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Analysis of Profitability, Technical Efficiency and Allocative Efficiency of Watermelon Production in Federal Capital Territory, Nigeria

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Abstract

This study evaluated analysis of profitability, technical efficiency and allocative efficiency of watermelon production in Federal Capital Territory Abuja, Nigeria. Multistage sampling technique was used. Data were collected through the use of well-structured questionnaire administered to 120 sampled Watermelon farmers in the study area, one questionnaire was not retrieved therefore the analysis was don based on the 119 retrieved questionnaire from the sampled respondents. The following tools of analysis were used to achieve the stated specific objectives of the study. Descriptive statistics, gross margin analysis stochastic production frontier function and stochastic cost frontier function. The results of the socioeconomic characteristics revealed that majority (95%) of sampled respondents were male while only 5% of the sampled respondents were female. The gross margin obtained was ₦97,652.12 with an operating ratio and rate of return on investment of 0.67 and 2.29 respectively. The significant factors influencing total output of watermelon were Seed (P<0.05), fertilizer NPK (P<0.1), fertilizer urea P<0.1) and Chemical (P<0.01). The technical inefficiency component shows that the factors influencing technical inefficiency are Sex (P<0.01), Marital Status (P<0.01), Educational Level (P<0.01), Occupation and Household Size (P<0.01). The mean estimated value of the allocative efficiency for the farmers was (0.46870 or 47%). The allocative inefficiency model revealed that the factors influencing allocative inefficiency includes age of the farmers (P<0.01), sex (P<0.01), educational level (P<0.05) and the household size (P<0.1). The watermelon farmers encountered the following constraints in the cause of production inadequate capital, lack of land availability, unavailability of improved seed, Government policy on land use, high costs of farm inputs and affordability, poor information network and bad roads. Therefore, the study recommends that female farmers should be encouraged to participate in watermelon production, however, government and non-governmental organizations should create more avenue for women and youth to have access to credit to enable them have a means of livelihood and financial freedom. Extension officers should be made available to train farmers and to expose farmers to the importance of watermelon farming which will help them have more access to production inputs like improved seeds, fertilizers, chemical and credit facilities. Farmers should be encouraged to increase the size of their production in order to increase total output to minimize cost and improve efficiency, improved seed, capital, chemical and fertilizer should be provided to farmers at subsidized rate. Farmers should be encouraged to form and join cooperatives organizations to enable them have access to good market price.

Keywords: Profitability, Efficiency, Stochastic frontier, Watermelon, Nigeria

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INTRODUCTION

Agriculture remains the bedrock for economic growth, attaining development and poverty eradication in developing countries including Nigeria. Agriculture has also been regarded as the major engine and panacea for economic prosperity in the Country (Dawang &Yusuf, 2011). “The existing battle for the long-term economic growth will only be won or lost in the agricultural sector”. However, how this pathway will lead to economic prosperity and economic growth is still subject to debate and argument among developmental specialists and top economists across the globe. Nigerian economy in the past decades strives on the agricultural sector. In most of the developing countries (low and middle-income countries alike), the agricultural sector still remains the major and the largest contributor to the economy providing inputs, food security, employment opportunities for youths, raw materials for other industries, foreign earnings from the exportation of the surpluses, and more importantly the enormous advantage of the value added in the various production processes (Dawang &Yusuf, 2011). After the discovery of the black gold in Nigeria, oil (post-oil boom), there was a tremendous decline in the agricultural sector’s share recorded, in terms of its major contribution to Real Gross Domestic Product (RGDP). Water melon *(Citrullus lanatus*) is classified as a tender, warm seasonal vegetable that belongs to the family Cucurbitaceae. Watermelon (*Citrullus lanatus*) is among the native of the tropical Africa, where it has been in used for longer period of time by the wild tribes (Lakdan & Stanzen, 2017). Watermelon *Citrullus lanatus* is one of the most important crops that is widely cultivated in the world (Adeoye et al, 2020). Watermelon can be cultivated in the areas where soils are mostly sandy loam and well-drained (Shrefler et al., 2017; Hogue et al, 2022). It has a high nutritious content and thirst-quenching ability and also contains vitamins C and A in the form of disease-fighting beta-carotene. Potassium is also available in it which is believed to help in the controlling of blood pressure and its possibility of preventing body stroke (De Lannoy, 2001). It has anti-cancer effects ant it can improve heart health, it relieves the soreness of the muscle, watermelon reduces inflammation and oxidative anxiety, it improves skin health and digestion metabolism (Agriculture, 2022). The fruit is effective in reducing cancer, cardiovascular disorders, diabetes, blood pressure, and obesity (Lum et al., 2019). The potentials of watermelon production as a cash-producing crop are very enormous for farmers, it increases the income level of farmers, especially those residing near the urban areas (Bahari et al., 2012). Dessert watermelon is grown worldwide, has a characteristic of sweet taste, it’s a low-calorie fruit that is mostly used in salads and juices (Bahari et al., 2012; Gbotto et al., 2016). The cooking type of watermelon, also called cow watermelon, is normally used in animal feed preparation, for cooking thick porridge, or mixed in dry maize (Zea mays L.) grain (Mujaju et al.,2011). The seed type watermelon is mostly grown in Central to West Africa and is used to extract oil, make egusi soup, snacks, and flour (Jensen, 2012). Watermelon fleshy fruits and rinds contains many edible nutrients that serve as a sources of carotenoids, it contains Vitamins A, B6, C, lycopene, and some elements of antioxidants (Jensen et al., 2011). Watermelon juice can be processed into wine, or other traditional brews. In some African Countries like Sudan and Egypt, they roast watermelon seeds, salt it and eaten as a snacks. Watermelon fruit provides juice that is used as alternative source of water for drinking during drought and dry season in some parts of Sudan and Nigeria (Ayodele & Shittu, 2013; Goda, 2007). Presently, Asia accounts for more than 80% of worldwide watermelon production. China is the number one producer accounting for 67.6% worldwide producing 134,175,133 tonnes per year (FAO,2019).

Africa, Europe, and North America have similar production output, around 3–4 million tonnes annually. Algeria is the leading watermelon producer in the African continent producing (4,300,921 million tonnes yearly), fifth in the world, contributing 1.6% to worldwide production, followed by Egypt (3,491,301 million tonnes yearly), nineth in the world while Nigeria produces 1,002,300 million tonnes as at 2017 (NBS,2017). Currently, Africa as a whole, is classified as the third producer of watermelon in the world (FAO, 2019 &Anonymous, 2019). Watermelon business acts as a means and sources of livelihood for the producers and marketers alike. It generates high revenue to the government through taxes and commissions from the marketers and producers as well. In Africa, watermelon production systems differ depending on the agro-climate, from greenhouses to open field with varying levels of technological application. In most rural communities, watermelon is grown as an intercrop with minimal inputs requirements (Maoto et al., 2019). The study of efficiency in agriculture is based on certain economic theories which describe various ways the production resources could be utilized to achieve maximum output level; one of which is technical efficiency, an engineering concept for measuring the performance of the system given the available resources. Technical efficiency is associated with behavioural objectives of maximization of output (Ndubueze-Ogaraku et al., 2021). Efficiency is generally associated with the possibility of attainment in optimal level of output from a given bundle of input at least cost (Ume et al., 2020). Efficiency is distinguished into three types of efficiency, technical, allocative and economic efficiencies. Technical efficiency is the capability of firms to utilize the best practice or technology in the production process so that the minimum possible resources are used to achieve the best or optimum output level (Ume et al., 2020). Measuring efficiency provides a way of quantifying and comparing the performance of each farmer, and identification of factors explaining any inefficiencies and differences in performances. The current major challenges of rising costs of water melon production requires a main focus on the issue of technically efficient method of production systems. Profit maximization in any farm business requires a farm business enterprise to produce the maximum output of watermelon given the level of production inputs employed during the process, use of the right mixture of inputs in the light of the relative prices of each input is also another challenge (input allocative efficiency) Ndanitsa, et al., 2021). Shortages of horticultural produce especially fruits and vegetables like watermelon are often very acute because of the low levels of technology used in its production process, harvesting system is labour intensive and the storage of water melon is very difficult, increasingly there is high demand for fruits and vegetables due to the desire for improving standards of living of the populace in Nigeria (Adeoye et al., 2020). Costs of production of watermelon would vary depending on the location where it is being produced, Costs of inputs such as water and land vary by the production location, but the amounts of inputs such as fertilizer, pesticide, and herbicides, depend on weather and soil (Adeoye et al., 2020). Generally, watermelon production is labour intensive, especially in harvesting and postharvest handling (Baameur, 2009). Several reasons have been the major reasons and the basis for the need of improving the production of watermelon; one of which is that it can survive even in a water logged area (Robinson, 2000). In addition, watermelon can serve the purpose of both a fruit and a vegetable; therefore, having a higher market demand creating a gap between demand and supply (Otunaiya & Adedeji, 2014). Deliberate efforts on production efficiency and profitability of watermelon needs to be enhanced for sustainability of its production. More awareness which is lacking is needed to market the fruit for its rich health and nutrition benefits and ensure profitability in its production for farmers who are in the production line. Several studies were conducted on watermelon farming at home and abroad. Rabbany et al., (2013) conducted research on the cost of production analysis of watermelon.

Yusuf et al., (2013) also reported profitability and adoption of watermelon technologies by farmers. Ibrahim et al. (2014) explored technical efficiency and its determinants in watermelon production. However, very little studies have been conducted jointly on profitability technical and allocative efficiency of watermelon production in the study area. Hence, this study was conducted to contribute to the existing literature by evaluating the watermelon farmer's profitability, technical efficiency and allocative efficiency in watermelon production. Therefore, this research study was designed to proffer solution to the following research questions.

Research Questions of the study

(i) What are the socio-economic and demographic characteristics of water melon farmers in the study area?
(ii) What is the costs, returns and the profitability level of the water melon production by the farmers in the study area?
(iii) What are the technical efficiency and the factors influencing technical inefficiencies of water melon production in the study area?
(iv) What are the allocative efficiency and the factors contributing to the allocative inefficiencies of water melon production among farmers in the study area?
(v) What are the constraints faced by water melon production by the farmers in the study area?

Objectives of the Study

The main objective of this study is to analyse Analysis of Profitability, Technical and Allocative Efficiency of Watermelon Production in Federal Capital Territory, Nigeria The specific objectives of this study are to;

(i) identify the socio-economic and demographic characteristics of watermelon farmers,
(ii) estimate costs, returns and the profitability level of water melon production,
(iii) evaluate the technical efficiency and factors influencing technical inefficiencies in water melon production,
(iv) evaluate the allocative efficiency and the factors contributing to allocative inefficiencies in water melon production,
(v) identify constraints faced by farmers involved in water melon production in the study area.

MATERIAL and METHOD

The Study Area

This study was conducted in Federal Capital Territory, Nigeria. The Federal Capital Territory, Nigeria came into being with the promulgation of Decree No 6 of 1976. The creation of the FCT came with four Area councils namely: Gwagwalada, Abaji, Kuje, Municipal Area Councils respectively (Ejaro, 2013). On October, 1st 1996, two more new area Councils Kwali and Bwari, were created to bring the total number of area councils in the Federal Capital Territory to six (Ejaro and Abubakar, 2013). The major crops grown in the area are Sorghum, Cowpea, Watermelon, Maize, rice among others.

Sampling Techniques and Sample Size

A multistage sampling technique was adopted for this study. In the first stage purposive sampling procedure was used to select Federal Capital Territory based of the numerous number and concentration of water melon producers in the area.

The second stage involved random selection of two area Councils Kuje and Bwari area Councils using ballot box method. In the third stage three villages were selected randomly from each area council based on the intensity of watermelon producers. In the fourth stage simple random sampling technique was used in each village to select the desired sample size of 120 farmers, one questionnaire was not retrieved therefore, the analysis was done based on 119 questionnaires returned back by the watermelon farmers.

Sources of Data

Primary data were used for this study and the data were collected with the aid of well-structured questionnaire. The output data collected includes the total yield of the watermelon produced cash receipts from selling, quantity consumed at home and those given out as gifts. The input data include farm size, quantity of agrochemicals, labour, quantity of seeds, quantity of fertilizers, cost of simple farm tools such as sprayers, cutlass, hoes and other simple farm implements used. The data generated also include the socio-economic characteristics of the farmers such as age, sex, marital status, household size, educational level, years of farming experience, extension contact, amount of credit received and years of membership of cooperative society.

Methods of Data Analysis

Descriptive Statistics: This involves the use of minimum, maximum, standard deviation, mean, range, percentages and frequency distributions in order to summarize the socio-economics characteristics of water melon farmers this was used to achieve the specific objective one (i) and pat of specific objective (ii).

Farm Budgetary Technique: The farm budgetary techniques adopted to determine the profitability, costs and returns of water melon production in the study area was Gross Margin Analysis (GM) and it is defined as the difference between the gross farm income (GFI) and the total variable cost incur (TVC). This was used to achieve the specific objective two (ii). The Gross Margin Model is stated thus:

$$GM = TR - TVC \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (1)$$

$$GM = \sum_{i=1}^{n} P_i Q_i - \sum_{j=1}^{m} P_j X_j \dots\dots\dots\dots\dots\dots\dots (2)$$

Where,

P_i = Price of water melon ($\frac{₦}{Kg}$),

Q_i = Quantity of water melon (Kg),

P_j = Price of Variable Inputs ($\frac{₦}{Unit}$),

X_j = Quantity of Variable Inputs (Units),

$TR =$ Total Revenue obtained from Sales from water melon (₦),

$TVC =$ Total Variable Cost (₦),

Financial Analysis: This analytical tool was used to determine the ratios to show the profitability of water melon production. The financial analysis was used to achieve part of specific objective two (ii). Gross Margin Ratio according to Ben-Chendo et al. (2015) is defined as:

$$Gross\ Margin\ Ratio = \frac{Gross\ Margin}{Total\ Tevenue} \dots\dots\dots\dots (5)$$

The operating ratio (OR) according to Olukosi and Erhabor (2015) is defined as:

$$Operating\ Ratio = \frac{TVC}{GI} \dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

Where,

TVC = Total Variable Cost (Naira),

GI = Gross Income (Naira),

According to Olukosi & Erhabor (2015) an operating ratio of less than one (1) implies that the gross income from water melon production enterprise was able to pay for the cost of the variable inputs used in the production enterprise.

The rate of return per naira invested (RORI) in water melon production by farmers is defined as:

$$RORI = \frac{NI}{TC} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (7)$$

Where,

$RORI =$ Rate of Return per Naira Invested (Unit),

$NI =$ Net Income (Naira),

$TC = Total\ Cost\ (Naira)$.

Stochastic Production Frontier Function Approach

The stochastic frontier production function was independently proposed by Aigner, *et al*., (1977); Coelli and Battese, (2005) and Farrel (1957). The stochastic production function is defined by

$$Y_i = f(X_i; \beta) = \varepsilon_i$$

$$\varepsilon_i = V_i - U_i$$

Where:

Y_i = observed total output of the ith sample farm f (*xi; β*) is a suitable functional form such as Cobb-Douglas production function, X_i vector of the inputs used by the i-th farm, β vector of unknown parameters to be estimated, ei is error term and random noise. The stochastic frontier production function model was estimated using the maximum likelihood estimation procedure (MLE) (Kumbhakar & Lovell, 2000; Battese & Corra, 1977). The technical efficiency of an individual firm is defined in terms of the observed output (Y_i) to the corresponding frontier output (Y_i*) given the available technology.

$TE_i = \frac{Yi}{Yi*}$

$$TE_i = F(\frac{(X_i; \beta)\exp(v_i - u_i)}{(X_i; \beta)\exp(v_i) = \exp(-u_i)}$$

So that 0 < TEi < 1

Therefore, the technical inefficiency is equal to 1 – TE

The stochastic frontier model for estimating the technical efficiency of the watermelon farms is empirically specified by the Cobb-Douglas frontier production function as:

$$LnY_i = \beta_0 + \sum_{i=1}^{6} \beta_i \, LnX_i + \cdots \beta_n LnX_n + V - U_i \ldots\ldots\ldots..(9)$$

The explicit function is stated thus:
$LnY_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 lnX_4 + \beta_5 LnX_5 + \beta_6 LnX_6 + V_i - U_i$. (10)
Where,
LnY_i = Output of Maize (Kg)
X_1= Seed Input (Kg)
X_2 = Farm Size (Hectares)
X_3 = Quantity of Fertilizer NPK (Kg)
X_4 = Quantity of Fertilizer Urea (Kg)
X_5 = Chemical Input (Litres)
X_6 = Labour Input (Man-days)
The Technical Inefficiency Component of the Stochastic Frontier Model is stated thus:

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \ldots\ldots\ldots (11)$$

Where,
$U_i = Technical\ Inefficiency\ Component$
Z_1= Sex (1, Male; 0, Otherwise)
Z_2= Age of Farmers (Years)
Z_3= Education Level of Farmers (Years Spent Schooling)
Z_4= Marital Status
Z_5= Extension Contact (Number of Contact per Month)
Z_6= Household Size (Number)
α_0 = Constant Term
$\alpha_1 - \alpha_6$ = Regression Coefficients
These were included in the model to indicate their possible influence on the technical efficiency.

Stochastic Cost Frontier Function is stated thus:

$$\mathrm{C_i} = \mathrm{f}\left(\mathrm{P_i}, \mathrm{Y_i};\ \beta_j\right) + (\mathrm{V_i} + \mathrm{U_i});\ \mathrm{i} = 1, 2, \ldots, \mathrm{n}\ \ldots..(12)$$

$$lnC_i = \beta_0 + \beta_q lnY_i + \sum_{j}^{k} \beta_j \, ln\left(P_{ij}\right) + V_i + U_i \ldots\ldots.(13)$$

where, C_i is total cost of production Y_i is total output, X_{ij} are input quantities, and the P_{ij} are input prices. V_i assumed to be independently distributed random errors. It is assumed to be independent, identical and normally distributed with a mean of zero and constant variance $\{V_j \sim N(O, \sigma_V^2\ )\}$ Intuitively, the inefficiency effect is required to lower output or raise expenditure, depending on the specification. The Cost efficiency of individual farmers is defined in terms of the ratio of the predicted minimum cost C_i^* to observed cost C_i that is

$$\mathrm{CE} = \frac{C_i^*}{C_i}$$

Thus allocative efficiency is derived from cost efficiency and it's an inverse of cost efficiency and it ranges between zero (0) and one (1) (Adejor et al, 2018). The explicit form of the stochastic cost frontier function is specified as shown below as used by (Dawang & Yusuf, 2011; Aboaba, 2020; Abdul et al, 2018; Adejor et al, 2018 and Bitrus et al, 2020).

$$L_nC_i = \beta_0 + \beta_1 L_nY_1 + \beta_2 L_nX_2 + \beta_3 L_nX_3 + \beta_4 L_nX_4 + \beta_5 L_nX_5 + V_i + U_i \text{ ......}(14)$$

$LnC_i =$ Total Cost of Watermelon Production
$L_nY_1 =$ Output of Watermelon (Kg)
X_2=Cost of Seed Input (Kg)
X_3 =Cost of Fertilizer (Kg)
X_4 =Cost of Chemical Input (Litres)
X_5 = Cost of Labour Input (Man-days)
The Allocative Inefficiency Component of the Stochastic Cost Frontier Model is stated thus:

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \dots\dots\dots (15)$$

Where,
$U_i = Allocative\ Inefficiency\ Component$
Z_1= Sex (1, Male; 0, Otherwise)
Z_2= Age of Farmers (Years)
Z_3= Marital Status
Z_4= Education Level of Farmers (Years Spent Schooling)
Z_5= Extension Contact (Number of Contact per Month)
Z_6= Household Size (Number)
$\alpha_0 =$ Constant Term
$\alpha_1 - \alpha_6 =$ Regression Coefficients
$V_i =$ Random Noise
$U_i = Inefficiency\ Component$

RESULTS and DISCUSSION

Socioeconomic Characteristics of the Watermelon Farmers in the study Area

Table 1 shows the results of the socio-economic characteristics of the sampled watermelon farmers in the study area, the result showed that majority (95%) of sampled respondents were male while only 5% of the sampled respondents were female this shows that watermelon production is dominated by male farmers in the study area. This result is in line with Anyiro et al., (2012) who suggests that water Mellon production is gender sensitive and requires innate physical exertion of carefully selected force. Also 89.1% of the sampled water Mellon farmers were married while 5% were single. This is also in agreement with Anyiro et al., (2012). The results further show that 56.3% of the sampled water Mellon farmers had 1-5 members per household while 38.7% had 11-15 number of persons per household. This is consistent with the findings of Effiong (2005; Idiong, 2006; Udensi et al., 2011 and Okoye et al., 2008) who reported that a relatively large household size is more likely to provide more labour required for farm operations such as weed control and fertilizer application. Though large household size may not guarantee for increased labour efficiency since family which comprises mostly children of school age are always in school. More so 33.6% obtained secondary school level of education while 46.2% had no formal education at all. The level of education of a farmer not only increases his farm productivity but also enhances his ability to understand and evaluate new production techniques. The implication of education level attained by farmers is that the respondents are better positioned to take advantage of new technique and innovation that could improve agricultural efficiency and boost food security.

Imburr et al., (2008) reported that improved education level brings about positive changes in the knowledge, attitude and skills through research and extension. About 33.6% were between the age ranges of 41-50 years of age while 29.4 were within the age range of 31-40. This result revealed that most of the sampled farmers are in their active age of productivity, this will make them allocate more time to farm activities in the study area. This result is also consistent with Obike et al., (2016) who observed that the age bracket of productivity is increased production and likelihood of poverty reduction in the area. The results further revealed that 42% had 1-10 years farming experience while 26.2% had 11-20 years farming experience and 25% of the sampled respondents had 21-30 years farming experience in the study area. This result is in consonance with the findings of Okoye et al., (2008) and Nwaru, (2003) who reported that farmers count more on their experience than educational attainment in order to increase their productivity. This result is also in line with Ebukiba et al., (2020); Ebukiba et al., 2022) who reported that farming experience increases the level of efficiency as the farmers accumulated experience results in increase in farm productivity. However, the more educated an individual farmer is, the less likely would he be available for agricultural labour. Table1 also depict that 60.5% of the sampled respondents had farm size ranges between 1-2 ha while 37.8% had a farm size of 3-4 ha this indicated that the watermelon farmers were dominated by smallholder farmers in the study area.

Table 1. Socioeconomic Characteristics of the Sampled Respondents in the Study area

Variables	Frequency	Percentage
Gender		
Male	107	89.92
Female	12	10.08
Marital Status		
Single	6	5.0
Married	106	89.1
Widow	2	1.7
Widower	5	4.2
Household size		
1-5	67	56.3
6-10	46	38.7
11-15	4	3.4
16 and above	2	1.7
Educational Status		1.7
Primary school	2	1.7
Secondary school	40	33.6
Tertiary institution	22	18.5
No formal education	55	46.2
Age		
20	7	5.9
21-30	18	5.1
31-40	35	29.4
41-50	40	33.6
51 and above	19	16.0
Farming experience		
1-10	50	42.0
11-20	31	26.1
21-30	30	25.2
31 and above	8	6.7
Farm Size		
1-2	72	60.5
2.1—4	45	37.8
4.1 and above	2	1.7
Total	**119**	**100**

Source: Field Survey (2022).

Institutional Variables Used by Watermelon Farmers in the Study Area

Table 2 shows that majority (64.7%) of the sampled respondents were members of cooperative organization and majority (86.6%) of the water mellon farmers had access to credit while only 13.4% could not access credit facilities. The results further revealed that 37% could not have any source of credit while 49.7% of the respondents source their credit through other means only 7.6 % of the respondents accessed credit through commercial banks in the study area. Majority (89.9) could not have access to extension services in the study area. This is in line with Adeoye et al., (2020) who reported that most of the watermelon farmers supplied their own capital by themselves. Also majority (68.9%) had access to fertilizer while 31.1 did not had access to fertilizer in the study area. This is consistent with the findings of Simonyan & Obiakor (2012) which indicated that membership of cooperative society and occupational status are both significant and positively related to household labour use. This result implies that farmers will rely more on their household members for labour if they do not belong to cooperative societies. Cooperative societies/farmers associations are sources of good quality inputs, labour, credit, information and organized marketing of products. This result also agrees with the findings of (Adeoye et al., 2020; Simonyan et al., 2011).

Table 2. Institutional Variables of Water Mellon Farmers in the Study Area

Variables	Frequency	Percentage
Cooperative membership		
Yes	77	64.7
No	42	35.3
Access to Credit		
No	103	86.6
Yes	16	13.4
Sources of Credit		
Non**e**	44	37.0
Commercial Banks	9	7.6
Cooperative Bank	7	5.8
Others	59	49.6
Total	119	100
Access to Extension		
Yes	12	10.1
No	107	89.9
Access to Fertilizer		
No	37	31.1
Yes	82	68.9
Total	119	100

Source; Field Survey Data (2022)

Costs and Return and Profitability of Watermelon Production in the Study Area

Table 3 presents the results of the estimated cost and returns involved in the watermelon production in the study area the analysis show that the cost of labour has an estimated value of ₦30,818.75 which represent 84.1% of the total variables cost incur in the water Mellon production in the study area followed by cost of chemical with an estimated average value of ₦4,605.00. This is in line with Okeke et al., (2020), who opined that labour requirement attracts higher cost in agricultural production. The total variable cost on average was ₦42,597.88 with an estimated total revenue of ₦140,250.00 on average basis, the gross margin obtained was ₦97,652.12 with an operating ratio and rate of return on investment of 0.67 and 2.29 respectively this result implies that watermelon production is profitable in the study area.

The rate of return of 2.29 indicates that every 1 naira invested in watermelon production will yield ₦2.29 returns on investment which covers profit, taxes, commissions, and other expenses incur in the process of water mellon production in the study area. This is in line with (Alabi et al., 2020 and Alabi et al., 2021) who reported in their research that those positive values of gross margin and farm income indicate that the water mellon enterprise is profitable in the area, this result is consistent with the findings of (Adeoye et al., 2020 and Ndanitsa et al., 2021) who asserted that Watermelon production was profitable based on the fact that an average farm in the area investigated recorded over 100 percent returns on investment.

Table 3. Average Cost and Returns obtained in Water Mellon Production in the Study Area

Items	Average Value (₦)/ha	Percentage
A. Variable Cost		
Seed	1,074.13	0.025
Fertilizer	1,100.00	0.026
Chemical	4,605.00	0.108
Labour	30,818.75	0.841
Transportation	5,830.63	0.019
B. Total Variable Cost	42,597.88	
C. Total Revenue	140,250.00	
D. Gross Margin	97,652.12	
Operating Ratio	0.69	
Rate of Return on Investment	2.29	

Source: Field Survey (2022)

Estimates of the Technical Efficiency of Watermelon Farmers in the Study Area

The results of the maximum Likelihood (MLE) of the parameters of the Stochastic frontier production function and inefficiency component were estimated for water mellon farmers using Stata software version 14. The MLEs of the Cobb-Douglas stochastic frontier model with half-normal distributional assumptions on the efficiency error term were estimated. The estimate of gamma is a measure of the level of the inefficiency in the various parameters and ranges from 0 to 1. Gamma estimate was 0.0083 water mellon farmer. Indicating the amount of technical inefficiency of the farmers in the study area. This result can be interpreted that 0.83% of the random variation in the output of watermelon farmers was due to difference in technical efficiency. The parameter of sigma square was 0.092. The mean value of technical efficiencies for watermelon farmers was 0.4978 implying that, on average the sampled respondents were able to obtain 50% of the potential output from a given mixture of production inputs, therefore, in a short run, there is a shortfall scope of (50%) and of increasing the efficiency of water mellon production among farmers by adopting the technology and techniques used by best watermelon farmers. This result shows that farmers are efficient but not at optimum level in the watermelon production in the study area. The estimated coefficient of seed was 0.282 and was significant at ($P<0.01$). The coefficient of seed 0.282 implies that a unit increase in the quantity of seed results in 28.2% increase in the total output of watermelon in the study area. The estimated coefficients for NPK Fertilizer was (0.19 was significant at ($P<0.05$). The positive signs of the coefficients of NPK fertilizer indicates that a unit increase in the quantity of NPK fertilizer as a result of more usage by farmers will result in increase and decrease in output of water mellon by 19.3%. This result is in line with the report of Sani et al, 2016). The estimated coefficient of labour was 0.126 and it was not significant.

This agreed with the findings of (Sani et al., 2016; Bitrus et al., 2020; Girei et al., 2013) who observed that the magnitude of the coefficient of labour would induce an increase in the output of crop, and vice versa. The estimated coefficient of chemical was (0.487). The coefficient of chemical 0.487 was positive and statistically significant at P<0.01), this shows that a unit increase in the quantity of chemical as a result of more usage will result in 49% increase in the output of watermelon in the study area. The technical inefficiency model estimates are shown in table 4. The negative sign of the estimated parameter means that the variable reduces technical inefficiency (increases technical efficiency). The positive signs increases inefficiency (decreases technical efficiency). The results revealed that the sex of the farmer's, marital status, educational level, occupation and household size were significant, and therefore reduces technical inefficiency (or increase technical efficiency). The variables sex and marital status has positive estimates and were statistically significant at (P<0.01), therefore decreases technical efficiency and increases technical inefficiency of watermelon production by 47% and 25% respectively. The estimated coefficient for household size was negative and statistically significant, the estimated coefficient of household size was (-0.369) this indicates a unit change in household size by one family member will result in the increases in technical efficiency of watermelon production by 37%, this could be due to the fact that small scale farming is characterized by family labour which is mostly supplied by the household members. These findings are in agreement with the findings of (Otunaiya & Adedeji, 2014). The estimated coefficient of education has a negative sign and was statistically significant at (P<0.01). This indicates that the literacy level of farmers increases technical efficiency, this could be as a result by the fact that education exposes and encourages the farmers to adopt new technologies, the farmers could also use their education in the use of available resources and they were more exposed to new methods of farming and were able to adopt new innovations with regards to watermelon production in the study area. This finding is contrary with the findings of Yusuf et al, (2022) who reported that educational level of farmers is not significant in watermelon production.

Table 4. Maximum Likelihood Estimates of the Stochastic Frontier Production Function for Watermelon Farmers in the Study Area

Variables	Parameter	Coefficient	Standard Error	Z-value
Stochastic frontier				
Constant	β_0	2.1322	1.0868	1.96**
Seed	β_1	0.2822	0.1338	2.11**
Fertilizer NPK	β_2	0.1931	0.1151	1.72***
Fertilizer Urea	β_3	-0.7258	0.4050	-1.79***
Labour	β_4	0.1263	0.2300	0.5
Chemical	β_5	0.4871	0.1948	2.50**
Farm Size	β_6	-0.1545	0.2705	-0.57
Inefficiency Model				
Age	Z_1	-0.0633	0.0495	-1.28
Sex	Z_2	0.4672	0.0769	6.07*
Marital Status	Z_3	0.2539	0.0667	3.80*
Educational Level	Z_4	-0.3866	0.0542	-7.14*
Occupation	Z_5	-0.4597	0.0840	-5.47*
Household Size	Z_6	-0.3693	0.0477	-7.74*
Sigma^2	$\boldsymbol{\sigma^2}$	0.0915	0.0154	
Gamma	$\boldsymbol{\gamma}$	0.0083	0.3689	
Log likelihood =		-15.8705		
Number of Observation	**N**	119		
Mean Tech efficiency	$\overline{\boldsymbol{TE}}$	0.4978		

Source: Field Survey Data, (2022). *** Significant at 10 percent level: ** Significant at 5 percent * Significant at 1 percent

Distribution of Technical Efficiency Score Among Watermelon Farmers in the Study Area

The estimates of the technical efficiency score distribution of the sampled watermelon farmers revealed that 3.4% of the sampled respondents fall within the technical efficiency range of 0-0.2 and 32.8% were within the range of 0.21-0.4 level of technical efficiency respectively while 47% of the watermelon farmers attained 0.41-0.6 level of technical efficiency. About 2.5% and 14.3% attained 0.61-0.8 and 0.81-1.0 level of technical efficiency respectively. The minimum technical efficiency value attained by individual watermelon farmer was 0.011 while the maximum technical efficiency attained was 0.999. The mean technical efficiency obtained by the watermelon farmers in the study area was 50%. This result show that, the watermelon farmers were not highly technically efficient in watermelon production but had a shortfall of 50% below perfection technically which need to be scalp up through the adoption of the available existing technology. This result is in line with Otunaiya & Adedeji, (2014) who reported similar results, this implies that there is need for improvement in the production performance of the watermelon farmers in the Study area.

Table 5. Distribution of Technically Efficiency Score Among Watermelon Farmers

Technical Efficiency Score		Frequency	Percentage
0-0.2		4	3.4
0.21-0.4		39	32.8
0.41-0.6		56	47.1
0.61-0.8		3	2.5
0.81-1.0		17	14.3
Minimum	0.0111		
Maximum	0.9990		
Mean TE	0.4978		

Source: Field Survey Data, (2022).

The Estimates of Stochastic

Cost Frontier Function of Watermelon Farmers in the Study Area

The estimated parameters of the stochastic cost function for watermelon farmers are presented in Table 6 the results showed that the variance of the parameter estimates, sigma squared (σ^2) was 0.1379. Gamma coefficient was 0.13. the estimated gamma parameter of 0.13 implies that about 13% of the variation in the total cost of production of water mellon among farmers were due to the differences in the cost efficiencies. This means that the cost inefficiency effect makes significant contributions to the cost of producing watermelon in the study area. The mean estimated value of the allocative efficiency for the farmers was (0.46870 or 47%). None of the samples respondents had 100% cost efficiency index. This implies that if an average farmer were to reach Allocative Efficiency level of its highest efficient counterpart, then the average farmer could realize 53% cost saving among the farmers. This in line with (Makuya et al., 2018; Maurice et al., 2015) who reported that the allocative efficiency of the sampled farmers ranged from 0.18 to 0.98. The mean allocative efficiency was estimated to be 47%, meaning that an average watermelon farmer in the study area has the scope for increasing allocative efficiency in the short-run under the existing technology. The cost of seed was negative and statistically significant at ($P<0.1$), cost of fertilizer, cost of labour were not significant while cost of chemical and total output were all positive and statistically significant at ($p<0.01$) probability levels for watermelon farmers. The coefficient of chemical 0.24 implies that a unit increase in the cost of chemical results in 24.48% increase in the total cost of watermelon production in the study area this shows that there is an association between the total cost of production and the cost of chemical among farmers. This result is in line with the findings of (Oladele, 2015).

The coefficients of total output 0.08 for farmers were positive and statistically significant at (P<0.01) probability level, this implies that a unit increase in the total output is associated with 8% increase in the total cost of production among farmers in the study area. This is in consonance with (Adeoye et al., 2020). The allocative inefficiency model component revealed that the factors influencing allocative efficiency includes age of the farmers, sex, educational level and the household size. The coefficient of age was (0.1719) and was positive and statistically significant at (P<0.01) probability level this implies that a unit change in the age of farmer will results in 17% increase in allocative efficiency this could arise as a result of old age as the age increases the farmer's ability to be efficient in cost allocation decreases due lack of adopting new technology in watermelon production, this finding is in line with Toluwase & Owoeye, (2017) who reported similar results. Other factors influencing allocative inefficiency in watermelon production were Sex P<0.01, Education P<0.05) and Housed Size (P< 0.01) respectively. This is consistent with Makuya et al., (2018) who reported that education level of watermelon farmers reduces cost inefficiency, an educated watermelon farmer has more ability to understand fast and produce according to good farming practices which will facilitate allocative efficiency in watermelon production than the one who is not educated or with less level of education.

Table 6. Maximum Likelihood Estimates of the Stochastic Cost Frontier Production Function for Watermelon Farmers in the Study Area

Variables	**Parameter**	**Coefficient**	**Standard Error**	**Z-value**
Stochastic frontier				
Constant	P_0	1.4468	0.5773	2.51*
Cost Seed	P_1	-1.6961	0.9701	-1.75***
Cost Fertilizer	P_2	-2.12e-07	6.62e-07	-0.32
Cost Labour	P_3	0.0627	0.0737	0.85
Cost Chemical	P_4	0.2430	0.0771	3.15*
Output	P_5	0.0888	0.0000	6.37 *
Inefficiency Model				
Age	Z_1	0.1719	0.0594	2.89*
Sex	Z_2	0.3015	0.0731	4.12*
Marital Status	Z_3	-0.0102	0.0729	-0.14
Educational Level	Z_4	-0.0770	0.0339	-2.27**
Occupation	Z_5	-0.1331	0.1003	-1.33
Household Size	Z_6	0.1227	0.0683	1.79***
Sigma^2	$\boldsymbol{\sigma^2}$	0.1378	0.0390	
Gamma	$\boldsymbol{\gamma}$	0.5756	0.1149	
Log likelihood =		1.2973		
Number of Observation	**N**	119		
Mean Allocative efficiency	$\overline{\boldsymbol{AE}}$	0.468		

Source: Field Survey Data, 2022 *** Significant at P<0.1: ** Significant at P<0.05 percent * Significant at P<0.01 percent

Distribution of Allocative Efficiency Score Among Watermelon Farmers in the Study Area

The estimated values of the allocative efficiency revealed that about 2.53% of the sampled respondents fall within the range of 0-0.2 while 33.6% fall within the distribution score of 0.2-0.4 level of allocative efficiency score respectively also majority 50.4% attained 0.41-0.6 level of allocative efficiency score. About 10.1% and 3.4% attained 0.61-0.8 and 0.81-1.0 level of allocative efficiency score. The minimum level of allocative efficiency value attained by individual watermelon farmer was 0.011 while the maximum level of allocative efficiency score attained by the watermelon farmers was 0.899 with mean allocative efficiency level score of 0.468.

This shows that the watermelon farmers were relatively efficient in allocating productive resources but not at optimum level. This result revealed that the watermelon farmers had a shortfall of 53% below perfection in allocative efficiency which need to be attained by the farmers to be perfectly efficient in allocating resources. This result is in line with (Adejor et al., 2018 and Abdul et al., 2018) who obtained similar results in their respective research study.

Table 7. Distribution of Allocative Efficiency Score Among Watermelon Farmers in the Study area

Allocative Efficiency Score	Frequency	Percentage
0-0.2	3	2.5
0.21-0.4	40	33.6
0.41-0.6	60	50.4
0.61-0.8	12	10.1
0.81-1.0	4	3.4
Minimum	0.011	
Maximum	0.899	
Mean AE	0.468	

Source: Field Survey Data, (2022)

Constraints Encountered by Watermelon Farmers in the Study Area

Table 8 shows the analysis of the constraints faced by the yam farmers in the study, the results shows that 44.5 % of sampled farmers were faced with inadequate capital, this result is in line with Idisi et al., (2019) who founded inadequate capital as the major constraints militating against yam production. They further buttress that non availability of credit to the farmers could limit adoption of yam production technologies, because the adoption of improved technology has cost implications while 47.9% of the respondents experienced lack of land availability.

Table 6 further shows that 40.3% were faced with challenges of government policy on land use as a major constraint militating against water Mellon production in the study area, more so 16.8% were faced with unavailability of hired labour in water mellon production while 63% encountered bad road to transport yam from the farm and to the market as some major constraints in the study area. This is similar to the findings of (Parmar et al., 2017). Furthermore 23.5% of the sampled respondents experienced unavailability of Mellon mini sett as some major constraints while 8.4% were faced with lack of fertilizer/chemicals. Also 27.7%, 10.9% and 75.6% were faced with unattractive price, lack of extension agents and high cost of farm inputs and affordability while 59.7% opined that poor information network was the major constraints faced by the sampled respondents in water mellon production in the study area.

This result is consistent with the findings of Idisi et al., (2019) who observed that most farmers generally were faced with lack of land availability, disease outbreak, bad roads, lack of extension services, unattractive prices and unavailability of hired labour as the major constraints in agricultural production.

Table 8. Results of Constraints Encountered by the Sampled Watermelon Farmers in the Study Area

Variable	**Frequency**	**Percentage**
Inadequate Capital	53	44.5
Lack of Land Availability	57	47.9
Government Policy on land use	48	40.3
Outbreak of Pest and Disease	12	10.1
Unavailability of Hired Labour	20	16.8
Inadequate transportation	37	31.1
Bad Roads	76	63.9
Inadequate marketing System	41	34.5
Unavailability of improved seed	28	23.5
Lack of Fertilizer/Chemical	10	8.4
Unattractive price	33	27.7
Lack of extension agents	13	10.9
Limited scale and uneven distribution	21	17.6
High Costs of farm inputs and affordability	90	75.6
Poor Information Network	71	59.7
Total	**119**	**100**

Source, Field Survey Data, (2022) Multiple Response Allowed

CONCLUSION

Based on the findings emanating from the study, the following conclusion were made. Most of the water mellon farmers were male**,** and majority of the farmers had no formal education, the sampled farmers are in their active age of productivity. Water mellon production is a profitable enterprise in the study area with an operating ratio and rate of return on investment of 0.67 and 2.29 respectively. The significant factors influencing total output of water mellon are Seed fertilizer NPK fertilizer urea and Chemical, the technical inefficiency component shows that the factors influencing inefficiency were: Sex, Marital Status, Educational Level, Occupation and Household Size. The farmers were not technically efficient in allocating resources they had a shortfall of 53% below the optimal frontier which need to be scalp up to make them operate at the optimal production level. The allocative inefficiency model revealed that the factors influencing allocative inefficiency includes age of the farmers ($P<0.01$), sex ($P<0.01$), educational level ($P<0.05$) and the household size ($P<0.1$). The water Mellon farmers encountered the following constraints in the cause of production inadequate capital, lack of land availability, unavailability of improved seed, Government policy on land use, high costs of farm inputs and affordability, poor information network and bad roads network.

Policy Recommendations

1. Production inputs such as fertilizer, seed and chemical should be subsidize to famers to encourage them operate at large scale level for earning more profit
2. Since the level of education was significant extension officers should be made available to train farmers and to expose farmers to the importance of watermelon farming which will help them have more knowledge on the usage of the production inputs like improved seeds, fertilizers, and agrochemicals
3. Farmers should be encouraged to increase the size of their production in order to increase total output to minimize cost and improve efficiency level.

4. More awareness should be created about watermelon farming among farmers using extension communication machineries such as media, internet, radio and farm visits. Farmers should be encouraged to form and join cooperatives organizations to enable them have access to good market price.
5. Adequate infrastructure such as good roads, market, storage facilities and good transport system should be provided to ease the farming activities in the study area

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Analysis of the Effect of Land Fragmentation on Crop Productivity in Jiroft, Iran

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Abstract

Agriculture plays a key role in the economy of Iran. However, its growth is decreasing in the recent past due to land fragmentation. It is a constraint for agricultural productivity. The study aims at analyzing the impact of land fragmentation on productivity and profitability of crops. The primary data were collected from 120 farmers of rural area of Jiroft. This study calculated the extent of land fragmentation by using Simpson index. Production function was employed to estimate the impact of land fragmentation on the crop productivity. The results suggested that higher the land fragmentation of the farms, negative is the impact on the productivity. The findings of the study have important implication for formulating of efficient land use policy.

Keywords: Agriculture, Constraint, Impact, Simpson Index

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INTRODUCTION

In Iran, agriculture sector's share is almost 8.3 percent in Gross Domestic Product (IRNA) and employs almost 24.7 percent of total labour force. However, with the passage of time, share of agriculture is decreasing and most of the people are suffering with low level of employment in this sector (IRNA, 2021).

Agriculture productivity is a significant determinant of Iran's economy. The foremost element for agricultural production is land which has a substantial value in rural areas due to its leading role as a sign of economic, social and political status. Land is a fixed and immovable natural resource that employed as a source of earning. Land also works as a safety against risks and shocks. Even though, land is the main strength in rural areas Iran, but its distribution is highly asymmetric (Ansari;TahmasebiNejad and Salami, 2018) and ownership is shrinking quickly due to fragmentation.

Land fragmentation refers to the existence of separate number of plots of same landowner at different places and they can be framed as single units. Agricultural fragmented land is a complicated phenomenon comprises on five aspects such as total fragmented plots, size of plot, topography and distance from the farm buildings of plots and plot scattering (Ashtiani, 2014).

Agricultural land fragmentation is widespread throughout the world resulted from social, political, institutional and historical factors such as land reforms, inheritance laws, consolidation, housing schemes, transaction costs and personal valuation of land ownership (Latruffe and Piet, 2014).

It has both positive and negative effects on agricultural productivity and efficiency. If the production strategies, price level of different inputs and production level are in favour of land fragmentation, then it does not affect agricultural efficiency but if this condition does not prevail then this leads to low efficiency of agriculture (You, 2010). Land fragmentation has great influence on the economic growth development of an economy and leads to subsistence agriculture. Economic growth and development are linked with mechanization, but land fragmentation is a big constraint for it (Mcpherson, 1982).

Land fragmentation is also common in Iran which is a main reason for low agricultural productivity, such as due to continued process of land fragmentation almost, 68 percent of total farms or about 80 percent of the cultivated area has become small, subsistent and below subsistent level farms where modern advanced technology for increased crop production cannot be effectively applied. In Iran, per capita arable landholding is only 0.2 ha (IRNA, 2021).

Studies on land fragmentation has analysed the determinants of land fragmentation (NajibiKhairabadiet al., 2010), impact of land fragmentation on land productivity (Kadigi et al., 2017), production diversification (Ciaian et al., 2018), technical efficiency (Jha et al., 2005), cost of production (Villanueva and Colombo, 2017), inefficient use of inputs and labor force availability (Nguyen et al., 1996; Shuhao et al., 2008). However, the findings of these studies are mixed as its effects are specific to each case. Keeping in view the importance of this subject area of research, the aim of this study to investigate the impact of land fragmentation on crop productivity and provide guidance for policy makers on land consolidation measures to promote agricultural sustainability.

MATERIAL and METHOD

Study area

The geographical location along with topographic condition has made Jiroft a diverse climate. Climatic conditions, fertile soils, and surface and groundwater resources have provided the basis for the production of millions of tons of tropical and cold products; So that, since a long time ago Jiroft has always been a very important center of agriculture in the country.

In this study, primary data were collected from wheat and Potato growers of Jiroft district in 2019. Potatoes are planted in early fall and wheat in early winter. In Southern Iran, there are two cropping seasons, Autumn and winter. Autumn starts from November and winter from January. Data were collected through multistage random sampling technique. Four administrative divisions of the district were selected. From each administrative division, two villages were selected randomly. A total of 120 farmers (small, medium and large) were selected following a multistage stratified random sampling procedure.

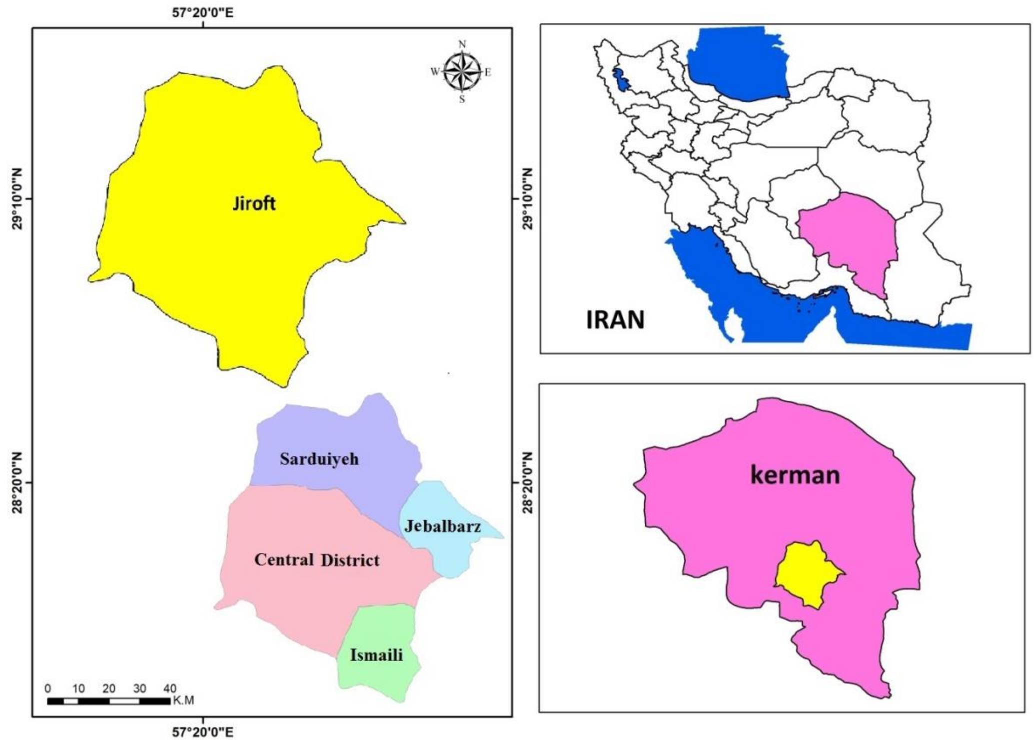

Figure 1. Geographical location of Jiroft

The results of the present article can be used by regional and national managers and policymakers on crop productivity in Jiroft .

The following formula was used to determine the sample size for the present study.

$$n = \frac{(P(1-P)Z^2}{e^2}$$

n: represents the total sample size selected for the study.

P: represents the estimated proportion of population being farmers. It was hypothesized that 60 percent of the rural population are engaged in agricultural sector.

Z: is the level of confidence according to the standard normal distribution. The present study considered 5 percent probability level (Z = 1.96)

e: is the tolerated margin of error set at 9 percent for this study. Putting these values in the formula yields a sample size of 114 respondents for the present study which, for ease of calculations, is increased to 120 respondents.

Descriptive statistics

The socioeconomic characteristics of farmers such as age, education family size, farm size, and input costs etc. are provided in Table 1.

Table 1. Summary statistics of the important variables

Variables	**Definition of Variables**	**Mean**	**S. D**
Output	Output value per hectares in rials	1405896.4	1215867
Age	Age of the household head in years	48	12.45
Education	Number of schooling years of household head	8.35	6.46
Family Size	Total household members	8.01	3.45
Farm Land	Total farm land in acres	15.41	13.35
Fertilizer cost	Expenditures on fertilizers in rials	16921.25	18222.25
Seed cost	Expenditures on seed in rials	230006.35	24731.05
Labor cost	Expenditures on hiring labor in rials	9770.85	11314.4

Net return, gross return and total cost of all three categories of farmers

Gross return, total cost and net return for wheat and potato producers were calculated.
The average net return, gross return and total cost per hectares of Wheat farm consumed by all three categories of farmers are indicated in Table 2.

Table 2. Net return, Gross Return and Total Cost per Acre of Wheat Growers

Wheat Farmer Category	**Average Gross Return/Hectares (Rials)**	**Average Total Cost / Hectares (Rials)**	**Average Net Return / Hectares (Rials)**
Small	228500.25	22280.13	570.12
Medium	23773.09	23069.37	703.5
Large	23042.25	22896.36	145.38
Overall	23222.03	22748.47	473.04

The total gross yield per hectare for small, medium and large farmers was 22850.25, 23773.09 and 23042.25rials, respectively. Similarly, for the average total cost per hectare, they consumed 22280.13, 23069.37rials and 22896.36rials, respectively. The average net yield per hectare for small, medium and large farmers was 570.12, 703.5 Rials and 144.38 rials, respectively.

The average net return, gross return and total cost per acre of Potato farm consumed by all three categories of farmers are indicated in Table 3.

Table 3. Net return, Gross Return and Total Cost per Acre of Potato Growers

Potato Farmer Category	**Average Gross Return/Hectares (Rials)**	**Average Total Cost / Hectares (Rials)**	**Average Net Return / Hectares (Rials)**
Small	40166.66	23904.48	16262.18
Medium	46887.82	33292.31	13595.51
Large	46450	40888.13	5561.87
Overall	44501.49	32694.97	11806.52

The total amount of gross return per hectares was rials40166.66for small farmer, rials46887.82for medium farmers and rials46450 for large farmers. While, these three group of respective farmers were consumed rials23904.48, rials33292.31and rials40888.13of average total cost respectively. The price for average net return per hectares was rials16262.18, rials13595.51and rials5561.87respectively by small, medium and large farmer. The overall result showed that the large farmer had more average gross return per acre that gained least profit as compared to the others.

Model specification

Analysis in which semi-logarithmic equation can be used to check the multiple linear regression model variables estimation results.

Ln Y=β0i + β1iSI +β2iEH + β3iAH + β4iFS + β5iFS +β6iSC+ β7Ifs+ β8Ilc+ vi ……………..…(1)

Y= βo + β1 (Simspon Index) + β2 to βnare socio-economic variables + vi (Disturbance term) With; βoi,…,β8i are unknown coefficients,vi is adisturbance term with standard properties, and i=1,…,120.

A spatial problem is fragmentation of land which depending on many facts, factors and parameters. Six relevant factors were cited by King and Burton (1982): number of parcels that belongs to holding, holding size, shape of every parcel, size distribution of parcel and the spatial distribution of parcels. In Iran, there are large complexions are present in land fragmentation. In this way, few roads are present to access parcel and ownership rights have many problems. For example, undivided shares that are owned to parcel, i.e. it may belong to more than one landowner; or a parcel may have dual or multiple ownership, i.e. the land is owned by one person whilst the trees growing on the land are owned by someone else and a third party has ownership rights to the water. In addition, a land parcel may not have a title deed. The existence of all these different factors highlights the complexity of representing and measuring land fragmentation. For measuring and representing the land fragmentation are used Simpson index, Average plot distance and Farm Size. Simpson's land fragmentation index formula are as follows:

$$SI = 1 - \frac{\sum_i^n ai^2}{(\sum_i^n ai^2)^2} \quad \ldots\ldots (2)$$

Where;

n: is denoted by number of plots

ai: is denoted by area of each plot.

Simpson index (SI) Value lies between the zero and one, 1 degree value of SI indicating the lower degree of land fragmentation and near to zero-degree value of SI indicating that higher degree of land fragmentation.

Simpson Index value can be determined by the average plot size, the number of plots and the plots size distribution. Distance to the plots and farm size cannot be captured by the SI. Distance between each parcel and the effect of economies of scale are captured by using the average distance of plots to the homestead and farm size within a farm.

Production function approach

In order to estimate the impact of land fragmentation on crop productivity, production function approach was used here. The typical examples of production function in literature are Cobb-Douglas and Translog production functions. Despite the well-known limitation, the Cobb-Douglas production form is used in this study because it has the advantage of being easily interpreted in economic term and has achieved widespread support from data of various industries, including agriculture and for various countries.

Thus, a typical Cobb-Douglas production function is specified as:

$$lnY_i = \sum_j \alpha_j \, lnX_{ij} + \sum_k \beta k + \varepsilon_i \ldots\ldots (3)$$

Where; Yi: represents the total value of agricultural output of farm household i.

Xij: is the quantity of input j used by farmer i.

α and β are input intensity parameters that represent the elasticities of output with respect to the individual inputs.

εi: is the error term summarizing the effects of omitted variables.

The variables included in the vector Xij are age, education of the household head, family size, farm land, fertilizer cost, seed cost, and labor cost.

RESULTS and DISCUSSION

Results of Simpson's land fragmentation index is givenin Table 4. The value of meanfragmentation indexis 0.62. Results indicated that land fragmentation is more at the small size of farm and very low land fragmentation at the large farm. Thus, it canberevealed that high extent of land fragmentation is linked with the farming of small plots. These results are in line with the study of Sundqvist and Andersson (Sundqvist and Andersson, 2007); Okezie et al., Latruffe and Piet (Okezie et al., 2012; Latruffe and Piet, 2014) who also quantified the degree of land fragmentation by using household level data.

Table 4. Extent of Land Fragmentation in study area

SI Index	No. of Respondents	Farm Size(Hectares)
0.01-0.20	40	1.25
0.21-0.40	45	5
0.41-0.60	32	8.75
0.61-0.80	17	15
0.81-1.00	11	25

The Cobb-Douglas production function approach was used to estimate the impact of land fragmentation and other different socio-economic variables onproductivity of wheat and potato growers. Theindependent variables included in model were farmsize, education, age, family size, total seed cost,fertilizer cost, labor cost and Simpson index. Thedependent variable in the model was productivityvalue of crop output per acre which is employed by previous studies.The value of each cropoutput is estimated by using village level medianprices of the prices that farmers indicate their cropswould currently fetch on the market. This avoids theproblem of using the same set of prices for all farm. The results of production function in Table 5 showsthat the coefficient of Simpson index is negative andstatistically significant, indicating that land fragmentationtends to decline crop productivity. High degree of landfragmentation results in uneconomic sub-division ofland that leads to high cost of production and hindering of mechanization. The results suggested that with the higher land fragmentation of the farms indicating the negative impact of impson index on the adoption of new technology and management practices by improving the requirement of labor for the betterment of the production throughout the year.

Table 5. Econometric Results of the Impact of Land on productivity of Farmers

Variables	Coefficients	T Statistics
Constant	3.24**	3.12
SI	-0.010**	2.60
Edu	0.073*	1.739
Age	0.095	0.930
Family Size	-0.168	1.614
Farm size	0.068*	2.22
Fertilizer Cost	-0.048	2.47
Seed Cost	-0.253	2.68
Labor Cost	-0.131	1.76
R^2	0.39	
Adjusted R^2	0.27	

Regarding socio-economic variables, education appeared to have positive and significant impact of crop productivity.Thus, these results highlighted the human capital theory as indicated by other studies (Kousar and Abdulai, 2015). Coefficient of family size is negative but statisticallyinsignificant.Physical assets of farmers like land appearedto have positive impact on land productivity. It indicates that physical assets of farmers like land appear to be important inputs in the productionprocess. The linkage of farm size and productivity isexpected to be positive because of the existence ofeconomies of scale.

These results offer evidence fromthe previous literature (Kousar et al., 2019). However, the link may not be positive in some cases as some previous isnot consistent on the presence of sucheconomies of scale in agricultural production likereported .The coefficient of expenditures on inputs like fertilizer,seed and labor have expected negative sign, indicating that higher input prices have negative effect on cropproductivity. This is probably due to the fact thatland fragmentation tends to enhance time and costof inputs such as seed, labour, and fertilizers whichin turn decline the crop productivity.

CONCLUSION

Land is important source of minerals, agriculturalconsumables and other primary products and hence,its role is very crucial for agricultural production.Land fragmentation is an arising issue since last twodecades. It refers to the existence of separate numberof plots of same land owner at different places andthey can be framed as single units. Agriculturalland fragmentation is a complicated phenomenoncomprised on five aspects such as number of fragmented plots, plot size, topography and distancefrom the farm buildings of plots and plot scattering. It is a constraint for agricultural mechanization hencetechnological advancement and the resulting economicgrowth. In developing countries like Iran, besidesland fragmentation, uneven distribution of cultivableland is also problematic. Agricultural productivity and profitability may suffer due to uneven distributionand fragmentation of land. The study in hand aims at analysing the impact ofland fragmentation on productivity and profitabilityof crops. The primary data has been collected from 120 farmers of rural area of Jiroft. Respondent were selected using multistage randomsampling technique. Multiple regression was used inorder to meet the set objective by using the collecteddata on the software of Social Package for SocialScientists (SPSS). For measuring and representingthe land fragmentation Simpson index, Average plotdistance and Farm Size were used. Simpson index (SI)value lies between zero and the one, 1-degree value of SI indicates the lower degree of land fragmentationand near to zero-degree value of SI indicates thehigher degree of land fragmentation. Simpson Indexvalue can be determined by the average plot size, the number of plots and the plots size distribution. Theresults suggested that higher the land fragmentationof the farms, negative is the impact of Simpson indexon the adoption of new technology and managementpractices by improving the requirement of labor for the betterment of the production throughout the year.The higher value of the Simpson index regarding labor cost, increases but fertilizer costs reduced,seed costs. While the impact of land fragmentation on the modern technologies and management have a negative effect on the productivity. The findings have important implication for the design of land consolidation programs that will help to employ modern technology. The problems associated with land fragmentation can be overcome by applying the specific land management programs like; voluntary parcel exchange, land consolidation, land funds, landbanking and cooperate farming. This study provides analysis to analyzing the impactof land fragmentation on productivity and profitabilityof crops. Calculated the extent of land fragmentationby using Simpson index. Production functionwas employed to estimate the impact of land fragmentation on the crop productivity. It is critical forimproving Iran's com-petitiveness in the world market through quality improvement and value addition.

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Impact of climate change on water resources in South Sudan

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Abstract

South Sudan, one of the least developed nations, is vulnerable to the socioeconomic losses and damages brought on by climate change since its people depend on climatically sensitive natural resources for their subsistence. Promoting the gathering and storage of water for various uses is a top concern given the country's recurrent droughts. Water availability may be directly impacted by poor water quality. The goal of this research article is to examine how climate change has affected water resources in order to help South Sudan's future use of water resources. The findings of this work will also be crucial for studies on the Nile River. In South Sudan, both the amount and quality of water have decreased during the previous two decades. This review article also demonstrates how droughts are becoming more frequent and rivers and streams are getting smaller as a result of climate change. Water flow has become seasonal in a number of formerly permanent rivers. Due to poor infrastructure, a number of developmental obstacles brought on by the protracted civil war, and the fact that 95% of the population depends on climate-sensitive natural resources, particularly rain-fed subsistence agriculture and total reliance on forests as a source of energy and other environmental goods and services, South Sudan is particularly vulnerable to the effects of climate change.

Keywords: South Sudan, climate change, water resources, water quality.

Review article
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INTRODUCTION

The influence of climate change on water resources is the main area of concern in science and policy because global warming continues to govern the world. According to the 1997 UN assessment of the world's freshwater resources, a third of the world's population resided in nations that were considered to be experiencing water stress and were using more than 20% of their available water supplies. The research went on to predict that by 2025, up to two-thirds of the world's population would reside in nations with water shortages (Jubek et al., 2019).

However, there can be significant regional variations in the impact's characteristics and intensity. Water shortages may occur in some areas. This is projected to cause a significant rise in the population at risk of water scarcity as a result of rising consumption. On the other side, the lives and livelihoods of millions of people may be in danger due to rising sea levels in densely populated coastal areas. In a large portion of the world, droughts and floods will likely become more frequent.

The risk of poverty and hunger will undoubtedly increase due to the high economic expenses and potential loss in crop yield. It is crucial that these effects be assessed with high spatial and temporal precision in order to make long-term strategic plans for a nation's water resources in the face of changing climate change consequences (Abbaspour et al., 2009). One of the most valuable natural resources in the nation is its water resources. The function of water is exposed in parallel to the population's increased dietary needs. One of the essential inputs for agricultural production and for important human life is water (Bağdatlı and Belliturk, 2016; Albut et al., 2018).

Water and climate systems are intricately intertwined. For instance, climate change has an impact on water availability and quality, but it also has an impact on water use. In general, water use, especially irrigation, rises with temperature and falls with precipitation. However, there is no conclusive proof of a historical trend in water use that is related to climate. This is because few water-use statistics and time series are available, and water use is mostly influenced by non-climatic causes (IPCC, 2007). Numerous regional climate models show that rising temperatures and falling precipitation will result in sharp declines in water resources.

Water resources in South Sudan are unevenly distributed both geographically across the nation and temporally since water availability varies greatly from year to year as a result of regular severe floods and droughts. Most of the nation is included in the hydrological basin of the Nile River. Water is stored in broad floodplains, seasonal pools, ponds, rivers, streams, and wetland areas, in addition to perennial rivers, lakes, and wetlands. Given the country's relatively low population, low density, and lack of industrial development, water demand is still low; however, with anticipated population growth and economic development, it is anticipated to rise sharply in the future. The Ministry of Water Resources and Irrigation noted in 2007 that there was already evidence of and growing worry about how human activities were affecting the availability and quality of water resources. Urban regions are experiencing diminishing water tables, decreased river flows, increased pollution, and contamination of both surface and ground waters (MWRI, 2007).

Water is a naturally recharging resource that circulates constantly. The flow of water should therefore be the primary consideration in assessments of water resources, even while water stocks in natural and artificial reservoirs assist in increasing the amount of water resources available for human civilization. The circulation rate of the available renewable freshwater resources (RFWR) is capped by the climatic system. More than two billion people live in extremely water-stressed regions, despite the fact that current global withdrawals are far below the upper limit due to the unequal distribution of RFWR in time and geography. Climate change is predicted to quicken the water cycle, increasing the RFWR that is available. This would reduce the number of individuals experiencing water stress, but adjustments to seasonal patterns and an increase in the likelihood of extreme occurrences would counteract this benefit. The first step in getting ready for such predicted changes will be to lessen current susceptibility (Jubek et al., 2019).

Competition over water has historically been a source of conflict, but it might also be an opportunity for coexistence and peace. The prudent management of Sudan's water resources is seen as a way to promote long-term growth and stability. With efficient institutions and appropriate legislation, water resources could considerably improve the economy, society, and environment (UNEP, 2020). The many facets of climate change in Sudan and South Sudan have been the subject of numerous studies. The two most important climate characteristics and extreme events, temperature and precipitation variations, were the focus of the majority of both the study that was conducted and the future forecasting effort (Nasreldin and Elsheikh, 2022). Consequently, this study was conducted to evaluate the effects of climate change on South Sudan's water resources.

WATER RESOURCES in SOUTH SUDAN

South Sudan is a landlocked nation that occupies 96% of the Nile River Basin in East-Central Africa. It shares borders with Sudan in the north, Ethiopia and Kenya in the east, Uganda and the Democratic Republic of the Congo (DRC) in the south, and the Central African Republic in the west. South Sudan is located in the tropical region between latitudes 3.5° and 12° North and longitudes 24° to 36° East. Its total area is 658842 km2. Huge grasslands, wetlands, and tropical woods dominate the entire nation. Significant agricultural, mineral, water, wildlife, forestry, and energy resources are among its natural assets (Jubek et al., 2019). The country has one of the lowest population densities in sub-Saharan Africa, with less than 13 persons per square kilometer. Seasonal agriculture, pastoralism, fishing, and hunting are the main sources of income in the northern arid zones. The low, wooded savannahs in the middle of the nation offer a variety of livelihood choices. Bahr el Ghazal in the northwest, Equatoria in the south, and Greater Upper Nile in the northeast make up the three areas (formerly historic provinces) that make up the nation. The country originally had ten states, but there are currently thirty-two (MOE, 2015).

The availability of water in trans-boundary river basins' upstream and downstream regions is a very delicate subject. Because South Sudan is situated in the "middle" of the Nile Basin, between the downstream Eastern Nile Countries (Egypt, Ethiopia, and Sudan) and the upstream Nile Equatorial Countries (Burundi, the Democratic Republic of the Congo, Kenya, Rwanda, Tanzania, and Uganda), natural water retention, water withdrawals, and development activities in the countries upstream of South Sudan have an impact on its water quantity and quality (Fernando and Garvey, 2013). Floods and groundwater flow are two ways that lateral water transfer travels from positive to negative places. It is challenging to evaluate the condition of the water flows in the entire transboundary Nile Basin since each individual country and water-use sector in the basin monitors water data, including withdrawals, stocks, wastewater return flows, and groundwater-well yields. Understanding the main water flows and fluxes in the Nile River Basin is made possible by earth observation data at the ecosystem scale (Bastiaanssen et al., 2014).

The Nile Basin's ability to meet future water demands in the region, especially those of South Sudan, is threatened by the amount of water that is used there. Irrigated agriculture uses more than 80% of the water that is withdrawn from the Nile Basin. South Sudan's water withdrawal is quite low in comparison to other nations in the Nile Basin (Jubek et al., 2019). Pre-2011, Sudan's total water withdrawal was estimated by the Food and Agriculture Organization of the United Nations to have been around 27,590 million m3 in 2005. Agriculture accounted for the vast majority of water use, using 26,150 million m3. Municipalities and industry were responsible for 1,140 million m3 and 300 million m3 of withdrawals, respectively. The Food and Agriculture Organization's calculations were based on data for Sudan prior to 2011 and made the following assumptions to arrive at an estimate for water use in South Sudan after that year: the same amount for both South Sudan and Sudan combined; No significant changes had occurred; almost all irrigation is located in Sudan; South Sudan's population was 17% of that of Sudan prior to 2011; and the majority (75%) of industries are situated in Sudan (particularly in the petroleum sector). With agriculture utilizing the most water and a per-person annual withdrawal of roughly 60 m3/year, it is predicted that surface and groundwater withdrawal (primary and secondary) will be about 658 million m3/year after 2011, or about 1.3% of the total renewable water resource. In contrast, yearly water withdrawal per person in Ethiopia is 106 m3, 911 m3 in Egypt, and 714 m3 in Sudan (FAO, 2016; MWRI, 2016).

As water resources become further stressed due to increasing levels of societal demand, understanding the effect of climate change on various components of the water cycle is of strategic importance in the management of this essential resource (Bağdatlı et al., 2015; Elsheikh et al., 2022a). Operational adjustments, demand management, and infrastructural alterations are just a few water management measures that could be taken into account to help with climate change adaptation. The design and operational assumptions used to determine resource supply, system demands, system performance requirements, and operational restrictions may alter as a result of climate change. Depending on the system, several strategy options will be offered for selection, and different options will have different preferences. The following highlights some of the difficulties in determining and putting the adaptation alternatives into practice, as well as some potential techniques that might be taken into account (Levi et al., 2009). Cooperation across big regions that share resources is recognized as an effective policy and management technique for improving water management. Such framework agreements will face further challenges from climate change and rising water demand in the coming decades, potentially leading to more localized conflict. For instance, taking unilateral action to address water shortages brought on by climate change may increase competition for water sources. Additionally, changes in land productivity may result in a variety of new or modified agricultural systems, including intensification practices, which are required to maintain production. The latter, in turn, may result in new environmental stresses that worsen existing environmental conditions and cause siltation, soil erosion, soil degradation, habitat loss, and diminished biodiversity (Meier et al., 2007; Bellitürk and Bağdatlı, 2016; Bağdatlı and Ballı, 2020). Where surface water resources are becoming inaccessible or unavailable, the demand for groundwater resources is likely to rise. Increased groundwater use could result from intensifying irrigated agriculture to accommodate the rising population's demand for food. Even though South Sudan has very few irrigation practices, managing water resources and predicting future demand are essential for the republic's population to remain stable (Jubek et al., 2019).

South Sudan's water resources management, operational adjustments, demand management, and infrastructural alterations are just a few water management measures that could be taken into account to help with climate change adaptation. The design and operational assumptions used to determine resource supply, system demands, system performance requirements, and operational restrictions may alter as a result of climate change (MOE, 2015). Depending on the system, several strategy options will be offered for selection, and different options will have different preferences. The following highlights some of the difficulties in determining and putting the adaptation alternatives into practice, as well as some potential techniques that might be taken into account. The South Sudanese government's water resource management strategy intends to advance the country's understanding and capabilities in water resource mapping, evaluation, and monitoring, to strengthen the water information system, and to advance conflict prevention and sustainable water resource management (MOE, 2015; Jubek et al., 2019).

The national governments of various nations, especially those that are less developed, must implement these crucial measures for water management institutions and policies to address the effects of climate change on water resources: Identify locations at risk of shortages due to climate change by conducting evaluations, which will help guide integrated water resource management; To enhance water availability, encourage the construction of water harvesting facilities such as dykes, water reservoirs, and canals; To increase water availability and quality, upgrade the infrastructure for water and sanitation in metropolitan areas; Create supplemental irrigation systems in rural regions to boost food security and agricultural output;

Create a legal framework that includes penalties for polluting water sources and allows for the monitoring of water quality; To ensure that water quality is maintained, create a sound waste management strategy. The South Sudanese government is gradually implementing water management policies and regulations, but the ongoing conflict, low population densities, and widely dispersed villages and towns make it extremely difficult to provide water facilities, services, and infrastructure in a way that is both efficient and affordable (Wada and Bierkens, 2014; Jubek et al., 2019).

The average surface air temperature around the world has significantly increased since 1970. Based on data from thousands of weather stations, ships, buoys, and satellites across the world, the estimated change in the average temperature of the Earth's surface is calculated. Different research teams independently compile, analyze, and process these measurements. There are several crucial processes in the data processing process (Elsheikh et al., 2022b). Estimates of changes in surface temperature on a global scale have been produced by a variety of research organizations worldwide (FAO, 2016). Other independent observations, such as the melting of Arctic sea ice, the retreat of mountain glaciers on every continent, reductions in the extent of snow cover, earlier blooming of plants in spring, and increased melting of the Greenland and Antarctic ice sheets, support the warming trend that is apparent in all of these temperature records. Since snow and ice reflect solar energy, as they melt, more heat is absorbed, which in turn causes more melting, creating a feedback loop (Trenberth et al., 2007). In addition, since the late 1940s, weather balloons and satellites have been used to measure the temperature above the surface. According to these measurements, the troposphere is warming, which is consistent with the surface warming. Additionally, they show stratospheric cooling. This pattern of stratospheric cooling and tropospheric warming is consistent with how we predict atmospheric temperatures to fluctuate in response to rising greenhouse gas concentrations and the observed ozone depletion (Santer et al., 2008). For a large portion of the world, increased dryness and wetness extremes are predicted, increasing the likelihood of droughts and floods. This has previously been noted, and it is anticipated to persist. With longer dry intervals in between, precipitation tends to be concentrated into heavier events on a warmer planet (Jubek et al., 2019; Bağdatlı and Arslan, 2020).

Around the world, precipitation is not distributed equally. Its average distribution is principally influenced by surface topographical impacts, atmospheric circulation patterns, and the availability of moisture. Temperature has an impact on the first two of these parameters. The amount, intensity, frequency, and type of precipitation have all changed since the 1980s, indicating that human-caused changes in temperature are altering precipitation patterns (Elsheikh, 2021; Bağdatlı et al., 2023). This is why it is expected that these changes will occur in the Republic of South Sudan. In the Republic of South Sudan, traditional subsistence agriculture dominates the economy, with crop cultivation and animal husbandry providing the primary means of subsistence for about 78% of households. Farmers rely on rain-fed agriculture and the application of conventional farming techniques. They become extremely vulnerable to climate change as a result of this combination, especially irregular rainfall. Unfavorable climatic conditions, such as recurrent droughts and yearly flooding, cause losses in livestock and crop production. While flash floods have decimated forests in South Sudan's low-lying regions, particularly those close to the Sudd and Marcher wetlands and the White Nile, droughts are also hastening the expansion of the desert (Jubek et al., 2019).

Global water issues will arise when the effects of climate change spread to other nations. To lessen the effects of global climate change, necessary actions should be taken as soon as possible (Bağdatlı and Arslan, 2019; Bağdatlı and Arıkan, 2020). Finding clean water in the future will be challenging since rising temperatures will cause more evaporation (Bağdatlı and Can, 2020).

It is essential to take steps to prevent the greenhouse effect and global warming in order to reduce the effects of this phenomenon. Cutting back on carbon dioxide emissions could be a solution (Bağdatlı and Can, 2019; Bağdatlı and Ballı, 2019). The Sudd, which is particularly important in regulating the weather patterns in the Sahel region, the Horn of Africa, and the broader East Africa region, is the largest designated Ramsar site of environmental importance and aids in purifying and buffering the excess water. It is located in South Sudan. Water resources are particularly vulnerable to the effects of climate change in South Sudan.

RECOMMENDATION and CONCLUSION

The Republic of South Sudan's government must strengthen the environmental health-related infrastructure to stop the development of water-borne diseases, which will be made worse by climate change as water quality deteriorates and negatively affects availability. The pressure on water resources will increase over the coming years as a result of rising population and water demand, with certain regions of the world experiencing this pressure more quickly than others. Climate change has the ability to both alleviate and increase the burden on water resources. The impact of climate change on water resources is discussed in this essay. It has been demonstrated that the influence of climate change on water resources is extremely sensitive to the scenario for climate change, the scenario for water demand, quality, and quantity, as well as the precise definition of water resource stress.

In South Sudan, both the amount and quality of water have decreased during the previous two decades. Water flow has changed from perennial to seasonal in a number of rivers. Siltation may result from lower water flows. The downstream portion of the river flow holds significant amounts of sediment. Water quality is deteriorating in metropolitan areas as a result of municipal wastewater, sewage, and industrial effluents directly entering water sources due to a lack of wastewater and sanitation management, and contaminated water is to blame for recurrent cases of gastrointestinal disorders and additional serious dangers to water resources.

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Antimicrobial Quality Assessment of Seabass Fillets Treated with Pomegranate Peel Extract During Refrigerated Storage

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Abstract

Maintaining the quality of seafood is a crucial concern because it is a highly perishable product. In this study, microbial changes in seabass (*Dicentrarchus labrax*) fillets treated with pomegranate peel extract (PPE) in different concentrations (0.5%, and 1%) were examined during storage at 4±1^{o}C. The total psychrophilic bacteria (TPB), total mesophilic bacteria (TMB), and total coliform bacteria (TCB) were determined. The findings indicated that PPE showed inhibitory effects on the growth of bacteria in seabass fillets. In both concentrations (0.5 and 1%) the usage of PPE performed better than the control group, where this was quite obvious. Therefore, it may be inferred that adding PPE to sea bass fillets during refrigeration prevented microbiological deterioration. Accordingly, adding PPE can be recommended to retain the microbial quality of seabass fillets.

Keywords: Seabass, pomegranate peel extract, shelf life, microbiological quality

Research article
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INTRODUCTION

Fresh fish has great nutritional value, including a high concentration of omega-3 fatty acids, proteins, and vitamins, making it one of the most vital products. It is nevertheless one of the most perishable products, and storage makes it vulnerable to both chemical and microbial deterioration. Digestive enzymes, lipid oxidation, and bacteria all actively contribute to fish spoilage, which results in a decline in the quality of fish and fish products (Hassoun and Çoban, 2017).

Fish must therefore be preserved with good preservation practices to maintain its freshness. In the past, fish and fish products have been preserved using temperature-based methods, including chilling and freezing (Sampels, 2015). However, lipid oxidation, protein denaturation, and microbiological activity cannot be entirely inhibited by cooling or freezing alone. Because of this, combining different processing and packaging technologies is becoming rather popular (Ucak and Afreen, 2022).

Natural additives, particularly plant extracts and essential oils, have recently been demonstrated to improve the quality of fish products when added to composite and/or bi-layer films (Ojagh et al., 2010). The phenolics and tannins found in pomegranate fruits (Punica granatum L.) support the fruit's antioxidant and antibacterial properties. They have a range of nutritional and biological functions as a result. The primary polyphenol source, pomegranate peel extract (PPE), has been linked to both antioxidant and antibacterial properties. Additionally, other studies have demonstrated that PPE has antibacterial action against both gram-positive and gram-negative bacteria (Akhtar et al., 2015). PPE's antioxidant activities delay or stop the commencement of lipid oxidation by blocking the beginning or continuing stages of oxidative chain reactions or by producing stable radicals (Shah et al., 2014). PPE has several biological effects in addition to its antioxidant capacity, including antibacterial activity (Viuda-Martos et al., 2010).

Numerous research have looked at how PPE's antibacterial and antioxidant qualities affect the quality characteristics of seafood products kept at low temperatures (Basiri et al., 2015; Topuz et al., 2015; Yuan et al., 2016; Berizi et al., 2018; Khojah, 2020; Yu et al., 2022). The current experiment aimed to assess the antimicrobial effects of PPE's on seabass fillets stored in refrigerated conditions.

MATERIAL and METHOD

Fresh seabass (*Dicentrarchus labrax*) were provided by the local fisherman in the Nigde city and were shipped to the laboratory in ice boxes. They were gutted, beheaded, and filleted before being washed. From nearby marketplaces, pomegranate peels were gathered.

Pomegranate peel extraction

Pomegranate peels were washed twice in tap water, then dried at 45^{o}C for 48 hours before being pulverized into powder. For the extraction process, 10 g of powdered pomegranate peel and 100 mL of 80% ethanol were placed in a flask and sonicated for 1 hour at (25°C) using an ultrasonic bath (Ifesan et al., 2014; Ucak, 2020). The pomegranate peels were concentrated after the extraction process using a rotary evaporator (IKA, HB-10 digital, Germany) operating at 45°C under vacuum.

Preparation of pomegranate peel extracts and application to seabass fillets

The following solutions were used as separate treatments on fish fillet samples for 5 minutes: the control solution only comprised distilled water, while the others contained 0.5% and 1% PPE solutions, respectively. All samples were placed in strofoam plates and covered by stretch film. Every three days, microbiological analysis was conducted after 12 days of keeping all samples at 4^{o}C.

Microbiological analyzes

Using the spread plate approach, plate count agar (PCA) was used to calculate the total numbers of mesophilic and psychrophilic bacteria (ICMSF, 1982). For the total mesophilic bacteria counts and psychrophilic bacteria counts the plates were incubated at 37^{o}C for 24-48 hours and at 8^{o}C for 7 days, respectively. Violet red bile agar (VRBA) was used for the total coliform bacteria count in accordance with Anonymous (1998) method. Pour plating was carried out by incubation at 37^{o}C for 24-48 hours.

Statistical analysis

Statistical analysis was done using SPSS software, and the Duncan multiple comparison test (one-way ANOVA) was used to analyze the results.

RESULTS and DISCUSSION

The primary factor causing the quality of fresh or scarcely preserved fish to deteriorate is microbial decomposition, which, in extreme situations, can lead to an up to 25% loss of marketable fish. Fish and fish products deteriorate for a variety of reasons, one of which is bacterial development (Tavares et al., 2021). The parts of fish supply a variety of nutrients for the exponential growth of microorganisms that the organism no longer controls, especially bacteria that are tolerant of a wide range of temperature conditions (Zhuang et al., 2021). Psychotropic bacteria spoil the bulk of the food stored in refrigerators and other aerobic storage conditions.

Figure: 1 shows changes in total psychrophilic bacteria counts of Sea-bass fillets and the impact of pomegranate peel extract on the microbial quality of sea bass fillets during refrigerated storage. The amount of TPB was 2.15 log CFU/g at the start of storage and grew in all groups throughout the course of that time. It was found that during storage, the amount of TPB in fish fillets treated with 1% PPE emulsion was considerably ($P<0.05$) lower than that in the control and 0.5% PPE groups. While the TPB counts of the control and the 0.5% PPE groups were 6.46 and 5.29 log CFU/g on the 12th day of storage, they were 5.06 log CFU/g in the 1% PPE group. The lowest APR count values during storage were observed in sea bass fillets treated with 1% PPE emulsion.

As reported by Ucak et al. (2020), rainbow trout had a TPB of 1.93 log CFU/g at the beginning of storage. The initial TPB was 2.59 log CFU/g in the rainbow trout fillets according to Ucak (2019), however Uçak et al. (2018) discovered that it was 2.47 log CFU/g and that it rose over time. The initial TPB was 3.48 log CFU/g in the fresh Shabout, according to Duman and Özpolat (2015), both of which are greater values than the one from the current investigation. 1.75 log CFU/g of TPB were initially found in sea bass fillets. The control group had the highest values, whereas the groups covered with films containing citrus seed extract had the lowest values, according to Ucak et al. (2021). This is similar to the quantity discovered in the current investigation.

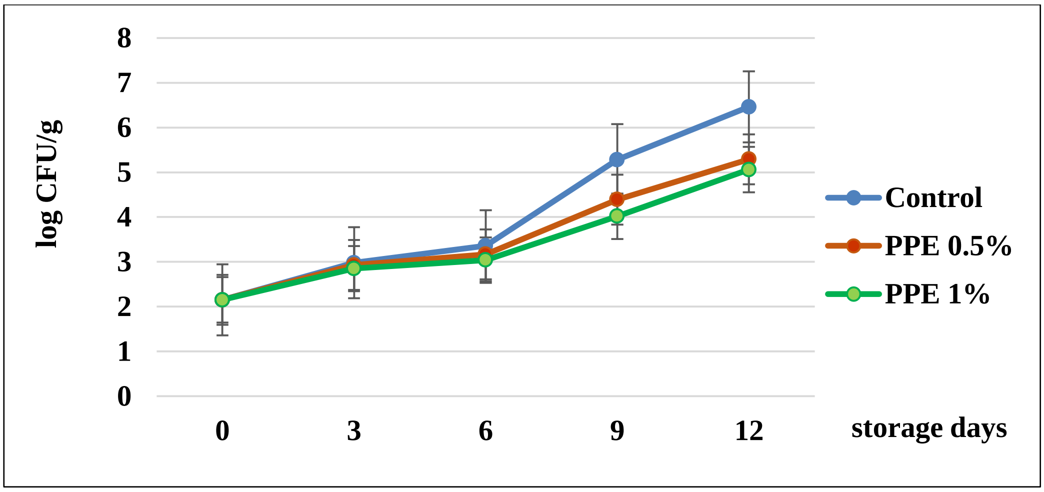

Figure 1. Changes in total psychrophilic bacteria counts of seabass fillets during storage period

The changes in total mesophilic bacteria (TMB) count of seabass fillets treated with PPE are presented in Fig. 2. At the beginning of the storage period, the TMB count of sea bass fillets was found to be 2.43 log CFU/g. This value increased in all groups throughout the storage period and showed the highest value as 7.17 log CFU/g in the control group, while it was 5.4 and 5.16 in 0.5% PPE and 1% PPE, respectively, at the end of the storage. The lowest (5.16 log CFU/g) TMB count was observed in the fish treated with 1% PPE at the end of storage, and it was also low during all periods of storage compared with other groups.

While Ucak (2020) reported the initial viable count of trout burgers as 2.92 log CFU/g, Keser and İzci (2020) discovered that the total bacterial count of the trout meatballs made with laurel and rosemary essential oils was found to be significantly higher (5.24 log CFU/g) than the current study. According to Zhuang (2019), PPE increases the shelf-life of carp fillets and prevents spoilage bacteria.

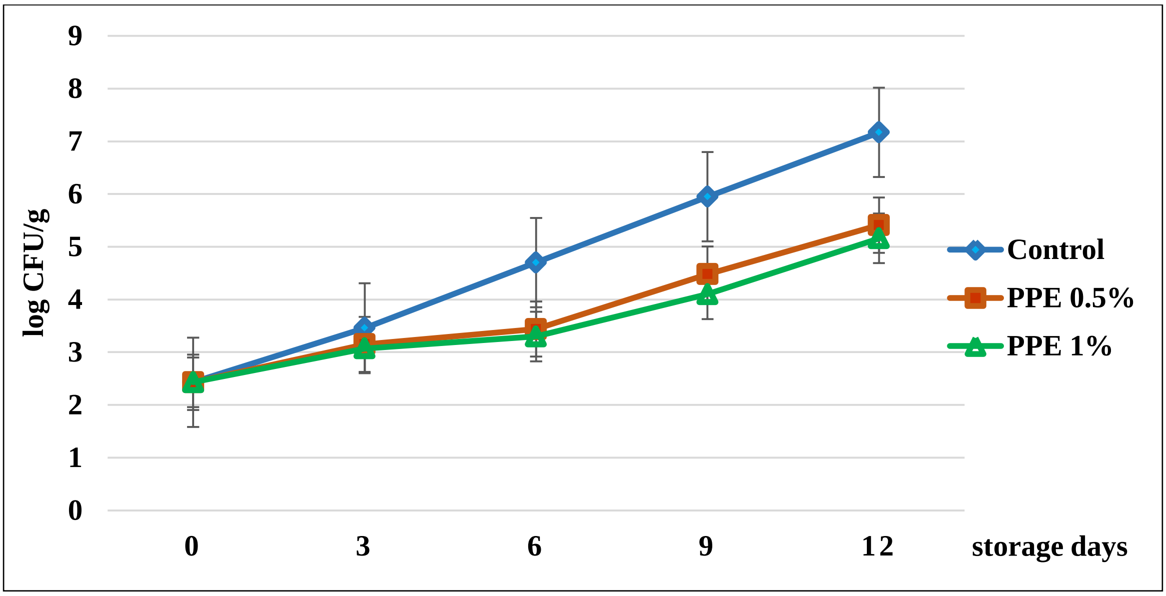

Figure 2. Changes in total mesophilic bacteria counts of seabass fillets during storage period

Figure 3 demonstrates the variations in the total coliform bacteria counts of sea bass fillets as well as the effect of pomegranate peel extract on the microbiological analysis of sea bass fillets at 4±1°C. The total amount of coliform bacteria is recognized as a good predictor of fish hygiene. Trout meat was found to contain 1.80 log cob/g of coliform bacteria at zero day. Coliform bacteria growth, which grew until the end of storage, was considerably reduced ($P<0.05$) in the groups to which 1% pomegranate peel extract was applied. The total number of coliform bacteria per day at the ending of storage in the control group was 5.47 log cob/g, while it was found to be 4.42 and 4.12 log cob/g in the PPE 0.5% and PPE 1% groups, respectively. Similar studies have shown that the growth of total coliform bacteria in fish and fish-derived products is inhibited by natural extracts (Ucak et al., 2018; Frangos et al., 2010; z, 2018; Rezaeifar et al., 2020).

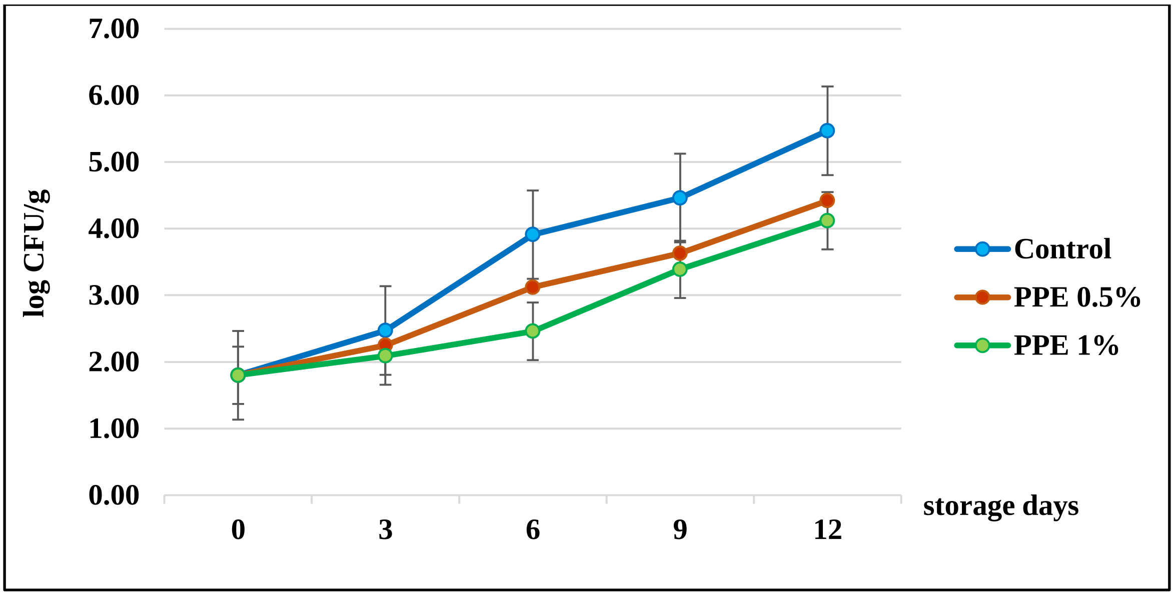

Figure 3. Changes in total coliform bacteria counts of seabass fillets during storage period

CONCLUSION

One of the most important concerns in recent years has been the examination of industrial food waste and the extraction and addition of antioxidant and antibacterial compounds to food from these wastes. Pomegranate peel is another of the by-products that make up a substantial portion of the potent antioxidants. The results obtained from this study show that pomegranate peel extract has positive effects on the characteristics of quality and microbial content of the seabass fillets. Microbial spoilage in fish fillets was delayed, and compared to the untreated group, the shelf-life was increased which clearly reflects the effectiveness of the antioxidants contained in pomegranate and their effectiveness in reducing the deterioration of quality in fish products.

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Agricultural Production and Food Security in Climate Change Process of Europe

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Abstract

Climate change is known as changing in weather and atmospheric air which remains for centuries and these changes could be happened naturally or due to human actions. These climatic changes might have negative effects on Agricultural production. In this review I will discuss about the negative effects of climate change on agriculture in Europe. These climatic changing negative factors include heavy rainfalls, drought and temperature instabilities, salinity, soil sterility, and insect pest outbreaks which leads to endangerment of natural life cycle, and have negative impacts on agricultural yield. In European countries temperature and rainfall are the major fluctuating factors which have negative impacts on agriculture food crops and becomes a threat for food security in future. The major food crops in Europe which can be effected by variability in climate includes wheat, rice, sorghum, maize and barley.

Keywords: Climate change, Agriculture production, crops, Food security

Review article
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INTRODUCTION

Conferring to scientists, climate change is a condition where atmospheric air have been changed and retain for centuries. Climate change known as collection of several atmospheric changes which can be happened by human activities or could be natural (Elsheikh et al., 2022b; Bağdatlı and Arıkan, 2020). This Global climate variation, negatively impacted on surrounding atmosphere by releasing carbon dioxide in the atmosphere (Bağdatlı and Can, 2019). It is considered that climate change produced due to Global warming which occurs by expulsion of many industrial gases included methane, nitrogen oxides, carbon dioxide, and ozone unceasingly in the air and enhancing the globe temperature (Bağdatlı and Belliturk, 2016; Bağdatlı and Arslan, 2020; Bağdatlı and Can, 2020). Growing Population is also an important reason for climate variation will raise several issue for worldwide food supply due to which numerous nutritional complications could rise in the upcoming future. Production of food is a major concern which could be effected by climatic variations (Bağdatlı et al., 2023), like upsurge in sea-level due to climate change, leads to the devastation of forests which are key source of food in many regions (Afreen et al., 2022).

Water, is an important element, for existence of living lives. Precipitation and Rainfall both are sources of water and various activities of living beings depends on both these aspects like life survival, Agricultural productivity, migration of living beings and urbanization (Bağdatlı and Arslan, 2019; Elsheikh et al., 2022a).

Global climatic variation also produce open surface evaporation causes rise in temperatures and precipitation, which are much significant dynamics for living lives, because it leads to continuing decline of water resources, endangerment of natural life cycle, and have negative impacts on agricultural yield. Plants growth and development also influenced by climatic variation, which also include drought and land ruining leads to less yield of agricultural crops (İstanbulluoğlu et al., 2013; Bağdatlı and Ballı, 2019). It was also observed that long-lasting tendency of growing temperature created a negative outcome of agricultural yield for the long period (Bağdatlı et al., 2014) like temperature of soil according to specific growing plant is also a significant aspect for improved yield of agricultural crops (Bağdatlı and Ballı, 2020).

All living beings like humans, plants, animals and fishes have been influenced by the life-threatening environmental situations all over the globe. The vulnerability to the global climatic situations has generated anxiety amongst the whole world because crop productivity might be conceded by variabilities in different environmental features that can threat food security (Lesk et al., 2016; Altieri and Nicholls, 2017). Climate variability and food uncertainty are the two main concerns of the 21st century era. About 815 million individuals are pretentious by malnutrition, hampering viable developmental schemes to attain the goal of eradicating hunger in 2030 (Richardson et al., 2018). The augmented frequency of heavy rainfalls, drought and temperature instabilities, salinity, soil sterility, and insect pest outbreaks are expected to declining crop production leading to extreme threats of hunger (Dhankher and Foyer, 2018).

Presently, the important concern is decreasing the stress on food security (Campbell et al., 2016). Sufficient food production for an increasing population has continuously been a challenge as humans turn out to be sedentary and began agriculture about 12,000 years back. This problem is not so far astounded, as the worldwide population remains to grow continuously (Cai et al., 2017). Higher level of agricultural crop production besides has its issues. The maximum use of agrochemicals joined with untenable practices of agronomy has directed to numerous external environmental factors. Agriculture also subsidizes to change in climate, accounting for almost 25% of the worldwide greenhouse gas secretions (IPCC, 2019). Climate variability will probably affect agricultural yield negatively by increasing temperatures, water stress, and increasing frequencies of extreme weather conditions.

This article presents an overview on changes in climate predicted at global level and successively focuses on the European Agricultural production. On the basis of studies on domestic crop yields, great differences in susceptibilities to existing changes in climate were identified across Europe. In Northern European region, the main concerns are cool temperature and short period for crop growth and development, whereas in Southern European region, extreme temperature and less rainfall limits the crop yield, though the utmost negative effects would be found for the main land climate in the Pannonian region, which comprises Serbia, Hungary, Romania and Bulgaria (Olesen et al., 2011).

It was expected that the increment of greenhouse gas secretions and sudden changes in climate will happen that might upsurge the crop productivity in North-Western Europe and decline the crop productivity in the Mediterranean region (Olesen and Bindi, 2002).

The European summer heat wave in 2003 was combined with predecessor lengthy drought era, caused an extensive shortfall of crop productivity in Southern parts of Europe and becomes the reason of approximate loss of 15 billion EUR (García-Herrera et al., 2010; Kurnik, 2017). Similarly in the 2018, northern and central European regions were facing a phase of abnormally extreme hot weather that has directed to record breaking drought and crop growth failure which was never happened in recent memory (The Guardian, 2018), except in 1976's extreme drought that happened in UK and rigorously affected agricultural production (Marsh et al., 2007). It was reported that, European drought 2018 has severely affected the European vegetable sector in the previous 40 years (Euractiv, 2018). In the latest history, Europe has faced numerous drought events, which were not only happened in the Mediterranean states and semi-arid states of Iberian Peninsula, but almost happened in whole territory, from Western Europe to East Europe, even in Scandinavia states (Spinoni et al., 2015).

CLIMATE CHANGE EFFECTS ON DIFFERENT CROPS

Wheat productivity is mainly influenced by the extreme temperature because of climatic variability in several countries, and might decrease the crop productivity by rising temperature (Asseng et al., 2015). The collective effect of drought and heat stresses on crop production have been observed in maize, sorghum, and barley. It was noticed that the collective effect of drought and heat stress had extra damaging results in comparison of individual stress (Wang and Huang, 2004). Likewise, if the temperature rise of around 30 ◦C at the time of blossom development it could be produce sterility in cereal crops. Throughout the meiotic phase, rice and wheat bared with 35–75% decline in grain set because of water deficiency, as drought stress significantly disturbs the procedure of anthesis and fertilization in rice crop (Ruf et al., 2015). It has been projected that agricultural productivity could decrease to 25.7% in 2080 because of climate variability and maize crop will be the maximum influenced crop in Mexico (Hellin et al., 2014). Wheat crop effected by drought stress throughout all developmental stages, however reproductive stage and grain formation are the utmost critical stages (Pradhan et al., 2012).

HOW CLIMATE CHANGE EFFECTS DIFFERENT EUROPEAN REGIONS

Assessments presents that European and non-European regions have differently effected by climate change and accordingly its influence on agriculture production and food security will differ for the different geographic regions. These influences on food security also include livestock production; growth of microalgae in oceans; mycotoxins growth on crops; remnants of pesticides and resistant pollutants; and pathogenic micro-organisms. Climatic conditions of different European regions is given below:

Central Europe

This region comprises Czech Republic, Poland, Hungary, Slovakia, Southern and Eastern Germany, Northern Romania, and Eastern Austria. It was estimated that Annual average temperature, has been increased 4 to 4.5 °C for Central European region and Black Sea Region.

Precipitation is estimated to upsurge in winter and lessening in summer, by an increasing risk of floods. Agriculture production of these regions is anticipated to be influenced by soil corrosion, loss of organic matter from soil, spreading of pests and crop diseases, drought and high temperature. In few regions, lengthy growing periods becomes advantageous for crops production (European Commission, 2007a).

Southern and South-Eastern Europe

This region comprises Spain, Portugal, Italy, Southern France, Greece, Slovenia, Cyprus, Malta and Bulgaria. It was estimated that annual average temperature, has been increased 4 to 5 °C for Southern European region and for the Black Sea region. Water availability, would be less, due to the possibility of hydropower commotion, especially in summer. When this condition combined with the increase of temperature might induce (i) declined agricultural productivity (ii) drought, (iii) heat stress (iv) ecosystem and soil degradation (v) finally desertification. The upsurge of fierce rainfall will increase soil erosion and consequently loss of organic material from soil (European Commission, 2007a).

Northern Europe

This region comprises Norway, Finland, Sweden, and Baltic States. It was estimated that annual average temperature, has been increased 3 to 4.5 °C in this region. Annual upsurge of precipitation up to 40% is also estimated with danger for floods and winter would be wetter (European Commission, 2007a). According to agricultural production, generally an increase in crop productivity was estimated due to frost free lengthy crop growing period and there could be a possibility for growing new crops, although new pests and crop diseases might appear (European Commission, 2007b). Pollution in the Baltic Sea and growth of Algal bloom could be produced in this region, which possibly causing food-related issues because of bio toxins accumulation in shellfish (European Commission, 2007a).

Western and Atlantic Europe

This region comprises Northern and Western France, Benelux, Northern Germany, United Kingdom, Netherlands, and Denmark. It was estimated that annual average temperature, has been increased 2.5 to 3.5 °C with dry and hot summers. There is greater intensities of precipitation exist, mainly in winter, and sturdy floods and storms are predicted to be more recurrent (European Commission, 2007a).

CONSEQUENCES OF CLIMATIC CHANGES IN EUROPE

Local conditions in regions of European Union will be influenced by the reduction in the amount of annual precipitation, extended dry periods and expected temperature upturns that may cause quicker growing periods and shorter lifespans. The length and timing of growing seasons may change geographically, so possibly changing the sowing and harvesting times and probably resulting in the necessity to alter crop varieties which have already used in a specific area. Crop systems might also be pretentious by rising of sea level and desertification which leads to decrease in cropping land. Crop productivity are estimated to vary crossways European countries. Southern Europe would possibly experience yield reduction in spring-sown crops like maize, soybean and sunflowers, the similar becoming further fit than before for farming in Northern regions.

Maize productivity is estimated to upsurge by 30 to 50% in Northern European areas whereas strongly decrease in the South of Europe (Wolf and Menne, 2007).

It was reported that higher temperatures, bigger occurrence and extent of extreme weather not only produce considerable changes in crop systems and productivity, but also increase amount of crop pests and changed transference ways of insects, pests, and plant infections, which will aggravate the productivity reduction and harm food security if suitable actions are not taken within due time. It was also noticed by scientists that fluctuation in precipitation patterns are more significant for crop pests and weeds' interfaces than a variation in yearly whole precipitation. The inconsistent heating at high elevations in winter can upset not merely crop growth and development, however also change the environmental balance amid the crop and its related pests (Rosenzweig and co-workers, 2001). The possible effect of climate variability on livestock does not much known for pubic as the effect on crop systems, however, both beneficial and harmful effects of climate variability on livestock could be assumed, according to the area and environmental conditions. The impacts of climate variability on livestock could be direct, like direct effect of high temperature stress on appetite of livestock. An indirect factor of climatic variability could be perceived in the demanded alteration of the quality and quantity of forages from grasslands and the sources of concentrates. Positive influences of climatic variability, like rising temperature and enough moisture, pretense advantageous consequences for efficient production in the affected areas (Watson et al., 2001; Bernstein et al., 2007).

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Postharvest Quality and Shelflife of Bitter Gourd (*Momordica Charantia*) at Varying Ultraviolet-C Illumination

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Abstract

Bitter gourd is highly perishable and is susceptible to senescence showing early signs of weight loss, yellowing, and softening. A study was conducted to determine the optimum exposure period to ultraviolet-C on the postharvest quality and shelflife of bitter gourd, investigate the chemical characteristics of bitter gourd as influenced by UV-C illumination, and evaluate the effects of UV-C illumination on the postharvest quality and shelflife of bitter gourd. An experiment was laid out in a Completely Randomized Design (CRD) with five samples per treatment and replicated three times. The treatments were designated as follows: T0 – Control, T1 – 30 mins. UV-C + Ambient, T2 – 60 mins. UV-C + Ambient, T3 – Without UV-C + 20°C, T4 – 30 mins. UV-C + 20°C and T5 – 60 mins. Results revealed that UV-C illumination at varying periods and storage conditions significantly affected the chemical characteristics, postharvest quality, and shelf life of bitter gourd. Fruits subjected to UV-C for 30 minutes and stored at 20°C significantly reduced weight loss, prolonged visual quality and shelf life, and delayed color changes or yellowing after 8 days of storage. Furthermore, oxidation-reduction potential (mV), pH, and chemical characteristics such as TSS and Vitamin C were significantly affected by different UV-C exposure and storage conditions of bitter gourd. UV-C-treated fruits stored at 20°C obtained the highest initial and final oxidation-reduction potential, pH level, and Vitamin C content. Further, the latter treatment had the highest initial and final oxidation-reduction potential, pH level, and Vitamin C content. Fruits subjected to UV-C for 30 minutes and stored at 20°C significantly prolonged the shelf life and maintained the quality of bitter gourd.

Keywords: Bitter gourd, ultraviolet-C, shelflife, chemical characteristics

Research article
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INTRODUCTION

Bitter gourd, scientifically known as (*Momordica charantia* L.) belongs to the Cucurbitaceae family and is widely grown for its edible fruits. In various regions of the world, it is called as bitter melon, balsam pear, karela, african cucumber, and bitter cucumber (Devi et al., 2019). Due to its hypoglycemic function, bitter gourd is a well-known vegetable for treating a variety of diseases, particularly diabetes. It has immense medicinal properties due to the presence of beneficial phytochemicals, which are known to have antibiotic, antimutagenic, antioxidant, antiviral, antidiabetic, and immunity-enhancing properties (Grover and Yadav, 2004).

A compound known as momordicin and charantin in the bitter gourd is used to treat diabetes by reducing blood sugar levels (Lotlikar et al., 1966). In addition to some minerals such as iron, zinc, phosphorus, sodium, and magnesium, it also provides a significant amount of vitamin C, which constitutes about 55% of the fruit's total vitamin content (Devi et al., 2019). However, high moisture content, large surface area to volume ratio, thin cuticle, and corrugated fruit surface of bitter gourd reduces its shelf life to 4 days under ambient conditions (Preetha et al., 2015). Bitter gourd fruit is perishable and is highly susceptible to senescence showing early signs of yellowing, softening, and red pigmentation in the arils if stored under ambient conditions (Zong et al., 1995). Hence, low-temperature storage could be a potential means of prolonging the shelf life of bitter gourd (Mohammed and Wickham, 1993). A number of studies were performed so far to extend the shelf life of bitter gourds, including the postharvest treatment of 1- MCP @ 5 L L 1 (Han et al., 2015), edible coating with carnauba wax (1.0%) (Bhattacharjee and Dhua, 2017), and improved atmospheric packaging (Preetha et al., 2015). Recently, green technologies are receiving more attention due to their chemical-free composition and lack of negative effects on human health and the environment. One such alternative for shelflife extension could be UV-C illumination. Studies have demonstrated that ultraviolet light significantly improved the quality of various postharvest fruits and vegetables, such as three-leaf vegetables (Liao et al., 2016), broccoli (Formica-Oliveira, Díaz-López, Artés, and Artés-Hernández 2017), apricot (Taze and Unluturk, 2018) and pineapple (Sari, Setha and Naradisorn, 2016). Additionally, it has been found to inhibit senescence, enhance various phytochemical components (phenols and antioxidants), promote the accumulation of secondary metabolites, and activate various defense-related compounds, all of which result in pathogen resistance and ultimately lengthen the food's shelf life (Martinez-Sanchez et al., 2019). Hence, a study was conducted to determine the effect of varying UV-C illumination on the postharvest quality, chemical characteristics, and shelf life of bitter gourd.

MATERIAL and METHOD

Fruit Samples and Sample Preparation

Bitter gourds were procured from a commercial vegetable farm at Barili, Cebu. The fruits were harvested at the mature green stage and carried out carefully to minimize mechanical injuries. Fruits were placed in a plastic crate and transported to the Center for Studies in Biotechnology – Cebu Technological University Barili Campus. Uniform and healthy fruits were randomly distributed on each treatment.

UV-C Treatment

Sample fruits were precooled to ambient condition after harvesting. The UV-C treatment was carried out in a sealed container that measured 40 cm (W) x 65 cm (L) x 60 cm (H) and was fitted with a germicidal tube (UV 20 W; 61.5 cm length; 28 mm diameter/T8, Philips, Poland) that emitted radiation at a wavelength of 253.4 nm. To maintain uniform light dispersion inside the chamber, aluminum foil was used as the interior covering and black paper as the exterior. The UV chamber was turned on for 15 minutes prior to usage to stabilize the UV-C dose. Uniform size of bitter gourd fruit was selected and kept at 25 cm distance from the light source. Following a review of earlier studies (Imaizumi et al., 2018; Pinheiro et al., 2015) in which cucumber, persimmon, and tomato were exposed to various UV-C doses to investigate its role in shelflife extension and phytonutrient retention, two different exposure times (30 minutes and 60 minutes) were chosen.

To guarantee that the fruit received the full amount of UV-C exposure, fruits were arranged in a single layer at a constant spacing (15 cm) and rotated at a 180° angle halfway through the treatment. Fruits were kept in ambient and low-temperature storage at 20°C after UV-C lighting.

Experimental Design

A study was laid out in a simple Completely Randomized Design (CRD) with 5 samples per treatment replicated 3 times. The treatments were designated as follows: T0 – Control; T1 – 30 mins. UV-C + Ambient, T2 –60 mins. UV-C + Ambient, T3 – Without UV-C + 20°C, T4 – 30 mins. UV-C + 20°C and T5 – 60 mins. UV-C + 20°C. All data were subjected to Analysis of variance (ANOVA) and treatment means comparison by the Least Significant Difference (LSD) was performed using STAR (Statistical Tool for Agricultural Research) program.

Physical and Chemical Characteristics

Evaluation of physical characteristics of bitter gourd was done every other day, including weight loss, visual quality rating, yellowing index, and shelflife. In addition, initial and final chemical characteristics were obtained, including pH, total soluble solids, titratable acidity, vitamin C, and oxidation-reduction potential.

RESULTS and DISCUSSION

Physiological Weight Loss

As shown in Table 1, physiological weight loss increases as the storage period increases, regardless of different UV-C exposure and storage conditions. Results revealed a significant effect on the weight loss of bitter as influenced by different UV-C treatment and storage conditions from day 2 to day 6. Fruits treated with UV-C for 30 minutes and stored at 20°C exhibited the least weight loss among treatments after 8 days of storage. A similar study conducted by Prajapati et al. (2021) found that UV-C treatment stored at 10°C can significantly reduce weight loss in bitter gourd. On the other hand, bitter gourd fruits stored at ambient conditions regardless of UV-C treatment obtained the highest rate of physiological weight loss after 4 days of storage. Comparable effects can be observed on fruits treated for 60 minutes UV-C and stored at 20°C. The respiration and transpiration of water from the product are attributed to the physiological weight loss of the samples (Wills et al., 1989).

Visual Quality Rating

Visual quality rating of bitter gourd fruits subjected to varying UV-C illumination and storage conditions is presented in Table 2. After 4 days of storage, bitter gourd fruits stored at ambient conditions regardless of UV-C treatment had significantly reduced visual quality ratings at 3.40, 3.80, and 3.67, respectively. Visual quality rating of 3 described as poor, defects serious and limit marketability. In contrast, after six days of storage, UV-C treated fruits for 30 minutes stored at 20°C prolonged the visual quality rating to 5.40. Comparable effects were observed on fruits stored at 20°C regardless of UV-C treatment. However, it was evident that the visual quality rating of bitter gourd fruits consistently decreased to 3 after 8 days of storage.

Table 1. Cumulative weight loss (%) of bitter gourd *(Momordica charantia* L.*)* as influenced by different UV-C doses and storage conditions.

Treatments	Cumulative Weight Loss			
	Day 2	Day4	Day 6	Day 8
T0 – Control	11.9ab	27.34a	–	–
T1 – 30 mins. UV-C + Ambient	12.12a	19.78b	–	–
T2 –60 mins. UV-C + Ambient	11.91ab	20.67ab	–	–
T3 – Without UV-C + 20°C	10.30bc	18.97b	32.84	–
T4 – 30 mins. UV-C + 20°C	9.28c	18.64b	31.57	37.61
T5 – 60 mins. UV-C + 20°C	11.61ab	19.62b	31.86	–
% CV	5.68	12.41	4.43	–

Means within the same column followed by a common letter and/ or without letter designation are not significantly different from each other at 5 % level of significance

Table 2. Visual quality rating of bitter gourd *(Momordica charantia* L.*)* as influenced by different UV-C doses and storage conditions.

Treatments	Visual Quality Rating				
	Day 0	Day 2	Day 4	Day 6	Day 8
T0 – Control	9.00	5.93b	3.40b	–	–
T1 – 30 mins. UV-C + Ambient	9.00	5.93b	3.80b	–	–
T2 –60 mins. UV-C + Ambient	9.00	5.80b	3.67b	–	–
T3 – Without UV-C + 20°C	9.00	7.00a	6.47a	4.33b	–
T4 – 30 mins. UV-C + 20°C	9.00	7.00a	6.87a	5.40a	3.67
T5 – 60 mins. UV-C + 20°C	9.00	7.00a	6.33a	4.47b	–
% CV		3.27	4.90	9.34	

Means within the same column followed by a common letter and/ or without letter designation are not significantly different from each other at 5 % level of significance

Yellowing

Bitter gourd fruits gradually changed color from green to yellow during storage (Table 3). Results indicated that fruits subjected to UV-C for 30 minutes stored at 20˚C delayed color changes after 8 days of storage. Comparable effects were observed in fruits stored at 20°C regardless of UV-C treatment. In contrast, untreated fruits stored at ambient conditions, regardless of UV-C treatment, significantly increased color changes.

Shelflife

A significant difference was observed in the shelflife of bitter gourd fruits as influenced by different UV-C illumination and storage condition (Figure 1). Fruits subjected to UV-C for 30 minutes stored at 20˚C significantly prolonged the shelf life for 8 days. In addition, fruits stored at 20°C regardless of UV-C treatment extended shelflife for 6 days. Bautista (1990) mentioned that produce stored in low temperature or cold storage with higher relative humidity is generally required to reduce the rate of the deteriorative process such as respiration and transpiration, which improves the visual quality appearance, thereby prolonging the shelflife of the produce.

On the other hand, fruits stored at ambient condition regardless of UV-C treatment shortened postharvest life for 4 days. Preetha et al., (2015) indicate that bitter gourd has a shelf life of just four days under ambient conditions due to its high moisture content, large surface area to volume ratio, thin cuticle, and corrugated fruit surface. According to Zong et al. (1995), if stored under tropical ambient conditions, bitter gourd fruit is highly susceptible to senescence and will exhibit early signs of yellowing, softening, and red pigmentation in the arils. As a result, low-temperature storage may be an alternative method of extending bitter gourd's shelf life (Mohammed and Wickham, 1993).

Figure 1. Visual quality rating of bitter gourd *(Momordica charantia* L.*)* as influenced by different UV-C doses and storage conditions. (A) Day 0; (B) Day 4; T0 – Control; T1 – 30 mins. UV-C + Ambient; T2 –60 mins. UV-C + Ambient; T3 – Without UV-C + 20°C; T4 – 30 mins. UV-C + 20°C; T5 – 60 mins. UV-C + 20°C.

Table 3. Yellowing index of bitter gourd *(Momordica charantia* L.*)* as influenced by different UV-C doses and storage conditions.

Treatments	Yellowing Index				
	Day 0	Day 2	Day 4	Day 6	Day 8
T0 – Control	1.00	2.47b	3.53	–	–
T1 – 30 mins. UV-C + Ambient	1.00	2.60b	3.60	–	–
T2 –60 mins. UV-C + Ambient	1.00	2.60b	3.60	–	–
T3 – Without UV-C + 20°C	1.00	2.00a	3.27	3.70	–
T4 – 30 mins. UV-C + 20°C	1.00	2.00a	2.93	3.30	4.50
T5 – 60 mins. UV-C + 20°C	1.00	2.00a	3.33	3.83	–
% CV		5.48	8.14	8.74	

Means within the same column followed by a common letter and/ or without letter designation are not significantly different from each other at 5 % level of significance

Chemical characteristics (TSS, TA and Vitamin C)

Chemical characteristics (TSS, TA and Vitamin C) of bitter as influenced by different UV-C exposure and storage conditions is presented in Table 4. Significant differences in initial and final total soluble solids were observed on bitter gourd fruits as influenced by UV-C exposure and storage conditions. Untreated fruits stored at 20°C obtained the highest level of total soluble solids, which were comparable to other treatments. Meanwhile, fruits treated with UV-C for 60 minutes and stored at ambient conditions attained the lowest total soluble solids.

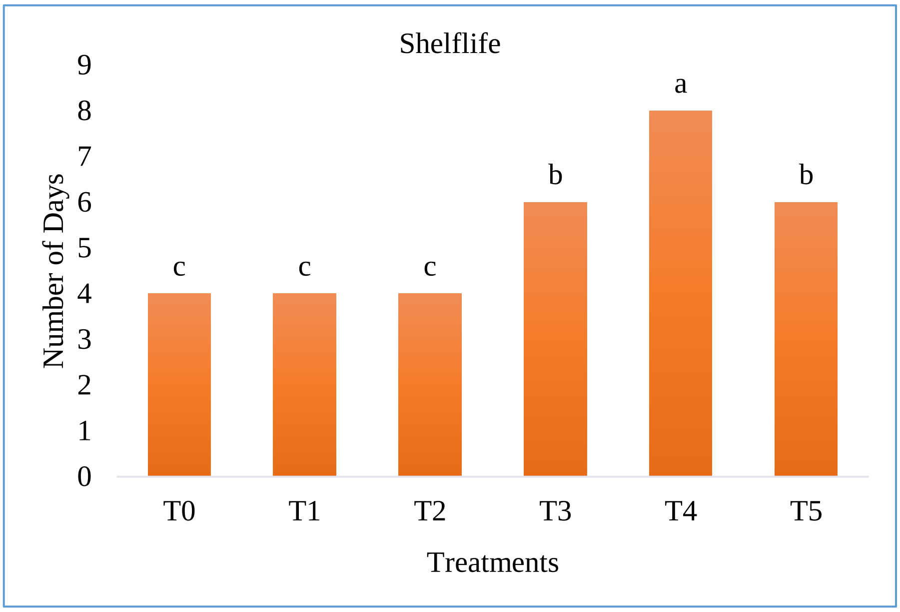

Figure 2. Shelflife of bitter gourd *(Momordica charantia* L.*)* as influenced by different UV-C doses and storage conditions.

Table 4. Chemical characteristics (TSS, TA and Vitamin C) of bitter gourd *(Momordica charantia* L.*)* as influenced by different UV-C periods and storage conditions.

Treatments	TSS		TA		Vitamin C	
	Initial	Final	Initial	Final	Initial	Final
T0 – Control	3.55ab	1.23bc	0.15	0.97	10.14	0.85b
T1 – 30 mins. UV-C + Ambient	3.47ab	1.50abc	0.15	0.85	9.49	0.85b
T2 – 60 mins. UV-C + Ambient	3.20b	1.17c	0.13	0.65	8.95	0.91b
T3 – Without UV-C + 20°C	3.80a	1.97a	0.14	0.81	9.19	1.06b
T4 – 30 mins. UV-C + 20°C	3.43ab	1.33bc	0.12	0.81	10.14	1.86a
T5 – 60 mins. UV-C + 20°C	3.33ab	1.73ab	0.13	0.80	9.82	1.10b
% CV	5.24	12.47	19.05	16.91	5.14	8.53

Means within the same column followed by a common letter and/ or without letter designation are not significantly different from each other at 5 % level of significance

Oxidation Reduction Potential (mV) and Power of Hydrogen (pH)

The oxidation-reduction potential (mV) and pH of bitter gourd, as influenced by different UV-C exposure and storage conditions, are shown in Table 5. Results indicated that UV-C treatment and storage conditions significantly affect bitter gourd's initial and final oxidation-reduction potential. UV-C-treated fruits stored at 20°C obtained the highest initial and final oxidation-reduction potential. Comparable effects can be observed on untreated fruits stored at 20°C. On the other hand, fruits either treated or untreated with UV-C stored at ambient conditions obtained the lowest initial and final oxidation-reduction potential.

Table 5. Oxidation Reduction Potential (mV) and pH of bitter gourd *(Momordica charantia* L.*)* as influenced by different UV-C exposure and storage conditions.

Treatments	Oxidation Reduction Potential (mV)		pH	
	Initial	Final	Initial	Final
T0 – Control	282.00b	204.33cd	6.56	5.50a
T1 – 30 mins. UV-C + Ambient	283.33b	195.33d	6.60	5.05b
T2 –60 mins. UV-C + Ambient	286.67b	215.67c	6.19	5.06b
T3 – Without UV-C + 20°C	302.00a	267.00b	5.96	4.94b
T4 – 30 mins. UV-C + 20°C	301.00a	275.33ab	6.56	5.58a
T5 – 60 mins. UV-C + 20°C	306.67a	283.00a	5.95	4.87b
% CV	1.63	2.26	5.01	3.04

Means within the same column followed by a common letter and/ or without letter designation are not significantly different from each other at 5 % level of significance

No significant difference was observed in initial pH as influenced by UV-C treatment and storage conditions. However, a numerical difference can be observed. The final pH level of bitter gourd was significantly affected by UV-C treatment and storage conditions. Fruits treated with UV-C for 30 minutes and stored at 20°C recorded the highest pH level, which was comparable with untreated fruits stored at ambient conditions. On the other hand, fruits treated with UV-C for 60 minutes and stored at 20°C obtained the lowest pH level, which was comparable to other treatments.

CONCLUSION

UV-C illumination at varying periods and storage conditions significantly affected the chemical characteristics, postharvest quality, and shelf life of bitter gourd. Fruits subjected to UV-C for 30 minutes and stored at 20°C significantly reduced weight loss, prolonged visual quality, and shelflife, and delayed color changes or yellowing after 8 days of storage. Further, the latter treatment obtained the highest initial and final oxidation-reduction potential, highest pH level, and Vitamin C content. Fruits subjected to UV-C for 30 minutes and stored at 20°C were found to be the best in maintaining quality and prolonging the shelf life of the produce.

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Technological Assessment of the Effect of Electricity Power Supply on Agriculture: Evidence from Southwestern Nigeria

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Abstract

The study examined the impact of electricity power supply on agriculture in the southwestern Nigeria. Multi-stage sampling technique was used to sample two hundred (200) small-holder farmers in Ondo and Ekiti States, through the use of validated structured questionnaire, out of which 188 copies were properly completed and found analyzable, thus representing 94% return rate. Data obtained were analyzed using simple percentages, mean with standard deviation as well as binary logistic regression model. The results showed that electricity power supply had high impact on preservation of farm produce. Also, unstable power supply was perceived by the farmers to have negatively affected the level of productivity ($\bar{x}$ = 2.61), makes preservation impossible ($\bar{x}$ = 2.88), leads to low level of profitability ($\bar{x}$ = 2.68), brings about low level of innovative farming activities ($\bar{x}$ = 2.74), increased running cost ($\bar{x}$ = 2.69) and high cost of living in rural areas. Furthermore, results of binary logistic regression revealed that power supply in the production of arable crops, shows that only age was identified as a significant factor influencing knowledge of the importance of power supply on agricultural activities,with younger farmers having the likelihood of increasing knowledge by two(2) times, while compared to older farmers. It was concluded that electricity power supply has a great effect on agricultural production and farmers' profitability.

Keywords: Assessment, Technology, Electricity, Effect

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INTRODUCTION

Agriculture is an important driver of any economy and a veritable engine of growth in any developing society as it provides employment, reduces poverty, ensures food security and enhances economic development (Oyakhilome and Zibah, 2014). It is therefore the backbone of the Sub-Saharan economies (Balarane and Oladele, 2012). As such, most Africans depend on agriculture for their livelihoods, and it is estimated that about 86 percent of rural people in the continent rely directly or indirectly on agriculture as source of income and for the provision of jobs for about 1.3 billion people (Tita, 2009). It is estimated that the yearly global quantum of food losses through wastage was averagely put at 40% for fruits and about 50% for vegetables and root crops as at 2011 (FAO, 2012).

Kalamkar, Swain and Bhaiya, (2015) opined that agricultural sector is critical in achieving economic goal of any nation, as it reduces poverty, provides food and nutritional needs of people, supplies raw materials for industries and generates foreign exchange for nations of the world; especially in the Sub-Sahara Africa. Equally, Olayemi, Adegbola, Bamishaiye and Aawagu (2012) stated that as much as 25% and 40% of fruits and vegetables respectively, are lost after harvest and reasoned that farmers could be experiencing serious postharvest losses in Nigeria, particularly, due to poor power supply and poor postharvest strategies in the country.

Chindarkar, Chen, and Sathe (2017) stressed that electricity is a key input necessary for sustainable agricultural growth; especially in terms of irrigation. To this end, electricity power supply has continued to be heavily subsidized in some parts of the world especially in India, (Word Bank, 2013).

Also, Goldemberg, La Rovere and Coelho (2004) have argued that despite the importance of stable power supply to every aspect of human endeavour, especially as it relates health, education and agriculture, its unhindered access has remained elusive in the developing countries of the world. According to the International Energy Agency (2013), the Sub-Saharan Africa countries are noted to have recorded an estimated 68% electricity deficit which has resulted in low level of productivity across various sectors of the economies of African countries. The agency therefore warned that if concerted efforts are no put in place in terms of policies and programmes, it is most likely that as much as 1.2 billion people would be without electricity power supply in this part of the world by the year 2030.

As part of the measures to address the deficiency of power supply in Nigeria, the Electricity Power Sector Reform Act (EPSRA) was passed in 2005 with the objective of transferring the control and operations of the industry from government to the private sector in order to ensure improved efficiency and more investment in the critical infrastructure so as to promote market determined pricing and structure, as well as to bridge the gap between power supply and demand in the country (Onyekwena, Ishaku and Akanonu, 2017).Therefore, there is a clear evidence supporting positive correlation between stable power supply and increased agricultural and other allied activities' productivity in any part of the world (Badiani and Jessoe, 2014; Fan, et al., 2002; Kumar, 2005).

In view of the importance of stable power supply and improved productivity, a number of researches have been undertaken by various scholars. For instance, Onuk, Shehu, and Anzaku (2018) examined factors affecting the marketing of perishable agricultural products in Minna, Niger State, Nigeria and discovered that 58 percent of farm products are lost to spoilage during loading and transportation to the markets; as the products are not in any way preserved before or during transportation from the farms to the points of purchase.

Also, Elusakin, Ajide and Diji (2014) assessed the importance of off-grid electricity generation projects as implemented in the various rural communities in Nigeria and discovered abysmal failure of these projects, essentially due to failure to adhere to the precautionary measures necessary to be undertaken before embarking on such projects. They recommended that proper planning before the implementation of any off-grid power generation project should be undertaken, as this would reduce cost, save time and of course minimize resources utilization on such projects. They equally added that this would ultimately put to an end, erratic power supply to the rural areas of Nigeria and would ultimately enhance productivity.

Equally, Ibeawuchi, *et al.,(*2015) examined the prospect of industrial processing of fruits and vegetables such as onions, tomatoes, okra, pepper, carrot and melon for sustainable agro-industrial growth and development in Nigeria and discovered that inadequate provision of infrastructural facilities such as good irrigation system for improved farming activities, good road network for the transportation of harvested farm produce and steady power electricity for storage facilities as major challenges facing that sub-sector of the Nigerian economy. Therefore, it was recommended that government should improve on the provision of infrastructural facilities such as good irrigations system for agricultural production, good road network for transportation and improved electricity power supply in order to facilitate storage facilities for fruits and vegetables. Also, government and the private sector are encouraged to sponsor research and development for capacity building and manpower development to help sustain the fruit and vegetable crop production efforts.

In the same vein, Akpan, Essien and Isihak (2013) analyzed the impact of epileptic power supply on the profitability of micro-sized enterprises in the rural areas of the Niger Delta region of Nigeria. The study revealed that organizations that generate their power supply through generating sets incurred as much as three times of the expenses they would have spent on the tariff of the nationally generated electricity power supply.

As good as these studies might appear to be, less research attentions are paid on the impact of electricity power supply on agricultural activities in Nigeria. Therefore, this study was set to examine the relationship between unstable power supply and agricultural productivity among small holder farmers. Specifically, the study assessed the perceived effect of power supply on farmers' productivity, examined the impact of power supply on the profitability of farmers and identified constraints farmers faced with respect to electricity power supply, aside from the financial losses they incur in the process of crop harvesting and post-harvest management activities in Nigeria.

The federal government of Nigeria, in an attempt to improve the living conditions of rural dwellers in the country has put in place a number of economic policies measures, aimed at making lives better, especially in the last two decades. According to Elusakin *et al.,* (2014) these policies and programmes are either not implemented at all, or are abandoned as a result of paucity of funds for their implementations. One of the identified factors responsible for the dwindling rural population in Nigeria is non-availability or inadequate provision of social amenities such as electricity power supply and potable water supply. Although, the Nigerian Rural Electrification Agency (NREA) was specifically established to address the electricity needs of the rural areas in Nigeria, the outfit currently lacks electricity spatial planning data that could that be used to provide basis for which mode of power supply in form of grid, mini-grid or off-grid that is most appropriate for different parts of rural areas, in terms of cost effectiveness, spread and efficiency (Ohiare, 2015).

Equally, Gustavsson, Cederberg, Sonesson, van Otterdijk and Meybeck (2011) argue that due to non-availability or unstable nature of electricity power supply, food wastages are normally reported in the Sub-Sahara African countries, and that it is important to curtail or eradicate such ugly incidence in order to ensure food sufficiency. They added that globally, about 40-50% of fruits, vegetables and root crops losses are recorded in various parts of the world.

Olayemi, Adegbola, Bamishaiye and Aawagu (2012) also estimated that as much as 25% and 40% of fruits and vegetables are lost to spoilage during harvest or post-harvest activities respectively, in Nigeria, due to poor post-harvest handling measures and unavailability of appropriate storage facilities that are powered by electricity. Therefore, stable power supply is a necessity and an indispensible facility for the day to day living condition of man in his relationship with industrial activities, agricultural mechanization, health delivery, education and leisure (Asumadu-Sarkodie and Owusu, 2017). Also, Odekanle, Odejobi, Dahunsi, and Akeredolu (2020) have argued that constant power supply is a requirement for industrial, domestic and agricultural purposes, as it has been established to have had a strong positive correlation with any society's infrastructural development. It has equally been established that accessibility to constant energy supply enhances overall well-being and living standard of people and has the capacity to increase a nation's exportation drive capabilities (Poveda and Martínez, 2011).

As a result of this, issues surrounding the epileptic power supply in Nigeria have been discussed variously by experts. For instance, the Nigerian Electricity Regulatory Commission (2018) reported that the country has a total of twenty three (23) on-grid generating plants with a total installed capacity of 10,396 MW, out of which 6,056 MW was available for transmission, on the highest basis. From this analysis, it is obvious that there was a serious imbalance between power generation and transmission in Nigeria. This is because the country has a transmission network capacity of 5,300MW as against 7,500MW on the average basis that was theoretically documented which was obviously 29% lower than installed capacity and about 41% lower than available generation capacity (Odekanle, *et al.*, 2020). In addition to this, about 7.4% of transmitted energy is lost in transmission due to poor transmission infrastructure in Nigeria (Nigerian Electricity Regulatory Commission, 2018). Equally, Technical losses in terms of transmission and distribution have equally been reported in the country's power sector, resulting in disproportional level of efficiency, emanating from huge commercial and tariff collection losses being reported in the industry, with less than 50 % of electricity consumed usually paid for and the balance of 50% usually unpaid (World Bank, 2009).

Essentially, electricity is generally required in farming activities for running electrical motors, for pumping water; especially for irrigation purpose, for preserving dairy products, for cold storage, for farm products processing and for animal feed grinding (Oparaku, 2003). In order to meet the challenges of meeting the power needs of farmers, especially in the rural areas, the federal government, through the then Federal Ministry of Power, Works and Housing (FMPW&H) put in place the Rural Electrification Strategy and Implementation Plan (RESIP) in 2016 which was being implemented by the Rural Electrification Agency (REA) with the objectives of promoting agriculture, industrial, commercial, and other socio-economic activities in rural areas, thereby raising the living standards of rural populations through improved water supply, lighting and security; and to promote the use of domestic electrical appliances to reduce the drudgery of household tasks, typically allocated to women. Other objectives of the plan include; promotion of cheaper, more convenient and more environmentally-friendly alternative sources of energy in place of kerosene, candle, fossil fuel-powered generating sets; protection of the nation's health and environment through reduction of indoor pollution and other energy-related environmental problems as well as ensuring reduction in rural-urban migration. In spite of the bold steps taken by the federal government to improve the level of power supply, especially to the rural communities in Nigeria, through its rural electrification strategy and implementation plan, the rate of power supply has remained abysmally low.

For instance, Olanrele (2020) reported that the power supply in Nigeria has remained highly insufficient, recording as low as 3,500MW despite its generation capacity of about 7,000MW and that the rural communities are even worse of; enjoying less than 34% of aggregate power supply in Nigeria. Naturally, the estimated electricity need for developing countries was put at about 1,000MW per one million people (The World Bank Development Indicator 2018). This implies that Nigeria needs an estimated 200,000 MW electricity power supply in view of it estimated population of 200 million people. Therefore, the current low level of power supply, as currently experienced in the country has serious implications for its rural areas, which constitute up to 50 percent of its population, and by extension its agricultural productivity.

MATERIAL and METHOD

The Study Area Description

Nigeria is broadly divided into two major regions- the North and the South, and each of these two regions is known for its agricultural potentials. Purposive sampling technique was used to select southwestern Nigeria for this study. Equally, Ondo and Ekiti Sates were arbitrarily chosen from this region, based on their impressive records of agricultural activities. For the purpose of selecting respondents for the study, Agricultural Development Programme (ADP) head-office in each of the selected states was contacted to identify Local government areas in which highest volume of farm produce were recorded in the last ten years. Based on the information obtained from Agricultural Development Programme (ADP) in each state, list of registered farmers was obtained from each of the local government areas, for the purpose of sample selection. Thereafter, Krejcie and Morgan (1970) sample size table was used to select the representative samples from the population of farmers at 5% error margin. Simple random sampling technique was used to select a total of 200 smallholder farmers at equal proportion of 100 each from the two states.

A total of two hundred copies of questionnaire were administered. However, one hundred and eighty-eight (188) copies were properly completed and retrieved; representing 94% return-rate for the study as stated in Table 1.

Survey Instrument: A structured questionnaire of four (4) main sections was developed and administered on the selected respondents. Section one: this contains information on the socio-economic characteristics of respondents (age, gender, and average income). The section two contains questions on the perceived importance of electricity power supply on cultivation, irrigation, preservation of seeds and seedlings, harvesting and among other variables. Here, farmers were asked to rate their perception of the importance of electricity power supply on their level of productivity, income and general economic status, using 5-point Likert Scale; that is, 1 for (Strongly Disagree) and 5 for (Strongly Agree) for positive statements and this was reversed for the negative statements, in the last 10 years (2011-2021).

Section three comprises of questions on the relevance of electricity power supply on post-harvest agricultural practices. This involves getting information on the level of farmers' awareness, interest, evaluation, trial and adoption of post-harvest practices having to do with the use of electricity power supply; such as refrigerating, drying, processing, branding and packaging of farm produce.

Section four captures the knowledge base of farmers concerning the use of electricity power supply as an inevitable input for agricultural production. The knowledge base of the farmers was measured on a 'Yes' or 'No' basis with '1' and '0' and the skill level of the farmers was measured in terms of importance and competence, with each variable measured on a 5-point rating scale, based on information concerning their awareness of the importance of electricity power supply on agricultural productivity.

Data collected were analyzed with the use of logistic regression, while simple descriptive statistics such as frequency counts, percentages, and mean scores were used to summarize others. For the logistic regression analysis, knowledge of unstable power supply was used as the dependent variable and it was categorized as low (0) and high (1) for the purpose of logistic regression as modeled thus:

Under the Binary Logistic response model, if there are N categories, the probability that a respondent (a farmer) is in a particular category j

$$Pij = \frac{exp\,(ijXi)}{\Sigma^{3}_{j=1}\,(exp(ijXi)}$$

Where $j=0$, if the level of knowledge is low, and 1 if the level of knowledge is high, based on the categories derived from the knowledge scores from the use of the mean value approach model. X_i represents a vector of explanatory variables for a respondent i^{th} with j level of knowledge, and β the coefficient of the parameters.

Where z denotes the linear regression function for the variable of knowledge of unstable power supply on farmers under consideration (i.e. $\beta_0 + \beta_1 X_1 + \beta_2 X_2$ -------+ $\beta_n X_n$)

$$P_i\,(Y = 1/X_i)\ \frac{p_i}{1-p_i} = e^{(\beta0+\beta1X1+\beta n\,Xn\,+u)} \quad\text{...}(1)$$

The explicit function is given as

$$P_i\,(Y = 1/X_i)\ \frac{p_i}{1-p_i} = e^{(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + u)} \quad\text{...}(2)$$

Where:

α= Constant/intercept

β= Slope (Regression coefficient)

Y = Dependent variable for the study (level of knowledge categorized into low (0), and high (1); and

X_1= Age (in years)

X_2= Monthly income

X_3= Sex (Male= 1, Otherwise = 0)

RESULTS and DISCUSSION

Description of Demographic Characteristics of Respondents

Table 2 presents the distribution of respondents based on their demographic characteristics. About 26.1% of the farmers were within the age bracket of 41 and 50 years, while 17.0%, 12.8%, 12.8%, 6.4%, 12.0% and 6.3% were in the age groups of 51 and 60 years, 31 and 35 years, 36 and 40 years, 60 years and above, 25 and 30 years and 20 and 24 years respectively.The findings show that majority (93.6%) of the farmers were below or equal to 60 years of age, while only 6.4% of them were above 60 years old.

The implication of this finding is that farmers in the study area were still in their productive age, just as it is always the case in the developing countries, especially in the Sub-Sahara Africa, where enormous energy is required for farming activities, in the absence of mechanized farming system, unlike what obtains in the developed part of the world.

The economically active age of 60 years and below has been documented in many scholarly articles across several academic disciplines. For example, the study of Adeyemo and Olatunji (2004) observes that at the age of 60 years and above, the strength to engage in productive ventures may have been drastically reduced and entrepreneurial spirit may not be strong enough to carry out strenuous activities that are associated with non-mechanical efforts in most African countries. Equally, Oluwale, Ilori and Oyebisi (2013) found that no cluster mechanic was above 60 years of age in their study conducted in the Southwestern Nigeria corroborates this finding. The finding was also consistent with the result of Olanrele (2020) who reported that 73% of the respondents who participated in the study that examined the effects of rural electrification on households' welfare were below 60 years old. The fact that peasant farming activities could be strenuous explains its relationship with age.

In terms of gender distribution, the study reveals that a little more than half (55.9%) of the respondents that participated in the study were males, while 44.1% of them were females. The implication of this minor gap difference between men and women participation in the survey may not be unconnected with the fact that there is a serious gender issue in terms of land ownership and land accessibility across African countries.In most cases, women are usually content with land inheritance issues from their husbands' genealogy as they are usually stripe off land entitlement from their original family background. This is because in many cultures in Nigeria, women are disadvantaged in land ownership. This is apart from the fact that many women usually do not have the financial capacity to purchase land or afford to pay for rented land for agricultural purposes. This study therefore confirms the earlier findings of Ajala (2017) who noted that Nigerian women are always denied of equal economic and political empowerment when compared to men, and as such, these discriminating practices are manifested in land ownership across all geographical parts of the country.

On estimated monthly income level in naira, about one-third of the respondents (32.5%) indicated that they were earning between ₦50,001 and ₦70,000 income, on monthly basis, while 20.7%, 18.1%, 15.4% and 13.3% earned between ₦70,001 and ₦90,000, above ₦90,000, less than ₦30,000 and between ₦30,001and₦50,000 respectively. This implies that on the average, most small-holder farmers, despite the numerous challenges facing farming activities in Nigeria, still earn over and above the new nationally approved minimum wage of ₦30,000.00 on monthly basis for civil servants.

Perceived Effects of Power Supply

Results in Table 3 as displayed below, show that, out of the total farmers sampled, about 54.3% indicated that unstable power supply had negative effects on the production of arable crops, through irrigation all year round and further analysis to determine these effects, using grand mean indicated that the effect of unstable power supply on the production of arable crops through the year was perceived to be low with the grand mean of 2.27 out of a total mean of 4.0 with a beach-mark of 2.5.

Also, farmers recorded perceived low effects in the use of power supply to preserve seeds with the mean of 2.43 at 58.5%. This means that arable crop farmers in the study area may be unaware of the use of power supply for irrigation purpose; as such, technologies are not commonly used in most developing countries, especially in Sub-Sahara Africa, because farming is still predominantly done in the traditional methods of using cutlass and hoes to till the ground. Similarly, stable power supply is useful for seeds preservation in countries where agriculture is driven by technologies. However, in the study area, it was observed that arable crop farmers could not establish a serious link between stable power supply and seed preservation, which is an indispensable input for seeds and seedlings preservation.

On the contrary, it was observed that preservation of perishable produce ($\bar{x}$ = 3.62) and powering of machines ($\bar{x}$ = 2.57) among others, recorded to have been influenced by the unstable power supply. This implies that unstable power supply was said to have had negative effects on these identified critical aspects of arable crop farming activities, such as packaging, the use of motorized spraying machines for herbicides and insecticides, extension agents' work of training, entertainment and recreation, as well as preservation of vaccines and chemicals. The farmers interviewed seemed to be familiar with the usefulness of electricity in the above listed activities and their responses seem to be consistent with the findings of Odekanle *et al.,* (2020) who observed that constant electricity supply was very important to agricultural development in terms of food price stability. Therefore, unstable electricity power supply has been argued to have hampered agricultural production in Sub-Saharan Africa as Gustavsson *et al.,*(2011) posited that non-availability of electricity supply has led to food wastages and poor level of profitability among farmers in the continent.

Impact of Unstable Electricity Power Supply

Data in Table 4 show the perceived impacts of unstable electricity power supply on the production of arable crops in the study area. It was shown from the analysis that low yields ($\bar{x}$ = 2.61), impossible preservation ($\bar{x}$ = 2.88), low profitability ($\bar{x}$ = 2.68), low level of innovative farming practices ($\bar{x}$ = 2.74), increased running cost ($\bar{x}$ = 2.69) and high cost of living in rural areas due to unavailability of electricity power supply ($\bar{x}$ = 2.28) had grand mean values of 2.0 and above, from a total mean of 3.0 and this implies that unstable power supply was said to have impacts on arable crops production among farmers in the study area. However, it was observed that unstable power supply was recorded not to have had high impacts on the mortality rate of animal among farmers as well as on supply of portable water. This may fall within the priori expectation, as farmers sampled for this study were predominantly inolved in the cultivation of arable crops, therefore, they may not be involved in livestock production, hence, unable to assess the impact of unstable electricity power supply on livestock production.

The above findings could be used to corroborate the findings of Ohiare (2015), who submitted that lack of electricity power has increased the cost of living in rural areas of Nigeria as food wastage was documented to be higher in rural environment when compared to what was obtainable in cities. Also, the findings of Olayemi *et al.,* (2012) also support the outcome of this research, in that; it estimated that between 25%-40% of arable crops, particularly fruits and vegetables are usually lost in postharvest activities in Nigeria.

Knowledge of the Benefits of Stable Power Supply

Data in Table 5 show that arable crop farmers had high knowledge of the benefits of stable power supply in refrigerators and freezers for the preservation of fresh vegetables and other perishable farm produce ($\bar{x}$= 3.71) and instant dissemination of innovative farming technologies, while they recorded low level of knowledge in the use of powered spraying pumps in the production of vegetables through irrigation practices and in the use of silos for grain preservation. This shows that arable crop farmers lack basic knowledge of stable electricity power supply in farming. This may be due to the fact that lack of electricity power supply to many rural communities must have made some of these farmers to develop alternative traditional methods of preserving their crops and some must have reduced their production capacity in order to reduce wastage. It is a known fact that Nigeria as a developing country with over 200 million people and has electricity transmission network capacity of only 5300MW as against 7500MW that was theoretically documented to have been produced in 2018 and this was obviously 29% lower than the installed capacity and about 41% lower than available generation capacity. In addition to this, about 7.4% of transmitted energy is lost in transmission due to poor transmission infrastructure (Nigerian Electricity Regulatory Commission, 2018).

Determinants of Farmers' Knowledge of Unstable Electricity Power Supply in Crop Production

Table 6 shows that results of binary logistic regression showing the determinants of farmers' knowledge of unstable power supply in arable crop production with only age indicated that older farmers had poor knowledge, while the younger ones had high knowledge. The odd ratio of 2.040 among farmers show that the likelihood of age influencing farmers' knowledge of the effects of electricity power supply is approximately 2 times higher among the younger ones when compared to the older respondents. Unfortunately, farmers' income derived from arable crop production did not in any way influence their knowledge of the importance of electricity power supply in the study area.

The availability and stability of electricity power supply may serve as a factor that promotes an increased level of knowledge. The fact that Nigeria as a developing country that produces electricity power that is far less than its population requirements, and that the country is still unable to utilize the available quantity of power generated means that its citizens, including farmers may not have had regular access to power supply. To worsen this situation, farming is predominantly done in rural areas and electricity power supply has been very unreliable to this areas, based on the findings of Ohiare (2015), that affirmed this through research. The implications of not having adequate power supply in rural areas may have negative impact on knowledge acqusition in these areas. This has therefore made the cost of living to be very high in rural areas and by extension, makes such locations unattractive to an average Nigerian to live.

Table 1. Questionnaire Response Rate Analysis

State	Number of questionnaires administered	Number of questionnaires retrieved	Percentage response (%)
Ondo	100	96	96
Ekiti	100	92	92
Total	**200**	**188**	**94**

Table 2. Distribution of Respondents Based on the Demographic Characteristics

Variable	Frequency	Percentage (%)
Age (year)		
20-24	12	6.3
25-30	22	12.0
31-35	35	18.9
36-40	24	12.8
41-50	49	26.1
51-60	32	17.0
Above 60	12	6.4
Gender		
Male	105	55.9
Female	83	44.1
Estimated monthly income (₦)		
Less than 30,000	29	15.4
30,001-50,000	25	13.3
50,001-70,000	61	32.5
70,001-90,000	39	20.7
Above 90,000	34	18.1

Source: Field Survey, 2022.

Table 3. Effects of power supply

Variables	Freq	%	Mean	Std. Dev
All year-round arable farming through irrigation	51	54.3	2.27*	0.13
Preservation of perishable farm products in terms of refrigeration and smoking	82	87.2	3.62**	0.27
An indispensable input resource for the preservation ofseeds and seedlings	55	58.5	2.43*	0.16
For powering agricultural tools and machines	67	71.3	2.57**	0.36
For the packaging of semi-processed agricultural products	72	76.6	2.55**	0.51
For spraying chemicals and pesticides	59	62.8	2.51**	0.29
For powering machines and equipment for gathering information on emerging developments, especially on farming techniques	87	92.6	3.74**	0.16
It is used by extension workers to train farmers	77	81.9	2.78**	0.18
For entertainment and recreation	69	73.4	2.58**	0.21
For preservation of fish, meat and other dairy products	91	96.8	3.83**	0.38
For preservation of vaccines	85	90.4	3.71**	0.09

*Source: Field Survey, 2022, **Mean > 2.5 = High effects and *Mean < = 2.5 Low effects*

Table 4. Impact of unstable electricity power supply on farming of arable crops

Variable	Mean	Std. Dev
Low level yield per hectare	2.61**	0.25
Impossible preservation of farm produce	2.88**	0.09
Low level of profitability	2.68**	0.15
Low level of innovative farming practices	2.74**	0.42
High level of mortality rate of farm animals	1.55*	0.51
Increased running cost of farming activities	2.69**	0.64
High cost of living in rural areas due to unavailability of power supply	2.28**	0.72
Poor supply of portable water	1.56*	0.19

*Source: Field Survey, 2022, **Mean > 2.0 = High impact and *Mean < 2.0 = Low impact*

Table 5. Knowledge of Electricity in farming

Knowledge of electricity in farming	Mean	Std. Dev
Electrical-powered spraying pumps are capable of ensuring production of vegetables even during the dry season of the year	2.11*	0.12
Refrigerators and freezers for the preservation of fresh vegetables and other perishable farm produce are indispensable for every farmer	3.71**	0.41
A mini-silo that is provided by government agencies would ensure availability of grains for consumption and for planting at any time of the year.	2.26*	0.13
The use of silo for the preservation of grains is a sure way of making them available at any point in time for consumption and for industrial purpose	2.16*	0.17
Instant dissemination of innovative farming technologies can only be made possible when constant power supply is guaranteed in the farming communities	3.59**	0.32
Provision of portable water for domestic use and for farming activities would generally improve the wellbeing of farmers in Nigeria	2.18*	0.13

Source: Field Survey, 2022.
****Mean > 3.0 = High knowledge and *Mean < 3.0 = Low knowledge**

Table 6. Determinants of Effects

Determinant	B	Odd Ratio	Decision
Age	-0.713	2.040	S
Income (Naira)	0.092	1.096	NS
Sex	0.192	1.212	NS

Source: Field Survey, 2022, -2log-likehood ratio = 119.3610, S = Significance, NS = Non-Significance

CONCLUSION and RECOMMENDATIONS

The importance of electricity power supply to agriculture cannot be overemphasized, especially in countries that have technological prerequisite for economic advancement. One of the problems of agriculture in developing countries has been unstable electricity power supply and this has been attributed to the huge post-harvest losses of perishable crops in Nigeria. Therefore, the study assessed the effects of unstable electricity power supply on agricultural sector using statistically selected arable crop farmers in Ondo and Ekiti States, Nigeria, with a view to examining the impacts of power supply on crop production. Purposive and simple random sampling procedure was used to select 188 arable crop farmers across the two states with the use of Krejcie and Morgan (1970) sample size table at a response rate of 94%. Data were collected with the use of structured questionnaire and analyzed with logistic regression while frequency, percentages and mean were used to describe the data.

Some of the findings revealed that about 87.3% of the sampled farmers were between the productive ages of 30 and 60 years and slightly above average (55.9%) were males, although women's population in arable crop production was equally high. Meanwhile, 84.6% of the farmers earned ₦30,000.00 and above as their monthly income. The respondents indicated that unstable power supply had low effects on some important aspects of farming in Nigeria, such as irrigation, seeds and seedlings preservation.They equally indicated that electricity power supply had high impact on preservation of farm produce, since many of their produce are highly perishable. Furthermore, unstable power supply was perceived to have had high impact on farmers' yields (Mean = 2.61), makes preservation impossible (Mean = 2.88), lead to low profitability (Mean = 2.68), low level of innovative farming practices (Mean = 2.74), increased running cost (Mean = 2.69) and high cost of living in rural areas, due to unavailability of power supply (Mean = 2.28).

Furthermore, the study revealed that farmers had high level of knowledge of the benefits of stable power supply in refrigerators and freezers for the preservation of fresh vegetables and other perishable farm produce (Mean= 3.71) and instant dissemination of innovative farming techniques. Results of binary logistic regression to identify the determinants of farmers' knowledge of unstable power supply in the production of arable crops show that only age was identified as a significant determinant, with younger farmers having the likelihood of increasing their knowledge by two(2) times. The findings concludes that arable crop farmers do not perceive the impact of unstable power supply high on the production of arable crops and this may be attributed to the low production status of most farmers in Nigeria, as traditional methods of production dominate the arable crop production activities in Nigeria.

The findings thus recommend that arable crop farmers in the study area should be sensitized on the importance of powered motorized farming system, particularly irrigation farming techniques as this will promote off season farming, which has been documented to be more profitable by many researchers. Also, government should ensure that regular power supply is guaranteed in rural areas, through the implementation of more electricity projects in rural areas of Nigeria, knowing well the significance of rural areas in food production the country.

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