2007). Plantains are high in dietary fibre (8.82%), resistant starch (16.2%), protein and fat contents (Ayodele and Erema, 2011). Dietary fiber lowers serum cholesterol and lowers the risk of heart attack, colon cancer, obesity, blood pressure, appendicitis, and a variety of other disorders in humans (Rehinan et al., 2004). The feasibility of baking with wheat/plantain composite flour has been investigated (Bamidele et al., 1990; Mepba et al., 2007; Idoko and Nwajiaku, 2013). With higher quantities of plantain supplementation, the composite flours' water absorption capacity and dough development time reduced (Bamidele et al., 1990).

The amount of wheat flour needed to create a specific impact in composite flours is highly dependent on the quality and quantity of wheat gluten present, as well as the nature of the product. Plantain flour, according to Akubor (1998), has a good potential for usage as a functional agent in baking products due to its high water absorption capacity.

Cocoyam is a key staple food in many African, Asian, and Pacific-Ocean countries. It is especially important in Sub-Saharan Africa. The crop's annual production and per capita consumption were expected to be 1.3 million MT and 40 kg, respectively, in 2014 (SRID, 2015). When compared to other root and tuber crops, cocoyam is said to have a greater crude protein content (6.4%) and digestible starch (Okpala and Okoli, 2011). Cocoyam is still used on a limited scale in Africa, ranking third behind other key roots and tuber crops such as yam and cassava (Wanyakha, 2016). Unlike cocoyam and other root harvests such as cassava and sweet potato, have been extensively researched in flour manufacturing (Mepba et al., 2007). They have been used to manufacture composite flour with wheat flour for a variety of pastry goods, and they have helped to reduce wheat imports by a small amount (Sanful and Darko, 2010).

The nutritional value of cocoyam is said to be superior to that of other root and tuber crops, particularly in terms of protein digestibility and mineral composition (Boakye et al., 2017). Cocoyam is key food security crop for many people in many tropical places, especially smallholder farmers. In terms of proximate and mineral content, cocoyam has surpassed taro (a similar aroid) (Matthews, 2002). For economic, nutritional, and/or health reasons, the quest for alternatives to partially or entirely replace wheat flour in bakery and other culinary applications has become imperative. Wheat prices on the global market have become erratic, according to Rodrick (2008), with prices doubling between 2005 and 2007, and increasing by 26% between October 2011 and October 2012. The commodity's price volatility puts a pressure on developing economies, which rely significantly on imports to meet their wheat demands. Using flours from root and tuber crops to partially substitute wheat flour has been offered as a potential solution to this problem. These root and tuber crops are widely available and reasonably priced. Their flours have the ability to improve the nutritious profile of the composite flour produced. Furthermore, consumers who are allergic to wheat gluten or have celiac disease will benefit because exposure to this wheat protein is reduced when non-gluten flour is used. The addition of cocoyam and plantain flour to doughnuts would improve the nutritional content of the product while also increasing the use of these underutilized crops. The purpose of the study was to evaluate the characteristics of wheat, plantain and cocoyam flour blends in doughnuts preparation.

MATERIALS AND METHODS

Source of raw materials

Prior to processing into flour, mature red cocoyam (*Xanthosoma sagittifolium*) and unripe plantain were purchased from a farm gate, sorted, cleaned, and stored in jute bags at room temperature. Soft wheat flour and other bakery ingredients were procured from Kumasi Central Market.

Preparation of cocoyam flour

Fresh cocoyam crowns were rinsed with water, peeled with a stainless steel knife, rewashed, and cut to a thickness of 0.5 cm. The slices were dried for 12 hours at 60°C in a mechanical dryer (Apex, UK). The dried cocoyam slices were crushed into flour with a hammer mill (Christy and Norris Ltd., Surrey, UK) and sieved at 250 μm before being packaged in flexible HDPE bags for subsequent usage.

Preparation of plantain flour

Plantains (*Musa paradisiaca*) were manually peeled using stainless steel kitchen knives, and the pulp was sliced into uniform sizes of around 1.5mm thickness according to the procedure of Adeniji et al., (2007). The slices were dried to a consistent weight in a 105°C oven for 24 hours before being milled into flour using Philip's grinder. The flour was then sieved in 500-mesh sieve to obtain fine smooth textured flour. The flour was packaged in plastic bags and stored at 4° C until it was time to make composite flours.

Preparation of composite flour

Composite flour was prepared by mixing proportions of the three component flours (wheat, cocoyam, and plantain), according to (Hugo, 2002) present in Table 1. Blends of the mixture were A (wheat flour, 100%), B (wheat 80%, Plantain 12% and Cocoyam 8%), C (wheat 60%, Plantain 15% and Cocoyam 25%), D (wheat 40%, Plantain 35% and Cocoyam25%) and E (wheat 20%, Plantain 30% and Cocoyam 50%). One hundred percent (100%) of wheat flour was used as control. The flours were packed in plastic containers until the preparation of the products and analysis.

Table 1. Formulation of Composite and wheat Flour for doughnuts Production

	SAMPLES				
Ingredients	**A**	**B**	**C**	**D**	**E**
Wheat flour (soft) (g)	100	80	60	40	20
Plantain flour (g)	0	12	15	35	50
Cocoyam flour (g)	0	8	25	25	30
Margarine (g)	30	30	30	30	30
Sugar (g)	40	40	40	40	40
Vanilla essence (ml)	2	2	2	2	2
Salt (g)	0.5	0.5	0.5	0.5	0.5
Baking powder (g)	1.5	1.5	1.5	1.5	1.5
Milk (ml)	30	30	30	30	30
Water (ml)	15	15	15	15	15
Egg	1	1	1	1	1
Vegetable oil (ml)	250	250	250	250	250

A (100% wheat flour), B (wheat 80%, Plantain 12% and Cocoyam 8%), C (wheat 60%, Plantain 15% and Cocoyam 25%), D (wheat 40%, Plantain 35% and Cocoyam25%) and E (wheat 20%, Plantain 30% and Cocoyam 50%)

Preparation of doughnuts

Prior to the production of doughnut, cocoyam and plantain flour were blended with wheat flour as shown in Table 1. The doughnut samples were produced with slight modification to the method of Paraggon Book Service (2013). The basic formulation consists of 100% wheat flour, fat, 30g, egg, 1, sugar, 10g, yeast, 10g, and milk, 20ml. The weighed wheat–cocoyam-plantain flour used was poured into a mixing bowl with the margarine and baking powder. It was then rubbed-in to a fined breadcrumbs texture. Salt, sugar, vanilla essence and egg were added to the diluted milk and were mixed together with rotary whisk. The mixture was incorporated into the flour and was again mixed to a thick batter consistency. A scoop was used to fetch the thick batter into the oil so as to obtain the same size and weight. Doughnuts were checked and removed. This method was repeated for each flour blend to obtain different samples of doughnut.

Proximate Analysis

AOAC (1995) techniques were used to determine the proximate composition of the whole wheat and composite doughnut samples. The moisture content (% MC) of samples was evaluated by drying them for 24 hours at 105°C. With the Kjeltec 8400 analyzer unit (FOSS, Sweden), the crude protein percentage (%CP) was calculated using the Kjeldahl method No 920.87 (AOAC, 1995) and the percentage nitrogen obtained was used to calculate the percentage of CP using the formula: percentage of CP = percent N X 6.25. The percentage ether extract (percent EE) was calculated using the Soxhlet system HT-extraction technique AOAC (1995) method, and the percentage (%) of ash was calculated by incinerating the samples at 550°C for four (4) hours in a muffle furnace. The ash was weighed after cooling in a desiccator. Dilute acid and alkali hydrolysis was used to measure the crude fibre percentage (% CF). Difference was used to compute carbohydrate (AOAC, 1995).

Determination of functional properties of the flour samples

Determination of water and oil absorption capacity

The method described by Okezie and Bello (1988) was used to determine the water and oil absorption capacities. In a flask shaker, one gram (1.0 g) of each sample was mixed with 20 ml distilled water (for water absorption capacity) and 20 ml oil (for oil absorption capacity) and centrifuged for 1 hour at 2,000 rpm. The difference between the initial and final volumes of water/oil absorbed by samples was computed. The averages of duplicates were calculated and reported.

Oil absorption capacity (% OAC) = $\frac{(y-z)\times d}{x} \times 100$

Where y= initial volume of oil added

Z= volume of supernatant collected

X= initial weight of (dried) sample taken

d= density of oil

y-z =volume of water retained by the sample after centrifugation

Water absorption capacity (% WAC) = $\frac{y-z}{x} \times 100$

Where y= initial volume of water added

Z= volume of supernatant collected
X= initial weight of (dried) sample taken
y-z =volume of water retained by the sample after centrifugation

Determination of bulk density

With minor modifications, the bulk density was calculated using Onwuka's (2005) approach. Fifty grams (50g) of each sample were placed in a clean 100 ml graduated measuring cylinder and gently tapped several times until no more decrease occurred. It was measured in volume, and the bulk density was computed using the following formula:

$$\text{Bulk density} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample (mL)}} \times 100$$

Determination of emulsion stability

Acuna et al., (2012) method of determining the emulsion capacity was used. Five milliliters (5 ml) flour dispersion in distilled water (10 mg/mL) was homogenized for 1 minute with 5 mL oil. The emulsion was centrifuged for 5 minutes at 1,100 rpm. The height of the tube's emulsified layer (EL) and total content (TC) were both measured. Emulsion capacity was calculated as follows:

$$EC = \frac{EL}{TC} \times 100$$

Determination of foaming capacity and stability

Foaming capacity and stability were studied as described by Narayana and Narasinga (1982). At 302oC, two grams (2g) of each flour sample were mixed with fifty milliliters (50 ml) distilled water. The whipped mixture was poured into a graduated cylinder with a capacity of 100 ml. The suspension was correctly combined and shaken to froth, and the volume of the foam was measured after 30 seconds. The foaming capability was measured in terms of volume increase as a percentage. To evaluate the foaming stability as a percentage of the initial foam volume, the foam volume was measured 1 hour after whipping.

Calculation of the capacity and stability is as follows:

$$\%\text{foaming capacity} = \frac{(volafterhomogenization) - (volbeforehomogenization)}{volbeforehomogenization} \times 100$$

$$\%\text{foam stability} = \frac{foamvolumeaftertime(t)}{initialfoamvolume} \times 100$$

Sensory Evaluation

Sensory evaluation was done to decide which doughnuts were the most preferred. A 50-member panel comprised of semi-trained Hospitality Management students evaluated the doughnuts. Colour, flavour, taste, hardness, and general acceptability were all considered when judging the doughnut variants. To disguise diverse qualities of the doughnut samples and so prevent bias, panelists worked in partitioned booths with no air flow, no noise or odours, and under off white light. The variations between the doughnut samples were measured using a nine-point hedonic scale.

Statistical data analysis

Data obtained were analyzed using statistical package for social sciences (SPSS version 20). To examine the variations in proximate composition, functional properties, and sensory qualities of the doughnut samples, a one-way ANOVA was used. Fisher's Least Significant Difference test (LSD) at $p \leq 0.05$ was used to separate the means.

RESULTS AND DISCUSSION

The moisture content of the doughnuts ranged from 16.29 to 20.15%. Doughnuts produced in 20% wheat, 30% Plantain and 50% Cocoyam doughnuts have the highest moisture content (20.15%) compared to other studies (Idoko and Nwajiaku, 2013; Ketiku, 1973; Asiedu, 1987) reported range of 49.40 to 62.0%. The close formation of composite doughnuts have shown that moisture increases as the rate of composite flour increases and this may be due to the ability of plantain and cocoyam flours to absorb more water than wheat flour as shown in Table 2. It was noted that the moisture of doughnut samples increased significantly ($p < 0.05$) as its substitution of cocoyam and plantain flour increased. This result differs from that (9.37–10.03%) reported by Echendu et al. (2004) of biscuits made from a mixture of pigeon flour. Low moisture is helpful because it will reduce product decay by improving its shelf life while the high moisture content is a conduit for microbial perforation (Nnam, 2002).

Crude ash was between 1.49-2.60% (Table 2), which was lower than previously reported (Lazos, 1986). Each treatment significantly ($P < 0.05$) increased the levels of crude ash as cocoyam and plantain flours increased. The control sample (100% wheat flour) has a small amount of ash (1.49%) while the sample mixture of combination E (wheat 20%, Plantain 30% and Cocoyam 50%), has a high ash content (2.60%). The increase in ash content could be credited to the higher levels of ash in the cocoyam and plantain flours as compared to wheat flour. The contents of the ashes are an indication of the minerals contained in the doughnuts.

The protein content also decreased significantly ($p < 0.05$) with an increase in the rate of non-wheat flour substitution in the samples but generally lower than the 100% wheat flour doughnuts produced. Raw protein was 9.36% for 100% wheat doughnuts (control), 8.64% for 80% wheat 12% Plantains and 8% cocoyam flour; 7.36% for 60% wheat, 15% plantain and 25% cocoyam flour, 6.35% for doughnuts produced from 40% wheat, 35% plantain and 25% cocoyam flour and 4.54% for 20% wheat, 30% plantain and 50% cocoyam flour blends respectively.

Fat content values were 46.35% in 100% wheat doughnuts (control), 44.36% in 80% wheat, 12% Plantain and 8%, cocoyam flour mixtures; 43.74% wheat 60% 15% plantain and 25% cocoyam flour, 41.65% for 40% wheat 35% plantain and 25% cocoyam flour and 38.35% for 20% wheat, 30% plantain and 50% cocoyam flour. It was noted that protein and fat were significantly reduced as the amount of cocoyam and plantain flour increased. The results also show that 100 g of doughnuts can provide more than one-third of the recommended daily protein (IOM, 2005) for a healthy adult when eaten.

The crude fibre content of all doughnut samples ranged from 0.34 to 3.12%, with the composite doughnuts sample E (wheat 20%, plantain 30%, and cocoyam 50%) having the highest fibre content. The fibre level was low (0.34%) in the 100% wheat flour doughnuts and thus, differs from that found by Kayode et al 1995 in bread made from 100% wheat flour. Fibre has numerous health advantages (Rehinan et al., 2004). According to Rehinan et al., (2004), the crude fibre content of plantain and cocoyam flours indicate that when included into a human diet, they can help lower serum cholesterol, reduce the risk of heart attack, colon cancer, obesity, blood pressure, appendicitis, and many other ailments.

The carbohydrate content of doughnut samples ABCDE ranged from 43.20 to 49.18%, with doughnut sample E (20% wheat, 30% Plantain and 50%Cocoyam flour blends) having the highest mean value (49.18%) while doughnut sample A (100 percent wheat flour) recorded the lowest (43.20%). The composite samples and the control sample differed considerably ($p<0.05$). It was discovered that increasing the amount of cocoyam and plantain flour in the doughnuts resulted in a comparable rise in carbohydrate content. The carbohydrate levels discovered in this study are lower than those reported by Eke et al. (2008) for cakes marketed in Port Harcourt. These variations could be attributable to variances in recipe composition and preparation methods. Furthermore, the high carbohydrate content of cocoyam and plantain may explain the considerable rise in carbohydrate with increasing cocoyam and plantain substitution levels. In roots and tubers, glucose predominates over all other solid nutrients (Enwere, 1998)

Table 2 Proximate composition of doughnuts

Samples	Moisture (g/100g)	Ash (g/100g)	Protein (g/100g)	Fat (g/100g)	Fibre (g/100g)	CHO (g/100g)
A	16.29^{a}	1.49^{a}	9.36^{e}	46.35^{a}	0.34^{a}	42.20^{c}
B	17.23^{b}	1.95^{b}	8.64^{d}	44.36^{b}	0.82^{a}	42.64^{a}
C	18.63^{c}	2.30^{c}	7.36^{c}	43.74^{c}	1.42^{c}	43.13^{b}
D	18.71^{d}	2.54^{d}	6.35^{b}	41.65^{d}	2.56^{d}	46.15^{e}
E	20.15^{e}	2.60^{e}	4.54^{a}	38.35^{e}	3.12^{e}	49.18^{e}

Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different ($p>0.05$). Keys: A (100% wheat flour), B (wheat 80%, Plantain 12% and Cocoyam 8%), C (wheat 60%, Plantain 15% and Cocoyam 25%), D (wheat 40%, Plantain 35% and Cocoyam 25%) and E (wheat 20%, Plantain 30% and Cocoyam 50%)

The water absorption capacity of wheat, plantain, and cocoyam flour blends, as well as 100% wheat flour, is shown in Table 3 at various ratios. The water absorption capacity of the flours ranged from 118.78 to 135.61 g/g, with wheat flour having the lowest value (118.78 g/g) and composite flour sample E (20% wheat, 30% plantain, and 50% cocoyam) flour blends having the highest WAC (135.61).

Carbohydrates and proteins, which contain hydrophilic elements such as polar or charged chains, are the main chemical components that improve flours' water absorption ability (Lawal and Adebowale, 2004). At varied ratios, there was a significant ($p<0.05$) difference in WAC between composite flour samples and the control (100% wheat flour). This is not surprising given that cocoyam flour has larger carbohydrate content than wheat flour and starch plays a substantial role in water absorption. The rise in WAC, on the other hand, has been linked to an increase in amylose leaching and starch crystalline structure degradation (Chandra et al., 2015). The higher carbohydrate value of cocoyam and plantain flour blends in the proximate composition supports this. Other investigations have found that cocoyam flour has a high WAC (Oke and Bolarinwa, 2011). A high WAC is important since it maintains product consistency while also increasing yield and consistency (Osundahunsiet al., 2003). This is an important metric in the value-added industry, and it suggests that cocoyam and plantain flours could be used in the preparation of dough and pastries.

With increasing amounts of cocoyam and plantain flours, the oil absorption capacity (OAC) of the flours declined, ranging from 68.21 to 96.44 g/g. Sample A had the highest OAC value of 96.44 g/g, whereas sample E had the lowest OAC value of 68.21 g/g (20 percent wheat, 50 percent plantain, and 30 percent cocoyam flour). The presence of more hydrophobic proteins, which exhibit dominance in binding lipids, may be the source of the increase in OAC. Intrinsic factors such as protein structure, amino acid, and surface divergence influence the OAC (Shrestha and Srivastava, 2017). The composite flours used in this study could be advantageous in food application such as flavour retention, increased palatability, and shelf-life extension in pastries and bread products where fat absorption is desired (Aremu et al., 2007). The results differed from those of Kaushal et al. (2012), who looked at taro (Colocasia esculenta), rice (Oryza sativa), and pigeon pea (Cajanus cajan) flour. The bulk density and emulsion capacity of the pure flours and their composites, respectively, ranged from 0.58 to 0.70 and 52.35 to 64.16. Bulk density is a property of proteins that is impacted by protein quantity and quality (Akubor, 2013; Ocloo et al., 2010), whereas emulsion capacity is a property of proteins that is influenced by protein content and quality. The results show that cocoyam and plantain flour blends were significantly bulkier in sample E (20% wheat, 30% plantain, and 50% cocoyam flour) (0.70) than the 100% wheat flour (0.58), implying that adding more cocoyam and plantain flours to the composite resulted in an increased in its density. High bulk, according to Udensi and Eke (2000), reduces paste thickness. Wheat flour had substantially higher emulsion ability (64.16%) than the composite flour samples. The emulsion capacity was reduced when a portion of wheat flour was replaced with cocoyam and plantain flours.

Foaming capacity (FC) is a measurement of flour's ability to foam, which is determined by the presence of flexible protein molecules that lower water surface tension (Asif-Ul-Alam, et al., 2014). The foaming capacity of the flours ranged from 6.23 to 13.05%, with wheat flour having the highest foaming capacity (13.05%) and sample E (20% wheat, 50% plantain and 30% cocoyam flour) had the lowest foaming capacity (6.23%). As the amount of cocoyam and plantain flours was raised, the foaming capability fell. Because flexible proteins have strong foaming capacity, foaming capacity is thought to be reliant on the configuration and type of protein molecules (Graham and Philips, 1976). The high foaming capability of 100% wheat flour could indicate that it can help improve textural and leavening properties. Food ingredients with good foaming power and stability, according to Akubor et al. (2000), can be employed in bread products. The low protein content of cocoyam and plantain flours has been blamed for their low foaming potential (Ibebuchi and Uzoegbu, 2002).

Heat treatment of cowpea resulted in a similar reduction in foaming capacity (Abbey and Ibeh, 1988). Kiin-Kabari, et al., (2015) found that when the substitution of bambara groundnut increased in wheat/plantain flours, the results varied (23.5 percent–65.0%).

Table 3. Functional Properties of wheat/plantain/cocoyam flour blends

Sample	WAC	OAC	BD	EA	FC
A	118.78 ± 0.66^{e}	96.44 ± 3.01^{a}	0.58 ± 0.03^{a}	64.16 ± 1.77^{e}	13.05 ± 0.00^{a}
B	120.97 ± 0.88^{d}	85.30 ± 1.48^{b}	0.63 ± 0.01^{e}	60.34 ± 1.69^{a}	12.43 ± 0.00^{b}
C	124.63 ± 1.50^{c}	78.63 ± 0.29^{b}	0.65 ± 0.00^{d}	58.42 ± 1.27^{b}	9.45 ± 0.00^{c}
D	128.10 ± 1.69^{b}	75.24 ± 1.90^{b}	0.67 ± 0.00^{c}	54.73 ± 1.18^{c}	7.13 ± 0.00^{d}
E	135.61 ± 2.29^{a}	68.21 ± 1.52^{b}	0.70 ± 0.05^{b}	48.16 ± 0.69^{d}	6.23 ± 0.00^{e}

Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different (p>0.05). WAC = Water Absorption Capacity, OAC = Oil Absorption Capacity, BD = Bulk Density, EA = Emulsion Ability, FC = Foaming Capacity

The sensory features of the cocoyam-wheat-plantain composite doughnut samples are shown in Table 4. The doughnut samples had significant differences in texture (crispiness), aroma, colour, taste and overall acceptance (p<0.05). The texture score ranged from 4.15-8.30 with sample A (100% wheat flour) scoring the highest (p<0.05), followed by sample B (80% wheat, 12% cocoyam, and 8% plantain flours), which scored 8.26 and 4.15 for sample E (20% wheat, 30% Plantain and 50% Cocoyam) respectively. Aroma scores varied from 6.81 to 8.45, with significant (p<0.05) variations between the samples. The panelists found no significant difference in colour, taste, or overall acceptability between the composite doughnuts with up to 12% and 8% cocoyam and plantain flour substitutions and the control, but they did differ significantly in texture, flavour, colour, taste and acceptability from the 100% wheat doughnuts at all levels of substitution. The average sensory scores for the entire doughnut samples were above average, implying that the doughnut samples were highly acceptable based on the parameters assessed. This finding matches that of Echendu et al. (2004), who used maize and pigeon pea flour blends to make doughnuts and biscuits. Table 4 shows that as the percentage of cocoyam and plantain flours in the doughnut samples increased, the doughnut samples scored low in colour, taste, aroma, texture, and acceptability.

Doughnut samples prepared from the 100% wheat doughnut as well as 8% Cocoyam and 12% plantain flour blends doughnuts were accepted since there were no significant (p>0.05) difference between the control and the composite sample B.

Table 4. Sensory attributes of the wheat, plantain and cocoyam flour doughnuts

Samples	Texture	Aroma	Colour	Taste	Overall Acceptability
A	8.30	8.45	9.60	10.50	10.63
B	8.26	8.40	9.53	10.48	10.59
C	8.20	8.34	8.47	9.50	9.35
D	5.26	7.15	7.92	7.60	9.10
E	4.15	6.81	7.47	7.54	8.05

Values represent means and standard deviation replicate readings for various parameters. Values in the same column with different superscripts are significantly different (p>0.05). Keys: A (100% wheat flour), B (wheat 80%, Plantain 12% and Cocoyam 8%), C (wheat 60%, Plantain 15% and Cocoyam 25%), D (wheat 40%, Plantain 35% and Cocoyam25%) and E (wheat 20%, Plantain 30% and Cocoyam 50%)

CONCLUSIONS

Cocoyam and plantain flours have been demonstrated to have high levels of proteins, ash, lipids, and carbohydrates, making them a valuable source of these nutrients when used to partially replace wheat flour in cooking. At all levels of substitution, nutritional analysis of the various composite doughnuts revealed that they have nutritious value that compares favorably to 100% wheat flour doughnuts and commercially available doughnuts. Its functional qualities made it a good candidate for use in composite flour blends. The study concludes that Cocoyam and plantain flours could be blended with wheat flour up to 8% and 12% in doughnuts and other pastries preparation with no apparent difference in taste, aroma, or acceptability.

Funding

Not Applicable

Conflict interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

Abbey B.W. & Ibeh G.O. 1988. Functional properties of raw and heat processed cowpea (Vigna unguiculata, Walp) flour. J. Food Sci. 53: 1775-1777

Acuna S. P. C., Gonzalez J. H. G. & Torres I. D. A. 2012. Physicochemical character-istics and functional properties of vitabosa (Mucuna deeringiana)andsoybean(Glycinemax). Ciencia E Tecnologia de Alimentos, 32,98–105. doi:10.1590/S0101-20612012005000007

Adeniyi T.A., Sanni L.O., Barimalaa L.S. & Hart A.D. 2006. Determination of micronutrients and color variability among new plantain and banana hybrid flour. *World J. Chem.* 1(1):23-27

Adeleke R. O. & Odedeji J. O. 2010. Functional properties of wheat and sweet potato flourblends. *Pakistan Journal of Nutrition,* 9(6), 535–538. doi:10.3923/pjn.2010.535.538

Adeyeye S. A. & Akingbal J.O. 2015. Quality characteristics and acceptability of cookies from sweet potato–maize flour blends.Nutrition & Food Science, 45(5), 703–715. doi:10.1108/NFS-03-2015-0020

Adeniji T.A., Sanni L.O., Barimalaa I.S. & Hart A.D. 2007. Nutritional composition of five new Nigerian musa hybrid cultivars. Implications for adoption in human nutrition. Fruits, 62, 135 – 142

Ahmad M., Shabbir G., Minhas N.M. & Shah M.K. 2013. Identification of drought tolerant wheat genotypes based on seedling traits, *Sarhad Journal of Agriculture*, 29 pp.21-27

Akubor P.I . & Ishiwu B. 2013. Chemical composition, physical and sensory properties of cakes supplemented with plantain peel flour. *International Journal of Agriculture Policy and Research*, 1(4), 087 – 092

Akubor P.I., Isolokwu P.C., Ugbane O. & Onimawo IA. 2000. Proximate composition and functional properties of African breadfruit kernel and wheat flour blends. *Food Res. Int.* 33:707-712

Akubor P.I. 1998. Functional properties of cowpea-plantain flour blends. Proceedings: 22nd Ann NIFST Conference, University of Agriculture, Abeokuta, Nigeria.

Akobundu E.N.T., Ubbaonu C.N. & Ndupuh C.E. 1998. Studies on the baking potential of non-composite flours. *J. Food Sci. Technol*. 25: 211-214

AOAC 1995. Official Methods of Analysis,"Association of Official Analytical Chemists methods, AOAC 16th Edition. Washington DC.

Aremu M.O., Olaofe O. & Akintayo E.T. 2007. Functional properties of some Nigerian varieties of legume seed flours and flour concentration effect on foaming and gelation properties. *Journal of Food Technology*, 5, 109-115. https://medwelljournals.com/abstract/?doi=jftech.2007.109.115

Asiedu J.J. 1987. Some physio-chemical changes during ripening and storage of plantain. *Trop. Sci*. 27(4):249-260.

Asif-Ul-Alam SM., Islam MZ., Hoque MM. & Monalisa K. 2014. Effect of drying on the physico-chemical and functional properties of green banana (Musasapientum) flour and development of baked product. *Amer. J. Food Sci. Technol.* 2(4):128-133.

Ayodele O.H. & Erema V.G. 2011. Glycemic index of processed unripe plantain meals. Afr. J. Food Sci. 4:514-521

Bamidele E.A., Cardoso A.O. & Olaofe O. 1990. Rheology and baking potential of wheat/plantain composite flour. *J. Sci. Food. Agric*. 51(3):421-424.

Boakye A. A., Guðjónsdóttir M., Skytte J. L., Chronakis I., Wireko-Manu F. D. & Oduro I. 2017. Characteristics of Xanthosoma sagittifolium roots during cooking, using physicochemical analysis, uniaxial compression, multispectral imaging and low field NMR spectroscopy. J*ournal of Food Science and Technology*, https://doi.org/10.1007/s13197-017-2704-7

Chandra S., Singh S. & Kumari D. 2015. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of Food Science and Technology,52, 3681-3688. https://doi.org/10.1007/s13197-014-1427-2

Chinma C.E., Ingbian E.K. & Akpapunam M. 2007. Processing and acceptability of fried cassava balls (Akara-akpu) supplemented with melon and soybean flours. J. *Food Proc. Preserv*. 31(2): 143-156.

Echendu C.A., Onimawo I.A. & Adieze S. 2004. Production and evaluation of dough and biscuits from maize-pigeon pea flour blends. Nigerian Food Journal 22:147-153.

Eke J., Achinewhu S.C. & Sanni L. 2008. Nutritional and sensory qualities of some Nigerian cakes. *Nigerian Food Journal*, 26(2), 12 – 13

Enwere N.J. 1998. Foods of Plant Origin. Snapp Press, Nigeria Ltd., Enugu. pp 24-102.

FAO 2005. Production Yearbook for 2005. FAOSTAT Data. Food and Agriculture Organisation of the United Nations, Rome.

Faturoti B., Madukwe M., Tenkouano A. & Agwu A. 2007. A review of policy acts and initiatives in plantain and banana innovation system in Nigeria. *Afr. J. Biotechnol*. 6(20):2297-2302

Graham D.E. & Philips M.C. 1976. The conformation of proteins at the air-water interface and their role in stabilizing foam. In: Akers RJ (Ed.) New York: Academic Press. Foams, pp. 237-255.

Hatae K., Miyamoto T., Shimada Y., Munekata Y., Sawa K., Hasegawa K. & Kasai M. 2003. Effect of the type of frying oil on the consumer preference for doughnut. *Journal of Food Science*, 68: 1038-1042

Ibebuchi C.E. & Uzoegbu J.O. 2002. Potential of wheat-cocoyam flour blends in biscuit making. Proc. 26th Annual NIFST conf., Nov. 4 – 8, Owerri, pp 37 – 38.

Idoko J.O. & Nwajiaku I. 2013. Performance of ripped and unripe plantain-wheat flour blend in biscuit production. Int. J. Biol. Food Vet. Agric. Eng. 7(12):848-851

IOM (Institute of Medicine) 2005. Dietary reference intake for energy, carbohydrate, fiber, fat fatty acids, cholesterol, protein and amino acids (macronutrients)

Kayode O. Esuoso F. & Bamiro O. 1995. International Journal of Food Science and Nutrition

Kaushal P., Kumar V. & Sharma H.K. 2012. Comparative study of physicochemical, functional, anti-nutritional and pasting properties of taro (Colocasia esculenta), rice (Oryza sativa), pegion pea (Cajanus cajan) flour and their blends. LebensmittelWissenschaft + Technologie, 48(1), 59-68. http://dx.doi.org/10.1016/j.lwt.2012.02.028

Ketiku A.O. 1973. Chemical composition of unripe (green) and ripe plantain (Musa parasidica). *J. Sci. Food. Agric.* 24:703-709.

Kiin-Kabari D.B., Eke-Ejoifor J. & Giami S.Y. 2015. Functional and paroting properties of wheat flour/plantain flours enriched with Bambara groundnut protein concentrate. *International Journal of Food Science and Nutrition Engineering*, 5(2) 75 – 81

Koehler P. & Wieser H. 2013. Handbook on sourdough biotechnology, 3rd Ed by Gobbetti, M and Ganzle, M. Springer, US. pp. 11-45.

Kumar P., Yadava R.K., Gollen B., Kumar S., Verma R.K. & Yadav S. 2011. Nutritional contents and medicinal properties of wheat: a review. *Life Science and Medical Research*, 22, 1-10

Lawal O.S. & Adebowale K.O. 2004. Effect of acetylation and succinylation on solubility protein, water absorption capacity, oil absorption capacity and emulsifying properties of muncuna bean (Mucuna pruiens) protein concentrate. Nahrung/Food 48(2):129-136.

Lazos E.S. 1986. Nutritional, fatty acid and oil characteristics of pumpkin and melon seeds. *J. Food Sci*.51, 1382–1383. http://dx.doi.org/10.1111/j.1365-2621.1986.tb13133.x.

Matthews P.J. 2002. Potential of root crops for food and industrial resources," pp. 484–497, Proceedings of the 12th Symposium of the International Society for Tropical Root Crops (ISTRC), Tsukuba, Japan.

Mepba H.D., Eboh L. & Nwaojigwa S.U. 2007. Chemical composition, functional and baking properties of wheat-plantain composite flours. African Journal of Food Agriculture, Nutrition and Development. 7(1): 1-22.

Narayana K. & Narasinga R.M.S. 1982. Functional properties of raw and heat processed winged bean flour. J. Food Sci. Technol. 42:1534-1538.

Nnam N.M. 2002. Evaluation of complementary foods based on maize, groundnut, pawpaw and mango flour blends. Nig. J. Nutr. Sci. 23:1-4

Ocloo F. C. K., Bansa D., Boatin R., Adom T. & Agbemavor W. S. 2010. Physico-chemical, functional and pasting characteristics of flour produced from jackfruits (Artocarpus heterophyllus) seeds. *Agriculture and Biology Journal of North America*, 1,903–908. doi:10.5251/abjna.2010.1.5.903.908

Odenigbo M.A. 2012. Knowledge, Attitudes and Practices of People with Type 2 Diabetes Mellitus in a Tertiary Health Care Centre, Umuahia, Nig. J. Diabetes Metab. 3:187-191

Ogechi U.P., Akhakhia O.I. & Ugwunna U.A. 2007. Nutritional status and energy intake of adolescents in Umuahia urban, *Nigeria. Pak. J. Nutr*. 6(6):641-646

Oke M.O. & Bolarinwa I.F. 2011. Effect of fermentation on physicochemical properties and oxalate content of cocoyam (Colocasia esculenta) flour. *Isrn Agronomy,* 2012. https://doi.org/10.5402/2012/978709

Okeke E,, Ene-obong H,, Uzuegbunam A,, Ozioko A. & Kuhnlein H. 2008. Igbo traditional food system: Documentation, uses and research needs. Pak. J. Nutr. 7(2):365-376

Okezie B.O. & Bello A.B. 1988. Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. J. Food Sci. 53:450-454Onwuka GI. 2005. Food Analysis and Instrumentation: Theory and Practice. Naphthali Prints, Lagos, Nigeria. pp. 133-137

Okpala L.C. & Okoli E.C. 2011. Nutritional evaluation of cookies produced from pigeon pea, cocoyam and sorghum flour composites. African Journal of Biotechnology, 10, 433-438

Osundahunsi O.F., Fagbemi T.N., Kesselman E. & Shimoni E. 2003. Comparison of the physicochemical properties and pasting characteristics of flour and starch from red and white sweet potato cultivars. *Journal of Agriculture and Food Chemistry,* 51, 2232-2236.https://doi.org/10.1021/jf0260139.

Paraggon Book Service, 2013. Love Doughnuts. Bath, UK: Love Food Editors, Paraggon Book Service

Rehinan Z., Rashid M. & Shah W.H. 2004. Insoluble dietary fibre components of legumes as affected by soaking and cooking processes. *Food Chem.* 85:245-249.

Rodrick D. 2008. Rising food prices: Causes and consequences. OECD Publishing. Retrievedfrom http://www.oecd.org/trade/agricultural-trade/40847088.pdf

Sanful R.E. & Darko S. 2010. Production of cocoyam, cassava and wheat flour composite rock cake. *Pakistan Journal of Nutrition,* 9, 810-814.

Shrestha R. & Srivastava S. 2017. Functional properties of finger millet and banyard millet flours and flour blends. *International Journal of Scientific Research* (Ahmedabad, India), 6(6), 775-780.

Shewry P.R. & Halford N.G. 2002. Cereal seed storage proteins: structures, properties and role in grain utilization. Journal of Experimental Botany.53, 947 958.https://doi.org/10.1093/jetbox/53.370.947

Šramková Z., Gregová E. & Šturdík E. 2009. Chemical composition and nutritional quality of wheat grain. Acta *Chimica Slovaca*, 2(1), 115-138. https://doi.org/10.9790/2402-1208012428

SRID 2015. Statistical, research and information directorate. Accra, Ghana: Ministry of Food and Agriculture

Van Ittersum M.K., Van Bussel L.G., Wolf J., Grassini P., Van Wart J., Guilpart N., Claessens, L., de Groot H., Wiebe K., Mason-D'Croz D. & Yang H. 2016. Can sub-Saharan Africa feed itself? Proceedings of National Academy of Science, 113, 1496414969. https://doi.org/10.1073/pnas.1610359113.

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:184-192

Comparative Analysis of Phenolic Content and Chemical Composition of Agro-industrial By-products of Citrus Species

Oyinkansola Olubunmi OLOWU[1], Sema Yaman FIRINCIOĞLU[2*]

[1,2]Department of Animal Production and Technologies, Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, Niğde, Turkey

[*]Corresponding author: semayaman@ohu.edu.tr

ORCID: 0000-0003-3005-1135[1], 0000-0001-9575-9981[2]

Abstract

Comparative analysis of phenolic content and nutritive value for agro-industrial by-products (peel and pomace) of *Citrus aurantıım* (Bitter orange), *Citrus paradisi* (Grapefruit), *Citrus reticulata* (Mandarin), *Citrus limon* (Lemon), and *Citrus sinensis* (Sweet orange) was done. All samples for phenolic content were extracted with 70% ethanol and absorbance reading taken at 765nm and nutritive value was also assessed by chemical analysis. The phenolic content of the five citrus peels significantly differed at P<0.01 from pomaces. Phenolic content from highest to lowest for peels was grapefruit > mandarin > lemon > bitter orange > orange while for pomaces, bitter orange > grapefruit > mandarin > lemon >orange. The principal component analysis showed that the phenolic content of citrus species had no correlation with the nutritive value hence they are non-dependent parameters. In addition, the dry matter of the citrus species was the most important component of the nutritive value. This study showed the high variation of the quality parameters (phenolics content and nutritive value) of citrus species among varieties and countries. Meta-analysis of quality parameters of citrus species is recommended to underpin the broad effects of fruit sourcing, maturation, genetics, sample preparation, extraction solvents and laboratory techniques on the agro-industrial by-products.

Keywords: Agro-industrial; Chemical Composition; Citrus; Phenolics; Principal Component Analysis

Research article
Received Date: 7 October 2021
Accepted Date: 10 November 2021

INTRODUCTION

Citrus agro-industrial by-products

Citrus seeds, peels and pulps constitute mainly citrus agro-industrial by-products obtained from the about 50% industrially processed citrus fruits (Zema, 2018). All in the Rutaceae family, orange, lemon, grapefruit and mandarin are industrially important citrus species (Rafiq et al., 2018; Satari and Karimi, 2018) among the world citrus producing countries, and Turkey is included (FAO, 2016; Uzun and Yesiloğlu, 2012).

Citrus agro-industrial by-products are produced in significantly large quantities that pose a major burden on the environment and management cost to the industries hence the need for economically viable and sustainable waste management options such as utilization for animal feeds (Zema, 2018).

Improving Animal Nutrition

Using citrus agro-industrial by-products for improved nutrition and production of animals is growing interest (Volanis and Zoiopolous, 2003) although this is currently being sub-optimally utilized considerably due to low economic capacity, skill, and infrastructure particularly in the low to middle-income countries (Tayengawa and Mapiye, 2018). In addition to these, there are knowledge gaps in the phenolic and nutritive value as it relates to improving animal nutrition.

Knowledge Gap

Fruits contain many phenolic compounds- flavonoids, lignans, stilbenes, and phenolic acids (Manach et al., 2004) and some of these are found in the citrus peels and less in the pulp (Singh et al., 2020). Most studies focus on either peels or pulps of citrus however, their agro-industrial wastes are neither peels nor pulps alone but pomaces, a mix of peels and some pulps. Table 1 shows the phenolic content variations across five different species as this study focused. Reporting the phenolic content is a function of the calibration standard (Valencia-Avilés, et al., 2018) and extraction solvent plays a vital role in the phenol content (Hegazy and Ibrahim 2012). It’s noteworthy that agro-climatic conditions of the environments where that citrus species are sourced are an important factor in the phenolic content in the citrus species (Singh et al., 2020). What remained unknown was if citrus species obtained for this study had different phenolic contents as previously reported and how the peels differed from the pomaces in the five citrus species examined.

Some studies of citrus species showed that dry matter for peels and pomaces ranged between 87 to 97%. Reported crude ash content was 1-10%, crude protein (2.8-9.5%), crude fiber (6-14%), and ether extract (0.5-5%) (Atta and El Shenawi, 2012; Beyzi et al., 2018; Castrica et al., 2019; El-ghfar et al., 2016; Figuerola et al., 2005; Ghanem et al., 2012; Gorinstein et al., 2001; Bejar et al., 2011; Lashkari and Tagizadeh, 2013; Marin et al., 2007; Magda et al., 2008; M’hiri et al., 2015; Nagarajaiah and Prakash, 2016; Özkan et al., 2017; Palangi et al., 2013; Vlaicu et al., 2020). The nutritive value variations may be associated with fruit source and maturation in addition to analytic techniques (Ammerman and Henry, 1991; Olowu and Yaman Fırıncıoğlu, 2019).

Despite these reports on phenolics and chemical composition, there is a gap of knowledge on how the chemical composition of many citrus species correlate with the phenolics as Rehman et al. (2020) is one of the very few to have comparatively assessed the total phenolics within different varieties of certain citrus species using the principal component analysis.

Table 1. Reports of Phenolic Contents Based on Ethanol Extract

SN	Citrus Species	Variety	Sample	Country	Phenolic content	Reference
1	*Citrus sinensis*	Hamlin	Pulp	Pakistan	222.3 (mgGAE/g)	Rehman et al (2020)
	Citrus sinensis	Red blood Succuri	Pulp		207.0 (mgGAE/g)	
	Citrus sinensis		Pulp		243.3 (mgGAE/g)	
2	*Citrus sinensis*		Peel	Sudan	35.6 (mgGAE/g)	Sir Elkhatim et al. (2018)
3	*Citrus sinensis*	Baladi	Peel	Egypt	169.50 (mgGAE/g)	Hegazy and Ibrahium (2012)
4	*Citrus sinensis*	Novel	Peel	Egypt	559.32(mgTAE/100g FW)	El-aal and Halaweish (2010)
5	*Citrus paradise*	Macfed	Pulp	Pakistan	165.6 (mgGAE g)	Rehman et al (2020)
6	*Citrus paradise*		Peel	Sudan	77.3 (mgGAE/g)	Sir Elkahatim et al. (2018)
7	*Citrus aurantium*		Pulp	Pakistan	158.9 (mgGAE/g)	Rehman et al (2020)
8	*Citrus aurantium*		Peel	Turkey	487 (mgGAE/10g)	Ersus and Can (2007)
9	*Citrus reticulata*		Pulp	Pakistan	180.6 (mgGAE/g)	Rehman et al (2020)
10	*Citrus limon*		Peel	Sudan	49.8 (mgGAE/g)	Sir Elkahatim et al. (2018)
11	*Citrus limon*		Peel	Israel	190 (mgChA/100g FW)	Gorinstein et al. (2001)
12	*Citrus reticulata*		Peel	Israel	179 (mgChA/100g FW)	Gorinstein et al. (2001)
13	*Citrus paradisi*		Peel	Portugal	155 (mgChA/100g FW)	Guimarães et al. (2010)

Study Objectives

This study had three clear objectives. Firstly, phenolic content of the peels and pomace samples of *Citrus sinesis* (sweet orange), *Citrus limon* (lemon), *Citrus reticulata* (mandarin), *Citrus paradisi* (grapefruit), and *Citrus aurantium* (bitter orange) were evaluated. Secondly, chemical composition assessments were carried out, and lastly, a comparative analysis was done on the phenolic content and chemical composition of the *Citrus* species.

MATERIAL and METHOD

Commercially mature *Citrus sinesis* (sweet orange), *Citrus limon* (lemon), *Citrus reticulata* (mandarin), *Citrus paradisi* (grapefruit), and *Citrus aurantium* (bitter orange) were obtained. Peels and pomaces samples were cut into pieces, oven-dried at 50ºC for 48 h, and finely grounded using a 1mm sieve in a Retsch ZM 200 laboratory mill. (AOAC, 1995). All procedures were carried out in the animal nutrition laboratory of the Faulty of Agricultural Science and Technologies in Niğde Ömer Halisdemir University, Turkey.

Phenolic Content Assessment

Folin-Ciocalteu's reagent method (Waterhouse, 2001) for the assessment of phenolic content was adapted in this study. Sample extracts (2.5ml) and 70% ethanol was used to prepare 25ml stocks and sample dilutions were done. In duplicates, 100µl of the sample dilutions were marked up with distilled water (900µl), Folin-Ciocalteu reagent (5ml), and sodium carbonate (4ml). These samples were vortexed, stored in the dark for 2 h and at 765nm, a UV spectrophotometer was used to measure the absorbance for each *Citrus* sample. Gallic acid calibration curve was determined (R^2 =0.9959) and phenolic contents of the samples were expressed as mg GAE/g.

Chemical Composition Assessment

Dry matter, crude ash, and crude protein analysis by the Kjeldahl method (AOAC, 1995) were carried out in duplicates on peels and pomaces samples of five Citrus species- (bitter orange, grapefruit, lemon, mandarin, and orange). Van Soest's (1991) method was used to assess the neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents of peels and pomaces.

Statistical Analysis

With the JAMOVI, R-based statistical package (Jamovi project, 2021), analysis of Variance (ANOVA) was done to determine the statistical significance ($P \leq 0.01$) of the phenolics concentrations and principal component analysis (PCA) were done to compare the phenolic concentrations to the chemical composition obtained.

RESULTS and DISCUSSION

Phenolic Content Assessment

Each Citrus species is significantly different from the other ($P <0.01$). Notably, pomaces of bitter orange, grapefruit, mandarin, and orange showed far higher concentrations of phenolics than their peels. Also, all the pomaces samples of the five Citrus species significantly differ from the peels except the lemon (peels and pomaces), mandarin (peels and pomaces), and orange pomace which did not significantly differ from each other ($P> 0.05$). In order of phenolic concentration among the citrus peels, grapefruit > mandarin > lemon > bitter orange > orange and for pomaces, bitter orange > grapefruit > mandarin > lemon >orange. *Citrus sinensis* (orange) had the lowest phenolic content for both peels and pomaces while bitter orange pomaces expressed the highest phenolic contents which significantly differed from the bitter orange peels (Figure 1).

In this study, results had been expressed in mg GAE/ g given that gallic acid was the calibration differently from mg TAE/ 100g (El-aal and Halaweish, 2010) having calibrated with tannin and mg ChA/100g (Gorinstein et al., 2001) with a chlorogenic acid calibration. Calibration standards may be reported with the standard used or re-evaluated with any other standard given that reactions leading to phenolic content estimates are independent, quantitative, and predictable (Singleton et al., 1999).

Citrus sinensis (Orange) peel (277.2 mg GAE/ g) in this study had higher phenolic content than in Hegazy and Ibrahim (2012) and much lower (35.6 mg GAE/ g) was reported by Sir Elkahatim et al., (2018). Similarly, orange pomace had higher phenolic content (462.8 mg GAE/ g) compared to all three orange varieties reported by Rehman et al. (2020).

The phenolic content of *Citrus reticulata* (mandarin) in this study is significantly higher than Gorinstein et al., (2001). Although the phenolic content of the mandarin pomace did not significantly differ from the peel, it was higher than the mandarin pulps reported by Rehman et al., 2020. Citrus reticulata (lemon) peels had a higher phenolic concentration than Gorinstein et al. (2001) who reported 179 mg ChA/ 100g. Similarly, 180.6 mg GAE/g in lemon pulp (Rehman et at., 2020) was lower than both lemon peel and pomace in this study. Prior reports of Citrus paradisi (grapefruit) peel and pomace differed from results obtained in this study as phenolic contents of grapefruit peels and pomaces were found to be significantly higher than as previously reported (Sir Elkahatim et al., 2018; Rehman et al., 2020). Citrus aurantium (bitter orange) in this study stands out differently from the reports of Ersus and Cam (2007) (487 mg GAE/ 10g for peels) and Rehman et al., (2020) (158.9 mg GAE/ g for pulp).

The difference in phenolic contents may be attributed to the effect of agro-climatic conditions on fruit quality (Hussain et al., 2017; Singh et al., 2020) given the difference in the agro-ecological zones of Egypt, Israel, Pakistan, Portugal, Sudan, and Turkey as reported by the previous studies. For instance, Washington navel orange grown in the Mediterranean climate (cool and wet winters; hot and dry summers) similar to Adana, Antalya, and Izmir- the top three provinces with high production of citrus in Turkey (Yesiloğlu et al., 2007) has been reported to have higher fruit qualities compared to those grown in coastal to desert areas (Davies and Albrigo, 1994; Zekri, 2011). In addition, these results further agree with the variations in parameters that have been associated with fruit source and maturation in addition to analytic techniques (Ammerman and Henry, 1991; Olowu and Yaman Fırıncıoğlu, 2019).

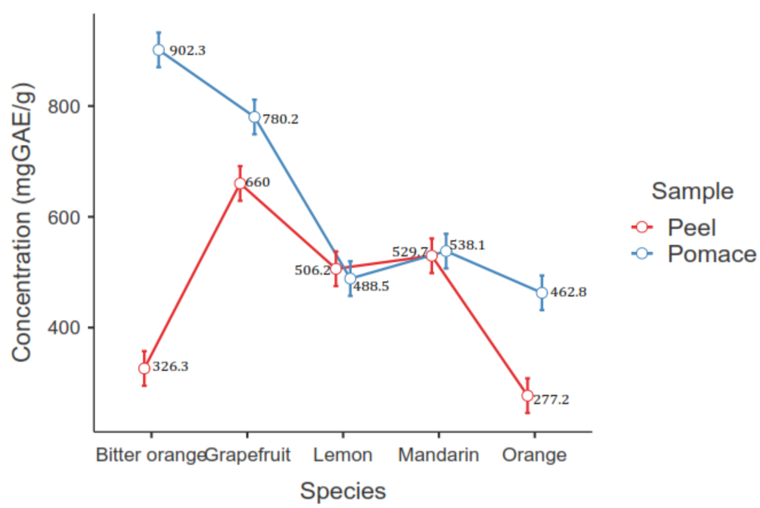


Figure 1. Analysis plot showing from highest (bitter orange pomaces) to lowest (orange peels) the different (P <0.01) phenolic concentrations of the peels and pomaces for the five *Citrus* species- grapefruit peel; grapefruit pomace; lemon peel; lemon pomace; mandarin peel; mandarin pomace; orange pomace.

Comparative Analysis of Phenolic Content and Chemical Composition

The principal component analysis (PCA) showed high variability between the phenolic content and the chemical composition of the citrus species assessed in this study (Figure 2). Dry matter is generally attributed as the most important determinant component of available soluble carbohydrates (Lashkari and Taghizadeh, 2013; Mamma and Christakopoulos, 2014). Although, ash content was positively correlated to dry matter, acid detergent fiber and neutral detergent fiber were less correlated with the dry matter. Ash content is indicative of available minerals for animal nutrition (Shariff et al., 2021) and is as important as the dry matter for the delivery of minerals. Crude protein also showed a low correlation to other chemical components despite being an important parameter in the feed composition.

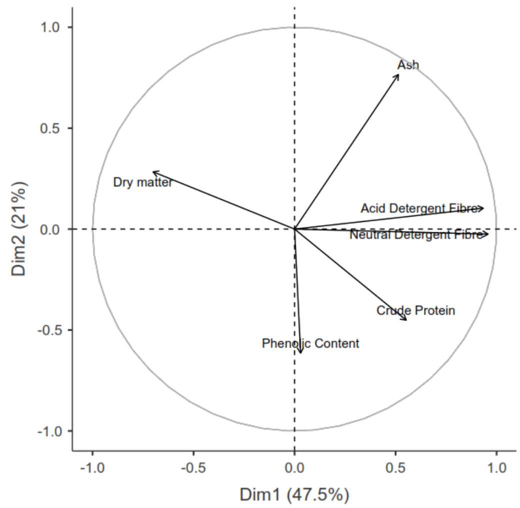


Figure 2. Result of PCA analysis showing three principal components (dry matter; ash, ADF; NDF, CP, and phenolics) that comparatively assesses phenolic content and chemical components (dry matter, ash, acid detergent fiber, neutral detergent fiber, and crude protein) of the *Citrus* species in this study

CONCLUSION

In this study, there is no correlation between chemical composition and phenolics of peels and pomaces of different citrus species. The importance of phenolics and chemical composition has been established by several authors and in this study as well. Noteworthy are the variations in the quality parameters of *Citrus species* by different studies and regions of the world which have mostly been attributed by researchers to effects of fruit sourcing, maturation, genetics, sample preparation, extraction solvents, and laboratory techniques. The limitation, however, is the determination of the major effect driving variation of quality parameters by the conventional experimental methods hence the need to further study this through a meta-analysis approach. Meta-analysis of the effect of quality parameters in *Citrus species* is recommended to provide an in-depth understanding of the variations and perhaps what to do differently when considering citrus agro-industrial by-products for enhanced animal nutrition.

ACKNOWLEDGEMENT

This study quoted from a part of the MSc thesis of Oyinkansola Olubunmi Olowu

REFERENCES

Ammerman C. B. & Henry P. R. 1991. Citrus and vegetable products for ruminant animals, *Proceedings, Alternative Feeds for Dairy and Beef Cattle, National Invitational Symposium, St. Louis, MO* 103–110.

Association of Official Analytical Chemists (A.O.A.C). 1995. *Official Methods of Analysis*, Washington. *DC* 15.

Atta M.B. & El- Shenawi G.M. 2012. Extraction of natural antioxidant from flavedo layer of Bitter orange (*Citrus aurantium*) peel, *CBAA, International Biotechnology Applications in Agriculture.* Benhar University, Moshtohor and Hurghada, Egypt 2, 51-59.

Bejar A.K., Ghanem N., Mihoubi D., Kechaou N. & Boudhrioua Mihoubi N. 2011. Effect of Infrared Drying on Drying Kinetics, Color, Total Phenols and Water and Oil Holding Capacities of Orange (Citrus sinensis) Peel and Leaves, *International Journal of Food Engineering*, 7(5).

Beyzi S., Ulger I., Kaliber M. & Konca Y. 2018. Determination of chemical, nutritional and fermentation properties of citrus pulp silages, *Turkish Journal of Agriculture Food Science and Technology 6*, 1833.

Castrica M., Rebucci, R., Giromini, C., Tretola, M., Cattaneo D. & Baldi A. 2019. Totalphenolic content and antioxidant capacity of agri-food waste and by-products, *Italian Journal of Animal Science 18*(1), 336–341.

Davies F.S. & Albrigo L.G. 1994. Environmental constraints on growth, development and physiology of citrus, *In Citrus, 1 ed. (CAB International),* 52–82.

El-aal H. A. & Halaweish F. T. 2010. "Food preservative activity of phenolic compounds in orange peel extracts (*Citrus sinensis* L.)", *Lucrari Stiintifice, 53*, 233–240.

El-ghfar, M. H. A. A., Ibrahim, H. M., Hassan, I. M., Abdel Fattah A. A. & Mahmoud M. H.2016. "Peels of Lemon and Orange as Value-Added Ingredients: Chemical and Antioxidant Properties", *International Journal of Current Microbiology and Applied Sciences 5*(12), 777–794.

Ersus S. & Cam M. 2007. Determination of Organic Acids, Total Phenolic Content, and Antioxidant Capacity of Sour Citrus Aurantium Fruits, *Chemistry of Natural Compounds*, 43(5).

Food and Agriculture Organization (FAO), 2016. Citrus fruit fresh and processed, *Statistical Bulletin*, 2016

Figuerola F., Hurtado, M. L., Estevez, A. M., Chiffelle I. & Asenjo F. 2005. "Fiber concentrates from apple pomace and citrus peel as potential fiber sources for food enrichment" *Food Chemistry 91*(3), 395–401.

Ghanem N., Mihoubi, D., Kechaou N. & Mihoubi N. B. 2012. Microwave dehydration of three citrus peel cultivars: Effect on water and oil retention capacities, color, shrinkage, and total phenols content, *Crops and Products 40*, 167–177.

Gorinstein S., Martín-Belloso, O., Park, Y.-S., Haruenkit, R., Lojek, A., Ĉíž, M., Caspi, A., Libman I. & Trakhtenberg S. 2001. "Comparison of some biochemical characteristics of different citrus fruits", *Food Chemistry 74*(3), 309–315.

Guimarães R., Barros, L., Barreira, J. C., Sousa, M. J., Carvalho A. M. & Ferreira I. C. 2010. Targeting excessive free radicals with peels and juices of citrus fruits: Grapefruit, lemon, lime and orange, *Food and Chemical Toxicology*, *48*(1), 99–106.

Hegazy A. E. & Ibrahim M. I. 2012. Antioxidant activities of orange peel extracts. *World Applied Sciences Journal, 18*(5), 684–688.

Hussain S.B., Anjum M.A., Hussain S., Ejaz S. & Kamran H.M. 2017. Agro-climatic conditions affect fruit quality of mandarin (*Citrus reticulata* Blanco) cultivars. *International Journal of Tropical and Subtropical Horticulture*.

Lashkari S. & Taghizadeh A. 2013. Nutrient digestibility and evaluation of protein and carbohydrate fractionation of citrus by-products, *Journal of Animal Physiology and Animal Nutrition 97*(4), 701–709.

Magda R.A., Awad A.M. & Selim K.A. 2008. Evaluation of mandarin and orange peels as natural sources of antioxidant in biscuits, *Journal of Food Science and Technology* 75–82.

Mamma D. & Christakopoulos P. 2014. Biotransformation of citrus by-products into value added products, *Waste and Biomass Valorization 5*(4), 529–549.

Manach C., Scalbert A., Morand C., Remesy C. & Jimenez L. 2004. Polyphenols: food sources and bioavailability. *The American Journal of Clinical Nutrition*, 79:727-747.

Marin F. R., Soler-Rivas C., Benavente-García O., Castillo J. & Pérez-Alvarez J. A. 2007. By-products from different citrus processes as a source of customized functional fibers, *Food Chemistry 100*(2), 736–741.

M'hiri N., Ioannou I., Ghoul M. & Boudhrioua N. M. 2015. Proximate chemical composition of orange peel and variation of phenols and antioxidant activity during convective air drying, *Journal of New Sciences*, *AT*.

Nagarajaiah S. B. & Prakash J. 2016. "Chemical composition and bioactivity of Pomace from Selected Fruits", *International Journal of Fruit Science 16*(4), 423–443.

Olowu O.O & Yaman Fırıncıoğlu S. 2019. Feed Evaluation Methods: Performance, Economy and Environment, *Eurasian Journal of Agricultural Research* 3 (2), 48-57.

Özkan Ç. Ö., Kaya E., Ülger İ., Güven İ. & Kamalak A. 2017. Effect of species on nutritive value and methane production of citrus pulps for ruminants, *Hayvansal Üretim 58*(1), 8–12.

Palangi V., Taghizadeh A. & Sadeghzadeh M. K. 2013. Determine of nutritive value of dried citrus pulp various using in situ and gas production techniques, *Journal of Biodiversity and Environmental sciences* 3(6), 8-16.

Rafiq S., Kaul R., Sofi S. A., Bashir N., Nazir F. & Ahmad Nayik G. 2018. Citrus peel as a source of functional ingredient: A review, *Journal of the Saudi Society of Agricultural Sciences 17*(4), 351–358.

Rehman U. S., Abbasi S.K., Quayyum A., Jahangir M., Sohail A., Nisa S., Tareen M.N., Tareen M.J. & Sopade P. 2020. Comparative analysis of citrus fruits for nutraceutical properties. *Food science and Technology*, Campinas, 40 (Suppl. 1): 153-157. Doi: https://doi.org/10.1590/fst.07519

Satari B. & Karimi K. 2018. Citrus processing wastes: Environmental impacts, recent advances, and future perspectives in total valorization, *Resources, Conservation and Recycling 129*, 153–167.

Shariff A. H., Wahab P. Z., Jahurul A.H., Romes N. B., Zakaria M., Roslan J., Wahab R.A. & Huyop F. 2021. Nutrient composition, total phenolic content, and antioxidant activity of tropical Kundasang-grown cucumber at two growth stages, *Chilean Journal of Agricultural Research.* 81(2).

Singleton V. L., Orthofer R. & Lamuela-Raventos R. M. 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu Reagent. *Methods in Enzymology***,** 299, 152-178.

Singh B., Singh J.P., Kaur A. & Singh N. 2020. Phenolic composition, antioxidant potential and health benefits of citrus Peel, *Food Research International* 132.

Sir Elkhatim K.A., Elagib R.A.A. & Hassan A.B. 2018. Content of phenolic compounds and vitamin C and antioxidant activity in wasted parts of Sudanese citrus fruits. *Food Science and Nutrition*, 6:1214–1219. https://doi.org/10.1002/fsn3.660

Tayengwa T. & Mapiye C. 2018. Citrus and winery wastes: Promising dietary supplements for sustainable ruminant animal nutrition, health, production, and meat quality, *Sustainability* 10(10), 3718, 2018.

The jamovi project. 2021. jamovi.(Version1.8)[Computer Software].Retrieved from https://www.jamovi.org

Uzun A. & Yesiloglu T. 2012. Genetic Diversity in Citrus, Genetic Diversity in Plants. Published byInTech . ISBN : 978-953-51-0185-7

Valencia-Avilés E., García-Pérez M. E., Garnica-Romo M. G., Figueroa-Cárdenas J.D., Meléndez-Herrera E, Salgado-Garciglia R. & Martínez-Flores H. E. 2018.Antioxidant Properties of Polyphenolic Extracts from Quercus Laurina, Quercus Crassifolia, and Quercus Scytophylla Bark, *Antioxidants 7*(7),81. https://doi.org/10.3390/antiox7070081

Van Soest P.J, Robertson J.D. & Lewis B.A. 1991. Methods for dietary fiber, and neutral detergent fiber and non-starch polysaccharides in relation to animals' nutrition, *Journal of Dairy Science* 74, 3583-3597.

Vlaicu Petru Alexandru., Untea A. E., Panaite T. D. & Turcu R. P. 2020. Effect of dietary orange and grapefruit peel on growth performance, health status, meat quality and intestinal microflora of broiler chickens, *Italian Journal of Animal Science*, 19(1), 1394–1405.

Volanis M. & Zoiopoulos P. 2003. Effects in utilizing locally available agro-industrial by-products and crop surpluses in dairy sheep feeding, *EAAP book of Abstracts*, *Rome*, *Italy* 9, 345.

Waterhouse A. L. 2001. Determination of total phenolics. In R. E. Wrolstad (Ed.), *Current protocols in food analytical chemistry*. New York, NY: John Wiley and Sons.

Yesiloglu T., Emeksiz F., Tuzcu O. & Alemdar T. 2007. Safe and high quality supply chains and networks for the citrus industry between Mediterranean partner countries. National citrus sector analysis: Turkey. *EuroMedCitrusNet*. P39.

Zekri M. 2011. Factors affecting citrus production and quality. *Citrus Industry 92*, 6–9.

Zema D.A., Calabro P.S., Folina A., Tamburino V., Zappia G. & Zimbone S.M. 2018. Valorisation of citrus processing waste: A review, *Journal of Waste management* 80, 252-273

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:193-202

Investigation of the Efficiency of Some Methods Used in the Estimation of Basin Water Yield

Erhan GÖÇMEN[1*], Ahmet İSTANBULLUOĞLU[2]

[1,2]*Department of Biosystem Engineering, Agricultural Faculty, Tekirdag Namık Kemal University, Tekirdağ, 59030, Turkey.*

[*]*Corresponding author:* egocmen@nku.edu.tr

ORCID: *0000-0001-6199-7842[1], 0000-0001-8080-0152[2]*

Abstract

Computing flood discharge of a watershed reliably is of great importance in the design of hydraulic structures. Many empirical methods used for this purpose produce different results. Therefore, methods taking regional climatic conditions and watershed characteristics should be employed. In this study, effectiveness of unitless Turc, Mc Math and Rational methods were investigated through comparing the calculated surface run off from these methods to the directly measured values and also calculated values of an individual methods to those of the others. Using Turc Method, which also includes coefficient suggested for the regional similar sub-basins, water yields were underestimated in comparison to the other methods. Having considered all the calculated and measured results, empirical methods with the new optimised coefficients representing the regional conditions were suggested in order to build reliable hydraulic structures and their spillways. In this way, total cost will be decreased and, on the top of that, the lives and properties will be secured.

Keywords: Edirne, hydrology, hydraulic structures, basin water yield

Research article
Received Date: 8 Novemberr 2021
Accepted Date: 10 December 2021

INTRODUCTION

The importance of water for all living things is known by everyone. The main ingredient of all living things is water. Increasing world population, changing climate conditions and economic activities are growing with each passing day makes it more important than water (Bağdatlı and Bellitürk, 2016). The efforts of people to benefit from water and to protect it from harm started in the early ages. Rich civilizations were established by utilizing water resources. If these resources are used in a disproportionate and irresponsible way, or if their damage cannot be controled, great disasters have occurred. In our age, benefiting from water resources has become much more important. The country's precipitation generally falls in the winter and spring months, and the summers are very dry. Although there is an excessive need for water in the summer months, the streams whose flow increases in the winter and spring are not utilized.

Global warming and climate change gradually reduce available water resources for irrigation in various parts of the world. Increasing domestic and industrial water demands are also reducing available water resources (Uçak and Bağdatlı, 2017). The Thrace region is the place where the industry and population increase is the most in Turkey. It is stated that the population will reach 32,8 million in 2050 and its current resources will be sufficient only for drinking and utility water after 2060 (Istanbulluoğlu et al., 2007). The fact that precipitation, which is of vital importance for living creatures around the world, tends to decrease especially in the seasons when rain is frequent will cause water resources to decrease (Bağdatlı and Arslan, 2019). In parallel with climate change, water resources the emergence of change also manifests itself as a result that cannot be ignored (Bağdatlı et al., 2014a). Soil and water resources potentials are one of the most important factors that shape the agricultural course of a Region (Bağdatlı et al., 2014b). Considering all these mentioned, the protection and development of water resources is very important for the future.

Various water structures, especially dams and ponds, are facilities that store, swell and canalize water so that it can be used for various purposes. The design of these structures, on the other hand, requires knowing the basin water yields. Currently, these estimates are made using empirical methods developed by the United States (US) Soil Conservation Service (SCS). The validity of these methods developed in the US conditions for the conditions of a certain region of our country is a matter of debate and has not yet been proven by research. However, there are many studies on a regional basis for the estimation of basin water yield. (Hawley and McCuen 1982, Karaş 1997, Demiryürek et al., 1999, Istanbulluoglu et al., 2002, Sadati et al., 2014, Rawat et al., 2021).

This study aims to overcome the problem encountered in the estimation of basin water yield in the water structures to be built in the rural areas of Edirne province in the Thrace Region and their spillway planning, by using which empirical method. For this, three sub-basins with different sizes were selected as research areas, and the application of Turc, Mc Math, and Rational methods was carried out.

MATERIAL and METHOD

Material

The research basins are located at a distance of 10 km to the northeast of the central of Edirne province in the Thrace Region. The basins, whose altitude is between 55 and 154 m above sea level, are between 26°40'- 26°45' east longitudes and 41°35'–41°45' northern latitudes. The basins consist of three sub-basins with different sizes. These are the Subaşı, Musabeyli and Kumdere Basins. Edirne province is generally under the influence of continental climate. Figure 1 shows the map of the area where the study was carried out.

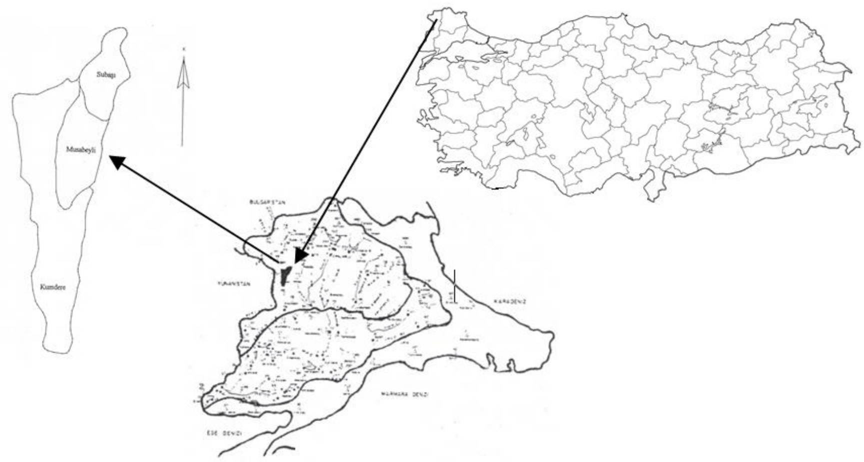


Figure 1. Research area

In terms of climate characteristics, the research basin is cold and rainy in winters and hot and dry in summers. Almost all of the precipitation in the region is in the form of rain, and according to annual averages, the number of days with snowfall is 9 and the number of days covered with snow is 17 days. Some annual and monthly average climate data of Edirne province are shown in Table 1.

Table 1. Some annual average climate data of Edirne province (DMI, 1984; 2004)

Months	Avarage temperature (°C)	Average relative humidity (%)	Wind speed (m s^{-1})	Total precipitation (mm)	Total evaporation (mm)	Sunshine duration (hour)
January	2,1	81	2,0	65,6	19,2	2,36
February	3,9	77	2,3	49,0	27,4	3,53
March	7,1	73	2,2	47,7	48,1	4,48
April	12,6	68	1,9	49,2	72,9	6,41
May	17,9	67	1,6	50,1	92,9	8,29
June	22,0	63	1,5	51,3	116,5	9,52
July	24,4	56	1,6	31,9	158,6	11,27
August	23,9	56	1,6	24,2	159,1	10,52
September	19,6	63	1,4	33,8	108,4	8,26
October	14,2	73	1,4	56,7	64,5	5,55
November	9,3	81	1,5	70,6	31,5	3,26
December	4,4	83	1,9	73,6	23,5	2,28
Yearly	13,5	70	1,7	603,7	922,5	6,34

The majority of the soils of the research basins are Limeless Brown, and only a few of them are made up of Vertisol large soil groups. The soils in the basins are deep, the topography of the basins is moderately sloping (6-12%) and has a corrugated structure. Most of the basins are third class land (Anonymous, 1984). Basin characteristics are parameters that have very important contributions, especially in comparing one basin with another. These are geomorphological such as area, shape, slope; hydrogeological such as stream shape, seepage; pedological characteristics such as soil physics and vegetation. Some basin characteristics and their values in the research basins are shown in Table 2 collectively.

Table 2. Some basin characteristics used to define the research basins

Basin characteristics	Basins		
	Subaşı	Musabeyli	Kumdere
Basin area, A (km^2)	4,4	10,2	27,3
Basin perimeter, P (km)	9,5	16,8	31,3
Basin length, L_H (km)	3,5	7,4	13,0
Basin width, W_H (km)	2,0	2,0	4,0
Basin maximum height, hmax (m)	154	154	154
Basin lowest height, hmin (m)	115	85	55
Basin relief, r (m)	39	69	99
Basin relative relief, r_n (%)	0,41		
Basin direction	North-South	North-South	North-South
Average height of the basin, hort (m)	140		
Basin median height, h_{med} (m)	135		
Basin mean slope, S_H (%)	4,0		
Figure index depending on the main stream path, S_1	2,7		
Length of main stream road, L (km)	3,6	7,8	14,5
The length of the basin center of gravity to the basin exit point, L_c (km)	1,9	3,7	8,4
Main stream road profile slope, S_s (%)	1,3		
Main stream path harmonic slope, S (%)	0,9	0,8	0,7

Edirne province has 627.595 hectares of land. Of this, 446.105 ha (71,1%) is cultivated land, 349.077 ha is dry fallow, 90.032 ha is irrigated, and the rest is vineyard-orchard farming. 117.888 ha (18,8%) of the province's land is covered with forest-heathland and 44.229 ha (7,1%) is covered with meadow-pasture areas (Anonymous, 1993). Wheat, sunflower and rice come to the fore in the plant production of the province. These products are produced in approximately 92% of the cultivated lands. Modern agricultural practices are carried out throughout the province. Animal husbandry is another important agricultural activity in the province, and high-yielding cultural breeds dominate the animal population (Anonymous, 2004).

Fallow dry farming is practiced in all the lands of the research basins. The dominant crop pattern is wheat–sunflower rotation system. In the plant rotation system, wheat is the plant that is predominantly planted.

Among the research basins, which have different sizes within themselves, the Subaşı basin is the smallest and upstream. There are a total of three precipitation stations, two of which are in this basin and one very close to the basin, and one flow station to measure the surface runoff at the exit of the basin.

The distribution of precipitation in place and time was monitored by placing a pulviograph at a height of 115 m at the outlet of the basin, at an altitude of 145 m in the middle of the basin, and at a height of 150 m outside the basin, very close to the upper border of the basin. For runoff observations, a 110 m high 1/5 sloped triangular flume was constructed at the basin outlet. A flow meter (limnigraph) was placed on the stilling pool, which is connected to the flume with a channel, right next to the flume construction, and the time distribution of the flow passing through the stream bed was measured with the help of the flume. The measurement values recorded from the mentioned precipitation and flow stations during the years 1985-2004 (20 years) were used in the research (Bakanoğulları and Günay, 2011).

Method

In the calculation of basin water yields to be obtained from the research basins; besides the direct runoff values measured in the Subaşı sub-basin, the following empirical equations are used.

a. Direct surface flow measurement

For this purpose, a limnigraph was placed in the stilling pool connected to the 1/5 inclined triangular channel built at 110 m height at the outlet of the Subaşı basin, and the time distribution of the flow passing through the stream bed was measured. Then, the curves in these measurement records were analyzed on a daily basis and direct flow values were obtained (Bakanoğulları and Günay, 2011).

b. Turc method

The method was developed by Turc as a result of basin studies in different climatic conditions. The following equations are used to calculate the annual water yield of the basin (Özer, 1990; Shaw, 1994).

$$h = P - E \qquad \text{(Eq.1)}$$

In equation; h is the amount or height of runoff from the basin (mm); P is the annual average precipitation amount falling on the basin (mm) and E is the annual average real evapotranspiration amount (mm) from the basin. The determination of the actual evapotranspiration amount is calculated with the following equation.

$$E = \frac{P}{\sqrt{0.9 + \frac{P^2}{L^2}}} \qquad L = 300 + 25\,t + 0{,}05\,t^3 \qquad \text{(Eq.2) (Eq.3)}$$

In equation; L is the parameter and t is the annual avarage temperature (°C) of the basin. This value should be corrected by taking into account the latitude and height differences between the structure to be built in the basin and the observation station. In addition, if the 300 coefficient in the equation used to determine the L parameter is used the same for all river basins, it turns out that it will be inaccurate since it has different characteristics. In order to eliminate this, the average precipitation and runoff values of the river basins in Turkey based on the observation results were taken, this time the calculation was reversed, and different coefficients were obtained instead of the A coefficient 300 value by using the basin average temperature in the L equation. This value was stated as 285,9 for the Meriç-Ergene basin, where the research basins are located (Özer, 1990).

The annual water yield of the basin is calculated by multiplying the amount of runoff obtained by the basin area.

$$Q = h \times A \times 10^3 \qquad \text{(Eq.4)}$$

In equation; Q is the basin water yield ($m^3\ y^{-1}$) and A is the catchment area (km^2). Also, the solution can be solved by the modified Turc method using the coefficients obtained for the region from the results of multi-year direct measurements and observations made in the sub-basins of the Thrace Region in Turkey. In the equation, the coefficient of 300 in the L parameter is used as 601 (Istanbulluoglu et al., 2002).

c. Mc Math Method

This method is especially used in calculating the capacity of surface drainage channels. However, it is recommended for side streams fed by steep slopes. The method is expressed with the following equation (Kızılkaya, 1988).

$$Q = 0.0023 \times C \times I \times S^{1/5} \times A^{4/5} \qquad \text{(Eq.5)}$$

In equation; Q is the amount of runoff ($m^3\ s^{-1}$); C, flow coefficient depending on basin vegetation, soil type and topography conditions; I is rainfall intensity ($mm\ h^{-1}$) equal to the collection time of precipitation for the chosen recurrence frequency; S is the main stream course bed slope x 1000 and A is the catchment area (hectares).

The first of the procedures followed in the use of this method is to find the basin surface flow coefficient by using the basin soil, topography and vegetation. The second is to find the rainfall intensity for a precipitation period equal to the collection time in the selected recurrence period, and finally to calculate the bed slope of the basin main stream road.

d. Rational Method

This method is widely used in the capacity calculations of side streams and surface drainage channels in small basins that do not have enough observations. It is expressed by the following equation (Kızılkaya, 1988).

$$Q = 0.0028 \times C \times I \times A \qquad \text{(Eq.6)}$$

In this equation; Q, runoff ($m^3\ s^{-1}$); C is the flow coefficient depending on the basin conditions; I is the rainfall intensity ($mm\ h^{-1}$) equal to the collection time of the precipitation for the selected frequency and A is the basin area (hectares). Although the surface flow coefficient (C) in this method is different from that described in the Mc Math method, it is calculated in a similar way. However, the calculation of the rainfall intensity (I) value equal to the collection time for the selected recurrence frequency of precipitation is completely different.

RESULTS and DISCUSSION

Basin rainfall and runoff characteristics

The average of the annual total (1985-1999) precipitation values of the region was 609,6 mm. The least precipitation was 121,0 mm in 1991 and the highest precipitation was 895,7 mm in 1999. The basins received below average precipitation for fifteen years and above average precipitation for ten years. Precipitation fell mostly in autumn and winter. November was the month with the most precipitation. The precipitation regime of the basin was very similar to the annual precipitation values of Edirne province, where it is located. Because the annual precipitation values of the province are 603,5 mm.

When the total annual (1985-1999) runoff values were examined, it was observed that no runoff occurred in 1987. The highest runoff was 130,05 mm in 1999. The average total runoff amount was 21,30 mm. The runoff was highest in the autumn months, when the amount of precipitation also increased. Considering the basin rainfall-runoff relations, no relationship was observed between years or even between months. However, the amount of runoff showed a significant decrease in the spring months. The reason for this can be said to be the development in the basin vegetation.

Turc method

The directly measured surface flow values in the basins in the research area and the values obtained as a result of the application of the Turc method to these basins were compared. The water yield calculation with the Turc method was made with the coefficients that were recommended and classically applied for the Meriç-Ergene basin, where the research basin is located. The runoff heights calculated for different probability percentages for different sized research basins and their corresponding runoff volumes are shown in Table 3. The values obtained here were much higher than the runoff values directly measured from the basin.

Table 3. Water yield values to be obtained from the research basins according to the Turc method (classic)

Research basins	Probability (A = 285.9)				
	50%	60%	70%	80%	90%
Subaşı	122,6* 539.440**	102,1 449.240	82,1 361.240	61,1 268.840	36,8 161.920
Musabeyli	1.250.520**	1.041.420	837.420	623.220	375.360
Kumdere	3.346.980**	2.787.330	2.241.330	1.668.030	1.004.640

*: Runoff height (mm y^{-1})
**: Runoff volume (m^3 y^{-1})

Subsequently, runoff heights and corresponding runoff volumes were calculated by using the Turc method, which includes the coefficients obtained by using the direct runoff values measured in different basins in the Thrace Region by Istanbulluoglu et al., (2002). These values shown in Table 4 were more for 50%, 60%, and 70% probabilities, approximately for 80% probability, and less for 90% probability compared to the values measured from the basins. This means that in the ponds built so far, a larger pond volume than it should be is planned.

Table 4. Water yield values to be obtained from the research basins according to the Turc method (recommended)

Research basins	Probability (A = 601.0)				
	50%	60%	70%	80%	90%
Subaşı	59,9* 263.560**	47,1 207.240	35,0 154.000	23,3 102.520	10,0 44.000
Musabeyli	610.980**	480.420	357.000	237.660	102.000
Kumdere	1.635.270**	1.285.830	955.500	636.090	273.000

*: Runoff height (mm y^{-1})
**: Runoff volume (m^3 y^{-1})

Mc Math and Rational methods

The flow values obtained by applying McMath and Rational methods to the basins in the research area are shown separately in Tables 5 and 6 for different recurrence intervals.

Table 5. Flood flows that will occur from the research basins according to the Mc Math method

Research basins	Recurrence intervals (year)*					
	2,33	5	10	25	50	100
Subaşı	3,4	4,2	5,3	6,1	6,8	7,5
Musabeyli	7,9	9,8	12,2	14,0	15,7	17,5
Kumdere	20,5	25,6	32,9	36,5	40,9	45,3

*: All flood flows, $m^3 s^{-1}$

Table 6. Flood flows that will occur from the research basins according to the rational method

Research basins	Recurrence intervals (year)*					
	2,33	5	10	25	50	100
Subaşı	13,7	17,0	21,4	24,4	27,4	30,3
Musabeyli	38,6	48,0	60,0	68,5	77,1	85,7
Kumdere	128,4	160,5	206,4	229,3	256,8	284,4

*: All flood flows, $m^3 s^{-1}$

Although two different methods were applied to the same basins, the results obtained were very different. Because the flow values obtained from the Rational method were greater than all the values obtained from the Mc Math method. While this size was 4 times in small basins, it increased 6 times in large basins. This means that the dimensions of the water structures to be constructed using the rational method, especially the channel cross-sectional areas, will be larger. In addition, these values were much higher than the runoff values directly measured from the mentioned basins.

CONCLUSION

A total of 609,6 mm of annual precipitation (1985-1999) fell on the research basins. 21,3 mm of this precipitation left the basin as runoff. Accordingly, the basin surface flow coefficient was calculated as 0,035. This value was much smaller than the flow coefficient of 0,13 (Bayazıt, 1995) for the Meriç-Ergene basin where it is located.

The results obtained with the Turc method, in which the annual water yield of the basin is calculated, were much higher than the direct measurement results obtained from the basin. For this reason, calculations were made with the Turc equation, in which the coefficients of the Turc method were developed using directly measured surface flow data. The values obtained from here gave results close to the values obtained for 80% probability within the method calculated in practice.

For the same basins, the flood flows calculated for different recurrence intervals by McMath and Rational methods were very different from each other. Rational method always gave larger values than Mc Math method. These differences have increased as the basin areas have grown.

The fact that the basin surface flow coefficient is very small makes it necessary to store the precipitation where it falls. This requires the water storage structures to be built in the region to be planned on a sub-basin basis.

In the calculation of pond volumes, the equations containing the new coefficients proposed for the Turc method should be used. Because under these conditions, more accurate pond volumes will be obtained with the calculated watershed water yields. Most of the time, it will allow the emergence of much more economical water structures.

ACKNOWLEDGMENT

This study was produced from the Master's thesis.

REFERENCES

Anonymous, 1984. Edirne İli Verimlilik Envanteri ve Gübre İhtiyaç Raporu. Köy Hizmetleri Genel Müdürlüğü Yayınları, TOVEP Yayın No: 34/741, s. 40, Ankara. (in Turkish)

Anonymous, 1993. Edirne İli Arazi Varlığı. Köy Hizmetleri Genel Müdürlüğü Yayınları, İl Rapor No: 22, s. 74, Ankara. (in Turkish)

Anonymous 2004. Edirne İli 2004 Yılı Çalışma Raporu. Tarım İl Müdürlüğü Raporu, 57 s, Edirne. (in Turkish)

Bayazıt M., 1995. Hidroloji. İstanbul Teknik Üniversitesi, İnşaat Fakültesi yayınları, 165, İstanbul. (in Turkish)

Bağdatlı M.C. & Belliturk K., 2016. Water Resources Have Been Threatened in Thrace Region of Turkey, *Advances in Plants & Agriculture Research,* MedCrave Publishing, 4(1):227-228.

Bağdatlı M.C. & Arslan O. 2019. Evaluation of The Number of Rainy Days Observed for Long Years Due to Global Climate Change in Nevşehir / Turkey, *Recent Research in Science and Technology Journal,* (11):9-11, ISSN: 2076-5061, doi: 10.25081/rrst.2019.11.6079

Bağdatlı M.C., İstanbulluoğlu A., Altürk B. & Arslan C. 2014a. Uzun Yıllık Sıcaklık Verilerindeki Değişim Trendinin Tarımsal Kuraklık Açısından Değerlendirilmesi: Çorlu Örneği, *Düzce Üniversitesi Bilim ve Teknoloji Dergisi,* 2(1):100-107, Düzce (in Turkish)

Bağdatlı M.C., İstanbulluoğlu A. & Bayar A.N. 2014b. Toprak ve Su Kaynakları Potansiyelinin Coğrafi Bilgi Sistemleri (CBS) Yardımıyla Belirlenmesi: Tekirdağ-Çerkezköy İlçesi Uygulaması, Afyon Kocatepe Üniv. Fen ve Mühendislik Bilimleri Dergisi, 14(1):17-25, Afyon (in Turkish)

Bakanoğulları F. & Günay S. 2011. Edirne-Merkez Kumdere Havzası Yağış ve Akım Karakteristikleri (1985-2009). Gıda, Tarım ve Hayvancılık Bakanlığı Tarımsal Araştırmalar ve Politiklar Genel Müdürlüğü, TAGEM-Topraksu, 2011/126, Ankara. (in Turkish)

Demiryürek M. Tongarlak E. & Okur M. 1999. Konya-Çiftliközü Karabalçık Deresi Havzası Yağış ve Akış Karakteristikleri (Ara Rapor 1979-1999). KHGM Toprak ve Su Kaynakları Araştırma Sonuç Raporu, APK Dairesi Başkanlığı, 115, Ankara. (in Turkish)

DMİ 1984. Ortalama, Ekstrem sıcaklık ve yağış değerleri Bülteni. Başbakanlık Devlet Meteoroloji İşleri Genel Müdürlüğü yayınları, s. 678 Ankara. (in Turkish)

DMİ 2004. Bölge İlleri Ortalama ve Ekstrem Kıymetler İklim Verileri. Devlet Meteoroloji İşleri Genel Müdürlüğü (in Turkish)

Hawley M. E. & McCuen R. H. 1982. Water yield estimation in western United States. *Journal of the irrigation and drainage division*, *108*(1), 25-34.

Istanbulluoglu A., Konukcu F. & Kocaman I. 2002. Modification of Turc Method to Determine the Water Yields of Sub-Basins in Thrace Region of Turkey. Journal of Central European Agriculture, 3(1): 45-52.

İstanbulluoğlu A., Konukcu F., Kocaman İ. & Göçmen E. 2007. Trakya Bölgesi İçme ve Kullanma Suyu İhtiyacının Belirlenmesi. *Tekirdağ Ziraat Fakültesi Dergisi*, *4*(2), 187-194

Karaş E. 1997. Su Veriminin Hesaplanmasında Kullanılan Ampirik Yöntemler ve Karşılaştırılması. Uludağ Üniversitesi Ziraat Fakültesi ve Kültürteknik Derneği. 6. Ulusal Kültürteknik Kongresi Bildirileri. 620-628, Bursa. (in Turkish)

Kızılkaya T. 1988. Sulama ve Drenaj. Bayındırlık ve İskan Bakanlığı. Devlet Su İşleri Genel Müdürlüğü Yayınları, s. 390, Ankara. (in Turkish)

Özer Z. 1990. Su Yapılarının Projelendirilmesinde Hidrolojik ve Hidrolik Esaslar (Teknik Rehber). Köy Hizmetleri Genel Müdürlüğü Yayınları. s. 714, Ankara. (in Turkish)

Rawat K. S., Singh S. K. & Szilard S. 2021. Comparative evaluation of models to estimate direct runoff volume from an agricultural watershed. *Geology, Ecology, and Landscapes*, *5*(2), 94-108.

Sadati S. K. F., Heydari M., Javaheri N. & Othman F. 2014. Water yield estimation in polrudwatershed based on empirical methods and modelling in geographic information system (GIS). *Journal of river engineering*, *2*(7), 1-9.

Shaw EM. 1994. Hydrology in Practice. Chapman and Hill Press, London, 569 pp.

Uçak A. B. & Bağdatlı M.C. 2017. Effects of Deficit Irrigation Treatments on Seed Yield, Oil Ratio and Water Use Efficiency of Sunflower (Helianthus annuusL.), Fresenius Environmental Bulletin, 26(4): 2983-2991

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:203-214

A Review on the Integrated Rice-Based Cropping Systems Practices in the Philippines

Kathlyn L. QUION[1], Ulysses A. CAGASAN[2*]

[1]Bohol Island State University, Tagbilaran City, Bohol, Philippines
[2]Visayas State University, Visca, Baybay City, Leyte, Philippines

[*]Corresponding author: ulycagasan@vsu.edu.ph

Abstract

In agriculture, crop production is the main activity. The income obtained from crops may hardly be sufficient to sustain the farm family throughout the year most especially due to the varying climatic conditions, pest infestations and disease infections. Thus, assured regular cash flow is possible when the crop is combined with other enterprises or integrating other crops. However, judicious combination of enterprises is also an important consideration and keeping in view of the environmental conditions in a locality to achieve greater dividends among the produce crops. At the same time, it will also promote effective recycling of residues/wastes. Some of the rice-based cropping system applied in the country includes rice + vegetable production system, rice + off-season vegetable production system, rice + fish production system, rice + duck integration system, rice-rice cropping pattern, rice-upland crops cropping pattern, irrigated lowland farming systems and sustainable agroforest land technology. Moreover, Integrated Farming Systems provided a steady and stable income to the farmers. Thus, amelioration of the system's productivity and achieve agro-ecological equilibrium through the reduction in the build-up of pests and diseases, through natural cropping system management. Likewise, multiple cropping systems productivity is higher in termsof harvestable products per unit area per unit time than those of sole cropping systems. Thus, this practice provided higher net income by the Filipino farmers.

Keywords: Integrated farming systems, rice based cropping, yield and income

Review article
Received Date:26 September 2021
Accepted Date:23 November 2021

INTRODUCTION

All over the world, farmers work hard but do not make money, especially small farmers because there is very little left after they pay for all inputs (seeds, livestock breeds, fertilizers, pesticides, energy, feed, and labor). However, (Kumara et al. 2017) stated that the emergence of Integrated Farming Systems (IFS) enabled the development of a framework for an alternative development model to improve the feasibility of small sized farming operations in relation to larger ones. Integrated farming system (or integrated agriculture) is commonly and broadly used word to explain a more integrated approach to farming as compared to monoculture approaches.

It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as Integrated Biosystems.

This system is an interrelated set of enterprises used so that the “waste” from one component becomes an input for another part of the system, which reduces cost and improves productionSince it utilizes wastes as resources, it does not only eliminate waste, but ensures overall increase in productivity for the whole agricultural systems. It also avoids the environmental impacts caused by wastes from intensive activitiessuch as pig farming (CARDI, 2010).

One of this integrated farming system include rice based cropping system. Rice based cropping system is described as a mix of farming practices that comprises of rice as the major crop, followed by the subsequent cultivation of other crops. Inter-cropping of rice andother compatible crops is also widely practiced in this system. The concepts associated with integrated farming system (IFS) are practiced by numerous farmers throughout the globe. A common characteristic of these systems is that they have a combination of crop and livestock enterprises and in some cases may include combinations of aquaculture and trees. It is a component of farming systems which takes intoaccount the concepts of minimizing risk, increasing total production and profits by loweringexternal inputs through recycling and improving the utilization of organic wastes and crop residues (CARDI, 2010).

Today numerous Integrated Farming and Waste Management Systems or Integrated Farming System models have been developed and applied. These systems combine livestock, aquaculture, agriculture and agro-industry in an expanded symbiotic or synergistic system, so that the wastes of one process become the input for other processes, with or without treatment to provide the means of production such as energy, fertilizer, and feed for optimum productivity at minimum costs. Example of this includes: pig tractor" systems where the animals are confined in crop fields well prior to planting and "plow" the field by digging for roots, poultry used in orchards or vineyards after harvest to clear rotten fruit and weeds while fertilizing the soil. While, the cattle or other livestock allowed to graze cover crop between crops on farms that contain both cropland and pasture, water-based agricultural systems that provide way for effective and efficient recycling of farm nutrients producing fuel, fertilizer and a compost tea/mineralized irrigation water in the process. In this respect integration usually occurs when outputs (usually by-products) of one enterprise are used as inputs by another within the context of the farming systems. The difference between mixed farming and integrated farming is that enterprises in the integratedfarming systems interact eco-biologically in space and time, are mutually supportive and depend on each other (CARDI, 2010).

Advantages of Integrated Farming System include pooling and sharing of resources/inputs, efficient use of family labor, conservation, preservation and utilization of farm biomass including non-conventional feed and fodder resources, effective use manure/animal waste, regulation of soil fertility and health, income and employment generation for many people and increase economic resources. Thus, Integrated Farming System is part of the strategy in ensuring sustainable use of the natural resources for the benefit of present and future generations (Munandar et al., 2015).

Hence, this paper was conceptualized to assess the technology of integrated farming systems practices in the Philippines particularly in rice-basedcropping system, to evaluate the significance of different rice-based farming systems practiced in the Philippine agriculture, to assess the productivity of the different farming systems practiced by the farmers in the Philippines.

Goals of Integrated Farming Systems

The Goals of this Integrated Farming Systems (IFS) are to: provide a steady and stable income rejuvenation/amelioration of the system's productivity and achieve agro-ecological equilibrium through the reduction in the build-up of pests and diseases, through natural cropping system management and the reduction in the use of chemicals (in-organic fertilizers and pesticides).

Advantages of Integrated Farming Systems

It improves space utilization and increase productivity per unit area. It provides diversified products, improves soil fertility and soil physical structure from appropriate crop rotation andusing cover crop and organic compost, reduce weeds, insect pests and diseases from appropriate crop rotation, Utilization of crop residues and livestock wastes, Less reliance to outside inputs – fertilizers, agrochemicals, feeds, energy, etc. Higher net returns to land and labor resources of the farming family

Scope of Farming System

Farming enterprises include crop, livestock, poultry, fish, tree crops, plantation crops, etc. A combination of one or more enterprises with cropping, when carefully chosen, planned and executed, gives greater dividends than a single enterprise, especially for small and marginal farmers. Farm as a unit is to be considered and planned for effective integration of the enterprises to be combined with crop production activity. Integration of farm enterprisesto be combined on many factors such as soil and climatic features of the selected area, availability of resources, land, labor and capital, present level of utilization of resources. Economics of proposed integrated farming system and managerial skill of the farmer.

Components of Integrated Farming Systems

The components of Integrated Farming Systems (IFS) include crops, fish farming, poultry, pigs, cattle, sheep and goat, fodder production and kitchen gardening. The feeds derived from "alternative" crops (sugarcane, roots and leaves of cassava, leaves of nacedero, mulberry, chaya, grasses) require"alternative" farming systems. Such examples are on small-scale which are highly productive.

RESULTS AND DISCUSSION

Rice-Based Cropping System Practiced in the Philippines

Philippines is predominantly an agricultural country which is generally small-scale and dependent on manual labor. It is also characterized by varying topographies and soil types; diverse flora and fauna and a mélange of cultures in numerous communities (Zamora and de Guzman, 2012). Thirty-two percent of the total land area of the country is agricultural lands, 51 and 44% of which is arable and permanent croplands, respectively (Philippine Statistics Authority, 2014). Although, there are some commercial and semi- commercial farms, but the majority are landless farm workers and small subsistence farms with a mean area of 2.0 ha per farm. Considering the importance of the agricultural sector to the Philippine economy, it isironic that today, 66% of the poor are in agriculture, forestry and fisheries sector. Poverty incidence in the rural areas is 68% compared to only 34% in the urban areas. The poorest ofthe poor are the indigenous peoples, small-scale farmers who cultivate land received through agrarian reform, landless workers, fishers, people in upland areas and women. The highest poverty incidence is found among corn farmers (41%), rice and corn workers (36%), sugarcane farm workers, coconut farm workers, forestry workers (33%), and fishers (31%) in the coastal waters (Zamora, 2010). A viable agricultural solution to this problem is the practice of diversified and integrated farming systems (Garrett et al 2017).

The idea of biodiversity-based farming systems is not new. For centuries, farming communities have painstakingly developed resilient and bountiful agricultural systems based on biodiversity, and on their knowledge of how to work with them in equally complex biophysical and socio-cultural settings. Farmers have used diversity for food and economic security through a complex array of home garden designs, agroforestry systems and diversified and integrated lowland farming systems. It differs substantially from conventional modern agriculture in that its focus is the establishment of functional diversity in the farm, rather than monoculture. These systems are time-tested and locally adapted (Zamora, 2010). Some of the rice-based cropping system applied in the country includes rice + vegetable production system, rice + off-season vegetable production system, rice + fish production system, rice + duck integration system, rice-rice cropping pattern, rice-upland crops cropping pattern, irrigated lowland farming systems and sustainable agroforest land technology.

Palayamanan Plus

Palayamanan is a term coined from the words palayan (ricefield) and kayamanan (wealth), which refers to a field where more wealth is created based on rice as well as some other crops. In the model established at PhilRice Maligaya, the concept is translated in terms of diversified rice-based farm operations. The Palayamanan diversified farming system has been designed as an alternative system of production that may solve some of the major concerns related to intensive rice production. According to (Thorat et al., 2015), intensive rice production leads to long-term biophysical changes that threaten the ecological sustainability of farming as reflected in the loss of diversity, declining productivity, falling profitability, input inefficiencies, and environmental and health risks. All these factors have serious implications for economic sustainability (Kabir, 1999).

Productivity of most multiple cropping systems is higher in termsof harvestable products per unit area given with the same levels of management as those of sole crops. Total biomass is also higher and helps to increase sustainability of the farm, Paciello, (2015). To optimize the viability of farming, it is important to choose and mix crops. The production of rice and some cash crops are very definite as dictated by the growing conditions. In the case of vegetables, the ideal times mostly preferred. Silici, et al. (2015) mentioned that as several crops are grown, failure of onecrop to produce enough or earn enough can be compensated for by other crops. It may be necessary to alter the combinations of crops to make more efficient use of resources such as nutrients, water, and labor to restore soil fertility, or to decrease populations of pests. Some suggested techniques are staggered planting, sequential cropping, relay cropping, rotation and succession (Singh et al., 2007). According to a study conducted by Corales et al., (2005) whom documented the economic analysis of different components of palayamanan, they concluded that palayamanan model farm shows how enterprises can be integrated in the same farm so that the overall operations becomes profitable and sustainable.

Based on the data they've presented, although the animal component of the model farm has not been fully completed, it has already generated a net income of more than P11, 000 for the two cycles in one year (Table 1).

Table 1. Analysis of the animal components for one-year cycle, 2002

Animals	Gross Income (P)	Expenses (P)	Net Income (P)
Feb-June 2002			
Pigs (5 head)	19,500	11,522	7, 978
Chicken (20 head)	6,300	3,840	2,460
Sub-total	**25,800**	**15,362**	**10,438**
August-Dec. 2002			
Pigs (5 head)	15,600	16,680	(1, 080)
Chicken (20 head)	7,170	4,862	2,308
Sub-total	**22,770**	**21,542**	**1,228**
Grand Total	**48,570**	**36,904**	**11,666**

A net income of more than P10, 000 obtained during the first cycle was attributed tothe reduction in feed expenses. The vegetable surplus supplemented almost 50% of the feed consumption. The loss incurred in the surplus production of the vegetables was absorbed bythe animal component. According to Anyaehie and Areji, (2015), animal keeping extends the risk reduction strategy beyond crop production, and thus increases the potential for economic stability of the farm. During the second animal cycle (August- December), a negative income from the pig production was attributed to high feed consumption and drop in the market price. The animals were generated a certain income was still realized from the animal component. As added benefits, animals transform biomass into quality organic nutrients more quickly than the natural system. Organic fertilizers harvested from the mixture of mulch beddings. Furthermore, economic analysis of the different crop production components is also shown in Table 2.

Based on their presented data, rice as a major component of the system can still generate a lucrative income despite controlled pricing by certain sectors. Several strategies can be mostly fed with commercial feeds during the growing period because of limited feed supplement coming from the crop production component. The loss incurred in the pig production was compensated by the income derived from the chicken production; employed such as planting special rice varieties, or employing production management which command higher prices like an organic-based production system. The production of special rice varieties and an organic-based system is feasible under the diversified farming system because of the limited area. In the model farm, we planted PJ lines and the Mestizo hybrid rice, special rice varieties, coupled with an organic-based system. Normally, the command price is more than P1 premium price per kilo over the ordinary rice. Much higherbenefit can be obtained when the rice is sold as milled rice, animal manure and urine is about100 bags per cycle or 200 bags per year.

Table 2. Analysis of the crop component, 2002 (area for each component=25 ha)

Component	Yield (kg)	Gross (P)	Expenses (P)	Income (P)
Rice-Onion				
Rice	1,500	18,000	2,955	15,045
Onion	2,400	24,000	6,800	17,200
Sub-total		42,000	9,755	32,245
Rice-Fish (2 cycle)				
Rice	2750	26,250	5,500	20,750
Fish	233	8,155	3,800	4,355
Gabi	1,000 pc	3,000	900	2,100
Sub-total		37,405	10,200	27,205
Cash crops				
Corn (green)	900	9,000	3,750	5,250
Vegetables		21,210	6,363	14,847
Sub-total		30,210	10,113	20,097
Grand Total		109,615	30,068	79,547

Another crop, onion is one of the most attractive crops after rice because of its high yield and high net income. However, it is becoming unpredictable due to the volatility of theprice. Thus, green corn is a more probable crop planted after rice. It can also provide a goodincome with lesser inputs. Vegetables also provide good income especially during their off-season. Vegetablesplanted during the dry season obtain higher yields but again they are subject to price fluctuations. In our experience, tomato is one of the volatile crops during the dry season because of very extreme low prices when the supply becomes too much for the market to absorb. Gabi production is also an added dimension of the overall farming system because it can be planted around the rice paddies and irrigation canals. It interferes the least with rice, needs minimal management, and is self-sustaining. Taro can be sold P3-5/plant farm gate price. The suckers are sold at P0.25-0.50 per piece. One of the farmers with diversified farm mentioned that the income generated from gabi was higher than that from the rice. In general, the crop production components can obtain considerable income much higher than in rice production alone despite some of the failures such as damaged crops, lessproduction due to weather and pest, and low prices inflicted to some of the crops especially vegetables.

This shows that the diversification of crops can buffer losses incurred in some individual crops. Moreover, the synergism of crop production to animal production plays animportant role in the revaluation of some product outputs such as discards. Normally these are wasted; they can be converted into nutrients for the benefit of succeeding crops. Value added can be produced by converting discards into animal feed supplements before they arebrought back into the farm in the form of manure or organic fertilizer (Corales et al., 2004).

Rice-Rice Cropping Pattern

The rice-rice cropping pattern reduce the period for land preparation and transplanting usually spent under traditional rice culture. The soil is prepared dry and plantingis done even before the first rain to give time for the second crop. The land preparation for the second crop be done as quickly as possible so that planting completed early to avoid waterstress from the oncoming dry season. The sequence of activities in rice-rice pattern is characterized by precise timing and pronounced peaks in the labor requirements occurring between the first crops and planting of the second crop. The time of planting is determined by the need to avoid time wastage rather than to suit the climatic condition. Consequently, the probability of water stress at seedling stage of the first crop and grain filling stage of the second crop is increased. Also, the harvesting period of the first cropusually coincides with peak rainy period making grain drying a problem.

Rice-Upland Crops Cropping Pattern

With a short life cycle of rice (less than four months), planting of other upland crops such as mungbean is used to maintain crop production all year long. A careful selection of fast maturing crops at different times of the year is made to cope with the cyclical fluctuationsof climate and economic environment of the farm. Usually, in a rice-upland crops cropping pattern the growing of upland crops is doneto make use of residual moisture present at this period usually towards the dry months. Important characteristics of upland crop planted after rainfed rice is that it must have short maturing and resistant to drought.

Sustainable Agroforest Land Technology (SALT)

SALT (Sustainable Agroforest Land Technology) is based on small-scale reforestation integrated with food production. Of the farm area, about 40% is used forcrops and 60% for forestry. This“food-wood” intercropping can effectively conserve the soil, thereby providing food, wood and income tothe sloping land farmers. It has been designed for a 2 hectares upland farm and aims to produce food, fruit, animal feed, fertilizer, fuelwood and timber. The farmer plants woody perennials to form hedgerows along the contour lines which are spaced 4-6m apart. Every first and second alley between the hedgerows is planted with annual crops which include corn, upland rice, beans, ginger, and pineapple. Crop rotation in these alleys helps maintain soil fertility and good soil formation. In every third alley, farmers plant fruit trees and other permanent cash crops such as coffee, cacao (*Theobroma cacao*), banana, calamansi (*Citrofortunella microcarpa*), guava, rambutan (*Nephelium lappaceum*), durian (*Durio zibethinus*), mango, jackfruit, and lanzones. During the initial development phase, shorttermcash crops such as cowpea (*Vigna unguiculata*), peanut, mungbean (*Vigna radiata*), eggplant, and tomato may also be planted. Hedgerows are cut when they grow to a height of 2 m.

Cut foliage is spread in the alleys to provide organic fertilizer. The 1-ha portion of the farm upslope from the agroforestry plot is used for tree production. Farmers are encouraged to plant a variety of species which are short, medium and long-term (Singh et al.).

Table 3. Annual net income of farmers before and after adopting SALT, on a 0.75 ha farms (Laquihon, 1897 cited by Watson, undated)

SALT Farmers	Mean net income before SALT	Mean net income afterSALT	Net increase after SALT	% increase after SALT
Farmers in Luzon*	1.83	3.53	1.70	3.72
Farmers in Visayas**	1.91	3.72	1.81	3.76
Farmers in Mindanao***	1.99	3.63	1.64	3.28
Mean 1.91	3.63	1.72	3.61	
***N = 34; **N = 21; *** N = 61**				

Sorjan Farming System

Last 2016, La Niña was forecasted to hit the country. To cope up the upcoming phenomenon experts from the Philippine Rice Research Institute (PhilRice) have evaluated the Sorjan cropping system in response to climate change, to maximize farm productivity and ensure food security and regular income of farming families. Sorjan, developed by Indonesian farmers, is a system that constructs an alternate of deep sinks and raised beds. Its features can adapt to both dry and wet seasons. The low bedscan be planted to lowland rice and can be used for fish and culture while the raised beds canbe used for upland crops as upland rice, corn, grain legumes and vegetables. This cropping system is advantageous as it allows diversification of crops, spreadrisks and when properly managed could provide a continuous food supply for the family.

Advantages of Rice-Based Cropping System

Rice (*Oryza sativa*) is a component of widely varying cropping systems. Rice – based cropping systems form an integral part of agriculture (Porpavai, et al. 2016). Several intensive rice based cropping systems have been identified and are being practiced by the farmers. While intensive agriculture, involving exhaustive high yielding varieties of rice andother crops, has led to heavy withdrawal of nutrients from the soil, imbalanced and discriminate use of chemical fertilizers has resulted in deterioration of soil health (Reddy and Sang-Arun, 2011). Thus, suitable rice based cropping has to be evaluated, to assess the stability inproduction.

Effects of Rice – Based Cropping System on the Available N of the Soil

In relation to post harvest soil available N, it was noted that the initial available nitrogen status of the soil was 217 kg/ha. Progressive increase in available N status after eachyear was observed with the inclusion of leguminous crop in the rotation.

Among the croppingsystems tested rice – rice – black gram, onion – rice – black gram, groundnut – rice – black gram and rice – rice – green gram cropping systems significantly improved the soil availablenitrogen status in the first, second, third and fourth year respectively.

The fixation of atmospheric nitrogen by the leguminous crops might have contributed for the increased soilN status (Mohanty et al., 2010b). When compared to first year, the soil available N status was improved in groundnut – rice – blackgram (14 kg/ha), rice – rice – greengram (12 kg/ha), rice – rice – blackgram (9 kg/ha) onion – rice – blackgram (8 kg/ha) atthe end of the fourth year. Though the quantity of available nitrogen contributed was not huge, positive trend was observed with the maintenance of soil available nitrogen status. The soil available N status was depleted in maize – rice – sesame (20 kg/ha) and rice – rice – sesame (19 kg/ha) due to the exhaustive nature of maize and sesame. This was followed by bhendi-rice-radish (13 kg/ha), rice-rice-onion (8 kg/ha) cropping systems. Rice – rice – blackgram, onion – rice – blackgram, groundnut – rice – blackgram and rice – rice – greengram cropping systems improved the post-harvest soil available N status. Increase in available nitrogen, phosphorus,potassium and sulfur content in cropping sequences involving vegetable, pea, green gram was reported by Kumar and Jain, (2005). Cultivation of legume crop is viewed more as asoil fertility improver than as independent crops grown for their grain output. This is becauselegume crops are self-sufficient in N supply (Devendra, 2011).

Effects of Rice – Based Cropping System on the Yield Performance

The preceding crop species can have a beneficial or detrimental effect on the performance of the succeeding crop. The well-known beneficial effects of preceding legume crop on cereal are also found in multiple cropping systems, but the magnitude of the effects varies with management practices and the legume species used. Progressive increase in the grain yield of kharif crops preceded by pulses was recorded in rice-rice- blackgram and rice-rice- green gram cropping systems in the second, third and fourth year. When compared to the first year, the yield increase of 430 to 446 kg was recorded in the fourth year**.** According to **(**Ehsanul, 2016) he reported similar result, pointing out the superiority of leguminous cropsin increasing the yield of the succeeding crops of rice. They also observed a reduction in theyield of rice grown after sesame. The grain yield of kharif season crops decreased in rice- rice-sesame, rice-rice-bhendi, lab-lab-rice- maize, bhendi-rice-radish, maize-rice sesame cropping systems. The grain yield of kharif season crops are maintained without any reduction in onion-rice-black gram, rice-rice-onion and groundnut-rice black gram croppingsystems. Legumes were potentially important to diversify cereal based mono cropping into cereal-legume sequences which had nutrient cycling advantages. Moreover, another study conducted by Ali, et al. (2012) revealed that green manuringof sesbania rostrate and legume crops (mungbean, cowpeas and lentil) produced significantlybetter grain yield of rice and wheat than the other crops.

Maximum paddy yield of 3.73 t/ha was produced by rice – wheat – sesbanian cropping system followed by 3.57, 3.52, 3.40 and 3.39 t/ha produced by rice – wheat – mungbean, rice – cropping systems respectively and these were statistically at par with each other. The other cropping patterns gave significantly lower yields. Rice - wheat system produce paddy yield of 3.34 t/ha. Sowingof sesbania rostrate increased rice yield by 12%, mungbean (7.2 %), Berseem (5.3 %), cowpeas (1.8 %) over the traditional rice – wheat cropping system.

Almost similar yield trends were found in case of wheat crop. Rice – wheat – sesbania increased wheat yield (2.81 t/ha), rice – wheat – cowpeas (2.69 t/ha) and rice – wheat – mungbean (2.63 t/ha) while the prevailing rice – wheat system produced wheat grain yield of 2.59 t/ha. Rice- wheat – sesbania cropping system increased wheat yield by 7.8 %, cowpeas (3.9 %), mungbean (3.5 %) over traditional rice – wheat cropping system. The paddy yield was slightly decreased incase of sunflower and canola crops (3.32 & 3.21 t/ha respectively) than rice wheat system where the yield was 3.34 t/ha which may be that these crops are nutrients exhaustive. Channabasavanna et al. (2009) reported similar results that rice – wheat yield increased after legume pulses e.g. chickpea and lentil. The results are also in line with (Gill, et al. 2009) who reported the best one year crop rotation was rice – wheat – mungbean. It is evident from the resultsthat mungbean and cowpeas which are pulses as well as leguminous crops can be adjusted inthe rice - wheat cropping system for increasing income per unit area and improving soil health. It is short duration (65 - 70 days) crops and can be grown easily during the fallow period between wheat and rice crop.

CONCLUSION AND RECOMMENDATIONS

The paper presented several examples of Integrated Farming System practicedin the Philippines. These farming systems mostly focused on resource-poor farmers, not only to improve their livelihood and nutrition, but also to conserve our resources as well as to protect our fragile environment. In general, diversified farming systems can sustain most of a family's food requirements, incidental expenses and generate reasonable net income from the different crops and animals. The application of cost-saving and yield-enhancing practices enhance the efficiency of operations in the farm, making it more economically stable. Moreover, productivity of most multiple cropping systems practiced by the farmers in the Philippines is higher in termsof harvestable products per unit area per unit time, given with the same levels of management than those of sole cropping systems. Thus, this practice provided higher net income by the Filipino farmers.

It is recommended that a regular evaluationof the performance of each component is important to make necessary adjustments to fit thelocal conditions and stability of the system. This shows that the diversification of crops can buffer losses incurred in some individual crops. Normally, farm wastes are discarded when in fact they can be converted into nutrients for the benefit of succeeding crops.

REFERENCES

Ali R. I. et al., 2012. Diversification of rice-based cropping systems to improve soil fertility, sustainable productivity and economics." *Journal of Animal and plant sciences* 22.1, 108-12.

Anyaehie M.C. & Areji A.C. 2015. Economic Diversification for Sustainable Development in Nigeria," *Open Journal of Political Science,* 5, pp. 87-94.

Ehsanul H.M.D., 2016. Suitable Integrated Crop-livestock Production System in Char area of Bangladesh, *Journal Fisheries Livest Prod* 4: 156.

Caribbean Agricultural Research and Development Institute (CARDI). 2010. A Manual on Integrated Farming Systems (IFS). www.belize.org (Data retrieved: April 10, 2017).

Channabasavanna A. S., Biradar D. P., Prabhudev K. N. & Hegde M. 2009. Development of profitable integrated farming system model for small and medium farmers of Tungabhadra project area of Karnataka. Karnataka Journal of Agricultural Science, 22(1), 25–27.

Corales R. G., Juliano L.M., Capistrano A.O.V. Tobias H.S., Dasalla N.V. Canete S.D., Casimero M.C. & Sebastian L.S. 2004. Palayamanan: Arice-Based Farming Systems Model for Small-Scale Farmers. *Philippine Journal of Crop Science* 29(1): 21-27.

Devendra C. 2011. Invited review – Integrated tree crops-ruminants systems in South East Asia: Advances in productivity enhancement and environmental sustainability. Asian-Australasian Journal of Animal Sciences, 24, 587–602.

Garrett R.D., Niles M., Gil J., Dy Philip, Reis J. & Valentim J. 2017. Policies for Reintegrating Crop and Livestock Systems: A Comparative Analysis," Sustainability, 9, 473, www.mdpi.com/ journal/sustainability, pp. 136-148.

Gill M. S., Singh J. P. & Gangwar K. S. 2009. Integrated farming system and agriculture sustainability. *Indian Journal of Agronomy*, 54(2), 128–139.

Kumar S. & Jain D. K. 2005. Are linkages between crops and livestock important for the sustainability of the farming system? *Asian Economic Review*, 47(1), 90–101.

Kumara O., Sannathimmappa H.G., Basavarajappa D.N., Danaraddi V.S., Pasha A. & Rajani S.R. 2017. Integrated Farming System - An Approach towards Livelihood Security, Resource Conservation and Sustainable Production for Small and Marginal Farmers, *International Journal of Plant and Soil Science*, 15(3), pp. 1-9.

Birthal P. S., Joshi P. K. & Narayanan A. V. 2011. Agricultural diversification in India: Trends, contribution to growth and small farmer participation. Patancheru: The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), mimeo.

Mohanty R. K., Thakur, A. K., Ghosh, S., & Patil, D. U. (2010b). Impact of rice fish prawn culture on rice field ecology and productivity. *Indian Journal of Agricultural Sciences*, 80, 597–602.

Munandar Gustiar F, Yakup, Hayati R. & Munawar A.I. 2015. Crop-Cattle Integrated Farming System: An Alternative of Climatic Change Mitigation, *Livestock Media Journal* 38(2), pp. 95-103.

Paciello M.C. 2015. Building Sustainable Agriculture for Food Security in the Euro-Mediterranean Area: Challenges and Policy Options," Edizioni Nuova Cultura, Roma.

Parreño-de Guzman, Lucille Elna, Oscar B. Zamora, & Dora Fe H. Bernardo. 2015. Diversified and Integrated Farming Systems (DIFS): Philippine Experiences for Improved Livelihood and Nutrition." *Journal of Developments in Sustainable Agriculture* 10.1: 19-33.

Porpavai, S., et al. 2011. Impact of various rice based cropping systems on soil fertility.*Journal of cereals and oilseeds* 2.3 (2011): 43-46.

Reddy V. & Sang-Arun J. 2011. Promoting coconut-based agro-ecosystem and efficient product utilisation for augmenting on-farm income, improving quality of environment and conserving natural resources. Occasional Paper, IGES. p. 25.

Silici L., Bias C. & Cavane E. 2015. Sustainable agriculture for small-scale farmers in Mozambique: A Scoping," Report. IIED Country Report, London.

Singh K., Bohra J. S., Singh T. K., Singh J. P., Singh Y., & Singh C. S. 2007. Productivity and economics of integrated farming system in irrigated agroecosystem of Uttar Pradesh. *Indian Journal of Agronomy*, 52, 7–10.

Thorat B. N., Thombre B. M. & Dadge A. V. 2015. Management of Dairy Cow and Buffalo in Integrated Farming Systems Model in Marathwada Region of Maharashtra," *International Journal of Tropical Agriculture*, Vol. 33, No. 2, pp. 653-657.

Zamora O.B. 2010. Fundamentals of Sustainable Agriculture: Resource Materials for Courses in Sustainable Agriculture. Crop Science Cluster, College of Agriculture, Universityof the Philippines Los Baños. 189 p.

Zamora O.B., de Guzman L.E.P. & Talubo J.P.P., 2014. Sustainable Upland Agricultural Practices of Some Indigenous Peoples in the Philippines. 25 p. In: Cairns, M. (Editor). A Growing Forest of Voices: Integrating Indigenous Knowledge in Sustainable Upland Farming. (in press).

http://www.philrice.gov.ph/philrice-adopts-sorjan-cropping system/#sthash.2ZWL8MGu.dpuf

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:215-224

A Study on the Determination of Socio-Economic Status and Their Problems of Grape Producers in Nevşehir Province

Evrim ŞİMŞEK[1], Halil İbrahim OĞUZ[2*] and Osman GÖKDOĞAN[3]

[1]*University of Nevşehir Hacı Bektaş Veli, Institute of Science, Department of Biology, 50300, Nevşehir, Turkey*
[2]*University of Nevşehir Hacı Bektaş Veli, Faculty of Engineering-Architecture, Department of Biosystem Engineering, 50300, Nevşehir, Turkey*
[3]*Isparta University of Applied Sciences, Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering, 32260, Isparta, Turkey*

[*]*Corresponding author:hioguz64@gmail.com*

ORCID: 0000-0002-5445-0950[1], 0000-0003-2213-7449[2], 0000-0002-4933-7144[3]

Abstract

Vitis vinifera L. is the most common species of vines, which is spread over a wide area and the widely cultivated in the world. Viticulture in Nevşehir province dates back to ancient times. The aim of this study is to analyze the socio-economic status of the grape producers in Nevşehir province, to determine their problems and to suggest solutions. For this purpose, a survey study was applied to 165 grape producers in Nevşehir province. According to the results of the survey study, it was determined that producers dealing with viticulture were old, young people were not interested in viticulture, the education level of the producers was low, the input costs of viticulture were high, especially the wine industry couldn't be developed, the income of viticulture was low compared to tourism or other sectors.

Keywords: Nevşehir, viticulture, socio-economic status, grape producer

Research article
Received Date: 7 September 2021
Accepted Date: 14 October 2021

INTRODUCTION

The vine belongs to the *Vitis* genus of the *Vitaceae* family. *Vitis vinifera L.* is the most cultivated species in the *Vitis* genus, which is spread over a wide area in the world (Celik et al., 1998; Winkler, 1974).

Viticulture had an important place in human history from past to present. When the history of the vine is examined, it coincides with the first beginning of civilization in Anatolia (Lloyd, 1989; Deliorman et al., 2011). Nevşehir province is one of the oldest viticulture centers of Anatolia, where viticulture has been practiced for centuries (Fidan, 1985; Gülyaz, 1997; Özgül Katlav et al., 2019; Türkben and Sivritepe, 2000).

According to TUIK 2020 year data, total grape production in Turkey is 4.208.908 tons, table grape production is 2.218.056 tons, raisin production is 1.534.499 tons, and wine grape production is 456.353 tons. The provinces with the highest grape production in Turkey are respectively Manisa, Mersin, Denizli, Mardin and Nevşehir provinces.

Total grape production is 1.498.287 tons in the Manisa province, 382.857 tons in Mersin province, 371.603 tons in the Denizli province, 161.930 tons in Mardin province and 101.024 tons in Nevşehir province. Nevşehir province constitutes 2.40% of Turkey's total grape production. In Nevşehir province, table grape production is 28.997 tons, wine grape production is 42.623 tons, and raisin production is 29.404 tons (TUIK, 2020).

Nevşehir province has an important potential in terms of viticulture culture therefore very valuable grape varieties are still produced. The most well-known local wine grape variety of Nevşehir province is Emir variety. The most common local table grape variety of the province is Parmak Üzüm variety. Another important variety of province is the Dimrit variety; this grape variety is used as table and raisins and also used in making grape molsses. In addition, Dimrit is a grape variety that is consumed abundantly and with pleasure by the local people due to its high sugar content (Uysal and Yaşasın, 2017).

It is known that vineyards in Nevşehir province are mostly grown with a conventional system. The most important reasons for this are that the transition to modern agriculture system is expensive, the grape producers are not open to innovations due to their old age and their income levels are low, and they do not seek innovation in viticulture because they consume the products obtained from grapes in local markets.

Viticulture culture in Nevşehir Province dates back to ancient times. However, due to the rapid development of tourism in the Cappadocia region in recent years and the development of the wine industry as parallel with tourism, the desired or expected production and potential in viticulture could not be reached. There is no reason why Nevşehir province should not compete with Bordeaux city in France. With good planning and production discipline, wine grapes production can be made easily. Cappadocia region soils have extremely suitable conditions for viticulture because they are volcanic tuff, have a porous structure, high water holding capacity and pH value close to neutral (Öztürk et al., 2019).

Revealing the soil characteristics of the vineyards will also stimulate yield increase. There are many research studies that show the distribution of large soil groups in agricultural lands, land use capability classes, slope conditions, areal distribution of soil depths and soil erosion by using digital soil maps. These studies will make significant contributions to agricultural production (Bağdatlı and Arslan, 2020; Bağdatlı and Arslan, 2021; Bağdatlı and Ballı, 2021; Bağdatlı and Can, 2021).

Considering the global climate change, in which we will have a drier climate in 2050 years with the increasing population, the per person amount water in Turkey is expected to decrease to 700 m^3 (Bağdatlı and Bellitürk, 2016). In a study conducted to evaluate temperature changes in Nevşehir province for many years (1970-2019), it was determined that the maximum temperature average in summer months was 33.5°C. It has been determined that there is an increasing trend in temperature changes especially in spring, winter, autumn, and summer months (Bağdatlı and Arıkan, 2020).

Studies have shown that the minimum number of rainy days in Nevşehir province for many years (1986-2019) is 77 days, the maximum number of rainy days is 142 days, and the average number of rainy days is 109 days (Bağdatlı and Arslan, 2019).

Considering climate change and global warming in recent years, it is obvious that viticulture is still a very important agricultural sector in Nevşehir province. In this context, since the vine is drought resistant, viticulture is a more suitable production model for drought management compared with other agricultural production sectors (such as potato production, corn production). In addition, the provinces with the most viticulture cultivate in Turkey; Çanakkale, İzmir, Nevşehir, Tekirdağ, Denizli, Balıkesir, Bursa are regions with high potential in terms of agricultural tourism (Agro Tourism). In recent years, the increase in wine consumption in parallel with the increasing domestic and foreign tourism has led to the creation of new vineyard areas and the cultivation of new grape varieties. Vineyard tourism should be encouraged in these regions. It has been reported that management and planning should be done for development of viticulture and wine production in parallel with agricultural tourism in similar regions of our country. (Türkben et al., 2012). In recent years, it is possible to see many abandoned vineyard areas in Nevşehir Center, Gülşehir, and Ürgüp districts and villages. The agricultural generation is getting older day by day in Turkey. The rapid growth of cities, the fascinating charm of urban life and uncontrolled urbanization encourage the migration of especially young people from rural areas to the cities. In addition, as in the whole agricultural sector, unplanned grape production and high input costs discouraged the production enthusiasm of the producers in agricultural production, and they lost their hope from this sector and needed to work in other fields. The aim of this study was to analyse the socio-economic status of the grape producers in Nevşehir province, to evaluate the problems of the producers by conducting a face-to-face survey with the producers, to find solutions to their production-related problems and to make suggestions.

MATERIAL and METHODS

The face to face survey study made with 165 grape producers in Nevşehir province was main material of the research. The informations acquired from the Nevşehir Directorate of Provincial Agriculture and Foresty and Turkish Statistical Institute were secondary materials of the research (TUIK, 2020). In this research, all data were evaluated by percentage calculations in the Excel program, and results were presented in tables.The number of enterprises studied in the research was determined according to the "Proportional Sampling Method". For a finite population, the sample volume according to the known or predicted proportion of those with a particular trait was given in the formula below. The p-value is the number of parts in the population with a certain characteristic, and the p-value can be obtained from previous studies or can be estimated intuitively. To achieve the maximum sample volume, p value = 0.5 should be taken. In cases which p value is unknown, p value = 0.5 should be taken because working with the maximum sample volume will reduce the possible error (Miran, 2003; Aksoy and Yavuz, 2012). The survey study was conducted with 165 producers contacted face-to-face in the research area with a 95% confidence interval and 5% deviation.

$$n = \frac{(\mathrm{N} * \mathrm{p} * (1 - \mathrm{p}))}{(\mathrm{N} - 1) * \alpha 2\mathrm{p} + \mathrm{p} * (1 - \mathrm{p})}$$

In the formula;
n: Sample size,
N:Number of businesses in the population,
α^2_p:The variance of the ratio: (0.0346),
p: Ratio of grape producers to the population,
The districts and villages where the study was conducted are given in Table 1.

Table 1. The districts and villages where the study was conducted

No	District	Village	No	District	Village
1	Gülşehir	Eski Yaylacık	**6**	Nevşehir	Sulusaray
2	Gülşehir	Karacaşar	**7**	Nevşehir	Merkez
3	Gülşehir	Merkez	**8**	Ürgüp	Çökek
4	Gülşehir	Oğulkaya	**9**	Ürgüp	Sarıhıdır
5	Nevşehir	Çat Town	**10**	Ürgüp	Ulaş

RESULTS and DISCUSSION

This study was conducted by evaluating surveys made with producers in Nevşehir Center, Gülşehir and Ürgüp. Face to face surveys were conducted with 42 grape producers in Gülşehir, with 59 grape producers in Nevşehir Center, and with 64 grape producers in Ürgüp. The socio-economic status and problems of the producers participated in the survey are given in Table 2,3,4,5,6,7,8,9 and 10.

Table 2. Age of grape producer

Age of grape producers	Number	Percentage (%)
30-45	42	25.45
50-70	107	64.85
74 and above	16	9.70
Total	165	100

In our study, it was determined that 25.45% of producers (42 producers) were 30-45 age range, 64.85% of them (107 producers) were 50-70 age range, 9.70% of them (16 producers) were 74 years and above (Table 2). In another study named potential and current status of viticulture undertaking in Savur (Mardin) District.It was determined as 54% of the producers surveyed (between 40 and 60 years old) and the average age of the surveyed manufacturers were found to be 47. 1% of the bond is determined as under 20. In another study, the average age of the producers participating in the survey was found to be 52, and it was determined that 29% were between the ages of 30-40, 25% between the ages of 41-50, and 17% between the ages of 51-60 (Çakır ve ark., 2017a). These studies show similarities with our study.

Table 3. Educational situations of grape producers

Educational situations of grape producer	Number	Percentage (%)
Primary school	52	31.51
Secondary school	35	21.21
High school	62	37.58
University	16	9.70
Total	165	100

In our study, it was found that 31.51% of producers (52 producers) were primary school graduates, 21.21% of them (35 producers) were secondary school graduates, 37.58% of them (62 producers) were high school graduates, 9.70% of them (16 producers) were university graduates (Table 3).

In a study that examined the present status of viticulture in the Dicle district of Diyarbakır province, its primary problems and possible solutions in Dicle district; In this study, when the educational status of the producers participating in the survey was evaluated, it was determined that 41% had a primary school, 10% had secondary school and 9% had a high school education. According to the data obtained, it was determined that a significant part of the producers (35%) did not receive training from any educational institution (Çakır et al., 2017b). In another study named potential and current status of viticulture undertaking in Savur (Mardin) District, According to the results of the questionnaire, it was determined that the level of education for producers dealing with viniculture in that district was low, 75.0% primary school (Çakır ve ark., 2015). In another study, it was determined that the education level of the producers was very low and 69% of the producers participating in the survey were primary school graduates and 14% were not educated (Çakır et al., 2017a).The results of this study are similar to the findings obtained from our study. According to all these studies, it has been understood that the education levels of the producers dealing with viticulture are mostly primary school graduates or literate.

Table 4. Number of individuals in the families of grape producers

Number of individuals in the family	**Number**	**Percantage (%)**
2-3 individual	17	10.30
4 individual	63	38.18
5 individual and above	85	51.52
Total	165	100

It was determined that 10.30% of the producers (17 producers) have a family of 2-3 individuals, 38.18% of them (63 producers) have a family of 4 individuals, 51.52% of them (85 producers) have a family of 5 individuals and above (Table 4). In a study conducted to examin socio-economic situations of potato producers in Nevşehir province, 48.7% of producers participated in survey declared that they have a family of 5 individuals and 30.8% of them have a family of 7 individuals (Yücel and Oğuz, 2019). The results of this study are similar to the findings otained from our study.

Table 5. Grape producers' time dealing with grape cultivation

Producers' time dealing with grape cultivation	**Number**	**Percantage (%)**
20 years	37	22.42
30 years	26	15.75
40 years	38	23.04
50 years and above	64	38.79
Total	165	100

It was determined that all of the grape producers continued the traditional viticulture inherited from their families. Producers interesting with viticulture from a young age, have shown how important this sector is for their livelihoods. It was found that 22.42% of the producers (37 producers) have dealed with grape cultivation for 20 years, 15.75% of them (26 producers) have dealed with grape cultivation for 30 years, 23.04% of them (38 producers) have dealed with grape cultivation for 40 years and 38.79% of them (64 producers) have dealed with grape cultivation for 50 years and above (Table 5).

In the Dicle district of Diyarbakir was carried in a study, it was determined that the producers were interested in both viticulture and agricultural production for at least 10 years, however, 23% of them were engaged in viticulture for 10-20 years and 15% for 41-50 years (Çakır ve ark., 2017b). The results of this study are similar to the findings otained from our study.

Table 6. Record-keeping situations of grape producers

Do you keep a record of input and output?	**Number**	**Percentage (%)**
Yes	42	25.45
No	123	74.55
Total	165	100

In our study, it was determined that the rate of producers keeping records from the beginning of production to harvest were 25.45% (42 producers), and the rate of those who do not keep records were 74.55% (123 producers) (Table 6).

Table 7. Cooperative situations of grape producers

Did you register the Farmer Registration System?	**Number**	**Percentage (%)**
Yes	103	62.42
No	62	37.58
Total	165	100
Are you a member of any agricultural cooperative or producer association?	**Number**	**Percentage (%)**
Yes	50	30.30
No	115	69.70
Total	165	100
If your answer is yes, which one are you a member of?	**Number**	**Percentage (%)**
Agricultural Credit Cooperative	46	92
Producer Association	4	8
Total	50	100

In our study, it was determined that the rate of producers registering in the Farmer Registration System were 62.42% (103 producers), the rate of those who do not register were 37.58% (62 producers), the rate of producers becoming member in the cooperative or association were 30.30% (50 producers), the rate of those who do not become were 69.70% (115 producers) in addition to 92% of producers (46 producers) becoming member in the cooperative or association were member in Agricultural Credit Cooperative and 8% of them (4 producers) were member in Producer Associations (Table 7). In a study named the current situation of viticulture, its main problems and solution proposals in Diyarbakır Dicle district; It has been determined that the majority of the producers participating in the survey (98%) are not members of cooperatives or unions and do not plan to become members. This study shows parallelism with our study (Çakır et al., 2017b).

Table 8. Do you have additional income?

Do you have additional income?	Number	Percentage (%)
Yes	147	89.10
No	18	10.90
Total	165	100

Do you have additional income? Survey question, while 147 producers have answered yes, 18 producers have answered no. Among 147 producers, it was determined that 13 producers worked in other sectors, 4 producers were potato producers, 12 producers were interested in trade, 15 producers worked in the agricultural sector and 103 producers were pension. According to the results, it was found that 89.10% of the producers have additional income, and 10.90% them don't have additional income (Table 8). In a study carried out to determine the problems of viticulture, as the land ownership of the producers and the presence of vineyard land were compared, determining 29% of the producers were engaged in viticulture in all of their agricultural lands (Çakır et al., 2017b). In the study we conducted, it has been observed that viticulture is done as an additional income or to continue a traditional production model.

Table 9. Evaluation and profitability of grapes after harvest

Where do you value the grapes after the harvest?	Number	Percentage (%)
Sell in the market	11	6.67
Making grape molasses	21	12.73
Sell to the wine distillery	99	60
Sell to the traders	34	20.60
Total	165	100
Is viticulture profitable in your province?	**Number**	**Percentage (%)**
Yes	69	41.81
No	96	58.19
Total	165	100

It was determined that rate of producers selling to the market was 6.67% (11 producers), rate of producers making grape mollases was 12.73% (21 producers), rate of producers selling to the wine distillery was 60% (99 producers), rate of producers selling to the trades was 20.60% (34 producers). Is viticulture profitable in your province? Survey question, while 41.81% of producers (69 producers) have answered yes, 58.19% of them (96 producers) have answered no (Table 9). In a study conducted in Diyarbakir in the Dicle; It has been stated that a significant part of the producers (91%) produce for both table and must use (Çakır ve ark., 2017b), in addition to, in another study conducted in Mardin, the production rate of wine grapes in the region where wine grape production is not realized was determined as 41% (Çakır et al., 2015). In our study, producers consume their products in local markets

Table 10. General problems of viticulture

What are the general problems of viticulture?	**Number**	**Percentage (%)**
Marketing problems	67	40.60
Deterioration of the agricultural sector	8	4.84
Insufficient government support	14	8.48
High costs	19	11.51
Low selling prices	13	7.88
Climate conditions	25	15.15
Diseases and pests	15	9.10
There is no problem	4	2.42
Total	165	100

It was understood that rate of producers stating marketing problems was 40.60% (67 producers), rate of producers stating deterioration of the agricultural sector was 4.84% (8 producers), rate of producers stating insufficient government support was 8.48% (14 producers), rate of producers stating high costs was 11.51% (19 producers), rate of producers stating low selling prices was 7.88% (13 producers), rate of producers stating climate conditions was 15.15% (25 producers), rate of producers stating diseases and pests was 9.10% (15 producers), rate of producers stating any problems was 2.42% (4 producers) (Table 10).

CONCLUSION

In this study, the current situation, problems and suggestions of viticulture in terms of grape producers in Nevşehir province were evaluated. In the survey study, it was determined that the age range of grape producers was mostly between 50 and 70 years old, the young people were not interested in viticulture, the majority of the producers were high school graduates, the number of university graduates was low, the families were generally a family member of 5 individuals, producers have grown grapes for over 50 years, the majority of producers didn't keep input and output records in their vineyards, viticulture was not very profitable, producers continued to traditional viticulture as a family inheritance and the biggest problem of viticulture was the marketing problem. The most important reasons of decrease in interest being viticulture in the province are that the producers dealing with viticulture are old, young people are not interested in viticulture, the education level of the producers is low, the input costs of viticulture are high, especially the wine industry cannot be developed, the income of viticulture is low compared to tourism or other sectors. Besides, It is concluded that the old vineyard areas are abandoned.

The following recommendations can be made as a result of this study.

In order to revive the viticulture culture in Nevşehir province, the preservation and development of local varieties should be given to the importance, standard table and wine grape varieties suitable for the province with adaptation studies should be determined, modern viticulture techniques should be applied, modern viticulture techniques and alternative evaluation methods of the product should be taught to the producers, and the wine sector should be developed in the province. Considering the tourism sector in marketing, organic vineyard products can be diversified with wine, grape juice, molasses, vinegar, köfter, raisins and grape leaves for domestic consumption (Anonymous, 2016). We believe that in Nevşehir province, the geographical indications of local grape products should be determined, preservation and evaluation methods should be developed and the sustainability of viticulture should be ensured. Besides, this study will contribute to more detailed studies in the future.

ACKNOWLEDGMENT

This study is summarized from Evrim ŞİMŞEK' s master's thesis.

REFERENCES

Aksoy A. & Yavuz F. 2012. Çiftçilerin küçükbaş hayvan yetiştiriciliğini bırakma nedenlerinin analizi: Doğu Anadolu Bölgesi Örneği. *Anadolu Tarım Bilim. Derg.,* 2012, 27(2), 76-79. (in Turkish)

Anonymous 2016. Kapadokya Ulusal Bağcılık Çalıştayı Sonuç Raporu (Editör Prof. Dr. Zeki Kara) 22-23, Aralık 2016, Nevşehir, p.10 (in Turkish)

Bağdatlı M.C. & Belliturk K. 2016. Negative Effects of Climate Change in Turkey, *Advances in Plants & Agriculture Research, Med Crave Publishing*, 3(2):44-46.

Bağdatlı M.C. & Arıkan E. N. 2020. Evaluation of Monthly Maximum, Minimum and Average Temperature Changes Observed for Many Years in Nevsehir Province of Turkey, *World Research Journal of Agricultural Science (WRJAS),* 7(2):209-220

Bağdatlı M.C. & Arslan O. 2019. Evaluation of The Number of Rainy Days Observed for Long Years Due to Global Climate Change in Nevşehir / Turkey, *Recent Research in Science and Technology Journal*, (11):9-11.

Bağdatlı M.C. & Arslan O. 2020. GIS Mapping of Large Soil Groups, Current Land Use, Soil Depths and Slopes, Soil Erosian in Kırsehir Province of Turkey, *World Research Journal of Agricultural Science (WRJAS),* 8(1):265-277, doi: 10.5281/zenodo.4334128

Bağdatlı M.C. & Can E. 2021. Spatial Evaluation of Land and Soil Properties in the Example of Nevşehir Province, Turkey, *International Journal of Engineering Technologies and Management Research (IJETMR),* 8(7):90-103, doi:10.29121/ijetmr.v8.i7.2021.1007

Bağdatlı M.C. & Arslan O. 2021. Classification and Mapping of Land Use and Some Soil Properties in Kırşehir Province, Turkey, *International Journal of Engineering Technologies and Management Research (IJETMR),* 8(8):81-93, doi: 10.29121/ijetmr.v8.i8.2021.1022

Bağdatlı M.C. & Ballı Y. 2021. GIS Mapping of Land Slopes, Soil Depths, Erosian Classes, Large Soil Groups and Some Soil Properties: A Case Study of Kayseri Province in Turkey, Universal Journal of Agricultural Research, 9(5):166-175, doi: 10.13189/ujar.2021.090503.

Çakır A., Sanyürek N.K., Karakaya E. & Şilan A. Y. 2017a. Nusaybin (Mardin) İlçesi Bağcılığı Sorunları ve Çözüm Önerileri. Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi, 34(1), 15-25. (in Turkish)

Çakır A., Karakaya E. & Uçar H. K. 2015. Mardin İli Savur İlçesi Bağ İşletmelerinin Mevcut Durumu ve Potansiyeli. Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 5(1), 9-19. (in Turkish)

Çakır A., İşlek F., Odabaşıoğlu M. İ. & Alanko M. 2017b. Diyarbakır ili Dicle ilçesi bağcılığının mevcut durumu, başlıca sorunları ve çözüm önerileri. Alatarım, 16(2), 37-46 (in Turkish)

Celik H., Agaoglu Y. S., Fidan Y., Marasali B. & Söylemezoglu G. 1998. Genel Bağcılık. Sunfidan. (in Turkish)

Deliorman O. D., Ergun F. & Orhan N. 2011. Anadolu medeniyetlerinde asma (vitis vinifera l.). *Tarih Araştırmaları Dergisi*, 30(50), 69-80. (in Turkish)

Fidan Y. 1985. Özel Bağcılık. A.Ü. Ziraat Fak. Yayınları 930. Ders Kitabı. 401. (in Turkish)

Gülyaz M. 1997. Doğanın Mucizesi Kapadokya, Ajansmat Matbaacılık A.Ş., Ankara 1997, s. 74,75. (in Turkish)

Lloyd S. 1989. Ancient Turkey, A Traveller's History. British Museum Pres, s.240, London,

Miran B. 2003. Temel İstatistik. Ege Üniversitesi Basımevi, Bornova, İzmir. (in Turkish)

Özgül Katlav E., Yönet Eren F. & Tuna M. 2019. Kapadokya'da bağcılığın gastronomi turizmi açısından değerlendirilmesi. (in Turkish)

Öztürk M. Z., Özkan D. & Şimşek M. 2019. Kapadokya bölgesinin drenaj özellikleri. *Coğrafya Dergisi*, (38), 1-1. (in Turkish)

TÜİK 2020. Türkiye İstatistik Kurumu, 2020 Üzüm Üretim İstatistikleri https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr (Access Date: 10.11.2021) (in Turkish)

Türkben C. & Sivritepe N. 2000. Aşılı asma fidanı üretiminde bazı dışsal uygulamaların aşı yerinde kallus oluşumu ve köklenme üzerine etkileri. II. Ulusal Fidancılık Sempozyumu, 25-29 Eylül 2000, Bademli/Ödemiş. Bildiri Özetleri, s 29. (in Turkish)

Türkben C. Gül F. & Uzar Y. 2012. Türkiye'de Bağcılığın Tarım Turizmi (Agro-Turizm) İçinde Yeri ve Önemi. *Karamanoğlu Mehmetbey Üniversitesi Sosyal Ve Ekonomik Araştırmalar Dergisi,* 2012(2), 47-50. (in Turkish)

Uysal T. & Yaşasın A. S. 2017. Asma genetik kaynaklarımız ve Nevşehir ili üzüm çeşitleri. *Nevşehir Bilim ve Teknoloji Dergisi*, 6, 132-136. (in Turkish)

Winkler A. J. 1974. General viticulture. Univ of California Press.

Yücel D. & Oğuz H. İ. 2019. Nevşehir İlinde Patates (Solanum tuberasum L.) Yetiştiriciliğinin Ekolojik ve Sosyo-Ekonomik Bakımdan Araştırılması. Türk Tarım ve Doğa Bilimleri Dergisi, 7(4), 1159-1170. (in Turkish)

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp: 225-232

The Effects of Global Warming on Fish Farming Water Resources

Maliha AFREEN

Nigde Omer Halisdemir University, Faculty of Agricultural Sciences and Technologies, Nigde, Turkey

Corresponding author: malihaafreen120@gmail.com

ORCID: 0000-0001-7542-1318

Abstract

Global warming is an issue which increasing day by day due to changes occur in climate and atmospheric conditions. This global warming can affect life in many aspects including agriculture, Human and aquatic life. In this review we will discuss about effects of global warming on water resources of fish farming. Changes in climate can influenced both coastline fish farming and domestic aquaculture, so it becomes a major threat for aquatic organisms because of various physicochemical changes occur in water. These changes also characterized as biological changes and physical changes occur in aquatic organisms. Changes occur in water reservoirs can be rise in temperature, increase in salinity of water and reduction of oxygen. There are many reasons due to which fish farming water resources can be polluted including use of fertilizer in nearest land, which release ammonia and phosphorus can be dangerous for aquatic organisms. Air pollution can cause eutrophication and acidification in water reservoirs of aquaculture, which leads to the reduction of oxygen and dangerous for aquatic life. Some anthropogenic factors are also involved to damage aquatic resources of fish farming like fishing, introduction of new species in aquaculture and introduction of different polluted chemicals in coastline reservoirs through industrial polluted water. These problems can be controlled by continuously filtering and reusing of water.

Keywords: Aquaculture, global warming, climate change, eutrophication, acidification, anthropogenic

Review article
Received Date: 14 November 2021
Accepted Date: 15 December 2021

INTRODUCTION

Global warming known as continuous changing in Atmospheric situations of earth due to variation in climate that happens whether directly or indirectly due to human actions. According to Intergovernmental Panel on Climate Change, 90% or greater probability of global warming is credited to human actions (IPCC, 2007) but also change in climate influenced Human survival due to disturbance in nature and it's a warning to economically and socially development of human. Increasing or decreasing changes in climatic values affect living things negatively and cause a decrease in productivity, especially in agricultural production (İstanbulluoğlu et al., 2013). Increasing world population, changing climate conditions and economic activities are growing with each passing day makes it more important than water (Bağdatlı and Bellitürk, 2016).

Change in climate has become a serious problem for worldwide fish farming and aquaculture. Except the monetary and physical factors, climate is a main factor that improves the sustainability and growth of aquaculture department. It's obvious that change in temperature, air moisture and rainfall negatively effects aquaculture assembly in ponds. It also creates social and economic problems for farmers. According to farmers perception continuous change in climate including ecological temperatures, pattern and intensity of rainfall and wind inconsistency could affect water reservoirs (George, 2010). (Dewit & Stankiewicz, 2006) expected that important negative effects will be sensed through 25 percent of aquatic ecosystems in Africa's inland due to change in climate.

In 2009 Food and agriculture organization, reported worldwide fish production 144 million metric tons including both captured fish and aquaculture production, but this is less as 2.2 million metric tons in comparison of fish production data of 2005 (FAO, 2009). Those factors which can suppress the fish production also include climate change which leads to coastline destruction, higher temperature, sea level rise, floods and storms.

Now a day's pollution is an important alarming factor for fresh water reservoirs specifically for aquaculture. The pollution level highly changing from coast-to-coast, on the basis of type and extent of pollutants and waste in water and on water stream capacity. According to European Environment Agency approximately 10% lakes and rivers in Europe having harmful quantity of heavy metals and polycyclic aromatic compounds. It was also reported that rivers and flowing water were not in bad condition as much as lakes and coastline waters (European Environment Agency, 2015).

TYPES of POLLUTION

Global climate change, which has increased the population and its impact in recent years, shows itself negatively in all areas. With the increase of carbon emissions in the air, the world has been threatened by climate change. Carbon is one of the basic elements of life when it is found in sufficient levels. However, when people consume more than they need, it causes serious CO_2 in the atmosphere and decreases the protective effect of the ozone layer and causes irregularities in precipitation. It is known that the increase in carbon will increase over the years. With this increase, CO_2 and greenhouse gases accumulated in the atmosphere descend to the earth with precipitation. This event is called acid rain. Acid rains change the pH of the water and affect the life of the living creatures in the water. It causes the natural structure of plants to deteriorate (Bağdatlı and Can, 2019).

The major causes of polluted water are different industrial discarded water including yeast, paper, canning, mining, textile and chemical industries. Another main reason of pollution for water reservoirs is agriculture fertilizers and pesticides which release many chemicals in shallow and groundwater. Except all these sources of pollution, recently water thermal pollution also becomes a continuously growing danger (Ficke et al., 2007).

Thermal pollution is considered when there is higher increment in water temperatures more than variation occur due to changes in season carrying to disturbances in the ecosystem including harmful variations in the plants and animal creature of water reservoir. When freshwater reservoir combine with pollution, it becomes dangerous for aquaculture unit.

There was a study of river water in Bulgaria, used for common carp fish farming. In that study scientists found that some agricultural chemicals caused water pollution in that river. These chemicals involved nitric compounds like ammonia, nitrogen dioxide and nitrate. These nitrate compounds caused nitrification process in the river. High amount of phosphate was also found in surroundings of fish farms which indicated that much amount of phosphate compounds released from pesticides and fertilizers. Ammonia concentration in surface level of water can be chronic for fish because harmless levels of ammonia for aquatic creatures are very low. Ammonia also can be converted into nitrate which causes reduction of oxygen from water and proved harmful for fish (Mueller et al., 1995).

Organic farming used animal compost as a fertilizer. This fertilizer contained urea and organic nitrogen in the compost are transformed to ammonia, then nitrites, and at the end into nitrates in the soil (Di and Cameron, 2002). Extreme absorption of nutrients, mostly phosphorus and nitrogen cause eutrophication in aquatic ecosystem, subsequently modifications in presence and variety of species, like algal blooms, leaching of nitrate to groundwater and deoxygenated dead regions. These modifications intimidate the enduring quality of aquatic ecosystem. So it can affect the facilities of aquatic ecosystem which involved recreation chances, drinking water consumption and fisheries (EEA, 2015).

It was stated in 1992 by Environment Protection Agency of United States. They stated that enhanced eutrophication due to excess of nutrients was one of the foremost problem of water sources. Contrary much less amount of nutrients is also not good for aquatic organisms. Consequently a balance nutritive environment required to get good production of fish in aquaculture (Stockner et al., 2000).

Acidification and eutrophication of soil and water also caused by air pollution which could be harmful for aquatic ecosystems. Air pollution can be produced by emissions from power generation, transport, and also through excretions from agriculture fertilizers. Air pollutant chemicals involve nitrogen oxide and ammonia also produce eutrophication in aquatic ecosystem. Carbon dioxide emission from green house due to human activity could increase the atmospheric temperature which is subsequently increase the temperature and acidification of aquatic environment. It is considerably dangerous for aquatic life specifically for fish (Smith et al., 1999).

Some Anthropogenic reasons including nutrient enrichment, fishing, entry of outlandish species, and chemical pollutants incline to behave differentially for specific specie (Evans et al., 1987). Many times fishery water not that much poor due to chemicals but stocking density of fishpond also responsible for deterioration. It was found that fish ponds with great stocking densities of fish (common carp) were considered with a constantly growing eutrophication which represent itself in bulk developmental growth of phytoplankton.

This directed to significant variations in concentration of oxygen and overall ammonia and huge quantity of fresh water had to be transfer into the pond to dilute the nutrients and algae (Lukowicz., 1982). Some researchers reported that lakes which have much quantity of common carp fish had great concentration of nutrients, great size of phytoplankton and less clearance of water. This issue observed mostly in Narrow lakes were utmost influenced by the presence of common carp (Jackson et al., 2010). These results shows that both exterior pollutants and inner biological factors in the ponds and lakes could enhanced eutrophication process concluded as bad status of water (Weber and Brown, 2009). In particular, measures to minimize the impact of greenhouse gases should be taken all over the world and will trigger this increasing the necessary studies and measures to minimize the emissions of carbon emissions will play an important role in reducing the effects of global warming (Bağdatlı and Ballı, 2019).

OVERVIEW on THE IMPACTS of CLIMATE CHANGE

Food and agriculture organization reported that change in climate influenced the whole ecosystem, economy, societies, living organisms and food chains in those regions which have delicate geological and ecological foundation (FAO, 2008; World Fish Centre, 2007). The increment of greenhouse gasses emissions in atmosphere along with the global warming and the changes of temperature and precipitation regimes, have lots of negative effects on agricultural crop production (Bağdatlı et al., 2015).

Aquaculture and fisheries are specifically susceptible because water territories directly captivated and stock some solar energy, particularly as maximum fish types are cold blooded. Therefore change in climate directly influenced quality of water by modifying physical and chemical characteristics through increase in water temperature, and subsequently become dangerous for aquatic organisms. Many experimental studies have been done on Nigeria aquaculture and fisheries to check the impact of climate change. These studies concluded that continuously increasing level of carbon dioxide and temperature will constantly heat up the earth which is directly affecting fisheries sector. Unexpectedly, it was also detected that changing in temperature also enhance dissolved oxygen in water briefly which will reduce later due to upsurge in demand of biochemical Oxygen.

It was also observed that increasing quantity of dissolve oxygen maintain the quality of water by decreasing concentration of carbon dioxide in waters. So it's a natural procedure in aquatic system to maintain the quality of water (Verweij et al., 2010).

Escalation of temperature can dangerously enhance food intake by fish, particularly small fishes, and subsequently enhance the cost of aquaculture. Therefore, upsurge demand of biological oxygen, delete existing dissolved oxygen which caused water pollution and sometime even leads to death. Depletion of oxygen producing an anoxia in water reservoirs. The good quality of a water reservoir is vital for the subsistence of fish life, both in marine and domestic aquaculture system (Verweij et al., 2010).

Variations in natural climate, even at moderate level influenced fisheries and their managing practices (Garcia and Rosenberg, 2010). The temperature of oceans and atmosphere will continue to increase in coming 50 to 100 years, which will melt the glaciers and sea level will escalate, consequently pH of oceans will be decrease to become acidic due to absorption of excess carbon dioxide, and transmission of aquatic organisms could vary at national and international level (Bindoff et al., 2007; Munday et al., 2008). Instabilities in fish reservoirs will have main economic issues for those regions which are much dependent on fisheries and aquaculture (Brander, 2010). The influences of climate change on fisheries can be categorized as biological and physical changes. Description of these Physical and biological changes is given following.

PHYSICAL CHANGES

Excessive increase and decrease of temperatures negatively affect the life of living things. It will be difficult to find clean water in the future as the increase of temperatures will increase the evaporation level (Bağdatlı and Can, 2020). Upsurge in temperature of the surface level water play an important role in adjusting worldwide climate. (Rosemary and Shirley, 2015) refer that both marine and freshwater resources can be effected by change in climate. Their heat absorption ability is almost thousand times more than that of the air atmosphere, so it captivate considerable extent of heat which entirely released (Barange and Perry, 2009).

Those changes which occur in marine ecosystem directed towards variations in movement arrays of fish and perhaps decrease fish jetties, particularly in coastline fisheries (African Action, 2007). For instance, higher marine temperature may influence upsurge beside the coastline regions, specifically the Atlantic region, due to which ocean become more unfavorable for fisheries, consequently causing a decline in activities of fishing (African Action, 2007). Domestic waters are also similarly susceptible and could be influenced intensely by changing in climate (IPCC, 2007).

INCREASING WATER SALINITY

World effects of global warming caused by changes in the climate system of the highest peaks, ocean depths, is felt throughout much of the world from the equator to the poles. The polar ice caps are melting, sea level is rising and soil losses are experienced in coastal areas. Sea level due to melting of glaciers increasing the temperature rose from 10 to 20 centimeters (Bağdatlı and Bellitürk, 2016). Influence of the global climate will have an effect on the change of seasons, especially in the observation of significant changes in temperature and precipitation (Bağdatlı and Arslan, 2020).

Change in climate influenced the salinity of water through many methods. Those oceans which occur in tropical regions are progressively changing into saltier, but those oceans which are nearest to the poles regions have converted into fresher. Variations in salinity of water have diverse effects which is based on acceptance level of the aquatic organisms and the environment of their ecosystem, whether it is marine water, estuarine water or freshwater, it was predicted that salinity of freshwater ecologies could escalate due to human activities related to climate transformation. These physical variations will adversely influence the inhabitants of both bigger fish and plankton by disturbing the organisms' capability to osmoregulate (Schallenberg et al., 2003).

Salinity is also known as one most significant factor for defining the endurance of aquatic life in estuarine ecologies; whichever by directly effecting the organisms or indirectly by abolishing their territory, together with their refinement and growing places (Abowei, 2010).

BIOLOGICAL CHANGES

Change in climate affects many significant biological developments, follow-on variations in prime production (Taucher and Oschlies, 2011) and variations in fish dissemination (Sumeila et al., 2011). These variations have adverse effect on food safety in numerous tropical coastline areas. Association of changing climate and upcoming prime production of marine ecosystem could be an important possible restraint on fish and production of fisheries (Dulvy et al., 2010). Changing climate can prompted variations in phenology and dissemination of fish larvae and their target prey which can also influence employment and production of fish assemblies (Brander, 2010).

CHANGES in FISH CIRCULATION

Modification in fish circulation is the most generally stated biological reaction of marine organisms (Sumaila et al., 2011; Ipinjolu et al., 2014). Many fish types are supposed to react to ecological changes like heating up temperatures of water by moving from latitudinal and deep ranges. These changes in marine subtleties could direct to variations in relocation arrays of fish and perhaps decrease fish jetties, particularly in coastline fisheries of several African states (African Action, 2007; Urama and Ozor, 2010).

Oceanic fisheries are chief food source, and consequently, alterations in the whole quantity of fish or changing in division in different regions accessible for harvest could possibly disturb food maintenance in different countries (Cheung et al., 2009).

RECIRCULATING AQUACULTURE SYSTEMS

Recirculating aquatic ecosystems are planned to regulate all ecological features of production by constantly treating, filtering, and reusing water, and by this means enhancing working efficacy and dropping threats from changing climate and public private partnership. Recirculating process of aquaculture systems required lesser direct water and land than old conventional aquaculture systems and facilitate greater keeping densities (Ebeling and Timmons, 2012) but are controlled by some factors including high expenses, great energy necessities, waste discarding issues, and danger of natural disastrous disease losses (Klinger and Naylor, 2012; Badiola et al., 2012; Badiola et al., 2018).

REFERENCES

Abowei J.F.N. 2010. Salinity, Dissolved Oxygen, pH and Surface Water Temperature Conditions in Nkoro River, Niger Delta, Nigeria, *Advance journal of food science and technology*, 2(1), 36-40.

Africa Action. 2007. Africa Policy Outlook. Available at www.africaaction. Org. 1-12.

Badiola M., Basurko O.C., Piedrahita R., Hundley P. & Mendiola D. 2018. Energy use in recirculating aquaculture systems (RAS), *Aquaculture Engineering*, 81, 57–70.

Bağdatlı M.C. & Belliturk K. 2016. Water Resources Have Been Threatened in Thrace Region of Turkey, *Advances in Plants & Agriculture Research, MedCrave Publishing,* 4(1), 227-228.

Bağdatlı M.C. & Can E. 2019. Analysis of Precipitation Datas by Mann Kendall and Sperman's Rho Rank Correlation Statistical Approaches in Nevsehir Province of Turkey**,** *Recent Research in Science and Technology Journal,* (11), 24-31.

Bağdatlı M.C. & Belliturk K. 2016. Negative Effects of Climate Change in Turkey, *Advances in Plants & Agriculture Research, Med Crave Publishing,* 3(2), 44-46.

Bağdatlı M.C. Belliturk K. & Jabbari A. 2015. Possible Effects on Soil and Water Resources Observed in Nevşehir Province in Long Annual Temperature and Rain Changing, *Eurasian Journal of Forest Science,* 3(2), 19-27.

Bağdatlı M. C. & Arslan O. 2020. Trend Analysis of Precipitation Datas Observed for Many Years (1970-2019) in Niğde Center and Ulukisla District of Turkey, *International Journal of Recent Development in Engineering and Technology (IJRDET),* 9(7), 1-8.

Bağdatlı M. C. & Can E. 2020. Temperature Changes of Niğde Province in Turkey: Trend analysis of 50 years data, International Journal of Ecology and Development Research (IJEDR), 6(2), 62-71.

Bağdatlı M.C. & Ballı Y. 2019. Evaluation with Trend Analysis of The Open Surface Evaporation in Observed for Many Years: The Case Study in Nevsehir Province of Turkey, Recent Research in Science and Technology Journal, (11), 15-23.

Badiola M., Mendiola D. & Bostock J. 2012. Recirculating aquaculture systems (RAS) analysis: main issues on management and future challenges. *Aquaculture. Engineering*, 51, 26–35.

Barange M. & Perry R.I. 2009. Physical and ecological impacts of climate change relevant to marine and inland capture fisheries and aquaculture. *In:* Climate change implications for fisheries and aquaculture, eds B.F. Phillips and M. Pérez-Ramírez, 7, PP. 45-62.

FAO. 2009. Fisheries and Aquaculture Technical Paper, 530, Rome, 7-106.

Bindoff N.L., Willebrand J., Artale V., Cazenave A., Gregory J.M., Gulev S., & Woodworth P. 2007. Observations: oceanic climate change and sea level.

Brander K. 2010. Impacts of climate change on fisheries. *Journal of Marine Systems*, 79(34), 389-402.

Cheung W.W.L., Lam V.W.Y., Sarmiento J.L., Kearney K., Watson R. & Zeller D. 2009. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change, *Global Change Biology*.

De Wit M. & Stankiewicz J. 2006. Changes in surface water supply across Africa with predicted change, *Science*, 311, 1917-1921.

Di, H.J. & Cameron K.C. 2002. Nitrate leaching in temperate agroecosystems: sources, factors and mitigating strategies, Nutrient Cycling in Agroecosystems, 46, 237–256.

Dulvy N.K., Reynolds J.D., Pilling G.M., Pinnegar J.K. & Phillips J.S. 2010. Fisheries management and governance challenges in a climate change. Available at Impacts of Climate Change on Fisheries, 133.

Ebeling J.M. & Timmons M.B. 2012. Aquaculture Production Systems. *In:* (ed. Tidwell, J.) (Wiley-Blackwell, 2012), pp. 245–277.

EEA. 2015. The European environment - state and outlook 2015, *synthesis report*, European Environment Agency, Copenhagen, Denmark.

Evans D.O., Henderson B.A., Bax N.J., Marshall T.R., Oglesby R.T. & Christie W.J. 1987. Concepts and Methods of Community Ecology Applied to Freshwater Fisheries Management, *Canadian Journal of Fisheries and Aquatic Sciences,* 44(S2), 448-470.

FAO. FAO Food outlook, Rome, FAO. 2008.

Ficke A.D., Myrick C.A., Hansen L.J. 2007. Potential impacts of global climate change on freshwater fisheries, *Review in Fish Biology and Fisheries*, 17, 581–613.

Food and Agriculture Organization-F.A.O. 2009.

George F.O.A. 2010. Indigenous and Emerging Technologies for climate change Adaptation in Aquaculture and Fisheries. *Journal of Sustainable Development*, 7(2), 34-42.

Garcia S.M. & Rosenberg A.A. 2010. Food security and marine capture fisheries: characteristics, trends, drivers and future perspectives, *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), 2869-2880.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change,* The Physical Science Basis', Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Summary for Policy Makers, Cambridge University Press, 13.

Ipinjolu J.K., Magawata I. & Shinkafi B.A. 2014. Potential Impact of Climate Change on Fisheries and Aquaculture in Nigeria, *Journal of Fisheries and Aquaculture Science*, 9(5), 338-344.

İstanbulluoğlu A., Bağdatlı M.C. & Arslan C. 2013. Uzun Yıllık Yağış Verilerinin Trend Analizi ile Değerlendirilmesi Tekirdağ-Çorlu İlçesi Uygulaması, *Tekirdağ Ziraat Fakültesi Dergisi*, 10(2), 70-77.

Jackson Z.J., Quist M.C., Downing J.A. & Larscheid J.G. 2010. Common carp (Cyprinus carpio), sport fishes, and water quality: Ecological thresholds in agriculturally eutrophic lakes, Lake and Reservoir Management, 26(1), 14-22.

Klinger D. & Naylor R. 2012. Searching for solutions in aquaculture: charting a sustainable course. *Annual Review and Environment and resources,* 37, 247–276.

Lukowicz M.V. 1982. Intensive carp Cyprinus carpio (L.) rearing in a farm pond in southern Germany and its effects on water quality, Aqua cultural Engineering, 1(2), 121–137.

Mueller D.K., Hamilton P.A., Helsel D.R., Hitt K.J. & Ruddy B.C. 1995. *Nutrients in ground water and surface water of the United States*, An analysis of data through 1992, U.S. Geological Survey Water Resources Investigations (WRI) Report, 95-4031.

Munday P.L., Jones G.P., Pratchett M.S. & Williams A.J. 2008. Climate change and the future for coral reef fishes, *Fish and Fisheries,* 9(3), 261-285.

Rosemary R. & Shirley V. 2015. Climate Change and the law of the sea. Elgar online, Utrecht University Library, 174.

Schallenberg M.C., Hall J. & Burns C.W. 2003. Consequences of climate-induced salinity increases on zooplankton abundance and diversity in coastal lakes, *Marine ecology progress series,* (251), 181-189.

Smith V.H., Tilman G.D. & Nekola J.C. 1999. Eutrophication: impacts of excess nutrient inputs on freshwater, marine, and terrestrial ecosystems, *Environmental Pollution,* 100(1-3), 179–196.

Stockner J.G., Rydin E. & Hyenstrand P. 2000. Cultural Oligotrophication: Causes and Consequences for Fisheries Resources, *Fisheries,* 25(5), 7-14.

Sumaila U.R., Cheung W.L., Lam W.Y., Daniel P. & Herrick S. 2011. Climate change impacts on the biophysics and economics of world fisheries, *Nature Climate Change,* (1), 449- 456.

Taucher J. & Oschlies A. 2011. Can we predict the direction of marine primary production change under global warming, *Geophysical Research Letters*, 38.

Urama K.C. & Ozor N. 2010. Impacts of climate change on water resources in Africa: the role of adaptation. *African Technology Policy Studies Network*, 29, 1-29.

Verweij W., Wiele V.D., Moorselaar V. & Grinten V.E. 2010. *Impact of climate change on water quality in the Netherlands.* National Institute for Public Health and the Environment. RIVM report. 607800007, 53.

Weber M.J. & Brown M.L. 2009. Effects of Common Carp on Aquatic Ecosystems 80 Years after “Carp as a Dominant”: Ecological Insights for Fisheries Management, *Reviews in Fisheries Science*, 17(4), 524-537.

World Fish Center. 2007b. The threat to fisheries and aquaculture from climate change. Policy Brief. World Fish Center, Penang, Malaysia.

Eurasian Journal of Agricultural Research 2021; Vol:5, Issue:2, pp:233-242

Negative Effects of Global Climate Change on Agriculture Production

Maham ZAHID

Nigde Omer Halisdemir University, Faculty of Agricultural Sciences and Technologies, Nigde/Turkey

Corresponding author: maham.zahid77@gmail.com

ORCID: 0000-0003-4255-3829

Abstract

Climate is a vital aspect of agriculture production. Change in climate is caused when greenhouse gases are released into the air. High concentration of gases like methane, nitrous oxide and carbon dioxide are the reason of global climate change. Climate change will cause high sea level, modified rainfall patterns and high atmospheric temperatures. As temperature gets higher, crop yields are most probably suffering if dry episodes occur during early stages. Climate changes have endangered the agriculture productivity making it susceptible both physically and economically. Globally, high frequency of unpredictable weather conditions will lead to decrease the agricultural productivity and greater prices, which will lead to food security concerns. Adaptations like alterations in variety of crops, upgraded irrigation and water management system and variation in planting plans and cultivation practices will be vital in restraining the negative impact and taking benefit of the positive effects of climate changes.

Keywords: Agriculture, Greenhouse Gases, Climate, Global Warming, Food Security

Review article
Received Date: 4 October 2021
Accepted Date:17 December 2021

INTRODUCTION

Climate change has become the focus of constant attention of living things and civilizations take into account the climate parameters determined their lifestyles. The increasing or decreasing direction in climate values, changes affect living things negatively. decrease in productivity, especially in agricultural production causes (İstanbulluoğlu et al., 2013).

Climate is a vital aspect of agriculture production. Change in climate is caused when greenhouse gases are released into the air. Accumulation of these gases in the air results in global warming. Parameters linked with climate change include precipitation, sea level, temperature and soil moisture. However, the consistency of the forecasts on change in climate is unclear. There are no evidences about what will certainly be the outcome of high level of greenhouse gases in the air. Agriculture is a main sector to study regarding climate change. Agriculture is not only contributing in climate changes but it is also being affected by changing climate. Anthropogenic activities that include urbanization, industrialization, agriculture, deforestation, modification in land usage patterns is leading to release of GHGs which is increasing the rate of climate change more rapidly.

Changes in climate include high temperatures, precipitation variations, and high carbon dioxide concentrations. Greenhouse Effect might be considered significant for agriculture in three ways. Foremost, high concentrations of CO_2 may have an effect on the rate of growth of plants directly. On Second, changes due to induction of atmospheric CO_2 can modify temperature levels and rainfall patterns. Lastly, increases in sea level can lead farmland loss by flood and high salinity of groundwater in seaside zones.

Climate change is progressing as one of the essential environmental issue faced by present world. Release of greenhouse gases, high concentration of gases like methane, nitrous oxide and carbon dioxide are the reason of global climate change. Change in climate will cause high sea level, modified rainfall patterns and high atmospheric temperatures. Due to change in climate patterns, storms, droughts and flood intensities are likely to be increased. Temperature will be increased globally by 1.8°C - 4°C with an average rise of 2.8°C (IPCC, 2007). We as human are accountable for this evolving enriched carbon dioxide world because excessive usage of fossil fuels and deforestation have raised CO_2 concentration from 280 ppm - 380 ppm (Stern, 2007). Agriculture productivity is reliant on climate conditions. Climate changes have endangered the agriculture productivity making it susceptible both physically and economically. Productivity may be affected by various factors that include rainfall sequence, temperature, variation in sowing and harvesting time, availability of water and suitability of land. Changes in climate might not have vast effects yet local effects are quite widespread. Few areas will get benefit from climate changes whereas some areas will be highly affected. Climate change will not only have an effect on agriculture productivity but it also disrupts the financial stability that will affect the supply and demand steadiness of agricultural produces, viability, trade and rates of these produces (Kaiser and Drennen, 1993). Increase in GHGs will affect the productivity of agriculture in under developed states in comparison to developed states (Kurukulasuriya et al., 2006; Seo and Mendelsohn, 2008). Economy of under developed states are more sensitive to climate as their economy depend on labor services, however; economy of developed countries can manage climate changes by using technology and adaptations (Mendelsohn et al., 2001).

Increases in carbon dioxide concentration due to human activities are now being considered the main reason of greenhouse effect, and experts are also considering that these will lead to earth warming (Houghton et al., 1996). It is evident that climate changes are expected to affect the local evaporation, temperature and precipitation patterns, certainly the whole array of agricultural, meteorological, ecological and hydrological relationships.

The greenhouse effect is producing the warm atmosphere near the earth. Though, the increase in greenhouse gases that include methane, carbon dioxide, water vapors, nitrous oxide, perfluorocarbons, sulfur hexafluoride and hydrofluorocarbons due to anthropogenic actions has cause a raise in temperature, which is now leading to global warming.

AGRICULTURE and CLIMATE

Agricultural activities have contributed around 20 % of the increase in anthropogenic GHGs emissions annually (Charoensilp et al., 1998). This area is contributing to global warming by increasing the concentration of CO_2, CH_4 and N_2O emissions.

The GHGs allow the light transmission reaching the earth, blocking the heat transmission which is trying to escape from the air, so traps heat as a 'greenhouse.' Methane has the maximum global warming potential, that is around 300 times more the potential of carbon dioxide and around 20 times more that of nitrous oxide. The major sources are nitrogen fertilizers, soil management, flooded rice fields, burning o biomass, conversion of land, and livestock production and linked manure management (IPCC, 1996).

CARBON DIOXIDE (CO_2)

Firstly, deforestation due to extension of agriculture and speculation of land was considered a main source of carbon gas emissions. When natural vegetation is renewed into agriculture land, a huge quantity of the soil carbon can also be gone as plants and other organic matter are removed. This occurrence contributed about a third of the over-all carbon dioxide emissions worldwide. In several regions, it is a communal drill to burn huge sizes of crop remains, which results in insects and pest killing and causes soil acidity to neutralize (IPCC, 1996). Respiration, photosynthesis and transpiration are few plant processes mostly affected by change in the concentration of carbon dioxide. Certain changes in plant growth pattern from these crucial effects, some will result in positive outcome while others result in negative (Rosenzweig and Hillel, 1998).

METHANE (CH_4)

CH_4 is the most important GHG released in the agriculture area. Maximum amount of the CH_4 come from paddy fields around 91% and less meaningfully from animal husbandry 7% and the remaining 2% from burning of agriculture wastes. The quantity of gas emission has recognized challenging as the emissions may vary with the amount of fertilizers, land cultivation, density of rice plants, water management and other agriculture practices. China is a major source of methane gas emissions among Asian countries. Livestock and related manure management causes almost 16% of the total yearly production of CH_4.

NITROUS OXIDE (N_2O)

Mostly nitrous oxide emissions in agriculture come from the use of nitrogen fertilizer, cropping of legumes and animal waste. Some nitrous oxide emissions are also added during burning of biomass. Several farmers use nitrogen fertilizers on their lands to improve plant growth. The plant takes up maximum nitrogen, but some of the quantity leach into nearby area and ground waters and remaining into the air. The nitrogen flux majorly depends on the microbial activity occurring in the soil. The amount of nitrous oxide emitted is quite lower in capacity than the amount of methane gas.

REDUCTION in GHG EMISSIONS

Improvement in land usage practices might work toward the lessening of greenhouse gases emissions. The irregular drying of soil and reduced land turbulences like zero tillage and mulching will be beneficial in reduction of emissions. Alterations of cultivation practices like change from planting seeds directly and suitable water management can also cause decrease in methane gas emissions. The organic material reduction and inorganic fertilizers use will help to reduce gas emissions. Some variations in agriculture productivity could be helpful and can cause reduction in necessary soil disturbances like a change from outdated to high-yielding crop varieties, or moving from rice to other crops.

ROLE of TEMPERATURE

High temperatures will affect patterns of agriculture production. Few crops growth might get direct benefit from less temperature, while other crops might be affected by high temperature; or indirectly through the effect of temperature on water, on the extension of insects, pests and diseases, on weeds in different habitats.

When the optimum temperature array for a particular crop in an area is increased, it usually tends to respond in a negative way which will result in low yield. Mostly crops are sensitive to higher temperature ranges. Atmospheric temperatures between 45 - 55°C that last for around half hour directly cause leaves damage in most surroundings; even low temperature ranges like 35 - 40°C might be damaging if they continue (Fitter and Hay, 1987). Susceptibility of plant crop to affect by higher temperatures may vary with developmental stages. As temperature gets higher, crop yields are most probably suffering if dry episodes occur during crucial growing phases.

ROLE of WATER

Increasing world population, changing climate conditions and economic activities are growing with each passing day makes it more important than water. This is where the water demand of the different species and in different locations (Bağdatlı and Bellitürk, 2016b). Global warming will cause temperature raise from 1.4 - 5.8°C in coming century, climate models predicts that both precipitation and evaporation will be increased, as well as occurrence and potential of precipitations. While few areas might become wetter, while others undergo the effect of an increased hydrological cycle result in loss of soil humidity and high soil erosion. Some areas that are already prone to drought might suffer for long duration and more intense dry period. Furthermore, with alterations in patterns of precipitation, moisture in soil will be declined in few mid latitude areas during the summer season, while snow and rain will probably be increased at high latitudes areas during the winter season.

Precipitation, the main source of moisture in soil, is likely to be the most significant factor decisive for crop productivity. Though climate models forecast a complete escalation in precipitation globally, their outcomes also indicate the potential for altered hydrological cycles. Climate change might affect over-all periodic precipitation, its within-season array, and it's between-season frequency. The water necessity of a crop is also susceptible to increase in the regular and seasonal frequency of evaporation and transpiration resulting from high temperature, dry air or windy conditions.

Overheated soil; It will reduce the amount of moisture contained in it and cause the plant to not get enough water. This situation will make the soil inefficient. As the soil temperature decreases, plants that are not suitable for climate conditions and resistant to cold will be affected by root and cause drying. As a result, a constantly increasing soil temperature will adversely affect plant life. It will decrease the efficiency. It will negatively affect your living life (Bağdatlı and Ballı, 2020).

Extremely wet years, might cause yield drops due to lodging, waterlogging and amplified pest infestations. Higher soil moisture content in tropical areas can also obstruct field processes. Extreme bursts of rain might destruct earlier plants and stimulate lodging of standing plant crops with maturing grains, also soil erosion. The level of crops destruction depends on the interval of flooding and precipitation, crop developing phase, and soil and air temperatures.

Drought situations might also be tempted by lesser precipitation. Periods of higher relative humidity, hail and frost might also affect crop yield and quality. Interannual alterations in precipitation is a main reasons of variations in quality of crops and yield percentage. By reduction in vegetative cover, droughts intensify erosion by water and wind, therefore affecting agricultural productivity. In grain crops, pollination, flowering and grain filling are particularly sensitive to water stress.

Consequently, management applications have been developed to increase crops growth in water scarcity situations. Drought and heat stress frequently occur at once; one intensifies the effect of the other. Higher solar irradiation might be supplemented by high frequency winds. When plant crops are exposed to drought condition, it cause stomatal closing, lessen transpiration and, therefore, rising temperatures.

ROLE of CARBON DIOXIDE

Global climate change, the industrial revolution of the then mankind atmosphere to release the carbon dioxide, methane, ozone and nitrogen oxides as gases are very quickly heat the earth by the greenhouse effect that occurred as a result of the increase is a result of an increase above normal. The accumulation of carbon dioxide and other greenhouse gas levels in the atmosphere have reached has increased rapidly since the industrial revolution (Bağdatlı and Bellitürk, 2016a).

High concentration of carbon dioxide stimulates photosynthesis in some plants as they tend to reduce their photorespiration. This is accurate for the major species worldwide and particularly in cold habitats. Few effects on yield is observed for tropical plant crops which are significant for the food security of various under developed countries.

Climate change includes high temperature ranges, precipitation variations, and high atmospheric carbon dioxide concentrations which might affect yield percentages, rate of growth, transpiration and photosynthesis, availability of moisture, irrigation practices and agricultural contributions like insecticides herbicides and fertilizers. Environmental factors like intensity and frequency of soil erosion and soil drainage, availability of land, reduce crop diversity might also affect productivity of agriculture. High carbon dioxide level in the air would result in high photosynthetic rates (Cure and Acock 1986; Allen et al., 1987). High level of CO_2 might also decrease transpiration. The decrease in transpiration rate could be around 30% in some plants (Kimball, 1983). Loss o yield caused by synchronized rise in carbon dioxide and temperature are mainly caused by high temperature tempted spikelet sterility (Matsui et al., 1997a). Higher CO_2 concentrations might also inhibit respiration at night when temperature is greater than 21°C (Baker et al., 2000).

Global warming will speed up various microbial processes in the soil-water system, which impact C and N cycle. Decomposition of crop residues may be changed. High soil temperature might also cause an increase in carbon dioxide loss from the soil caused by root exudates, root respiration and fine-root turnover. Bacterial and fungal pathogens are also expected to be increased in regions where precipitation rates are high. Under warm and humid situations cereal crops would be more susceptible to the outbursts of diseases and pests thus reducing yield percentages.

NEGATIVE IMPACT of CLIMATE CHANGE

Over-all, agriculture contributes slightly to total greenhouse gas emissions. However, the agricultural area remains the key emitter of nitrous oxide gas, which come from manure and fertilizers and methane gas which is coming from rice fields and livestock. Furthermore, deforestation is the another source of carbon dioxide gas emission. Therefore, any impact of climate change on forestry and agriculture unavoidably feeds back to the climate system.

The decrease over time of the changes in the surface of the water is noticeable. This also shows itself as the effect of disorder in the vaporization and current precipitation regime in the water sources dependent on climate change (Albut et al., 2018).

Excessive increase and decrease of temperatures negatively affect the life of living things. It will be difficult to find clean water in the future as the increase of temperatures will increase the evaporation level. Increasing or falling temperatures will cause climate change (Bağdatlı and Can, 2020).

The impact of climate changes on agriculture will be different globally. It is complex to determine how climate change will have an impact on agriculture. Variations in temperature and rainfall sequences and an increase in carbon dioxide gas concentration expected to change climate will have significant impact on agriculture worldwide, particularly in the humid areas. It is anticipated that productivity of crops will be altered due to these variations in climate, changed weather conditions and varying pest's activity. The appropriate land parts for cultivation of important crops could experience geographical modifications in response to climate changes. Demonstration of impacts due to climate changes for local food supplies are challenging for few reasons that include;

- Unreliability in local climate change forecasts;
- Our consideration of few agriculture processes like 'fertilization', response of different plant crops to higher concentration of atmospheric carbon dioxide and the probability of changed distributions and patterns of pests, diseases, insects and weeds remains inadequate;
- Ambiguity related to the possibility for adaptation for advanced agriculture practices.

The impact of global climate changes on agriculture productivity are expected to be minor to modest. Though, local effects could be important across the world. Crop yield percentages and productivity changes will be different noticeably across many zones. These positive and negative changes will possibly result in a considerable decline of agriculture productivity.

Susceptibility of climate changes ae dependent on biological, physical and socioeconomic parameters. Inhabitants with less income are reliant on agricultural systems are mainly exposed to hunger. Such populations are already food insufficient, even the least decrease in yields could be very destructive in such regions. The adverse negative effects are anticipated in dryland zones at low latitudes and in dry and semi-dry areas, which are particularly dependent on rain fed agriculture.

It is indicated that marginal farmers might be the most susceptible both to short duration weather variations and long term climate changes. Comparatively little climate changes could noticeably modify the potential for agriculture, therefore causing an incompatibility between current farming practices and current climate factors for agriculture in these regions (Matthews et al., 1994a; Matthews et al., 1994b)

The potential negative effects due to climate changes could influence agriculture productivity undesirably due to;

- Geographic and yield changes in agriculture,
- Water availability reduction for irrigation
- Land loss due to rise in sea level and salinization

The yields of various crops and geographical restrictions might be transformed by variations in moisture content of soil, precipitation, temperature, cloud amount, also carbon dioxide levels. The low rainfall and higher temperatures could cause reduction in soil moisture in many regions, dropping the water availability for irrigation and damaging crop growth in non-irrigated land of the many areas.The variations in soil characteristics like loss of organic matter in soil, leaching down of nutrients in soil, soil erosion and salinization are an expected outcome of climate change. The threat of loss due to insects, weeds and diseases is expected to be increased.

The variety of various insects will be expanded and novel combinations of diseases might appear as natural environments response. The impact of climate on insects and pests might enhance effect of other parameters like the pesticides overuse and biodiversity crisis.

Agriculture in regions nearby to river might be affected by an increase in sea level. Flooding will possibly become an important issue in few already flood affected areas. Reductions in agriculture productivity are most probably in such areas, which are already prone to flood (WRI, 1998). Changes in temperature and rainfall patterns might be inflated and destructive to agriculture.

CLIMATE CHANGE IMPACT on WORLD'S AGRICULTURE

Global reduction of farming lands and population growth rate along with the climate change phenomenon will cause lots of problems for worldwide food supply and we will face numerous nutritional problems in the near future. By gradually reaching to the 8 billion population on the earth, the mankind is really in challenge to provide the growing population food needs. The uncontrolled transformations of climate parameters such as temperature and rainfall affect the agricultural productions in a negative way (Bağdatlı et al., 2015).

Climate changes are expected to have an impact on food production worldwide. Increased temperatures can cause a reduction in interval of several crops and therefore lessen final yield. In regions where temperature ranges are already near physiological maxima for plant crops, warming will effect yields instantly (IPCC, 2007). Worldwide agriculture is facing a severe decrease within this era because of global warming. Generally, agriculture productivity is estimated to decrease by 3 - 16 % by 2080. Under developed states, which already have an average temperature that is close to crop tolerance level, are expected to suffer a typical 10 - 25% decrease in agriculture productivity by 2080s. developed countries, which have usually low temperatures, will experience a much slighter or may be positive effect, ranges from an 8% rise in productivity to a 6% decrease. Individual under developed countries may face even greater drops.

AGRICULTURAL PRODUCTIVITY and FOOD SECURITY

Changing climate conditions will be an important factor in the current situation and the problems that may arise in the coming years. For this reason, solutions are needed for global warming and reduction of greenhouse gases that cause climate change (Bağdatlı and Arslan, 2020). Climate change has either direct or indirect impact on food security. Any change in the climate factors like humidity and temperature which manage crop development and growth will have an impact on food quantity directly. Certain indirect association relates to fatal actions like drought and flood which are expected to increase as a result of climate changes which will lead to massive crop loss and will leave large areas of arable patches unfit for further cultivation and therefore increases food security concerns. Overall impact of food security is dependent on the coverage to worldwide environmental changes and the capability to handle and improve from environmental changes across the globe. Globally, high frequency of unpredictable weather conditions will lead to decrease the agricultural productivity and greater prices, which will lead to food security concerns. This effect of global warming has important concerns for agriculture production for under developed countries, also a high risk of deprivation.

ADAPTATION

Changes will be essential in order to counter any adverse effects of climate. Agriculturalists must have the capability to amend variations by using latest techniques and modifications. Adaptations like alterations in variety of crops, upgraded irrigation and water management system and variation in planting plans and cultivation practices will be vital in restraining the negative impact and taking benefit of the positive effects of climate changes. More effective use of inorganic fertilizers and some other changes in agriculture practices might also help to counter the impact of climate change.

Different types and levels of scientific and socioeconomic modifications to climate change are promising. The level of these modifications depend on the economical aspect of such methods, mainly in under developed countries. Recent research shows that high costs of agriculture production due to climate changes would be a thoughtful financial problem for under developed countries. Other main aspects will be knowledge of technology, the frequency of change in climate and few biophysical restraints like soil properties, genetics of crops and availability of water (Darwin et al., 1995).

The adaptation of discrete farmer to climate change situation will include variations in crop selection, cultivation practices, irrigation management and pests control. Better climate predictions can help agriculturalists to get ready for any changing weather conditions.

Eventually, the capability of producers to adjust efficiently will not just define the success or failure of specific producers but also might contribute in countries economy. Global warming is not only offering challenges to the agriculture sector but also proposing opportunities. Few farm management practices are acting as a shield against climate changes and reducing GHGs concentrations in the air. Restoration and conversion of land have increased content of organic matter in soil through a process of sequestration while at the same time cause reduction in emissions. Expansions in fertilizer productivity and application of environment friendly types can decrease nitrous oxide emissions. Lastly, biofuels production and usage recycle carbon dioxide gas, therefore giving a direct counterbalance to gas emissions from nonrenewable sources.

REFERENCES

Albut S., Bağdatlı M. C. & Dumanlı Ö., 2018. Remote Sensing Determination of Variation in Adjacent Agricultural Fields in the Ergene River, *Journal of Scientific and Engineering Research,* 5(1): 113-122.

Allen Jr L. H., Boote K.J., Jones J. W., Jones P. H., Valle R. R., Acock B. & Dahlman R. C. 1987. Response of vegetation to rising carbon dioxide: Photosynthesis, biomass, and seed yield of soybean, *Global biogeochemical cycles,* 1(1), 1-14.

Baker J.F.T., Jr L. R.A., Boote K.N.J. & Pickering N. B. 2000. Direct effects of atmospheric carbon dioxide concentration on whole canopy dark respiration of rice, *Global Change Biology,* 6(3), 275-286.

Bağdatlı M.C. & Belliturk K. 2016a. Negative Effects of Climate Change in Turkey, *Advances in Plants & Agriculture Research, Med Crave Publishing*, 3(2):44-46.

Bağdatlı M.C. & Belliturk K. 2016b. Water Resources Have Been Threatened in Thrace Region of Turkey, Advances in Plants & Agriculture Research, MedCrave Publishing, 4(1):227-228

Bağdatlı M.C., Belliturk K. & Jabbari A. 2015. Possible Effects on Soil and Water Resources Observed in Nevşehir Province in Long Annual Temperature and Rain Changing, *Eurasian Journal of Forest Science*, 3(2):19-27.

Bağdatlı M. C. & Can E. 2020. Temperature Changes of Niğde Province in Turkey: Trend analysis of 50 years data, *International Journal of Ecology and Development Research (IJEDR),* 6(2):62-71.

Bağdatlı M. C. & Ballı, Y. 2020. Soil Temperature Changes (1970-2019) in Ulukışla District in Turkey by Trend Analysis Methods, *International Journal of Plant Breeding and Crop Science (IJPBCS),* 7(2): 851-864.

Bağdatlı M. C. & Arslan O. 2020. Trend Analysis of Precipitation Datas Observed for Many Years (1970-2019) in Niğde Center and Ulukisla District of Turkey, *International Journal of Recent Development in Engineering and Technology (IJRDET),* 9(7):1-8

Charoensilp N., Promnart P. & Charoendham P. 1998. An Inter-regional Research Programme on Methane Emission from Rice Fields. In Thailand-IRRI Collaborative Research Planning Meeting on June, pp. 25-26.

Cure J.D. & Acock B. 1986. Crop responses to carbon dioxide doubling: a literature survey, *Agricultural and forest meteorology*, 38(1-3), 127-145.

Darwin R., Tsigas M., Lewandrowski J. & Raneses, A. 1995. World agriculture and climate change: Economic adaptations. Agricultural Economic Report No. 703. Natural Resources and Environmental Division, Economic Research Service, U.S. Department of Agricultures, Washington, DC.

Fitter A.H. & Hay R.K. 2012. Environmental physiology of plants. Academic press.

Houghton E. 1996. *Climate change,* 1995. The science of climate change: contribution of working group I to the second assessment report of the Intergovernmental Panel on Climate Change, 2, Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC). 1996. In: Climate change 1995: Impacts, adaptations and mitigation of climate change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC 2007. The physical science basis. Contribution of Work Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate, Cambridge University Press, United Kingdom.

İstanbulluoğlu A., Bağdatlı M. C. & Arslan C., 2013. Uzun Yıllık Yağış Verilerinin Trend Analizi ile Değerlendirilmesi Tekirdağ-Çorlu İlçesi Uygulaması, *Tekirdağ Ziraat Fakültesi Dergisi*, 10(2):70-77, Tekirdağ

Kaiser H.M. & Drennen. T. 1993. Agricultural dimensions of global climate change. St. Lucie, FL: St. Lucie Press.

Kimball B.A. & Idso, S.B. 1983. Increasing atmospheric CO_2: effects on crop yield, water use and climate, *Agricultural water management*, *7*(1-3), 55-72.

Kurukulasuriya P., Mendelsohn R., Hassan R., Benhin, J., Deressa T., Diop M., Mohamed H., Fosu K.Y. Gbetibouo G., Jain S., Mahamadou A., Mano R., Mariara J.K., El-Marsafawy S., Molua E., Ouda S., Ouedraogo M., ISe´ne I., Maddison D., Niggo S. & Seo A. 2006. Will African agriculture survive climate change, *The World Bank Economic Review*, 20, 367-388.

Matsui T., Namuco O.S., Ziska L.H. & Horie T. 1997. Effects of high temperature and CO_2 concentration on spikelet sterility in indica rice. Field Crops Research, 51(3), 213-219.

Matthews R.B., Kropff M.J. & Bachelet D. 1994 (a). Climate Change and Rice Production in Asia. *Entwicklung und Landlicherraum*, 1, 16-19.

Matthews R.B., Kropff M.J. Bachelet D. & van Lar, H.H. 1994(b). The impact of global climate change on rice production in Asia: A simulation study. Report No.ERL-COR-821. Corvallis, OR: U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis.

Mendelsohn R., Dinar A. & A. Sanghi. 2001. The effect of development on the climate sensitivity of agriculture. Environment and Development Economics 6, 85-101.

Rosenzweig C. & Hillel D. 1998. Climate Change and the Global Harvest (Oxford University Press Inc.: New York.).

Seo N. & Mendelsohn R. 2008. A Ricardian analysis of the impact of climate change on South American farms. *Chilean Journal of Agricultural Research*. 68, 69-79.

Stern N. & Stern N. H. 2007. The economics of climate change: the Stern review. Cambridge University press.

World Resources Institute (WRI) 1998. World Resources 1998/99. A joint publication by The World Resources Institute. The United Nations Development Programme, The United Nations Environment Programme and The World Bank. New York, Oxford University Press.