JOURNAL OF AGRICULTURAL PRODUCTION

Year: 2022 | Volume: 3 | Issue: 1 | e-ISSN 2757-6620 | agriprojournal.com

Journal of Agricultural Production

Volume: 3 Issue: 1 Year: 2022

e-ISSN: 2757-6620

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www.agriprojournal.com
dergipark.org.tr/en/pub/japro

e-ISSN: 2757 – 6620

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Journal of Agricultural Production (2022) 3(1), 1-8 https://doi.org/10.29329/agripro.2022.413.1

JOURNAL OF AGRICULTURAL PRODUCTION
https://agriprojournal.com ISSN: 2757-6620

RESEARCH ARTICLE

Yield and Quality Response of Canola to Seed Row and Side Banded Ammonium Sulfate and Ammonium Thiosulfate

Ikenna Mbakwe* • Omotayo Adegeye

SynergyAG Services Inc., Govan, Saskatchewan/Canada

ARTICLE INFO

Article History
Received: 17.02.2022
Accepted: 14.03.2022
First Published: 17.03.2022

Keywords
Canola
Sulfur
Ammonium sulfate
Ammonium thiosulfate

ABSTRACT

Ammonium sulfate (AMS) and ammonium thiosulfate (ATS) are two of the most common sulfur products applied during canola seeding in the Canadian Prairies. A better understanding of how application methods affect the efficiency of these products is warranted. A field trial was conducted on a clay loam soil in Pense, Saskatchewan to evaluate the effect of seed row and side banded sulfur applications on canola yield and quality. Plots received 34 kg ha^{-1} sulfur either from AMS or ATS applied during seeding either in the seed row (SR) or side banded (SB). A treatment without sulfur was included as a control. All plots received the same amounts of all other nutrients. Results showed that average seed yields increased for all sulfur-treated plots, however, only side banded applications (AMS(SB): 4020 kg ha^{-1}, ATS (SB): 3883 kg ha^{-1}) were significantly better than the control (3072 kg ha^{-1}). Side banded sulfur applications generally produced more protein than seed row applications and were significantly different from the control. AMS (SB) had the highest protein content (21.07%) while the control had the least (18.13%). Oil content was similar except for AMS (SB) (46.72%) which was significantly lower than the control (48.68%). However, this oil difference was more than compensated by the increased yield from AMS (SB). Applying AMS and ATS in the seed row can decrease the yield and protein response that might otherwise be seen when these products are side banded. There were no significant differences in the measured parameters between AMS and ATS.

Please cite this paper as follows:
Mbakwe, I., & Adegeye, O. (2022). Yield and quality response of canola to seed row and side banded ammonium sulfate and ammonium thiosulfate. *Journal of Agricultural Production*, *3*(1), 1-8. https://doi.org/10.29329/agripro.2022.413.1

Introduction

Canola (*Brassica napus* L.) is considered Canada's most valuable crop because of its immense contributions to the Canadian economy (Bandara et al., 2018). Canola seeds are processed into oil and meal, which are then used to manufacture a wide variety of products. It is also desirable as a feedstock for biodiesel production (Blackshaw et al., 2011).

Canola production typically requires more plant nutrients than cereals (Rathke et al., 2005), and sulfur is one of its key nutrients. Compared to cereals, canola has a high sulfur demand and is particularly sensitive to sulfur deficiency (Urton et al., 2018). Pods per plant and biological yield has been found to increase with increase in sulfur level (Ahmad et al., 2011). In the Canadian Prairies, sulfur is the third most limiting nutrient, after nitrogen and phosphorus (Grant et al., 2004; Malhi et al., 2005). Sulfur deficiencies in Prairie soils are becoming increasingly common because of higher crop yields and reduction of atmospheric deposition of sulfur compounds (Grant et al., 2004). The spatial variability of sulfur in a field (Piotrowska-Długosz et al., 2017; Behera et al., 2021) has often meant that soil sulfur test results of composite soil sampling may not be reliable in making sulfur fertilizer recommendations for an entire field.

Ammonium sulfate (AMS) and ammonium thiosulfate (ATS) are two of the most common sulfur products used by canola farmers. Ammonium sulfate is especially useful where both nitrogen and sulfur are needed, because of its higher

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nitrogen concentration. Because all the sulfur in AMS is in the plant-available sulfate form, AMS is also desirable where immediate sulfur availability is required. In ammonium thiosulfate only a portion of its sulfur becomes immediately available when applied to the soil (Malhi et al., 2005), while the remainder has to be converted to plant-available sulfate by bacteria. Ammonium thiosulfate may therefore be beneficial in situations where the slow release of sulfur is desired to continue supplying sulfur to plants during the growing season. This is especially advantageous in situations where sulfate is not adequately adsorbed onto organic matter and clay particles and is therefore, vulnerable to leaching. However, this slow-release nature of ammonium thiosulfate may also be detrimental when, because of unfavourable soil and weather conditions, the elemental sulfur portion does not convert quickly enough to plant-available sulfate when plants need sulfur. Because sulfur oxidation is mainly due to microbiological processes, the rate of conversion of elemental S to sulfate is influenced by factors such as soil moisture, aeration, pH and temperature (Germida & Janzen, 1993).

Ammonium thiosulfate may also improve nitrogen use efficiency because it can delay urea hydrolysis (Sullivan & Havlin, 1992) thereby reducing ammonia volatilization. It has also been found to slow down the rate of nitrification (Gezerman, 2019) thereby reducing the loss of nitrogen through nitrate leaching. However, these inhibitory capabilities are not as effective as commercially available products, such as NBPT, designed specifically for that purpose (McCarty et al., 1990).

Seed placement and side banding are two methods that farmers can use when applying fertilizers during spring seeding. Seed placement gives newly emerged seedlings early access to the applied nutrients and is especially beneficial for those nutrients that are less mobile in the soil (Qian et al., 2012). However, seed placement can inhibit seed germination and crop emergence because of the salt toxicity of fertilizers. Malhi et al. (2005) noted that the effectiveness sulfur placement method depends on the form of sulfur in the product (Sulfate-S or Elemental-S) as well as soil and weather conditions.

The aim of this study was to determine the effect of method of application on the efficiency of ammonium sulfate and ammonium thiosulfate in improving canola yield and quality in the year of application.

Materials and Methods

Trial Establishment

The trial was conducted in Pense, Saskatchewan, Canada (50°23'54.1"N 105°03'07.6"W) in 2020. Total rainfall received during the 2020 growing months of May to August was 135 mm. The 30-year rainfall average in this area for these months is 197 mm. Maximum daily temperatures for this period ranged from 19.9 °C in May to 38.5 °C in August. The soil is a clay loam (pH: 8.5). Wheat had been grown on this field during the previous season.

In early Spring, an area of the field was marked out into plots consisting of six 6 m-long rows with 25 cm row spacing. Plots were clearly identified with plot stakes. The plots and trial area were separated sufficiently by distance and buffer crop to prevent drift and damage while conducting assessments.

Three soil samples (0-15 cm) were taken per plot, bulked into one sample per plot (making a total of 15 composite samples for the trial site) and analyzed for soil properties. The soil characteristics of the experimental site are listed in Table 1.

Table 1. Some soil properties of the experimental site before application of treatments

Parameter	Mean
pH (water)	8.5
OM (%)	3.8
CEC (meq 100g^{-1})	40.7
Nitrate (ppm)	23
P (Olsen) ppm	13
K (ppm)	558
S (ppm)	17
Mg (ppm)	1337
Ca (ppm)	7120
Zn (ppm)	2.6
Fe (ppm)	109
Cu (ppm)	5.2
B (ppm)	1.6
Al (ppm)	483
Mn (ppm)	170
Silt (%)	49.48
Clay (%)	34.08
Sand (%)	16.44
EC (1:1) dS m^{-1}	1.1

Experimental Layout and Treatments

The trial was setup in a randomized complete block design (RCBD) with five treatments and three replicates. Two sulfur products (Ammonium sulfate (AMS) and Ammonium thiosulfate (ATS)) were used in the trial. These were applied during seeding either in the seed row (SR) or side banded (SB). A treatment without sulfur was included as a control. The treatment list is shown in Table 2.

Table 2. Treatment list

ID	Sulfur Treatments	Rate of Sulfur Application (kg ha^{-1})	Product Rate (kg ha^{-1})	Method of Application	Nutrient Analysis (% wt.)			
					N	P_2O_5	K_2O	S
1	No S (Control)	None	None	N/A	-	-	-	-
2	Ammonium sulfate (AMS)	34	140	Seed row (SR)	21	0	0	24
3	Ammonium thiosulfate (ATS)	34	129	Seed row (SR)	12	0	0	26
4	Ammonium sulfate (AMS)	34	140	Side banding (SB)	21	0	0	24
5	Ammonium thiosulfate (ATS)	34	129	Side banding (SB)	12	0	0	26

Seeding and Product Application

Canola (L233P) was seeded 18 May 2020 at a seeding rate of 6 kg ha^{-1}, depth of 1 inch (2.5 cm) and operating speed of 2 mph using a small plot SeedMaster drill. At seeding, fifty-six (56) kg ha^{-1} phosphorus (MAP: 11-52-0) was side banded, and nitrogen (urea: 46-0-0) was side banded to achieve a rate of 56 kg ha^{-1} of N (adjusting for the N contents of AMS, ATS and MAP). Seventy-eight (78) kg ha^{-1} of N had been applied in the fall. Thirty-four (34) kg ha^{-1} of S (either from AMS or ATS) were applied either side banded 0.75 inch (1.9 cm) below and away from the seed row, or directly with the seed in the seed row. No sulfur was applied to the control plots.

Trial Maintenance and Monitoring

Three weeks after planting, when the plants were at 2-3 leaf stage, plant stand counts were taken using a hula hoop. Three counts (top, middle and bottom) were done per plot and averaged. Because of pressure from volunteer wheat, an herbicide application of 4 L ha^{-1} Liberty and 0.19 L ha^{-1} Centurion was sprayed on 23 June using a handboom. Fungicide Lance WDG (350 g ha^{-1}) and Boron 10% (1.2 L ha^{-1}) were applied on 12 July as a precaution for *Sclerotinia*, and to add Boron. Tissue sampling was done in July and August and samples were analyzed for nutrient content following standard laboratory procedures.

Harvesting

Plots were harvested on 10 September 2020 using a Wintersteiger small plot combine with a HarvestMaster Classic GrainGage to collect yield data. Moisture content at harvest was determined and yield adjusted accordingly to provide dry yield. Protein and oil contents in seed were determined using near infrared spectroscopy (Prem et al., 2012). Thousand seed weight (TSW) was determined by counting and weighing seeds. Yield and quality data were analyzed using ANOVA and differences separated using a Tukey test.

Results and Discussion

Plant Count

The effect of the treatments on plant count is shown in Figure 1. The data show a numerical reduction of plant count when AMS and ATS were applied in the seed row compared to the control or when these products were applied side banded. This is attributed to the increased contact of product with seed when applied in the seed row, which leads to higher salt toxicity effect of the sulfur products (Qian et al., 2012). These sulfur products have high salt indexes and when applied to calcareous soils such as this, can produce significant amounts of ammonia resulting to ammonia toxicity and osmotic damage (Grant et al., 2004).

Plant count for side banded ATS was significantly higher than plant count for seed row applied AMS and ATS. This difference in plant population may, however, not affect final yield because canola naturally compensates for variations in plant population over relatively wide plant population ranges, with very little effect on final yield (Angadi et al., 2003).

Nutrient Uptake

Sulfur application numerically increased nitrogen uptake both in the July sampling and the August sampling (Figure 2). However, differences between treatments were not statistically significant. Increase in N uptake as a result of sulfur application has been reported by several authors such as Urton et al. (2018). Our data did not identify any other notable nutrient uptake trend at the two sampling times. The lower nitrogen content in August compared to July support the observation that in general, nitrogen concentrations in plant tissue decrease with age (Sedberry et al., 1987). This decline is attributed to a dilution effect because during aging, the plant biomass increases comparably more than the nutrient accumulation (van Maarschalkerweerd & Husted, 2015).

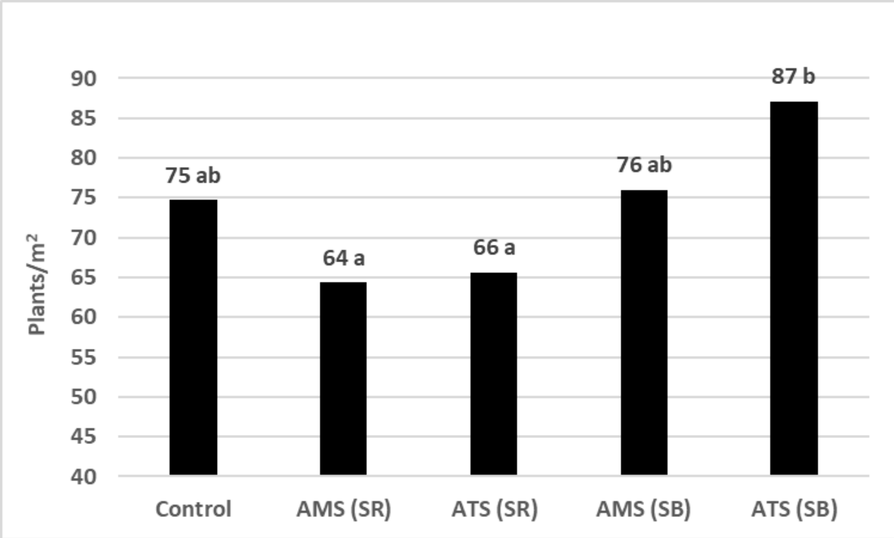

Figure 1. Effect of seed row (SR) and side banded (SB) sulfur products on canola plant count 3 weeks after planting. Means with the same letter are not significantly different from each other (p<0.05).

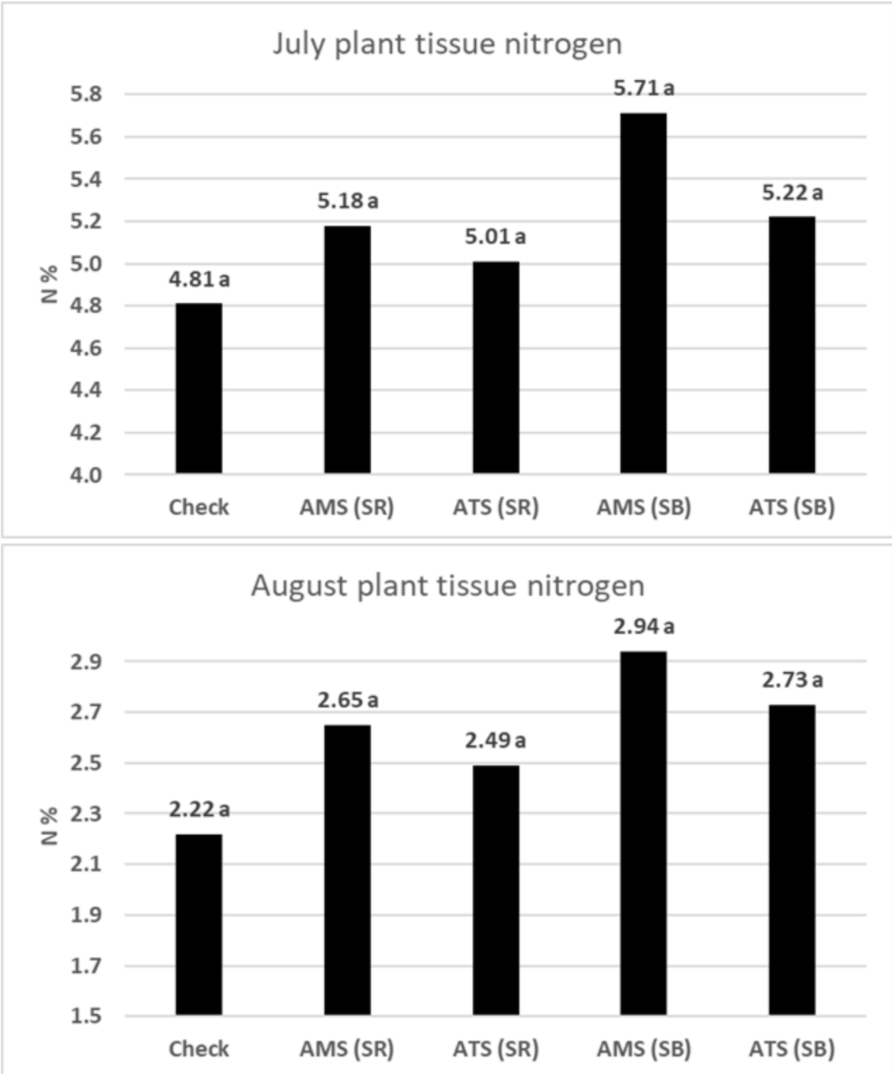

Figure 2. Effect of seed row (SR) and side banded (SB) sulfur products on nitrogen content of canola tissue. Means with the same letter are not significantly different from each other (p<0.05).

Yield

Average yield from sulfur-treated plots were higher than the control, highlighting the usefulness of sulfur in canola production even when soil tests do not identify serious sulfur deficiency (Figure 3). Because sulfur is immobile in plants, its deficiency at any growth stage can cause a reduction in seed yield (Malhi & Gill, 2002). Grant et al. (2004) found that ammonium sulfate and ammonium thiosulfate were effective sulfur sources to enhance crop growth in the year of application.

Side-banded sulfur produced higher average yields than seed row application. Only side banded treatments were significantly different from the control ($p<0.05$). This trend agrees with Malhi and Gill (2002) who from a study on six sites across Northern Saskatchewan reported that 30 kg S ha^{-1} applied side-banded produced on average, a higher seed yield (1068 kg ha^{-1}) than seed row treatments (915 kg ha^{-1}).

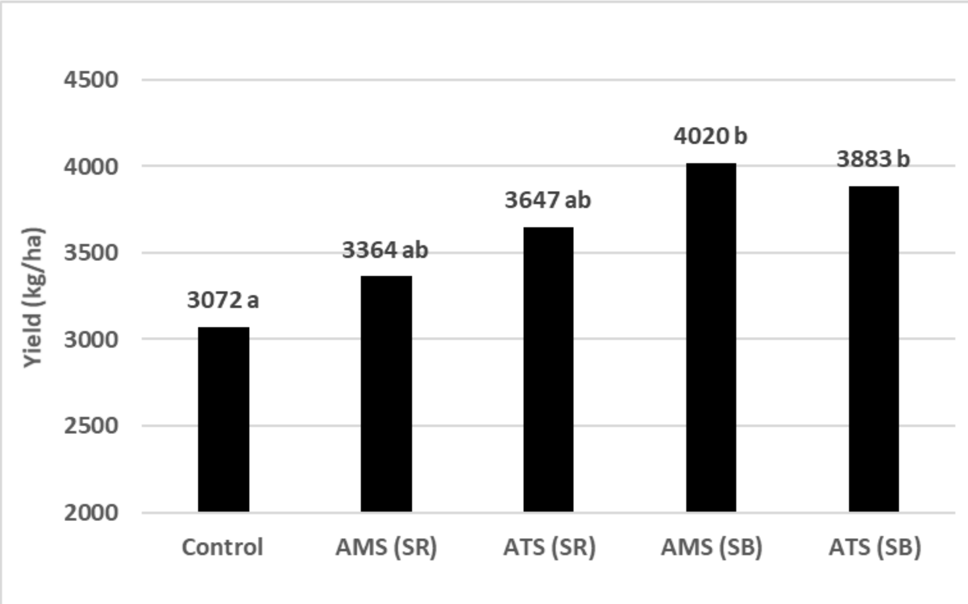

Figure 3. Effect of seed row (SR) and side banded (SB) sulfur products on canola yield. Means with the same letter are not significantly different from each other ($p<0.05$).

Oil, Protein Content and Thousand Seed Weight

Effect of treatments on oil, protein content and thousand seed weight (TSW) are shown in Figure 4.

The control had the highest average oil content although it was only significantly different ($p<0.05$) from AMS (SB). Effect of sulfur on canola oil has been varied with studies reporting either an increase (e.g., Grant et al., 2003; Govahi & Saffari, 2006; Ahmad et al., 2011), or a decrease (e.g., Wetter et al., 1970). However, even where there is a decrease in percent oil content, total oil yield per hectare will be increased because of the increase in seed yield (Wetter et al., 1970).

Sulfur application resulted to an increase in protein content. The control had the lowest protein content and was significantly different from all other treatments except ATS (SR). These results are useful considering the growing importance of canola as a desirable source of plant protein for both livestock and human consumption (Campbell et al., 2016). Other studies have also reported increase in seed protein content as a result of sulfur application (e.g., Malhi & Gill, 2006; Ahmad et al., 2007).

Although not statistically significant, there was an average increase in thousand seed weight (TSW) for sulfur applications (except when AMS was applied in the seed row). Ahmad et al. (2011) found significant increases in seed weight for sulfur level up to 40 kg ha^{-1}. Govahi and Saffari (2006) also found that TSW increased with increasing levels of sulfur application. Larger seeds have been shown to produce more vigorous plants and higher yields. For example, Elliott et al. (2008) found that compared with small seeds, large seeds improved seedling establishment, shoot weight, biomass and yield.

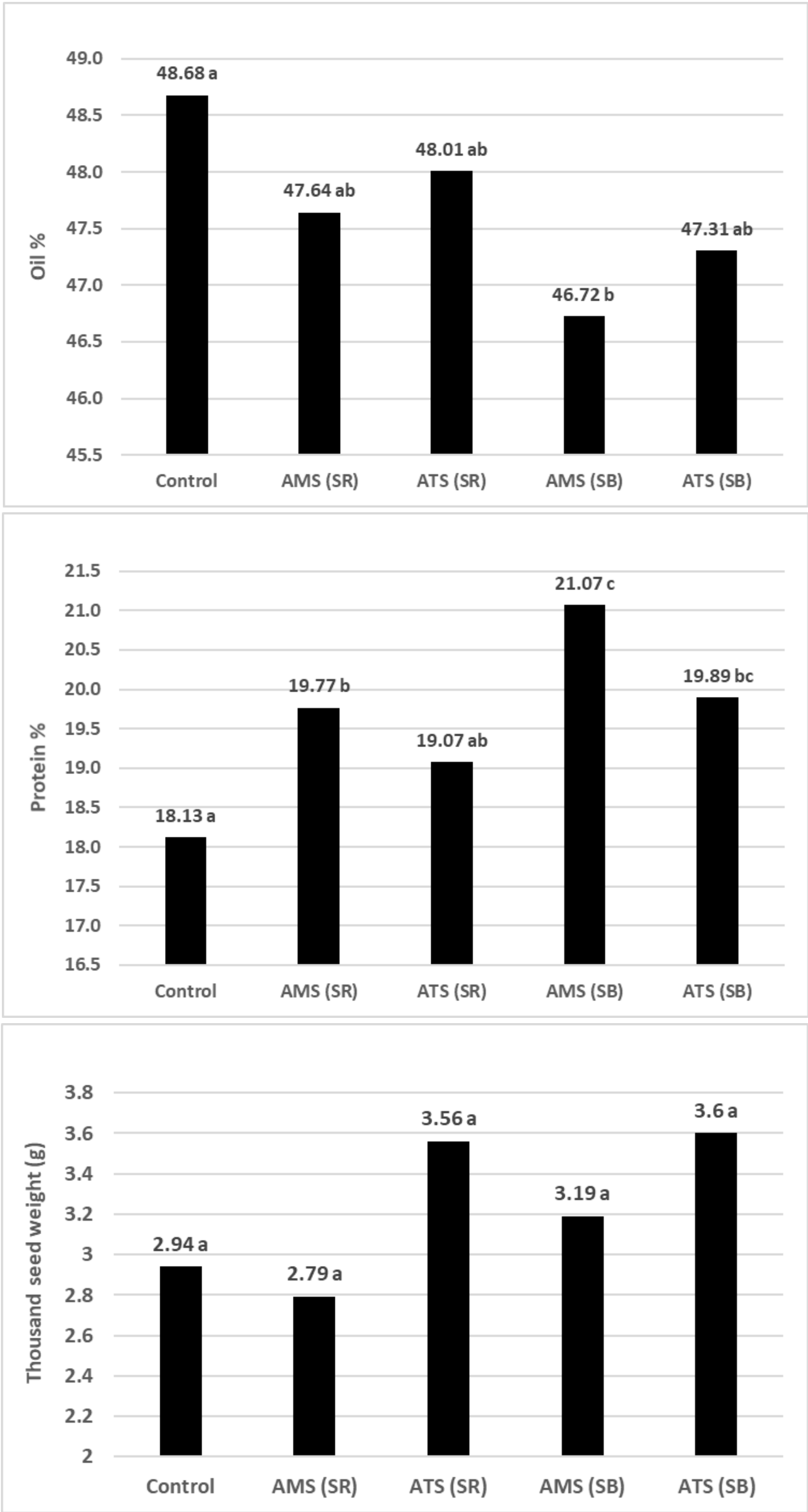

Figure 4. Effect of seed row (SR) and side banded (SB) sulfur products on canola thousand seed weight, oil, and protein content. Means with the same letter are not significantly different from each other ($p<0.05$).

Conclusion

This study sought to determine how method of sulfur application affects canola yield and quality, and to understand how two sulfur products (ammonium sulfate and ammonium thiosulfate) differ in their effect in the year of application. Results showed that side banding these products provided better yield and protein improvements than applying them in the seed row. Results also showed that there were no significant differences between AMS and ATS under the conditions of this study for any of the parameters evaluated.

Conflict of Interest

The authors declare that they have no conflict of interest.

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JOURNAL OF AGRICULTURAL PRODUCTION
https://agriprojournal.com ISSN: 2757-6620

RESEARCH ARTICLE

Willingness of Agriculture Students to be Involved in Agripreneur Career in Southeast Nigeria

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ARTICLE INFO

Article History
Received: 05.02.2022
Accepted: 05.04.2022
First Published: 13.04.2022

Keywords
Willingness
Agricultural students
Agripreneurship
Southeast Nigeria

ABSTRACT

Africa has over 420 million youth that could be asset, conversely' they continue to face challenges of unemployment, underemployment and poverty despite the potentials of agricultural sector in providing income-generating opportunities. The limiting factors for their participation in agriculture is not well documented. This study, therefore investigated how willing of agricultural students in agripreneurship in Southeast, Nigeria. A multi-stage sampling procedure was used. Southeastern Nigeria was purposively selection due to high unemployment and poverty. Two Federal Universities were purposively selected. Students were randomly selected proportionate to the population size. In all, 120 respondents were selected. Structured questionnaire was used to capture data. Data were analyzed using descriptive statistics and logit regression α=0.05. The study revealed that Sex (β=0.80), previous year of participation (β=0.17), vision to be an employer (β=1.26) and experience (β=2.90) positively influenced willingness to participate while high unemployment rate (β= -1.66), inadequate agricultural facilities and lack of government support/credit facilities (β= -2.15) and insecurity/herdsmen menace (β= -0.037) had negative effect. The study also found out that major perceived constraints in taking up agripreneurship were lack of start-up capital, inadequate infrastructural facilities, marketing challenges and poor accessibility to agricultural loan. Therefore, effective youth-oriented policies and innovative development strategies such as inclusion of agripreneurship training in their early school day training, revitalization of farm settlement scheme, provision of inputs and credit facilities among others are drivers to tap the energy of young Nigerian labour force for productive and beneficial ventures.

Please cite this paper as follows:

Komolafe, O. J., Nwankwo, T. N., & Chilaka, P. C. (2022). Willingness of agriculture students to be involved in agripreneur career in Southeast Nigeria. *Journal of Agricultural Production*, *3*(1), 9-16. https://doi.org/10.29329/agripro.2022.413.2

Introduction

Mokaya et al. (2012) stated that after thorough review and analysis of literatures that the concepts of entrepreneur, if considered in isolation fail to give a perfect explanation of its meaning. Consequently, Mokaya et al. (2012) defined entrepreneurship as a process that involves creativity and innovation, environmental browsing, identifying opportunities and evaluating them, marshalling resources to implement them, establishing and running a business that grows by making profit.

Nine billion is projected as the global population by 2050. Youth (aged 15 to 24) is equally projected to be 1.3 billion (14% of the projected global population) by the same year with Africa and Asia, having the largest share of the increase as shown by United Nations (2011). The youths in these continents continue to face challenges of unemployment, underemployment and poverty, despite the ample potential of the agricultural sector in providing income-generating opportunities. Youths in Africa would have been the greatest asset provided they were adequately harnessed coordinated and

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utilized in developing their economy. An economy with active population supports increased productivity and an inclusive economic growth and development. Conversely, majority of African youths are unemployed or underemployed due to lack of proper coordination of Africa's demographic dividend that could have given the continent great economic dividend (African Development Bank Group, 2016). About twelve million youths enter the workforce annually, but only 3.1 million jobs are created, leaving over eight million youths unemployed. As a result of this situation, Africa witnessed low standard of living, mass emigration, conflict and crises. International Labour Organization (2020) report indicated that 268 million (35.4%) were outside labour force, 456 million (60.2%) were employed while 33 million (4.4%) are unemployed. The distribution of the employed 456 million revealed that 29% are employed by employee, 3% are employer of labour, 20% contributes to family labour and 48% engaged themselves. This report indicates that more entrepreneurs are required to mob up the teemed population of African unemployed youth.

Youth unemployment in Africa from 2000-2021 as reported by United Nations Conference on Trade and Development, (2015) revealed a progressive increase from 23.5–34.8 million and in West Africa within the period unemployment rose from 3.7 million to 8.1 million (International Labour Organization, 2020). Consequently, West Africa countries kept on experiencing increasing rate of crime, unrest and suicide to mention but a few. This situation needs to be urgently attended to, so that workable policies that will enable our youths to be gainfully employed is formulated and implemented.

In the last 15 years, some countries in African continent enjoyed rapid economic growth that was not 'pro-poor' but a sectorial growth that generated few employment opportunities. Therefore, the need to promote growth in sectors that is capable of absorb the youth population, particularly in agricultural sector that could bring about 'pro-poor' growth, improves the economy, promotes food security, raises rural incomes, creates employment along the food value chain, and empowers the marginalized groups.

Table 1. Unemployment data of Nigeria for the year 2020 (National Bureau of Statistics, 2020)

Age	Labour force population	Unemployment	Unemployment (%)	Underemployment (%)
15-24	16,709,724	6,819,539	40	30.5
15-34	23,328,460	7,167,429	30.7	26.5
35-44	20,124,531	4,097,429	20.4	28.6
45-54	13,089,047	2,242,945	17.1	28.2
55-64	7,040,132	1,457,289	20.4	31.0
Gender				
Male	41,664,913	9,561,740	22.9	26.3
Female	38,626,981	12,202,818	31.6	31.0
Residence				
Urban	28,513,287	7,251,897	23.2	25.4
Rural	51,778,607	14,512,720	31.5	28.0

Table 1 above shows the Nigeria unemployment data by age, gender and place of residence and the unemployment rate and underemployment rate.

In Nigeria, about 65% of the working population are involved in agriculture and this sector plays a vital role in economic growth and social improvement. The agricultural sector contributed 28.5% to the Gross Domestic Product (GDP) of the nation in 2019. Notwithstanding, the contribution of the agricultural sector to GDP in 2019 is below what it was before independence (65.7%) (National Bureau of Statistics, 2014; Komolafe & Adeoti, 2018).

A nation's economy is broadly categorized into two principal sectors: agriculture and industry (Uche & Familusi, 2018). Agriculture which is rural based, supplies raw material to industry. Recent fall in the price of crude oil in the international market has expedited the Nigerian government's advocacy for diversification of the economy. Thus, emphasizing the export of agricultural commodities as an additional foreign exchange generator. Introduction of entrepreneurial principles into agricultural production in Nigeria will be a strong driver to the intending programme and improve on the existing structures in the agricultural sector.

Nigerian farmers are facing serious challenges like inadequate infrastructure, difficulty in accessing credit and absence of training opportunities for smallholder farmers among others, mitigating these constraints would improve Nigeria's food security, develop agribusiness, increase the GDP and raise foreign exchange earnings (Uche & Familusi, 2018).

With adequate and planned investment in agriculture, achievable through agripreneurship, daily rise in food prices can be halted and Nigerians will be food secure. Technological development in the agricultural sector in Nigeria is a serious challenge for our aged farmers. This problem can adequately be resolved by incorporating youths into agricultural enterprise. As a result of which there will be adequately knowledge transfer and challenges of aged farmers in production, processing, packaging and marketing can easily be solved.

Nigeria's agriculture potential and fortunes are dwindling, this situation is placing urgent need on the development of a system that will eliminate the constraint placed on this sector by the low technical know-how and institutional weaknesses among others factors. For the agricultural sector to remain competitive and relevant in the global economy, new ideas needed to be developed and applied for value addition and sustainability (Uneze, 2013). Consequently, agripreneurship is a key in this direction (Global Forum for Rural Advisory Services, 2016). Therefore, effective youth-oriented policies and innovative development strategies are drivers to tap the energy of young Nigerian labor force for productive and beneficial ventures (Aladejebi, 2018) instead of engaging in civil unrest and crime. The advantages of agriculture in Nigeria can adequately be annex only if the youths are willing and other stake holders are prepared to give the required support. On this note, this study seeks to know the willingness of graduating students of agriculture to take up agripreneur career in solving the problem of unemployment and profile the needed support by the willing graduates.

Materials and Methods

Primary data used for this study were collected using well-structured questionnaire. Data collected include graduating students of agriculture's socio-economic characteristics, willingness to take up agripreneurship as a career and the support required to take off. The study adopted a multi-stage sampling procedure. The first stage was the purposive selection of Southeastern Nigeria due to high level of unemployment in the area (National Bureau of Statistics, 2020). Second stage was the selection of two Federal Universities that offers agriculture as a course of study in Southeastern Nigeria. Third stage involved random selection of final year students in the Faculty of Agriculture proportionate to the total number population size. The total number of respondents selected were one hundred and twenty.

Table 2. Sampling procedure for selection of respondents

Name of University	Department	Total Final Year Students	Selected Final Year Students	No of Questionnaire Administered and Analyzed
Federal University of Technology Owerri (F.U.T.O)	Agricultural economics	115	17	17
	Agricultural extension	76	11	11
	Fisheries technology	54	8	8
	Animal science	63	10	10
	Forestry and wild life	52	8	8
	Crop science	61	9	9
	Soil science	65	10	10
	Total	**486**	**73**	**73**
Nnamdi Azikiwe University	Agricultural economics and extension	52	8	8
	Animal science	47	7	7
	Crop science	26	4	4
	Fishery	24	4	4
	Forestry and wild life	27	4	4
	Food science and technology	110	17	17
	Soil science	23	3	3
	Total	**309**	**47**	**47**

The analytical tools employed by the study were descriptive statistics and Logit model. The descriptive statistics used include some measures of central tendencies like the mean, standard deviations and frequency distributions tables, percentages and Likert scale.

Logit Model

The determinants of graduating agricultural students' willingness to participate in agripreneurship was analyzed by the use of Logit Model. Logit regression models relationships between a dichotomous response variable as the dependent variable and a set of independent (regressor) variables.

According to Gujarati (2004) the LM is quite applicable to this study because it is employed when individuals make choice between two alternatives and with each case it is assumed that the alternatives are mutually exclusive. Also, it has the advantage of not treating categories in any continuous form, this make it also to be different from ordered or sequential Probit models. Logit models estimate the effects of the explanatory variables on a dependent variable with unordered response categories. The advantages above ordinary least square model are it eliminates heteroscedasticity in the error term, make the error term to be normally distribute and the predicted probabilities ranges between 0 and 1. Additional advantage of Logit model is its computational ease and also it is relatively robust, as measured by goodness of fit or prediction accuracy (Gujarati, 2004).

Assuming the probability that graduating agricultural students will be willingness to participate in agripreneurship (WP) or not (NWP), then the student's empirical models to be estimated is specified as:

$$\text{WP} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + \varepsilon_i \quad (1)$$

$$\text{NWP} = \gamma_0 + \gamma_1 X_1 + \gamma_2 X_2 + \ldots \gamma_n X_n + \varepsilon_i \quad (2)$$

Where, WP = Willingness of agriculture undergraduate to participate in agripreneurship, NWP = Non-willingness of agriculture undergraduate to participate in agripreneurship and are vectors of respective parameters to be estimated. β= Vectors of explanatory variables. ε = Error terms.

The explanatory variables include:

X_1 = Age (years)

X_2 = Sex (Male = 1, otherwise = 0)

X_3 = Previous participation and experience (participation = 1 otherwise = 0)

X_4 = Years of participation (years)

X_5 = Vision of becoming an employer of labour through agripreneur (yes =1, no =0)

X_6 = High unemployment rate (if high rate of unemployment will push you into agripreneurship =1, otherwise =0)

X_7 = Parental support (Had Parental support = 1 otherwise = 0)

X_8 = Inadequate agricultural facilities and lack of government support (if inadequate agricultural facilities and lack of government support will push you away from agripreneurship =1, otherwise =0)

X_9 = Insecurity/ herdsmen problems (If insecurity/ herdsmen problems will push you away from agripreneurship =1, otherwise =0).

Results and Discussion

Socioeconomic/demographic Characteristics of Respondents

Figure 1 and 2 show the age distribution and gender of respondents, respectively.

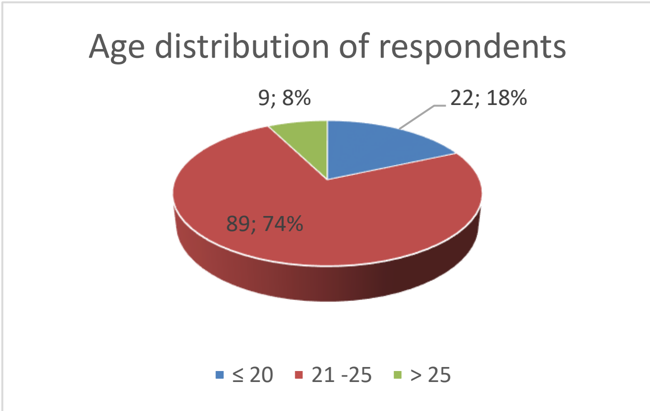

Figure 1. Age distribution of respondents.

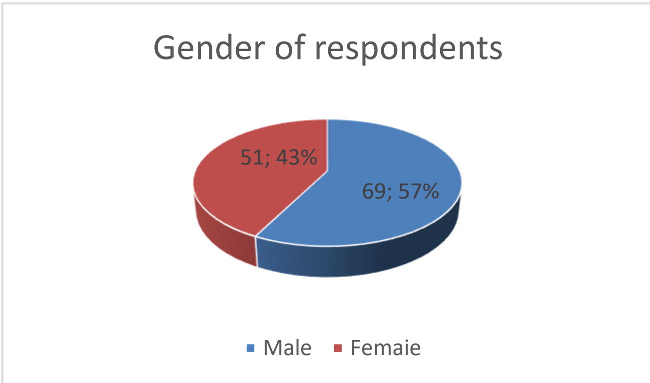

Figure 2. Gender distribution of respondents.

Socioeconomic Characteristics of Undergraduate Students

The socioeconomic characteristics of undergraduate students were presented in table1. Average age of the respondents in the study area was 23.06years ±1.22 years. This implies that all the respondents are in their economic active age and should be ready to contribute to the national economy. Male (57.0%) respondents were 14 more than the female respondents (43.0%). Larger proportions of respondents were single (92.50%). Majority (93.0%) of respondents were Christians, only (7.0%) practice Islamic religion. Most of the respondents (64.2%) lived in rented hostels off campus, (25.0%) of the respondents lived in school hostel and only (10,8%) of them lived with their parents. Parent and guardians (83.3%) were the main source of respondents' stipend for their education, (16.7%) were self-sponsored, (7.5%) out of the self-sponsored respondents engaged in part time work while (9.2%) were self-employed. Majority (43.3%) of the respondents' parents were civil servants, while (33.3%) were businessman, (15.0%) were public servants and (8.3%) were orphans. Majority of the students (64.20%) had received training in agripreneurship elsewhere apart from the practical they were involved in, in the course of study agricultural science in the university, likewise majority (75.0%) had information about agribusiness from journals, other sources of information were internet (66.7%), television (50.0%) and radio (33.3%). Average stipends received by respondents from parents and guardians stand at (₦145,375 ± ₦112,776). A total of (51.7%) were not willing to study agriculture in the university, but resigned to fate.

Table 3. Socio-economic characteristics of respondent undergraduate students

Characteristics	Frequency	%Age	
Marital status			
Single	111	92.5	
Married	09	07.5	
Religion			
Christianity	112	93.0	
Islam	08	07.0	
Source of stipend			
Parent/guardian	100	83.3	
Self-employed	11	09.2	
Part time work	09	07.5	
Students' residence			
School hostel	30	25.0	
Rented hostel off campus	77	64.2	
Living with their parent	13	10.8	
Parent's occupation			
Civil servant	52	43.3	
Public servant	18	15.0	
Business owners	40	33.3	
Had no parent	10	08.3	
Training on agripreneurship			
Yes	77	64.2	
No	43	35.8	
Source of information on agripreneurship			
Internet	80	66.7	
Journals	90	75.0	
Television	60	50.0	
Radio	40	33.3	
Average annual stipend (#)			
30,000 – 100,000	52	43.3	₦145,375±112,776
100,001–300,000	60	50.0	
300,001 – 600,000	08	06.7	

Table 4. Initial course applied for by respondent

	Frequency	%Age
Agriculture	58	48.3
Not agriculture	62	51.7
Course applied for initial, if not agriculture		
Medical related courses	34	28.3
Biological science courses	26	21.7
Engineering courses	02	01.7
Total	**62**	**51.7**

Willingness of Final Year Undergraduate to Take Up Agripreneurship

Majority (57.5%) of the respondents were willing to take up agriculture as their business after their course of study. All the respondents gave conditions that will enable them to take up agripreneur as a career. Majority (33.3%) aspired to be self-employed (32.5%) aspired to be a job creator, (26.7%) were willing because of high youth unemployment rate, (24.2%) were willing because they studied agriculture, (22.5%) believed that agripreneurship is profitable, (22.5%) were willing because of their love for agriculture, (12.5%) due to their background believed that agriculture is easy and simple for them, (11.7%) received encouragement from their relatives and 10.8% were willing because they aimed continue their parent's business.

Table 5. Willingness of final year undergraduate to take up agripreneurship

	Frequency	%Age
Willing to venture into agripreneurship after graduation?		
Yes	69	57.5
No	51	42.5

Table 6. Conditions for respondents to participate in agripreneurship

Condition Stated	Frequency	%Age
Studied agriculture	26	21.7
Aspire to be a job creator	39	32.5
Passion for agriculture	27	22.5
High unemployment rate	32	26.7
Profitable of agripreneurship	27	22.5
Aspire to be self-employed	40	33.3
Encouragement from relatives	14	11.7
Agripreneurship experience	15	12.5
Take up my parent's business	13	10.8

Determinants of Undergraduate Students of Agriculture's Willingness to Participate in Agripreneurship

Table 7 presented the logit model result used to estimate the determinants of undergraduate students of agriculture's willingness to participate in agripreneurship. Nine variables were allowed in the model, but only seven were significant. The likelihood ratio is -50.70 and Pseudo R^2 = 0.41, chi-square of 67.59 with a p-value of 0.000 reveals that the model as a whole is statistically significant. Mean VIF =1.4 established the absence of Multicollinearity.

Sex

Sex is significant at (5%) and positively affects willingness to participate in agripreneurship. The marginal effect showed that being a male increases the likelihood of respondent's willingness to participate in agripreneurship by 4.5%. This corroborates the findings of Food and Agriculture Organization of the United Nations (2014) and United Nations Women (2018).

Previous participation and experience

Previous participation in agribusiness and experience is significant at (1%) and positively affects willingness to participate in agripreneurship. This corroborates the findings of Adeyanju et al. (2021). The marginal effect shows that previous participation and experience increase the likelihood of respondent's willingness to participate in agripreneurship by 61%.

Years of participation

Years of participation is significant at (5%) and positively affects willingness to participate in agripreneurship. This corroborates the findings of Adeyanju et al. (2021). The marginal effect shows that a year increase in participation in agribusiness increases the likelihood of respondent's willingness to participate in agripreneurship by 42%**.**

Vision of becoming an employer of labour

Respondent's vision of becoming an employer of labour is significant at (5%) and positively affects willingness to participate in agripreneurship.

The marginal effect shows that respondents having the vision of becoming an employer of labour increases the likelihood of respondent's willingness to participate in agripreneurship by 30%.

High unemployment rate

High unemployment rate is significant at 10% and negatively influenced willingness of respondents to take up agripreneurship. This implies that with increase in unemployment there is likelihood that the willingness to take up agripreneurship will decrease and the marginal effect shows that the decreases is likely to be to the tune of 39%. This obviously revealed that to enhance participation enabling environment must be provided.

Inadequate agricultural facilities and lack of government support

Inadequate agricultural facilities and lack of government support is significant at (1%) and negatively influenced willingness of respondents to take up agripreneurship. This implies that with inadequate agricultural facilities and lack of government support there is likelihood that the willingness to take up agripreneurship will decrease and the marginal effect shows that the decreases is likely to be to the tune of 49%.

Insecurity/herdsmen problems

Insecurity and herdsmen problems is significant at (5%) and negatively influenced willingness of respondents to take up agripreneurship. This implies that with insecurity and herdsmen problems there is likelihood that the willingness to take up agripreneurship will decrease by 2%.

Table 7. Determinants of undergraduate students of agriculture's willingness to participate in agripreneurship (Mean VIF =1.4)

Logit Regression Result			**Marginal effect**	
Variables	**Coefficient**	**P>|z|**	**Coefficient**	**P>|z|**
Age	0.04	0.14	0.10	0.14
Sex	0. 806	0.001	0.045**	0.04
Previous participation and experience	2.90	0.000	0.61***	0.000
Years of participation	0.17	0.008	0.42**	0.009
Vision to be an employer of labour	1.26	0.12	0.30*	0.09
High unemployment rate	-1.66	0.053	-0.39*	0.02
Parental support	1.32	0.20	0.29	0.12
Inadequate agricultural facilities and lack of government support/credit facilities.	-2.15***	0.000	-0.49***	0.000
Insecurity/ herdsmen problems	-0.037**	0.006	-0.02**	0.001
Constant	-3.07	0.05		
Log likelihood = -50.70; Prob > chi^2 = 0.000; LR chi^2 (8) = 67.59; Pseudo R^2 = 0.41; No of obs = 120				

***1% significant level; **5% significant level; *10% significant level

Constraints Militating Against Respondents' Willingness to Participation in Agripreneurship

The major perceived constraints according to their severity in militating against the uptake of agripreneurship after graduation by students of agriculture were; lack of start-up capital with a mean score of (3.38), inadequate infrastructural facilities with mean score of (3.36), marketing challenges with mean score of (3.23), poor accessibility to agricultural loan with mean score of (3.13), they ranked 1st, 2nd, 3rd, 4th respectively. Other constraints identified that militated against respondents' willingness to participate in agripreneurship have mean scores below 3.0 indicating that they were not so severe. These were poor government policies implementation and funding of agriculture (2.95), follow by wrong public perception on agripreneurship (2.74), the next was lack of information on agricultural technologies and innovations (2.60), followed by past failure experiences in agripreneurship (2.52), then discouragement from parent/ guardian (2.41), then fear of vagaries or failure of weather (2.31) and last in the four Likert Scale was religious belief on production of certain live stocks (1.92).

Table 8. Constraints militating against willingness to participation in agripreneurship

Limiting factors	Very severe	Severe	Moderately severe	Not severe	Mean	Rank
Lack of start- up capital	60(50.0)	35(29.2)	9(7.5)	3(2.5)	3.38	1st
Inadequate agricultural infrastructural facilities	67(55.8)	57(47.5)	12(10.0)	6(5.0)	3.34	2nd
Marketing challenges	47(39.2)	48(40.0)	13(10.8)	3(2.5)	3.24	3rd
Poor accessibility to agricultural loans	37(30.8)	65(54.2)	14(11.7)	4(3.3)	3.13	4th
Poor government policies implementation and funding on agriculture	29(24.2)	62(51.7)	26(21.7)	3(2.5)	2.95	5th
Wrong public perception on agripreneur	25(20.8)	51(42.5)	33(27.5)	11(9.2)	2.74	6th
Lack of information on agricultural technologies and innovations	20(16.7)	44(36.7)	43(35.8)	13(10.8)	2.60	7th
Past failure experience in agripreneurship	15(12.5)	50(41.7)	37(30.8)	18(15.0)	2.52	8th
Discouragement from parent	30(25.0)	20(16.7)	39(32.5)	31(25.8)	2.41	9th
Weather failure	11(9.2)	31(25.8)	61(50.8)	17(14.2)	2.31	10th
Religious belief on production of certain live stocks	11(19.2)	17(14.2)	43(35.8)	49(40.8)	1.92	11th

Conclusion

In conclusion, the study provided empirical evidence that youth willingness to participate in agripreneurship is hinged on gender, previous participation and experience, vision to be an employer of labour, state of security, government support by providing of adequate facilities and enabling environment/credit facilities.

Policy implications and recommendations:

(i) The willingness of female youth in taking up agripreneurship is low, therefore policy that will spur them into being willing like training, provision of inputs and credit facilities among others should be preferentially extended to them.

(ii) Experience, training participation were the main driver for youth's participation in agripreneurship, therefore, they should be exposed to agribusiness early in life. Inclusion of agripreneurship training in their early school days will enhance their willingness by giving them a vision of future opportunities in agriculture.

(iii) Government needs to improve the security situation by allowing community policing so as to encourage our youths to stay securely on the farm.

(iv) Government needs to revitalize farm settlement scheme and provide the needed incentives in form of land, housing, poultry houses and pens, machineries and equipment for youths to work with.

Conflict of Interest

The authors declare that they have no conflict of interest.

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JOURNAL OF AGRICULTURAL PRODUCTION
https://agriprojournal.com ISSN: 2757-6620

RESEARCH ARTICLE

A Preliminary Study on the Cultivation of Brown Seaweed *Sargassum cristaefolium* Using Fixed-off Bottom and Raft Methods

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ARTICLE INFO

Article History
Received: 03.03.2022
Accepted: 24.04.2022
First Published: 10.05.2022

Keywords
Fixed-off bottom method
Raft method
Sargassum cristaefolium
Specific growth rate
Survival rate

ABSTRACT

Sargassum is a great source of alginate, a phycocolloid with vast uses in nutraceutical and pharmaceutical areas. Hence, the cultivation techniques of this species need special attention and are worth investigating. In this study, a preliminary study on the cultivation of *Sargassum cristaefolium* was carried out in coastal water of Pasiagan, Bongao, Tawi-Tawi, southern Philippines, using fixed-off bottom and raft methods with two types of seedlings (T_1 = with holdfast and T_2 = vegetative cutting). Results revealed that the specific growth rate (SGR) of T_1 (-1.51±0.6% day^{-1}) and T_2 (-2.03±0.23% day^{-1}) in the fixed-off bottom method did not significantly differ (p>0.05) after 45 days of culture. In raft method, SGR of T_1 (1.5±0.12% day^{-1}) and T_2 (1.12±0.40% day^{-1}) did not significantly vary (p>0.05) after 45 days. The survival rate of T_1 (43.33±6.67%) was greatly higher (p>0.05) than T_2 (13.33±3.33%) after day 45 cultured in the fixed-off bottom method. However, the survival rate of T_1 (30.01±15.27%) and T_2 (16.68±12.01%) did not differ significantly in the raft method. This study suggests that both seedling types can be used in raft method for *Sargassum* cultivation. This study would serve as preliminary information on the cultivation of *Sargassum* in Tawi-Tawi, southern Philippines.

Please cite this paper as follows:

Yangson, N. A. T., Edubos, J. I., Tahiluddin, A. B., Toring, C. C., & Toring-Farquerabao, M. L. B. (2022). A preliminary study on the cultivation of brown seaweed *Sargassum cristaefolium* using fixed-off bottom and raft methods. *Journal of Agricultural Production*, *3*(1), 17-29. https://doi.org/10.29329/agripro.2022.413.3

Introduction

Sargassum is a class of Phaeophyceae in the order Fucales, which is composed of 359 officially accepted species (Guiry & Guiry, 2022). It consists of a higher amount of protein, essential and non-essential amino acids that carry out many bodily functions, necessary fatty acids, and minerals than kelp (Laminariales). Phycocolloids (alginate), bioactive compounds, and polyphenols isolated from different *Sargassum* species may have possible nutraceutical and medicinal use (Nisizawa, 2002; Gupta et al., 2011; Namvar et al., 2013), and is an effective immunostimulant against *Aeromonas hydrophila* in rainbow trout (Sönmez et al., 2021). Hence, *Sargassum* spp. have a great possibility to be used as ingredients in pharmaceutical to nutraceutical areas (Yende et al., 2014). *Sargassum* is extensively distributed in tropical and temperate waters, particularly in the Indo-West Pacific region and Australia (Cheang et al., 2008). It is distinct and forms vast beds along the rocky shores (Marquez et al., 2014).

Sargassum is commonly cultivated in Japan, Korea, and China and is utilized as human food (sea vegetables) and as medicine (Nanba et al., 2008; Yu et al., 2013; Redmond et al., 2014; Kim et al., 2017; Amlani & Yetgin, 2022). In Indonesia,

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Wahyuningtyas et al. (2018) showed that 25 cm plantation depth using the longline method has highly increased the growth rate of *Sargassum*. Longline is a traditional culture method in Korea where 5-10 cm of *Sargassum* seedlings were inserted into a rope at an interval of 5-10 cm (Pang et al., 2008). In China, the zygote of *S. hornerie* cultured in a polypropylene tank reached 5-7 cm, while in suspension culture, the seedlings reached a size of 1.5-2.5 cm after 3 months (Pang et al., 2006). Furthermore, the incorporation of nutrient enrichment showed to increase the *Sargassum* productivity (Feibel, 2016), similar response to other seaweeds (Harrison & Hurd, 2001; Tahiluddin et al., 2021a; Tahiluddin et al., 2021b). For instance, in Florida (USA), growth rates of both *S. fluitans* and *S. natans* cultured in a shipboard flowing seawater culture system and in situ cages in the western Sargasso Sea had reached 0.03 to 0.04 doublings day^{-1} enriched with nitrate or ammonium; while in phosphate enrichment, growth rate ranged from 0.05 to 0.08 doublings day^{-1} (Lapointe, 1986). In the Philippines, different species of *Sargassum* are mainly harvested from the wild, and studies on *Sargassum* cultivation are still in their infancy. Recently, an initial experiment on the cultivation of *Sargassum* in the Philippines was conducted, particularly in the study of Aaron-Amper et al. (2020) in Bohol, central Philippines, where a zygote of *S. aquifolium* was successfully produced in the hatchery and reared its germlings in the field out-planting using various substrates.

The seaweeds in the Philippines are remarkably diverse, with more than 800 species recorded (Silva et al., 1987; Tahiluddin & Terzi, 2021). Harvesting of *Sargassum* spp. in the Philippines is mainly dependent on the wild population, which is generally used as a liquid fertilizer and animal feed. In addition, *S. cristaefolium* showed a promising result as potential organic fertilizer for *Kappaphycus* (Irin, 2019). Species of *Kappaphycus, Eucheuma*, *Caulerpa,* and *Gracilaria* are the primary cultivated seaweed species in the country (Trono & Largo, 2019). In Tawi-Tawi, southern Philippines, seaweed diversity is high, with 79 species recorded, including *Sargassum* spp. (Puig-Shariff, 2015). Since the 1970s, only *Kappaphycus* and *Eucheuma* spp. have been commercially cultivated in Tawi-Tawi using the line and stake methods, which are considered one of the major livelihoods for coastal villagers. *Sargassum* spp. are potential cultured seaweed species and are only collected and used as cover during the transport of *Kappaphycus* species in Tawi-Tawi (Sarri et al., 2022). However, there is a limited existing study on the cultivation of *Sargassum*. Thus, a preliminary study was conducted on the growth and survival rate of brown seaweed (*S. cristaefolium*) cultivated in the coastal water of Pasiagan, Bongao, Tawi-Tawi, southern Philippines, using fixed off-bottom and raft methods.

Materials and Methods

Study Site and Time

The study was conducted along the coastal water of Pasiagan, Bongao, Tawi-Tawi, southern Philippines (Figure 1) with a duration of 45 days from February 17 to April 03, 2019.

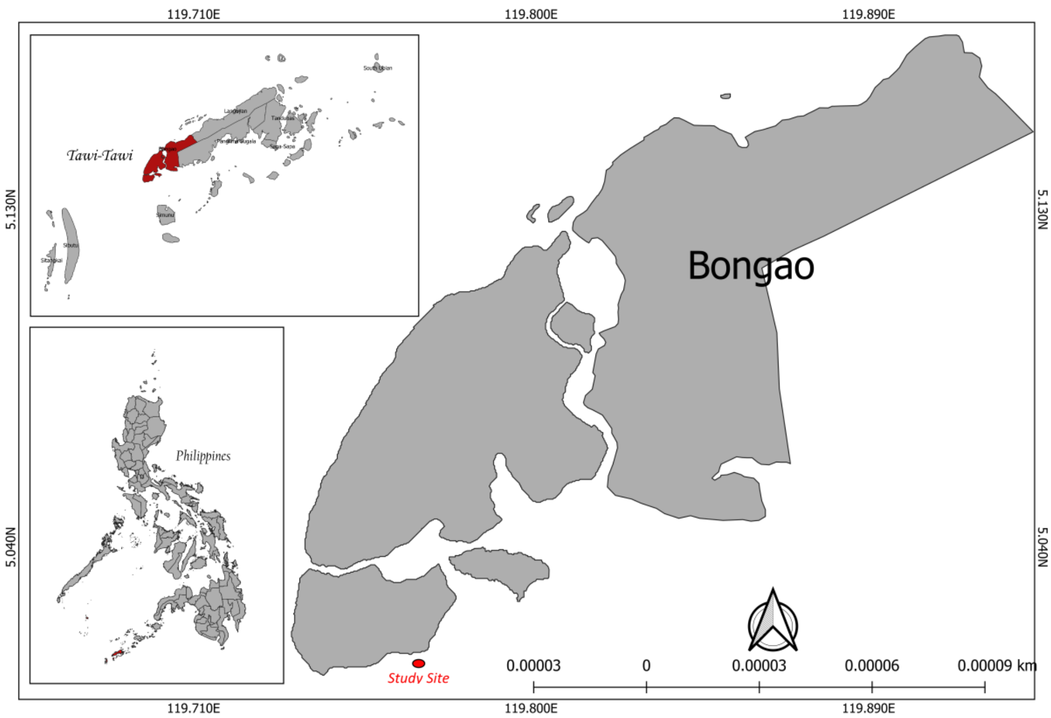

Figure 1. Map showing the study site.

Preparation of the Farm Site

The study site was cleaned from all obstacles, predators like sea urchins and starfishes by removing them one by one in the farm site to avoid grazing.

Source of Seedlings and Conditioning

The seedlings of *S. cristaefolium* were collected from the Sunkist beachside area in Sanga-Sanga, Bongao, Tawi-Tawi, southern Philippines. The freediving technique was used to collect these samples. The whole part of the seaweed, including holdfasts, was included and was immediately placed into styrofoam boxes filled with seawater, then transported to the culture area. Acclimatization was done by submerging the box slowly into the sea of the farm site allowing the seawater to mix with the water in the box for 10 minutes. The acclimatization period was done 6 days before the actual planting.

Preparation of Seedlings

There were two types of seedlings used in the study as treatments, Treatment I (T_1) for the seedlings with holdfast and Treatment II (T_2) for vegetative cutting. The T_1 has a corresponding range of 40-50 g with an initial length of 13-36 cm. While for T_2, the seedlings were cut into 40-50 g using a knife with an initial length of 14-32 cm. For the fixed-off bottom method, seedlings in both treatments were tied into a 2.5 m rope line with an interval of 25 cm. T_1 was individually tied in available stones or broken corals using a soft tie, while T_2 was directly tied in a rope. For the raft method, seedlings in both treatments were tied up to a sand-filled plastic bottle (500 ml) with 25 cm rope. These were placed in a basin and transported to the farm site.

Planting of Seedlings

For the fixed-off bottom method, the seedlings in both treatments were randomly planted following Hurtado et al. (2008) with few modifications. The lines were stretched and attached to stakes, where the seedlings touched the seabed (Figure 2). For the raft method, the seedlings were randomly planted following Wahyuningtyas et al. (2018). Seedlings were hanged in a 2.5 m bamboo with a distance interval of 25 cm and a depth of 25 cm below the sea surface (Figure 3).

Experimental Designs

The applied design in this study was Randomized Complete Block Design (RCBD) with 2 treatments, and it was triplicated per treatment for both methods.

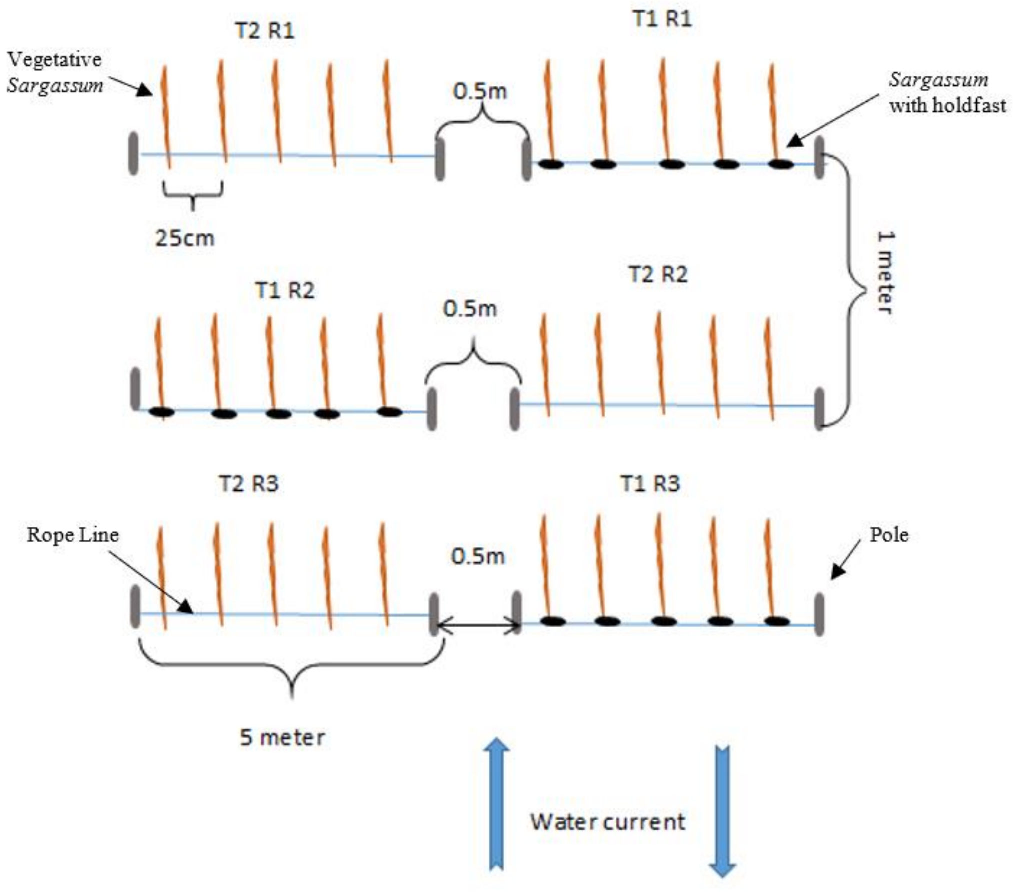

Figure 2. Lay-out of fixed-off bottom method of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting, $R_{1,2,3}$ =replicates).

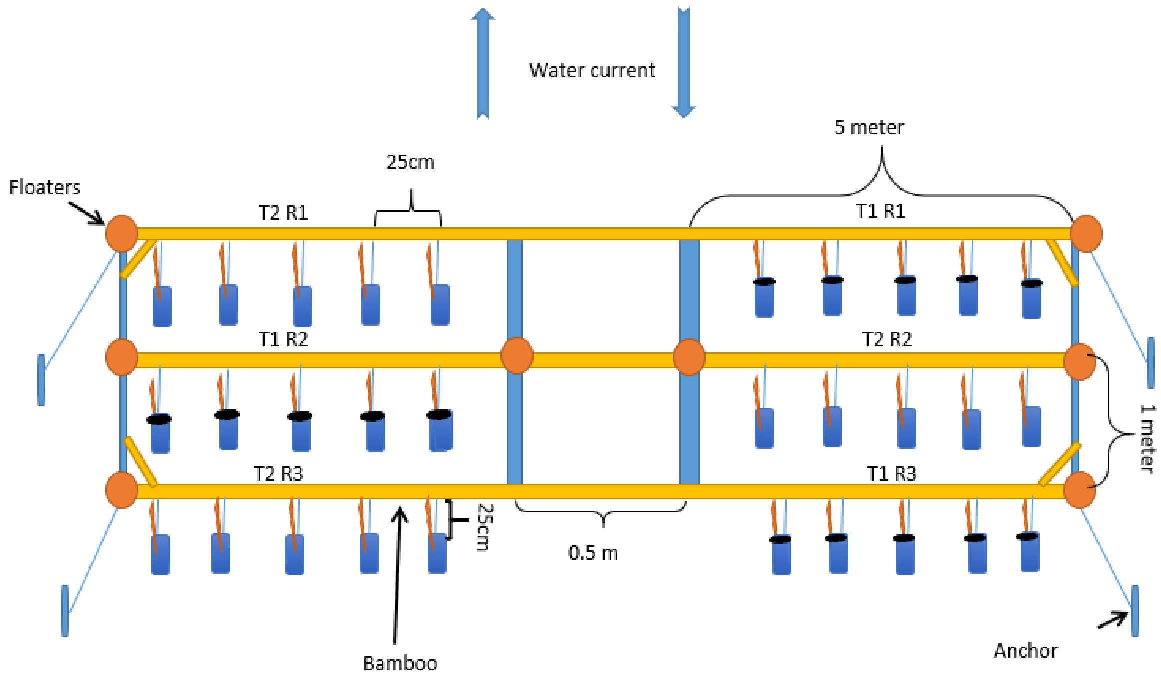

Figure 3. Lay-out of raft method of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting, $R_{1, 2, 3}$ =replicates).

Sampling

Growth rate

The growth rate of seedlings was obtained after 45 days of culture. All seedlings were harvested. Weighing of the samples was done by patting them with a white cloth, and they were then put on a digital weighing scale. The length of the samples was measured every 15 days by measuring the seedlings one by one starting from its lower tip up to the upper tip of the *Sargassum* using a meter stick. Mean weight and length were computed every 15 days. Using the formula of Luhan et al. (2015), growth (μ) expressed as a specific growth rate (SGR) was determined at the end of the study. SGR was calculated as follows:

$$\mu = \frac{\text{In (Wf)} - \text{In (Wi)}}{\text{Days of culture}} \text{ x } 100 \qquad (1)$$

Where,

W_f = final weight

W_i = initial weight

Survival rate

Monitoring of the survival rate was done every 15 days by checking and counting the mortality of the seaweeds. Missing bunches were considered mortality. The survival rate was computed using the formula below.

$$\text{Survival rate} = \frac{\text{Final number of seaweeds}}{\text{Initial number of seaweeds}} \text{ x } 100 \qquad (2)$$

Monitoring of Water Parameters

The water parameters such as temperature, salinity, and pH were measured every 7 days (9:00 A.M. – 12 P.M.) using a thermometer, refractometer (Atago Master), and pH meter (Smart Sensor), respectively. Water current and depth were determined using improvised drogue and calibrated rope, respectively.

Data Analysis

A t-test was applied to determine the significant difference between the means of two treatments in terms of growth and survival rates using SPSS software version 20. Data were presented as mean±SE (standard error). The level of significance used in the study was 0.05.

Results

Growth

Fixed-off bottom method

The specific growth rate (SGR) of *S. cristaefolium* (T_1 = with holdfast and T_2 = vegetative cutting) cultured in the fixed-off bottom method is shown in Figure 4. T_1 and T_2 attained SGR of -1.51±0.6% day^{-1} and -2.03±0.23% day^{-1}, respectively. Analysis using a t-test showed no significant difference (p>0.05) between the treatments. The mean weight is shown in Figure 5. After 45 days of culture, the t-test revealed no significant difference (p>0.05) between the treatments, with mean weights of 33.89±9.14 g (T_1) and 20.50±2.18 g (T_2). The average length between sampling periods is shown in Figure 6. There was no significant difference (p>0.05) in T_1 from day 0 to 30, day 0 to 45, day 15 to 30, and day 30 to 45. But, T_1 significantly increased (p<0.05) from day 0 to 15 but significantly decreased (p<0.05) from day 15 to 45. The average length of T_2 did not significantly change ($p>0.05$) from day 0 to 15, day 0 to 30, day 15 to 30, and day 30 to 45. However, there was a significant increased ($p<0.05$) from day 0 to 45 and day 15 to 45.

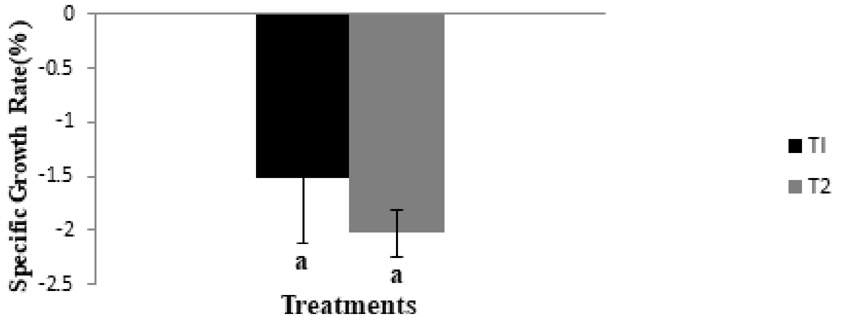

Figure 4. SGR of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in fixed-off bottom method after 45 days. Bars with the same letters are not significantly different ($p>0.05$). Error bars in SEM (standard error of the mean), n= 17-60.

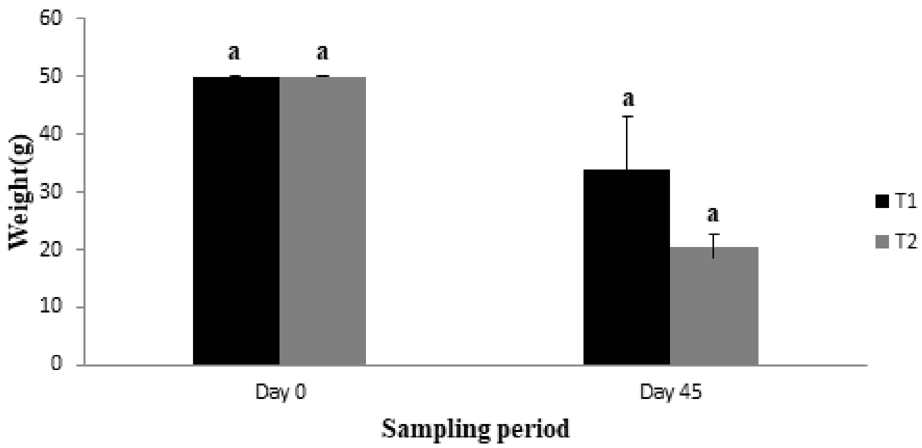

Figure 5. Mean wet weight of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in fixed-off bottom method after 45 days. Bars with the same letters are not significantly different ($p>0.05$). Error bars in SEM (standard error of the mean), n= 17-60.

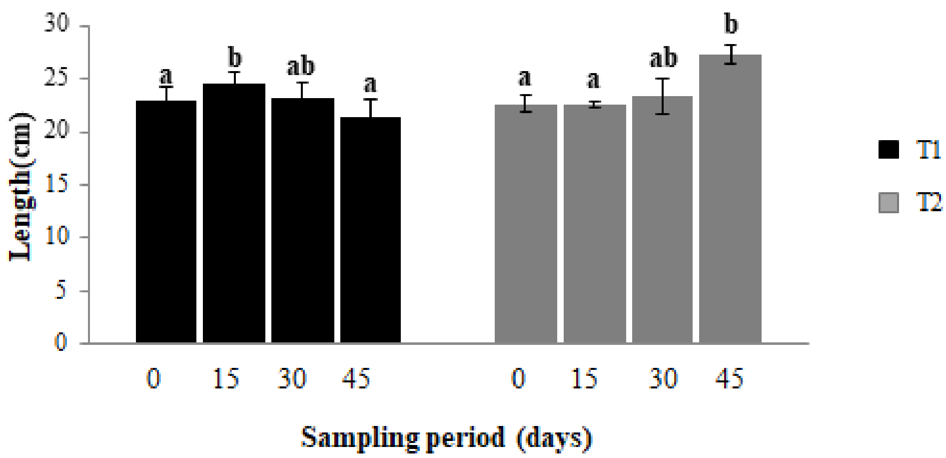

Figure 6. Average length in every sampling period of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in the fixed-off bottom method for 45 days. Bars with different letters are significantly different ($p<0.05$). Error bars in SEM (standard error of the mean), n=17-60.

Raft method

The SGRs of *S. cristaefolium* in T_1 (with holdfast) and T_2 (vegetative cutting) cultured in the raft method were 1.5±0.12% day^{-1} and 1.12±0.40% day^{-1}, respectively (Figure 7). A t-test revealed no significant difference (p>0.05) among the treatments. After 45 days of culture, no significant difference (p>0.05) showed among the treatments, with mean weights of 110.07±0.68 g for T_1 and 86.25±12.75 g for T_2 (Figure 8). A t-test analysis revealed that the average length of T_1 did not significantly change (p>0.05) from day 0 to day 45. The average length of T_2 significantly increased (p<0.05) from day 0 to 15 and day 0 to 30. However, there was no significant change (p>0.05) from day 0 to 45, day 15 to 30, and day 30 to 45 (Figure 9).

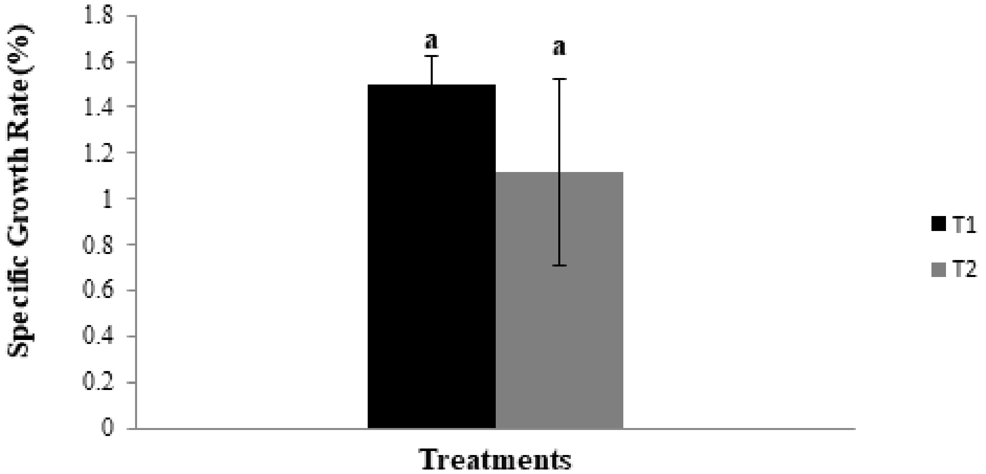

Figure 7. SGR of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in raft method after 45 days. Bars with the same letters are not significantly different (p>0.05). Error bars in SEM (standard error of the mean), n=14-60.

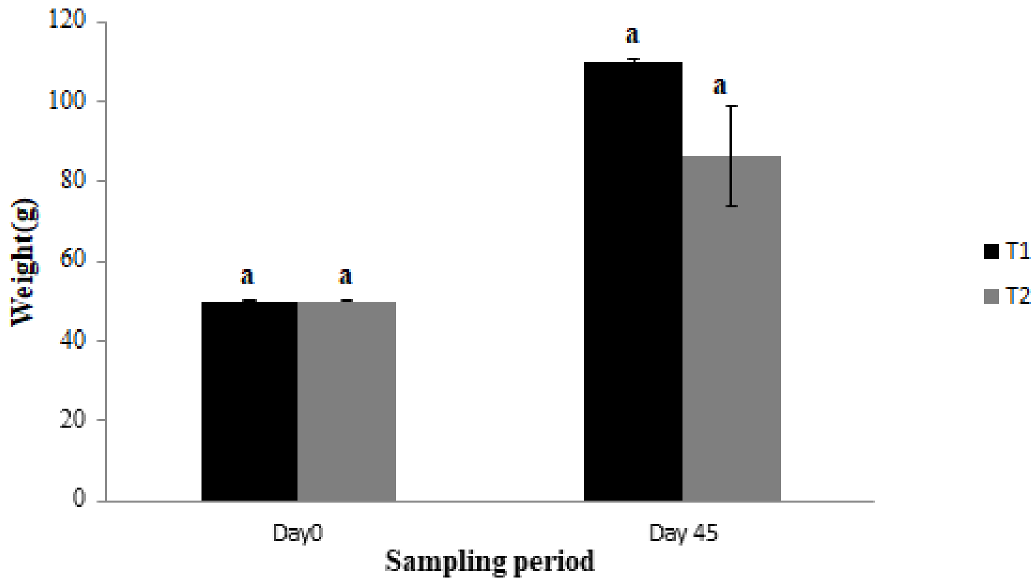

Figure 8. Mean wet weight of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in raft method after 45 days. Bars with the same letters are not significantly different (p>0.05). Error bars in SEM (standard error of the mean), n=14-60.

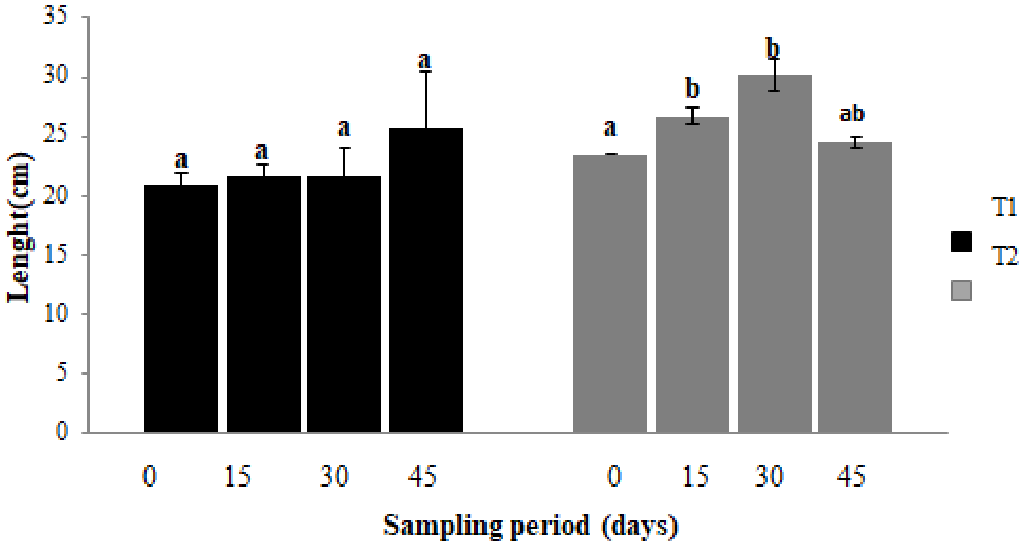

Figure 9. Average length in every sampling period of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in raft method for 45 days. Bars with different letters are significantly different (p<0.05). Error bars in SEM (standard error of the mean), n=14-60.

Survival Rate

Fixed-off bottom method

The survival rate of *S. cristaefolium* in T_1 (96.65±3.33%) showed no significant difference (p>0.05) from T_2 (100±0%) on day 15 (Figure 10). However, the survival rate of T_1 (80±5.77%) was higher (p<0.05) than T_2 (46.67±6.67%) at day 30. At day 45, the survival rate of T_1 (43.33±6.67%) was also significantly higher (p<0.05) compared to T_2 (13.33±3.33%).

The change in the survival rate of *S. cristaefolium* is shown in Figure 11. In T_2, the survival rate did not significantly change (p>0.05) from day 0 to 15, day 0 to 30, and day 15 to 30. However, the survival rate in T_1 significantly decreased (p<0.05) from day 0 to 45, day 15 to 45, and day 30 to 45. There was no significant change (p>0.05) in T_2 from day 0 to 15, but from day 0 to 30, day 15 to 30, and day 30 to 45, survival rates significantly decreased (p<0.05). From day 0 to 45, day 15 to 45, survival rates of T_2 significantly dropped (p<0.05).

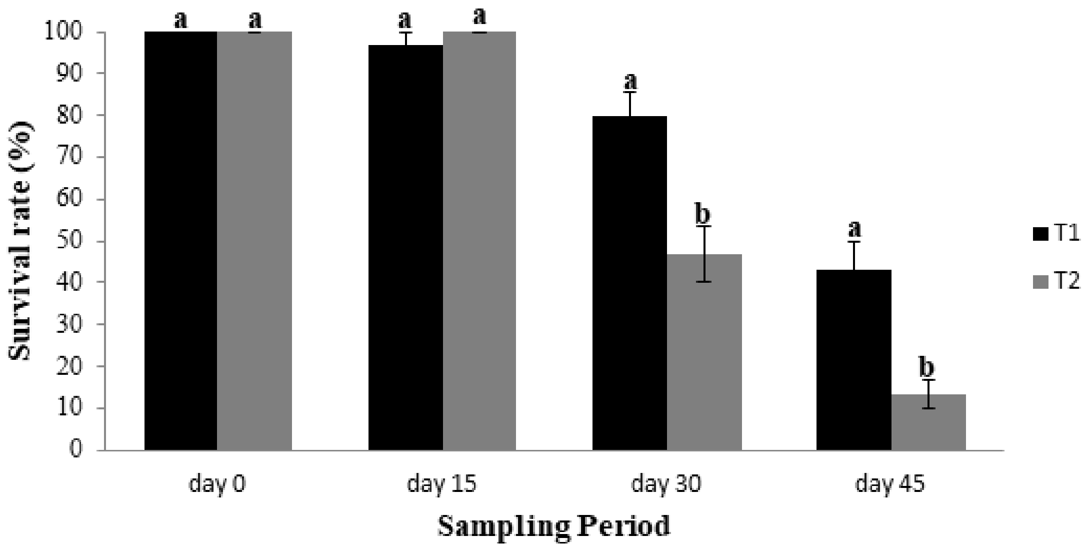

Figure 10. Survival rate of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in the fixed-off bottom method for 45 days. Bars with different letters are significantly different (p<0.05). Error bars in SEM (standard error of the mean), n= 17-60.

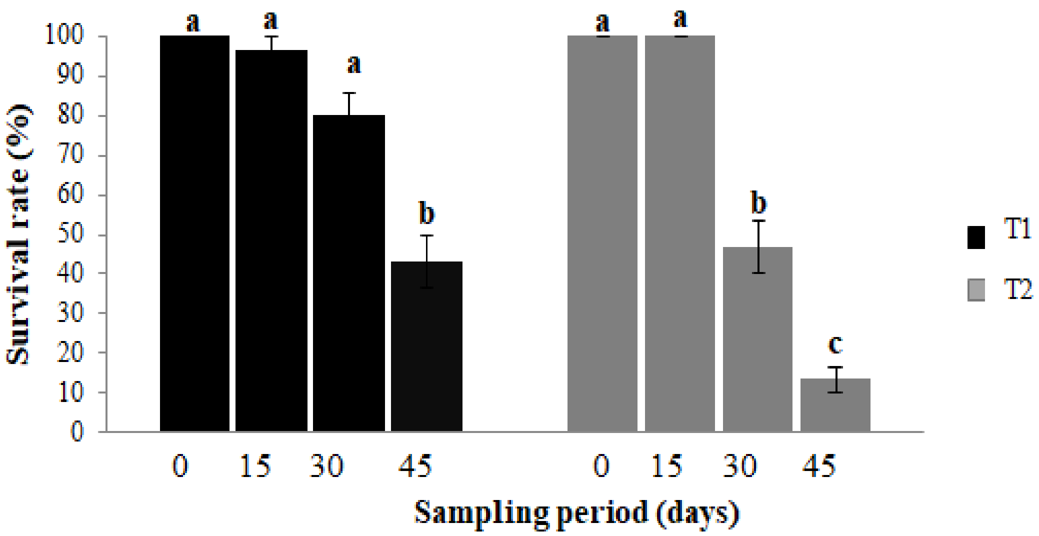

Figure 11. Change in survival rate in every sampling period of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in the fixed-off bottom method for 45 days. Bars with different letters are significantly different (p<0.05). Error bars in SEM (standard error of the mean), n= 17-60.

Raft method

The survival rates of T_1 and T_2 did not significantly differ (p<0.05) in every sampling period, as shown in Figure 12. T-test analysis revealed that T_1 did not significantly change (p>0.05) from day 0 to 15, day 15 to 30, and day 30 to 45. However, from day 0 to 30 and day 0 to 45, there was a significantly dropped (p<0.05) in survival rate. T_2 significantly decreased (p<0.05) in survival rate from day 0 to 45 and day 15 to 45 but did not significantly change (p>0.05) from day 0 to 15, day 0 to 30, and day 15 to 30 (Figure 13).

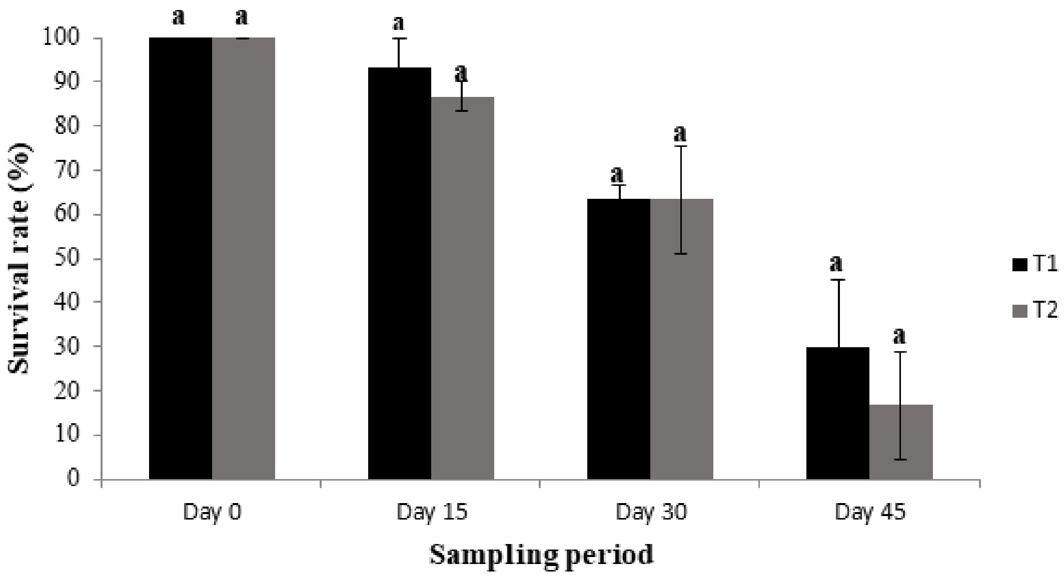

Figure 12. Survival rate of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in raft method for 45 days. Bars with same letters are not significantly different (p>0.05). Error bars in SEM (standard error of the mean), n=14-60.

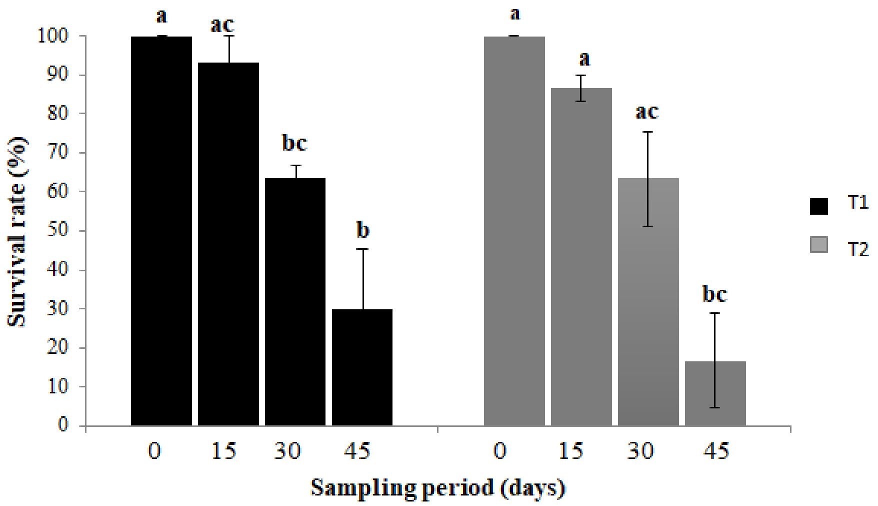

Figure 13. Change in survival rate in every sampling period of *S. cristaefolium* (T_1 = with holdfast, T_2 = vegetative cutting) cultured in raft method for 45 days. Bars with different letters are significantly different (p<0.05). Error bars in SEM (standard error of the mean), n=14-60.

Physico-chemical Parameters of Farms

Fixed-off bottom method

Table 1 shows the environmental conditions of *S. cristaefolium* farm using the fixed-off bottom method. The water depth of the farm ranged from 37±1.15 to 132.33±1.45 cm. The salinity ranged from 35.33±0.33 to 35.67±0.33 ‰. The temperature fluctuated throughout the culture period ranging from 34±1.61 to 27±0 ºC, and the pH levels of the farm ranged from 8.34±0 to 8.20±0.01. Water current velocity varied depending on the depth and tides, ranging from 0.008±0 to 0.061±0 m s^{-1}.

Table 1. Physico-chemical parameters of *Sargassum cristaefolium* farmed in the fixed-off bottom method

	Sampling Period						
Parameters	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Depth (cm)	37±1.15	152±1.00	91.67±2.03	112.33±1.45	123.67±0.88	99.67±0.88	132.33±1.45
Salinity (‰)	35.33±0.33	35.33±0.33	34.67±0.33	34.67±0.33	35.33±0.33	34.67±0.33	35.67±0.33
Temperature (˚C)	34±1.61	29.77±0.98	30.20±0.29	29.23±0.13	28.43±0.03	28.30±0.26	27±0
pH	8.34±0	8.33±0.01	8.49±0.02	8.22±0.04	8.21±0.02	8.10±0.01	8.20±0.01
Current (m s^{-1})	0.008±0	0.02±0	0.021±0	0.098±0	0.084±0	0.045±0	0.061±0

Raft method

The environmental parameters of *S. cristaefolium* farm using the raft method varied every 7 days (Table 2). The water depth of the farm during the culture period was between 103 cm to 204 cm. The salinity fluctuated during the sampling period ranging from 34.33±0.33 to 35±0.58 ‰. The temperature varied during the culture period ranging from 28±0 to 29.50±0.36 ºC. pH levels of the farm site ranged from 7.19±0 to 8.45±0.06. Water current velocity varied depending on the depth and tides, ranging from 0.01±0 to 0.11±0.003 m s^{-1}.

Table 2. Physico-chemical parameters of *Sargassum cristaefolium* farmed in the fixed-off bottom method

	Sampling Period						
Parameters	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Depth (cm)	103±1.7	170.33±5.17	120.33±2.60	166.6±4.41	173.33±0.88	135.33±0.88	204.33±2.3
Salinity (‰)	34.67±0.33	35±0.58	34.67±0.33	34.67±0.33	34.33±0.33	35±0	34.67±0.33
Temperature (˚C)	29.50±0.36	28.60±0.29	29.40±0.35	28.57±0.12	28.97±0.15	28.33±0.32	28±0
pH	8.33±0.02	7.19±0	8.39±0.03	8.25±0.02	8.45±0.06	8.01±0.03	8.02±0.08
Current (m s^{-1})	0.02±0.004	0.07±0.009	0.01±0	0.11±0.003	0.06±0.002	0.03±0	0.05±0.006

Discussion

Fixed-off Bottom Method

The present study revealed that *S. cristaefolium* cultured in the fixed-off bottom method attained an SGR of -1.51±0.6% day^{-1} and -2.03±0.23% day^{-1} and a final mean weight of 33.89±9.14 g and 20.50±2.18 in T_1 (w/ holdfast) and T_2 (vegetative cutting), respectively. The survival rate of *S. cristaefolium* in both treatments suddenly dropped as the culture period lengthened. The results coincided with the study of Aaron-Amper et al. (2020), where the survival rates of *S. aquifolium* grown using different substrates in the field declined through time. It was also observed by Fortes (1994) that all varieties of brown seaweeds cultured in a fixed-off bottom method generally yielded low growth rates and were greatly affected by season and highly susceptible to grazing pressure and epiphytes. According to Hung et al. (2009), after 60 days of the culture, the brown morphotype *Kappaphycus alvarezii* showed a higher growth rate (3.5-4.6% day^{-1}) from the month of September to February and a lower growth rate (1.6-2.8% day^{-1}) from March to August using fixed-off bottom method. The presence of grazer-like sea urchin (*Tripneustes* sp. and *Strongylocentrotus* sp.) has been observed throughout the sampling period, even though regular maintenance was done. This is maybe the main reason why *S. cristaefolium* cultured in the fixed-off bottom method attained negative SGR and mean weight as well as the survival rate decreased after 45 days in both treatments. Herbivory by sea urchins is known to exert an important influence on kelp forests in temperate water, although effects on microalgae vary depending on the species of sea urchins (Lawrence, 1975). Dworjanyn et al. (2007) investigated the preference of sea urchin (*T. gratilla*) for marine plants with which it co-occurs naturally in New South Wales, Australia displayed a significant preference for the brown alga (*Ecklonia radiate*) used as feeding stimulants. Seaweeds are important components of the coastal ecosystem and serve as food for small crustaceans, fish, grazers, and other herbivores. Grazing fauna prefers tender seaweed species such as *Enteromorpha* sp. and *Sargassum* sp. (Singh, 2017). According to Trono (1992), the plants that are attacked by benthic grazers are easily washed out when the area has a strong water current.

Both treatments (*Sargassum* with holdfast and vegetative cutting) can be used when culturing *S. cristaefolium* using the fixed-off bottom method. According to Norton (1976), *Sargassum* possesses a perennial holdfast that remains on the substrate after the rest of the plant has either been broken off or died away. Thalli of *S. muticum* arising from a small discoid holdfast may reach up to 5 cm total length with few primary lateral branches (Sabour et al., 2013). It is probably because the holdfast, which was in contact with the substratum, fastened the thallus for the attachment strength of each individual. The ability of seaweed to remain fastened in place on the bottom is the crucial performance of the holdfast. The perennial holdfast is responsible for the build-up of one or more main axis with manifold branches to produce branching thallus (Taylor, 1957). According to Silander (1986), vegetative regeneration mainly contributes to local population growth. Other species of *Sargassum*, such as *S. horridum* possess cauline, a structure that is responsible for the growth of primary branches and may also generate a new plant. Reproduction occurs through vegetative fragmentation when pieces of existing plants of *Sargassum* break off to form new branching individuals (Sorcia & Rodrigues, 2011).

Raft Method

The result of *S. cristaefolium* cultured in raft method after 45 days obtained positive SGRs (1.5±0.12% day^{-1} and 1.12±0.40% day^{-1}) and gained a final mean weight that doubled from the initial weight. This was perhaps due to the insusceptibility to grazers like sea urchins and sea stars when cultured in the raft method opposite to the fixed-off bottom method. The raft or longline method provides more space compared to the other methods. Trono (1993) said that this method is opposite to the other method where it makes probably has more advantages and becomes less obstruction against wave action and water current flow. But this water motion or wave can be considered the primary factor in determining productivity. According to Neushul et al. (1992), the rates of nutrient uptake and growth would increase if the marine farm were designed and operated to increase water movement over the plants being grown. This was also observed in the study of Zabala (2005), where the longline method always obtained the highest growth rate and mean weight of red seaweed *Kappaphycus*. *Sargassum* has been already cultured in other places like in Florida, USA, where *S. fluitans* and *S. natans* nutrient-enriched with nitrate and ammonium reached 0.03 to 0.04 doublings day^{-1}. Similarly, when enriched with phosphate, these species obtained growth ranging from 0.05 to 0.08 doublings day^{-1} cultured in a cage and shipboard flowing seawater (Lapointe, 1986). In China, cultured *S. hornerie* in a suspension tank from zygote obtained a length of 5.7 cm, while in tank culture, *S. hornerie* ranged from 1.5 cm to 2.5 cm after 3 months (Pang et al., 2006).

Sargassum with a holdfast and vegetative cutting can be used in the raft method because it obtained the highest SGR, mean weight, and length after 45 days of culture. According to Taylor (1957), the holdfast in *Sargassum*, also called the perennial holdfast, helps give rise to one or more main axes with manifold branches to produce a bushy, branching thallus that can be 20-200 cm or more in length. It also helps the *Sargassum* from the strong wave motion. Most of the brown seaweeds depend on their survival from the holdfast. The holdfast performance is crucial to the ability of the seaweeds to remain fastened on the bottom (Kawamata, 2001). According to Silander (1986), vegetative regeneration can mainly contribute to local population growth. Some of the *Sargassum* species possess a cauline structure that is responsible for the growth of some primary branches and may also be the reason that a plant can generate a new structure (Sorcia & Rodriguez, 2011). In the study of Moreira and Suárez (2002), vegetative fragmentation causes reproduction when pieces of the existing plant break off, forming a new branching individual.

The survival rate of *S. cristaefolium* cultured in the raft method decreased after 45 days in both *Sargassum* with a holdfast and vegetative cutting. The probable reason could be due to the garbage and other waste materials that flowed through the farm and got trapped. These may block the sunlight and may hinder photosynthesis. Grazers like herbivorous fish (*Siganus* spp.) also affect the survival of the *Sargassum*, which was present during the culture period. Grazing adversely affects the production in the *Kappaphycus* seaweed farm (Romero, 2002).

Conclusion

In conclusion, both types of *S. cristaefolium* seedlings (with holdfast and vegetative cutting) can be used for cultivation in raft method. However, both seedlings attained a negative SGR in the fixed-off bottom but gained a positive SGR in the raft method. A continuous decline through time in survival rates for both seedlings and methods was also observed due to grazers and floating wastes, respectively. This study would serve as preliminary information on the cultivation of *Sargassum* in Tawi-Tawi, southern Philippines.

Conflict of Interest

The authors declare that they have no conflict of interest.

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JOURNAL OF AGRICULTURAL PRODUCTION

https://agriprojournal.com ISSN: 2757-6620

RESEARCH ARTICLE

The Effect of Non-woven Cover and Seedling Techniques on Plant Growth and Bulb Yield of Onion

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ARTICLE INFO

Article History
Received: 14.04.2022
Accepted: 23.06.2022
First Published: 28.06.2022

Keywords
Non-woven
Onion
Seedling
Tolerance

ABSTRACT

This study aims to determine the effect of different cultivation techniques on onion plant growth and bulb yield in harsh continental climates and the short vegetation period. Three onion varieties with different dry skin colors were used as plant material. The techniques tried were: direct seed sowing, covering with non-woven fabric after sowing of seeds, planting seedlings, and covering with non-woven fabric after planting seedlings. The study was carried out in open field conditions in the Kayseri province where located in the central Anatolia region for two years. As a result of the study, it was determined that the interaction effects of the cultivar x cultivation technique had a statistically significant effect on all measured parameters. Although germination and emergence were observed in all varieties in both cultivation techniques, which started with direct seed sowing, plant development remained weak. The bulb formation was observed in only one variety in cultivation with seed sowing. In both techniques with seedlings, all varieties formed bulbs. Seedling planting + use of cover material had a positive effect on both yield and quality criteria for the bulbs. When all the results are evaluated together, it is understood that although the degree of effectiveness varies depending on the cultivars, seedling planting is a very effective technique for onions production in these climate conditions.

Please cite this paper as follows:

Kara, E., & Hanci, F. (2022). The effect of non-woven cover and seedling techniques on plant growth and bulb yield of onion. *Journal of Agricultural Production*, *3*(1), 30-34. https://doi.org/10.29329/agripro.2022.413.4

Introduction

Onion (*Allium cepa* L.) is one of the oldest known vegetables in the world. It is reported that this vegetable has great importance in terms of its nutritional and medicinal properties, as well as its widespread use in meals (Devi et al., 2014). Bulb onion cultivation in the world could be done in three ways in general: (1) Production by direct seed sowing. (2) Production by seedling. (3) Production with bulblets (small size bulbs) (Vural et al., 2000). Bulb formation physiology in onions is a subject that scientists are interested in intensively. Photoperiodicity (day length) is the most important environmental factor affecting bulb formation (Brewster, 2008). In addition to photoperiodism, the age of the plant and the number of leaves are other important factors affecting the head yield and quality (Rabinowitch & Brewster, 2009). The most important problem in onion cultivation in harsh-terrestrial climate conditions is that the leaf development cannot reach the desired level on the dates when the day length is at its highest level because of late seed sowing. This situation causes the plants to start to form heads when they are not physiologically ready yet, thus leading to a loss of yield. Taller plants provide more photosynthetic areas as a result of the sowing period for all onions, with cooler days being considered for the synthesis of the growth components of the onion stem (Mashayekhi et al., 2022). Farmers try to sow seeds of onion as early as possible to overcome this problem, but due to harsh climatic conditions, this is not always possible compared to other regions.

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Agro-textiles have a long history of use in agriculture. In their simplest form, textiles have been used for thousands of years to protect plants and animals from extreme conditions. With the development of agricultural techniques over time, the development and application of agro-textile production have expanded (Palamutcu & Devrent, 2017). Non-woven fabrics are fabric-like materials obtained by combining fibers of different lengths with various methods (chemical, mechanical, heat, etc.). Nonwoven fabrics (non-woven agro-textiles) are innovative products with special structural performance that can protect the plant against factors such as weeds, wind, and sudden temperature changes. In addition, nonwoven fabrics can be used as shade fabrics to reduce solar radiation and high temperatures. Using natural fibers for new ingredient improvement is one of the Food and Agriculture Organization (FAO) priorities as their use is expected to increase the performance and sustainability of agricultural industries worldwide (Kopitar et al., 2022). All over the world, nonwoven agro-textile applications have been tried in various products and their performance in reducing yield/quality losses has been revealed (Marasovic & Kopitar, 2019).

The study hypothesizes that seedling planting and nonwoven fabric applications will promote bulb formation in onions. This study aimed to compare three different onion cultivars in Central Anatolian conditions with three different methods alternative to direct cultivation from seed.

Materials and Methods

The study was carried out in the laboratories and open fields of Erciyes University Faculty of Agriculture during 2019-2020. Three commercial onion varieties were used as plant material. Among these varieties, "Çorum moru" is a long-day onion variety. Dry skin color is dark red/purple. It is especially well adapted to high altitudes and harsh climatic conditions. Gordion is an onion variety that leads to long/mid-day conditions. The dry skin color of this variety is yellow. "Snow-white" is a variety that binds the head in long-day conditions. The outer dry skin color is bright white. The flesh color is slightly more greenish-white. The sowing period for all varieties is indicated by the developers as January - March. The treatments were planned as direct sowing (control), seedling planting, non-woven fabric covering on the seed sowed area, and non-woven fabric covering on the seedling planted area. In seed sowing and seed sowing+covering with non-woven fabric applications, the seeds were sown on April 14, 2019, in 2 m2 plots with 7x30 cm row spacing. White-colored non-woven fabric with a density of 50 g/m2 was covered after seed sowing on the same day. On May 20, 2019, the cover was completely removed from the plants. In applications based on the use of seedlings, seeds were sown in plastic viols on 25.01.2019. The seedlings were planted on April 14, 2019, in 2 m2 plots with 7x30 cm row spacing. White-colored non-woven fabric with a density of 50 g/m2 was covered on seedlings. On May 20, 2019, the cover was completely removed from the plants. At the end of the study; pseudo-stem diameter (mm), leaf diameter (mm), pseudo-stem length (cm), bulb diameter (cm), bulb length (cm), bulb-neck diameter (cm), bulb diameter/height ratio (value), bulb weight (g), soluble dry matter (%), dry skin amount (number) were measured in the harvested plants. In addition to these, leaf length (cm) and leaf number (piece) values were measured in 10-day periods on four different dates. The study was planned in a randomized plot design with three replications. The averages were calculated by measuring 6 plants from each replication. The obtained data were subjected to analysis of variance (ANOVA) and LSD (minimum significant difference) test was used to determine the differences between applications.

Results

According to the results of the variance analysis, the effect of the double interaction of the cultivation techniques and varieties was found to be significant for all parameters examined. Leaf lengths were measured just before transplanting in seedling planting applications. At this stage, approximately 15 cm long seedlings were used for all cultivars. Two months after the establishment of the field trial, the leaf lengths were measured for the first time. Three more measurements were made in the following 10-day periods. While evaluating the results, all four measurements were statistically compared within themselves. Accordingly, in the first measurement, seedling planting and seedling planting + Non-woven cover applications had a significant positive effect on leaf lengths in all varieties (Table 1). This effect was also observed in other measurements, but differences were observed between the maximum lengths reached due to the variety effect. In the last measurement, the highest value was determined at 79.33 cm in the seedling planting application of the "Gordion" cultivar. The positive effect was observed in the "Kar beyaz" variety in the application where the non-woven cover was combined with the seedling planting. Leaf lengths remained remarkably small in applications starting with direct seed sowing. The number of leaves is one of the most important factors that indirectly affect the head tying in onions. To achieve the ideal head size, the plants should have a large number of leaves during the maximum day length period when bulb forming is physiologically triggered. In the applications that started with the seedling planting, three leafy plants were used as starting material. As with the leaf length values, the first counts were made two months after the establishment of the field trial. Three more counts were made in the following 10-day periods. While evaluating the results, all four counts were statistically compared within themselves. Accordingly, in the first count, seedling planting and seedling planting + non-woven cover applications had a significant positive effect on the number of leaves in all varieties (Table 2). This effect was also observed in ongoing counts. In the last count, the highest value was determined in the seedling planting application of the

"Gordion" variety with 9.17 units/plant. In the applications that started with direct seed sowing, the number of leaves decreased significantly.

Table 1. The effect of treatments on the length of leaves

Variety	Treatment	Start (cm)	1. Count (cm)	2. Count (cm)	3. Count (cm)	4. Count (cm)
Çorum moru	Seedling	15.00	67.83 a	74.50 ab	74.50 ab	74.50 ab
	Seedling + Non-woven cover	15.00	67.67 a	70.00 bc	73.67 ab	76.17 ab
	Seed sowing	0	17.33 b	26.00 d	28.00 d	32.17 e
	Seed sowing + Non-woven cover	0	10.00 c	10.00 ef	10.00 f	10 f
Gordion	Seedling	15.00	69.50 a	78.33 a	79.17 a	79.33 a
	Seedling + Non-woven cover	15.00	66.83 a	71.17 bc	71.17 b	71.17 bc
	Seed sowing	0	14.50 b	16.17 e	19.17 e	30.17 e
	Seed sowing + Non-woven cover	0	0 d	0 f	0 g	0 g
Kar beyaz	Seedling	15.00	67.83 a	70.67 bc	70.67 bc	70.67 c
	Seedling + Non-woven cover	15.00	67.00 a	68.67 c	73.67 ab	73.67 b
	Seed sowing	0	14.17 b	19.50 e	21.83 e	43.00 d
	Seed sowing + Non-woven cover	0	0 d	0 f	0 g	0 g

Means within a column that has a different small letter are significantly different from each other ($p < 0.01$). The lettering was made according to the results of variance analyses.

Table 2. The effect of treatments on the number of leaves

Variety	Treatment	Start (cm)	1. Count (cm)	2. Count (cm)	3. Count (cm)	4. Count (cm)
Çorum moru	Seedling	3.00	7.67 bc	8.50 abc	8.50 ab	8.83 ab
	Seedling + Non-woven cover	3.00	7.50 c	8.16 c	8.50 ab	8.50 abc
	Seed sowing	0.00	3.33 d	3.50 d	3.83 d	7.00 bc
	Seed sowing + Non-woven cover	0.00	3.00 d	4.00 d	4.00 d	4.67 d
Gordion	Seedling	3.00	8.33 ab	9.00 a	9.17 a	9.17 a
	Seedling + Non-woven cover	3.00	7.83 abc	8.17 c	8.67 ab	8.67 ab
	Seed sowing	0.00	3.17 d	3.50 d	3.50 d	6.33 c
	Seed sowing + Non-woven cover	0.00	0 e	0 e	0 e	0 f
Kar beyaz	Seedling	3.00	8.50 a	8.50 abc	8.67 ab	8.67 ab
	Seedling + Non-woven cover	3.00	8.50 a	8.83 ab	8.83 ab	8.83 ab
	Seed sowing	0.00	3.00 d	3.50 d	4.67 c	4.67 d
	Seed sowing + Non-woven cover	0.00	0 e	0 e	0 e	0 f

Means within a column that has a different small letter are significantly different from each other ($p < 0.01$). The lettering was made according to the results of variance analyses.

While investigating the bulbs, data from a diameter of less than 2 cm were not taken into consideration because they did not have any economic importance. Accordingly, while all three varieties formed bulbs in seedling and seedling + non-woven cover applications, only the "Gordion" variety was able to form a bulb with seed application (Table 3). In this variety, there was no statistical effect of the non-woven application on the diameter of the heads, while the diameter values increased with the application of seedling + non-woven cover in the other two varieties. This effect occurred mostly in "Çorum moru" variety (18.4%). No bulb could be obtained from any of the seed + non-woven cover applications. When the effects of the treatments on the length of the bulb heads were examined, it was seen that the non-woven cover application made a statistically positive contribution to the "Kar beyaz" and "Çorum moru" varieties after the seedling planting. In Gordion variety, there was no statistical difference between the results obtained from seedling and seedling + non-woven cover applications.

The diameter/length ratio is not an independent variable in onion bulbs. It is data obtained using previous measurement results. However, because there is numerical data about the bulb shape, which is a very important character in terms of quality in onions, it has been examined under a separate heading. If this value is close to "1", it means spherical heads, if it is larger than "1", it indicates a flattened sphere, and if it is less than "1", it indicates a cylindrical shape. According to the findings, the bulb shape was slightly cylindrical in the "Kar beyaz" variety and no effect of non-woven cover application was observed. The bulbs of the "Gordion" variety obtained from the seed were also cylindrical as in the "Kar beyaz" variety, but the bulb shape changed to slightly flattened in two different applications made with seedlings. In the "Çorum moru" variety, on the other hand, spherical bulbs were obtained in cultivation with seedlings, while more flat-shaped bulbs emerged in cultivation with seedlings + non-woven cover. Among all the cultivars, the water-soluble dry matter content of the "Çorum moru" variety was higher than the other varieties. Non-woven cover application increased the amount of water-soluble dry matter in all three varieties. This increase was more pronounced in the "Çorum moru" variety (17.6%). It was observed that the seedling planting + non-woven cover applications caused a serious weight increase in the "Kar beyaz" and "Çorum moru" varieties. This increase was 58% in "Çorum purple" variety and 38% in "Kar beyaz" variety. The amount of dry skin in onion bulbs is an important quality criterion, especially in terms of storage period. The treatment seedling planting caused an increase in the number of dry skin on the bulbs. The cover material used harmed the number of dry skin in all varieties.

Table 3. The effect of treatments on the bulb characters

Variety	Treatment	BL (cm)	BD (cm)	BLD	DMC (%)	BW (g)	NDS
Çorum moru	Seedling	6.25 d	6.25 c	1.01 ab	9.33 ab	112.00 c	4,67 abc
	Seedling + Non-woven cover	6.83 c	7.40 a	1.08 a	11.33 a	177.33 a	5,00 ab
	Seed sowing	0 f	0 e	0 c	0 g	0 e	0 d
	Seed sowing + Non-woven cover	0 f	0 e	0 c	0 g	0 e	0 d
Gordion	Seedling	6.90 c	7.12 ab	1.03 a	6.50 ef	183.67 a	4,50 bc
	Seedling + Non-woven cover	6.85 c	7.32 ab	1.07 a	7.00 de	184.33 a	5,17 a
	Seed sowing	4.40 e	4.07 d	0.93 b	6.00 f	27.00 d	5,00 ab
	Seed sowing + Non-woven cover	0 f	0 e	0 c	0 g	0 e	0 d
Kar beyaz	Seedling	7.45 a	6.78 bc	0.93 b	7.67 cd	143.50 b	4,17 c
	Seedling + Non-woven cover	8.25 a	7.60 a	0.93 b	8.50 bc	199.00 a	4,33 c
	Seed sowing	0 f	0 e	0 c	0 g	0 e	0 d
	Seed sowing + Non-woven cover	0 f	0 e	0 c	0 g	0 e	0 d

Means within a column that has a different small letter are significantly different from each other ($p< 0.01$). The lettering was made according to the results of variance analyses. BL: Bulb Length, BD: Bulb Diameter, BLD: Bulb Lenght/Diameter, DMC: Dry Matter Content, BW: Bulb Weight, NDS: Number of Dry Skin

Discussion

Soil preparation and seed sowing were only possible in the second week of April under harsh climatic conditions. Germination and plant growth was observed in all cultivars in seed sowing application. However, the biodegradable non-woven cover laid on the seed sowing areas adversely affected the germination of two varieties (Gordion and Kar beyaz). Marketable bulbs were obtained in all three varieties in cultivation with seedlings. This proved that bulb formation can be achieved by planting seedlings even at a late period. Significant increases were observed in the yield and quality characteristics of the heads with the use of seedling planting and non-woven cover material together. In particular, head weight, water-soluble dry matter ratio, and dry skin number were positively affected by the use of the cover material.

Lee et al. (2019) investigated the effects of different mulch types (non-woven polypropylene cover, clear plastic mulch, black plastic mulch, or bare ground) and different planting times on the growth and yield of two onion varieties. It has been demonstrated that marketable head yields can be increased with a nonwoven polypropylene cover covering, especially in onions grown with black plastic mulch or planted without mulch. In our study, it was observed that seedling planting + mulch cover applications caused a significant increase in the weight of onion heads in "Kar beyaz" and "Çorum moru" varieties.

Although in addition to some positive effects, some researchers have reported that mulching or coating applications cause bolting or double bulbing in onion heads (Suh & Kim, 1991; Varina & Roka, 2000) no head bolting or deformity was observed in our study. Suh and Kim's (1992) study, which reported significant differences in bolting and double bulb formation levels for onions depending on planting dates, varieties, and year (possibly weather-related), explains this difference.

Conclusion

In conclusion, when all results are considered together, it has been understood that although there are partial differences between onion genotypes and cultivation techniques, seedling planting instead of direct seed sowing provides a great advantage in terms of bulb formation, yield, and quality criteria in harsh continental climate conditions. In addition to planting seedlings, it was concluded that the use of biodegradable non-woven cover material can be recommended especially because of its positive effects on quality.

Acknowledgment

The study was supported by the Research Fund of Erciyes University (Project Number: FYL-2020-10031). This study consisted of a part of Kara's master thesis.

Conflict of Interest

The authors declare that they have no conflict of interest.

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JOURNAL OF AGRICULTURAL PRODUCTION
https://agriprojournal.com ISSN: 2757-6620

RESEARCH ARTICLE

The Timing of Vegetative and Generative Development of 'Memecik' and 'Gemlik' Olive Cultivars

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ARTICLE INFO

Article History
Received: 27.05.2022
Accepted: 23.06.2022
First Published: 28.06.2022

Keywords
BBCH
Maturity
Olive
Shoot elongation
Temperature

ABSTRACT

The research is carried out to determine the effects of different dates and temperatures on shoot length, fruit weight, oil content %, and maturity index of Gemlik and Memecik olive cultivars. The phenological growth stages of cultivars in 'yield' year were also described in the study using the BBCH (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie) scale. The shoot length observations were made on trees in the 'on' and 'off' periods between March 15, 2017, and December 29, 2017, every 15 days. It was determined that the shoot elongation of the trees in the 'off' period was even longer compared to the trees in the 'on' year. While the fruit weight of Gemlik had the highest value (3.775 g) on October 30, it had the highest value (3.330 g) on November 15 in Memecik. While fruit weight increased for 153 days for Gemlik, this period was determined as 122 days for Memecik. The maximum oil contents (%) were determined in Gemlik with 29.071 % on December 30 and in Memecik with 22.180 % on December 15. The maturity index of olive fruits reached its maximum level on December 15 in both varieties. As a result, it has been revealed that there is no serious difference between the phenological stages of the trees in the period of 'on' and 'off' depending on the periodic fruit yield. Moreover, the shoot development is generally more in the trees with 'off'in terms of the course of shoot development, and when the pomological analysis regarding the productivity status are examined, there are some serious differences.

Please cite this paper as follows:
Baysal, F., Mete, N., & Cetin, O. (2022). The timing of vegetative and generative development of 'Memecik' and 'Gemlik' olive cultivars. *Journal of Agricultural Production*, *3*(1), 35-41. https://doi.org/10.29329/agripro.2022.413.5

Introduction

Olive, whose origin is Anatolia, is among agricultural products, it is a very important fruit in terms of both production value and the area it covers. Although Turkey ranks fourth or fifth in terms of production amount in the world conjuncture, it can be said that the yield per tree is low. The reason for this can be shown as 'alternate bearing' in trees. In the national olive collection, it has been revealed that many olive varieties in Turkey show severe 'alternate bearing' (Kaya et al., 2011).

Memecik and Gemlik varieties, which are important oil and table varieties, show severe and moderate 'alternate bearing', respectively (Canozer, 1991). It is known that the lack or excess of basic climatic factors (temperature, precipitation, etc.) in the generative stage (flowering and fruit set) of olive increases the 'alternate bearing'. The world's largest olive-producing countries have evaluated the effects of production by examining the correlations between yield and climate parameters (Osborne et al., 2000; Fornaciari et al., 2002; Orlandi et al., 2005b; Motisi et al., 2008). Efe et al. (2009) reported that the places where the annual average temperature is 16.7 °C and close are the places where olives can be grown under optimum conditions. According to the findings obtained in a study aiming to determine the relationship between climate variables that are effective in olive production, it has been determined that the

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olive tree in Aydın province has an average total temperature demand of 392.08 days-degrees during the period from resting to fruit harvest (Colakoglu, 2009).

Correlative studies in olives using data from different locations or years suggest that temperature can modulate crop oil yield and oil composition (Garcia-Inza et al., 2014). In addition, a negative relationship between oil synthesis duration and temperature was found and data from different years and varieties were used, covering a narrow range of variation in average temperature (29.5-31.5 °C).

In this study, it is aimed to reveal the vegetative and generative development progress of the Memecik and Gemlik olive cultivars, which are important cultivars of Turkey, in terms of periodic shoot length and fruit stages in the period of 'on' and 'off'. Additionally, this paper describes the phenological growth stages of olive trees using the BBCH (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie) scale.

Materials and Methods

The research was carried out at Bornova Olive Research Institute, Bornova, Izmir, Turkey in 2017 and 2018. The average and minimum temperature data were supplied from Bornova Meteorology Station, Izmir, Turkey. The study was carried out with five replicates of Memecik and Gemlik cultivars. All measurements and observations were made from December to March. Representative trees were photographed to illustrate the primary and secondary phenological stages by using the BBCH (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie) scale (Sanz-Cortes et al., 2002).

Shoot length (cm) measurements were made in each tree after the shoot development activity of four shoots in different directions (north, south, east, and west). The length was determined by measuring the part from the beginning of the development of the branch to the tip of the shoot in centimeters (cm with the help of a tape measure). In this way, it is aimed to reveal shoot development courses in on and off years in olive trees. At the same time, the first measurements were made at the beginning of the vegetation period, and the last measurement was carried out at the end of the vegetation.

Determination of the maturity index (MI) is based on the calculation made using the following formula on a 100 olive fruit samples recommended by Boskou (1996). In the formula, the same letters that determine the color classes are used as a multiplier to evaluate the development of the fruit. This index can assist in determining when a certain time, for each region, has been reached in the formation of other maturity-related features (Solinas, 1990).

$$MI = (a \times 0 + b \times 1 + c \times 2 + d \times 3 + e \times 4 + f \times 5 + g \times 6 + h \times 7) / 100$$

a, b, c,…h are the number of olives belonging to each of the 8 categories below;

a: Olives with dark green skin

b: Olives with yellow or yellowish skin color

c: Olives with yellowish skin color with reddish spots

d: Olives with reddish or light violet skin color

e: Olives with black skin color and fruit still completely green

f: Olives with black skin color and violet up to half the thickness of the fruit

g: Olives with black skin color and violet flesh almost to the core

h: Olives with black skin color and completely dark flesh.

The oil ratio of olive (%) samples was determined by the Soxhlet extraction method as specified in TS EN ISO 659:2010, using n-hexane as a solvent, and the results were stated as ratio (%) (Anonymous, 2010).

Results

The phenological growth stages of Memecik and Gemlik olive cultivars in on year were described in the study using the BBCH scale. In Table 1, some important vegetative and generative stages of Memecik and Gemlik cultivars according to the BBCH scale are given according to dates. Figure 1 contains visuals of the cultivars.

The shoot length observations were made on trees in the 'on' and 'off' periods, between March 15, 2017, and December 29, 2017. Observations were made on trees every 15 days. Bud development is seen in Figures 1a-1b. The bud bursts of Gemlik and Memecik varieties were started on March 15th, 2017, and March 16th, in 2017, respectively.

The shoot length values of the cultivars are given in Figure 2 according to the year of 'on' and 'off'. While shoot elongation continued until September, 30 in Gemlik (73.50 cm), it continued until August, 15th in Memecik (60.00 cm). In both cultivars, shoot length remained the same until the end of the vegetation period. According to Figure 3, it was observed that the minimum (24.88°C) and average (30.63°C) temperature peaked on August, 30. While Memecik continued to elongate shoots up to the highest temperature, Gemlik cultivar continued after the decrease in temperature. Moreover, Gemlik continued its shoot elongation until September 30th (average temp. 14.28°C and minimum temp. 19.27°C) when September temperatures peaked. It was determined that the shoot elongation of the trees in the 'off' period was even longer compared to the trees in the yield year. The Gemlik reached a length of 110.250 cm on July 30th, while Memecik reached a length of 162.50 cm on October, 30th. Shoot elongation continued until September 30 in the yield period in Gemlik. Although Gemlik trees in the period of 'off' had a longer shoot length, the shoot elongation period continued only until July 30th. That is, there was a 45-day difference between the plants that lived during the two periods. When Memecik is examined, that difference was 15 days, unlike Gemlik. Moreover, Memecik trees in the 'off' period continued shoot elongation longer than Gemlik trees in the 'off' period.

Table 1. BBCH scale of Gemlik and Memecik olive cultivars

BBHC Scale	Stages	Dates
Principal growth stage 0: Bud development	00: Foliar buds at the apex of shoots grown the previous crop-year are completely closed, sharp-pointed, stemless and ochrecoloured (Figure 1a- 1b)	Gemlik-March 15, 2017 Memecik-March 16, 2017
Principal growth stage 1: Leaf development	11: First leaves completely separated. Grey-greenish coloured	Gemlik-March 30, 2017 Memecik-April 4 2017
Principal growth stage 3: Shoot development	37: Shoots reach 70 % of final size.	Gemlik-May 11, 2017 Memecik-May 23, 2017
Principal growth stage 5: Inflorescence emergence.	50: Inflorescence buds in leaf axiles are completely closed. They are sharp-pointed, stemless and ochre-coloured.	Gemlik-May 16, 2017 Memecik-May 30, 2017
Principal growth stage 6: Flowering	60: First flowers open	Gemlik-May 16, 2017 Memecik-May 30, 2017
Principal growth stage 7: Fruit development	79: Fruit size about 90 % of final size. Fruit suitable for picking green olives	Gemlik-October 10, 2017 Memecik-October 13, 2017
Principal growth stage 8: Maturity of fruit	89: Harvest maturity: fruits get the typical variety colour, remaining turgid, suitable for oil extraction	Gemlik-November 15, 2017 Memecik-November 30, 2017

Figure 1. Some bud, leaf, shoot and fruit development stages according to the BBCH scale. 1.a.- 1b. Bud development, 2.a.-2b. Leaf development, 3.a.-3b. First leaves completely separated. Grey-greenish coloured, 4.a.-4.b. Inflorescence buds in leaf axiles are completely closed. They are sharp-pointed, stemless and ochre-coloured, 5.a.-5.b. The corolla changes from green to white colour, 6.a.-6.b. Full flowering: at least 50 % of flowers open, 7.a.-7.b. Fruit size about 10 % of final size, 8.a.-8.b. Fruit size about 50 % of final size. Stone starts to lignificate (it shows cutting resistance), 9.a.-9.b. Fruit size about 90 % of final size. Fruit suitable for picking green olives, 10.a. Harvest maturity: fruits get the typical variety colour, remaining turgid, suitable for oil extraction -10.b. Overripe: fruits lose turgidity and start to fall.

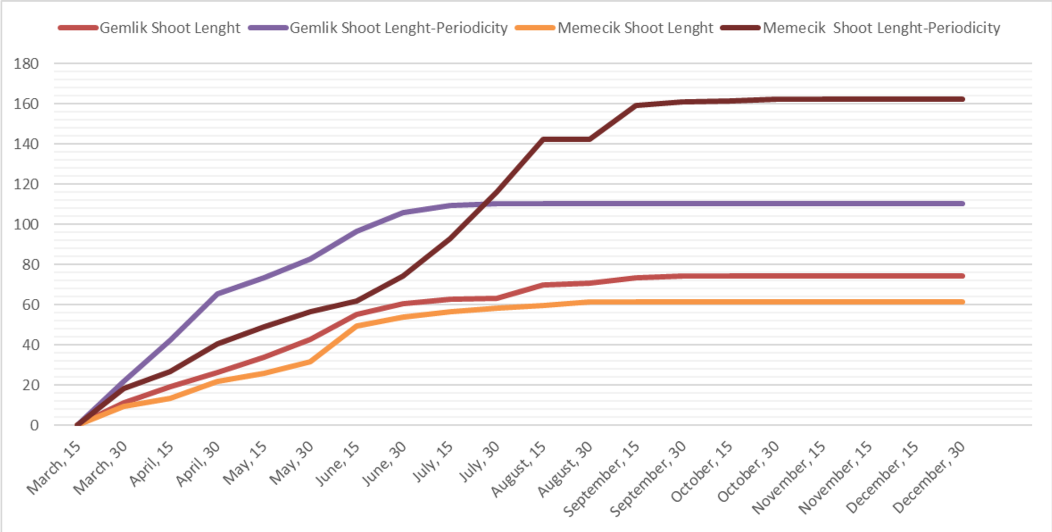

Figure 2. The shoot lenghts of Gemlik and Memecik varieties according to the 'on' and 'off' periods.

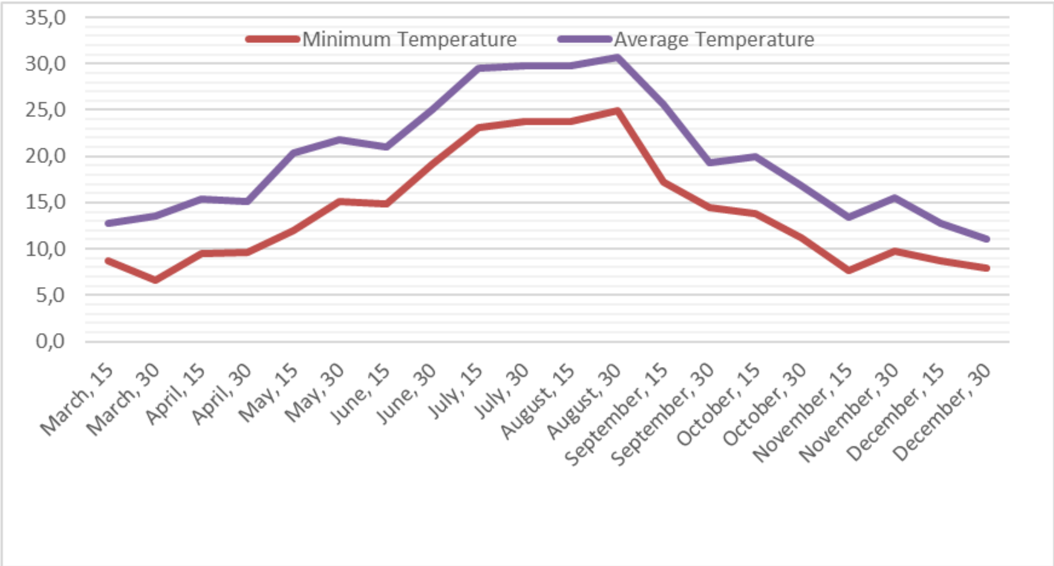

Figure 3. The average and minimum temperatures of vegetation period

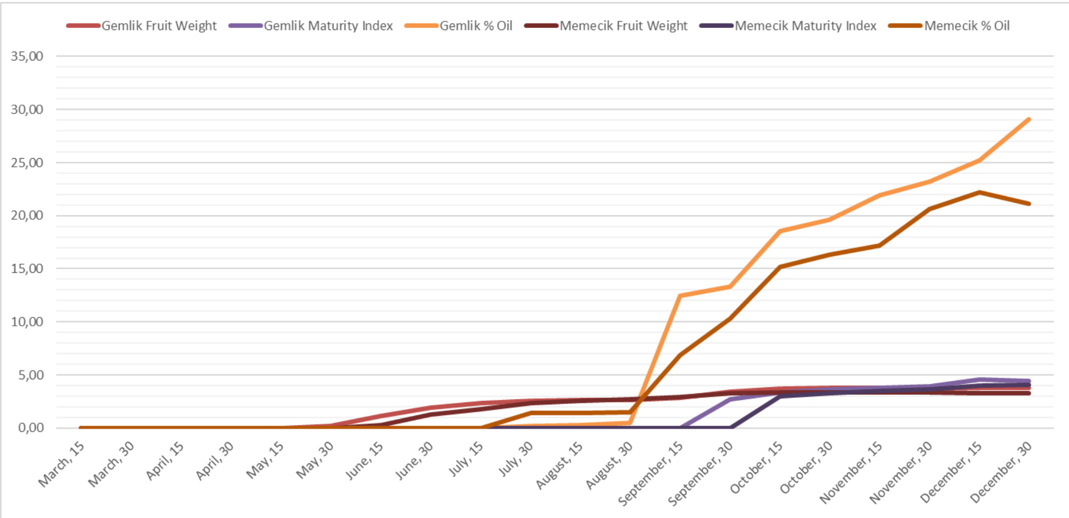

Figure 4. The fruit weights, fruit maturity indexes, and oil contents (%) of Gemlik and Memecik varieties according to the 'on' periods.

The fruit weight, fruit mature index, and oil content ratios (%)of the varieties are given in Figure 4 according to the period of yield. The average fruit weight of the Gemlik was 0.221 g on May 30, while the fruit of the Memecik has not yet formed. The average fruit weight of Memecik was 0.24 g on June 15th. While the fruit weight of Gemlik had the highest value (3.775 g) on October 30, it had the highest value (3.330 g) on November 15th in Memecik. While fruit weight increased for 153 days for Gemlik, this period was determined as 122 days for Memecik. After these dates, fruit weights decreased partially. From the date when the temperature was highest (August 30th), the oil content of the fruits increased rapidly. The oil content (%) increased in both varieties until December 15th. The maximum oil content ratios were determined in Gemlik with 29.071% on December 30th and in Memecik with 22.180% on December 15th. The maturity index of olive fruits reached its maximum level on December 15th in both varieties.

Discussion

The common problem encountered in the identification of olive varieties is the variability of the investigated characters depending on ecological conditions. The BBCH scale was used for the phenological observations. Sanz-Cortes et al. (2002) reported that the BBCH scale had advantages in identifying cultivars. For example, in the evaluation we made with the scale, it was determined that Memecik bloomed earlier and reached harvest maturity faster than Gemlik. Garrido et al. (2021) reported that the average vegetation period was 259 days in their study with Arbequina variety in North-Western Spain. In our study, it took approximately 261 days. The period from inflorescence to harvest was determined as approximately 184 days. Garrido et al. (2020), in their study using the BBCH scale, determined the time from the inflorescence emergence to the harvest as 216 (Arbequina), 221 (Frantoio) days in 2016, and 195 (Arbequina), 195 (Frantoio) days in 2017. It was observed that the cultivars used in our study had a shorter generative period. At this point, it can be said that there are other variables (temperature, soil, variety, harvest time, etc.) that affect cultivation.

The flowering date is mainly dependent on spring and summer temperatures. Many authors report that spring temperatures have a significant influence on the flowering date in olives (Alcala & Barranco, 1992; Recio et al., 1997; Galan et al., 2001, Perez-Lopez et al., 2008), and our data confirm the important influence of April and May temperatures (Figure 4). Because during these dates the temperature has started to rise rapidly.

In olive drupes, endocarp expansion is complete within 8-10 weeks (Rallo and Rapoport, 2001), while the mesocarp continues to grow for much longer (Rallo & Rapoport, 2001; Costagli et al., 2003). For common drupes such as plum, apricot, sour cherry, and peach, the period of mesocarp cell division typically lasts approximately 15 to 20% of the total fruit growth period (Bollard, 1970). The six-week period of cell number increase for Manzanilla variety corresponds with this pattern (Rallo & Rapoport, 2001). Contrary to these studies, fruit weight increase, that is, endocarp and mesocarp growth, took about 20 weeks in Gemlik and 18 weeks in Memecik in the study. In parallel with our study, Tombesi (1994) also reported that mesocarp development continued from the beginning to the end.

Several studies have highlighted the importance of shoot length (i.e., spur shoots vs long shoots) in determining a tree's ability to support fruit production (Johnson & Lakso, 1986). In our study, longer shoot structure was determined in the trees in the period of 'off' in both cultivars. Recent studies have suggested that short shoots are prone to flowering and fruiting, while long shoots tend to be vegetative (Bell, 1991). Previous authors reported that this situation may be related to the different wood to leaf biomass ratios of long and short shoots, affecting the timing and intensity of carbon export (Lauri & Terouanne 1991; Lauri 1992; Lauri & Kelner 2001).

Temperature regulates growth and development in plants. In a correlative study in olive, the duration of the fruit growth phase was shown to be reduced by high temperature while no effect of temperature on fruit growth rate was detected (Trentacoste et al., 2012). In addition, a negative relationship between oil synthesis duration and the temperature was found (Garcia-Inza et al., 2014). In our study, with the month of July, when the temperatures reached the highest level, percentage of oil in both varieties started to increase. However, when the temperatures started to decrease, the oil content (%) continued to increase partially. Here, the air temperature was expected to approach almost 30°C for oil formation.

Maturity index values varied every month in the study. Although all cultivars are grown under the same ecological conditions, the fact that the maturity indexes differ in all of them as a result of monthly controls shows that genetic characteristics have a greater effect on olives than ecological conditions. When the maturity indexes of the cultivars were compared, it is observed that Gemlik is the most mature cultivar. Similar to the results of our study, Gundogdu & Seker (2012) reported that in their study on Arbequina, Ascolana, Gordales, Hojiblanca, Manzanilla de Carmona, Manzanilla de dos Hermanas, Negral, and Verdial cultivars, all cultivars were almost immature (green-yellow) in August and took mature (purple-violet color) in November. Many studies are showing that the oil content of olive fruit increases as maturity progresses (Barone et al., 1994; Nergiz & Engez, 2000; Salvador et al., 2001; Shibasaki, 2005; Al-Maaitah et al., 2009). Colakoglu (1986) also stated that the highest oil level is reached when there is no green fruit on the tree.

Conclusion

The relationship between climate and yield is important in estimating the amount of olive product in the world. In the study, the flowering date in olives has depended on the temperatures recorded mainly in April and May and it was also determined that the temperatures of August and July are important for oil formation.

As a result of our study, we found that in the 'yield' period, generative development is high and vegetative development is low in olive trees; In the 'on' or 'off' period, it is seen that there is no generative development as well as excessive vegetative growth.

Conflict of Interest

The authors declare that they have no conflict of interest.

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