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Effect of Intra Row Spacing on Growth, Yield Components and Yield of Garlic (*Allium Sativum L*) at Fitch, North Showa Zone of Oromia, Ethiopia

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Abstract

Garlic (*Allium sativum* L.) is a monocotyledonous aromatic plant belonging to the Alliaceae family and genus Allium. It is used as a spice and medicinal plant. The production of garlic in Ethiopia is low as compared to other growing countries. This is due to different factors like the unavailability of appropriate disease-free seeds (Cloves), inappropriate agronomic practices, i.e., sowing time, seed rate, and both intra- and inter-row spacing. That is the reason why the research report was studied. A field experiment was conducted at the Fiche, Salale University, General Tadesse Biru campus demonstration site during the 2020 cropping season. The objective of the study was to identify the effect of intra-row spacing on the growth, yield, and yield components of garlic. One local variety of garlic, which was bought from Fiche Market, was used for the field experiment. The experiment was laid out using a randomized complete block design (RCBD) with three replications and four treatments/intra-row spacing, i.e., 8cm, 10cm, 12 cm, and 14cm between plants. Growth, yield, and yield components data were collected and subjected to analysis of variance (ANOVA) using SAS 9.3, and least significant difference (LSD) at $p<0.05$ probability was used to separate means. The ANOVA showed significant variation among all collected parameters. The wider the plant spaced, the better the growth performance of the garlic plant. However, the yield-related parameters are good indicators of yield. Thus, treatments, which are bulb weight and number of cloves per bulb, showed better performance of morphological parameters and also suggest a positive relationship with increasing plant spacing statistically. According to those ANOVA results, farmers or growers may produce more yield with a plant spacing of 14*25 because all parameters are significant as compared to other treatments.

Keywords: Garlic; Growth; Intra row spacing; Yield component; Randomized Complete Block Design

Introduction

The monocotyledonous fragrant plant known as garlic (*Allium sativum L.*) is a member of the Alliaceae family and genus Allium, which has around 600 species [1]. With 16 chromosomes (2n = 2x = 16), it is diploid. Although there are no known true wild species of garlic, Allium longicuspis, a closely related species to cultivated garlic with its origins in

central Asia, is thought to be so. Worldwide, there is a great deal of variation and improvement in garlic. It is cultivated as a major spice and medicinal plant throughout the world in all temperate to sub-tropical regions [2]. China is the largest consumer of garlic in the world [3].

Of the 26.57 million tons of garlic produced worldwide in 2016, Asia, Europe, the Americas, and Africa shared 91.8, 3.1, 2.6, and 2.5% of the total. With 21 million tons produced annually, China is the world's largest producer of garlic, with India coming in second with 1.4 million tons. With an average production of 9 tons/ha, Ethiopia produces 0.14 million tons from 15,381 ha, accounting for 0.52% of global production [4].

Around the world, garlic is used as a condiment in a wide variety of foods; without it, many of our favorite dishes wouldn't have the flavor and personality that make them special. Garlic's strong smell, unique flavor, and pungency, as well as its health advantages, are attributed to its volatile oil, which contains numerous sulfur-containing compounds [5]. Around the world, garlic is used as a condiment or seasoning, mostly to enhance the flavor of food and as a medicinal herb [6]. Garlic is a crucial bulb crop grown in Ethiopia that is used as a spice, culinary seasoning, medicine, and a source of income for farmers and the country's economy [7]. One of the most researched therapeutic herbs is garlic, and its antiseptic and antibacterial qualities are widely recognized. It has treatments for tumors, worms, headaches, and bites [8]. Garlic was also used medicinally in Ethiopia to cure a variety of skin and stomach issues, as well as illnesses like the common cold [9]. According to Metasebia, et al. [10], one of the most significant bulb crops grown by small and commercial growers for both domestic and international markets is garlic. The primary purpose of the crop's production is cash crop exportation to the USA, Europe, and the Middle East in order to generate foreign exchange. Additionally, the Horticultural Development Corporation had been producing it commercially at Debre Zeit, Guder, and Tseday State Farmers [11].

Generally speaking, Ethiopia produces less garlic than other developing nations. The lack of suitable disease-free seeds (Cloves), improper agronomic techniques (such as sowing time, seed rate, and intra- and inter-row spacing), inadequate irrigation and fertilizer requirements, and inadequate pest and disease control are some of the contributing factors to this [12]. Garlic cloves planted larger will yield larger bulbs than cloves planted smaller. The size of the planted cloves and plant spacing has a direct impact on the size of the harvested bulbs. Plant density decreases with an increase in bulb production, which has been demonstrated to be correlated with the crop leaf canopy's percentage of light interception [13]. It's possible that the low garlic production is the result of improper plant spacing, as advised in Ethiopia. Plant spacing of 5 cm and 11 cm produced the best results for leaf area, leaf length, plant height, bulb size, bulb fresh weight, bulb dry weight, number of cloves bulb-1, and yield ha-1, according to Muneer N, et al. [14]. For the cultivation of garlic, plant spacing of 5 to 11 cm and row spacing of 14 cm are appropriate. Based on the average outcomes attained and the mean maximum bulb diameter of 56.0 mm. The variety Buner Local reported its yield (8.6 tons ha-1) and bulb diameter (56.0 mm) for comparison with other variations. Illnesses, pest insects, insufficient soil fertility, and inadequate post-harvest technologies [15].

Garlic is widely used worldwide for a variety of purposes, including pharmaceuticals, food, and spice [15]. Despite its many uses, Ethiopia's productivity (9 tons/h) is very low when compared to other countries due to a number of different constraints, including poor agronomic practices like plant density, a lack of improved variety, inappropriate disease, and pest management. If the plants are densely planted, there is a high likelihood that they will compete with one another for nutrients, and if the land is far from optimal space, productivity will be lost without productivity. Based on the above mentioned information, this study was carried out to determine the ideal intra-row spacing for improved garlic growth, yield, and yield components as well as to assess the impact of intra-row spacing on these factors at Fitch, Ethiopia.

Materials and Method

Description of the Study Area

The field experiment was conducted at General Tadesse Biru campus demonstration site of Salale University, Fiche from February 2020 – July 2020. The experimental site is located 112 kilometers from Addis Ababa city at latitude 90 48''0'' N and longitude 380 42''0'' E, at an altitude of approximately 2750 meters above sea level. The institution is located in the Grar Jarso area of Fiche town, which is distinguished by a cold, highland agro-ecological zone with an average yearly temperature of 16.50 °C and 1150 mm of precipitation. According to Abera, et al. [16], the study area's soil type is clay with a pH of 6.4.

Description of Planting Materials

Plant material for this study was local cultivar garlic cloves that were purchased from Fitch Market.

Treatments and Experimental Design

Using RCBD, three replications of the field experiment were conducted. Four levels of plant spacing (8, 10, 12, and

14 cm) were used as treatments and were randomized to the experimental plots. 40 m2 in total (5 m * 8 m) was used for the experiment. Three homogeneous blocks, or replications, were created out of the entire experimental region. Each block has a full set of treatments that are randomly assigned to the plots inside it. The plot measured 1 meter by 1.25 meter, or 1.25 m^2. There is one meter between each block (replication) and 0.5 meter between plots. Every plot had five rows with constant row spacing of 25 cm and there was 0.5 m of empty space on all sides of the experimental area.

Experimental Procedures and Agronomic Practices

Land Preparation: The selected land was ploughed by oxen to a depth of 25–30 cm; plots were prepared based on the pre-determined design; then a ridge was made by hand.
Planting: Based on the prearranged treatment, large, healthy cloves were planted in each plot.
Fertilizer Application: The sources of nitrogen and phosphorus were urea and NPSB fertilizer, respectively. Two splits of nitrogen fertilizers were applied, half at planting and half after complete emergence (two weeks post-planting), in the form of urea.

Every other type of management activity, including hoeing, weeding, earthing up, and insect control, was carried out consistently for every plot.

Data Collection

Five randomly chosen plants from the three middle rows of each plot were used to gather data on the growth, yield component, and yield of the garlic. The average for each parameter was then calculated.

Growth Parameters

Plant Height (cm): The average plant height was determined by measuring the distance between the soil's surface and the tips of five randomly chosen, physiologically mature plants.
Leaf Length (cm): The longest leaf at physiological maturity from five randomly chosen plants in each of the three central rows was measured in centimeters to determine the leaf length (cm), and the average was calculated.
Leaf Width (cm): Five plants were randomly chosen from the three central rows, and their leaf widths were measured to determine the leaf width (in centimeters). Every sample plant's leaf was measured at its broadest point at physiological maturity, and the average was determined.
Leaf Number per Plant (cm): the average of the five randomly selected plants from the middle three central rows at physiological maturity was calculated based on the total number of healthy leaves.

Yield and Yield Component

Bulb Weight (g): the weight of five randomly chosen plants' bulbs was measured with a beam balance, and the average was calculated.
Number of Cloves per Bulb: Cloves produced from five randomly chosen plants or bulbs were counted, and the total number of cloves produced from each bulb was divided by the total number of bulbs to get the number of cloves per bulb (g).

Data Analysis

SAS version 9.3 was used to do statistical analysis (ANOVA) on the gathered data. According to Gomez, et al. [17], mean separation is carried out using LSD at 5% probability whenever treatment effects are significant.

Results and Discussion

Effect of Intra Row Spacing on Growth of the Garlic Plant

Plant Height: According to Appendix 1, the results of the analysis of variance show that there was a significant ($p<0.05$) difference in plant height across treatments. The outcome of the experiment demonstrated that intra-row spacing had an impact on plant height. As the plant's intra-row space rose, the plant's height fell. When compared to other treatments, the 8x25 cm treatment had a statistically significant impact on plant height. The plants were arranged as follows: 8 x 25 cm, 10 x 25 cm, 12 x 25 cm, and 14 x 25 cm. Nevertheless, mean separation revealed that treatment 1 (8 cm) had the highest average plant height (65.773 cm), followed by treatments 2 (10 cm), 3 (12 cm), and 4 (14) with average plant heights of 65.77 cm, 63.19 cm, 61.59 cm, and 60.88 cm, in that order (table 1). The shortest plant spacing generally resulted in the highest plant height being measured. Competition for light at high plant population densities may be the cause of this. But plants were not impacted by plant density when they were spaced farther apart because there was less competition for light and other resources. These results are in agreement with the results obtained by Martha Mebratu [18] on garlic; who reported longest plant height (38.16 cm) at 12 x 30 cm, and the shortest plant height (37.32 cm) at 8 x 30 cm.
Leaf Length: According to Appendix 2, the results of the analysis of variance show that there was a significant ($p<0.05$) difference in plant height between the treatments. With 10x25cm, 12x25cm, and 14x25cm, the highest leaf length (49.18) was observed from 8x25cm, and the shortest leaf length (46.47) was observed from 14x25. Consequently, a treatment with 8x25cm spacing was significantly different with treatments on leaf length (table 1). In general, as intra-row distance rose, leaf length exhibited a declining

tendency. This indicates that treatment one produced the longest leaf, which was followed by treatments two, three, and four (Table 1). This suggests that leaf length reduces with increasing plant separation. These findings are inconsistent with those of Martha Mebratu [18], who studied the effects of spacing on garlic plants and reported longest leaf (34.36) at 10 x 30, while the shortest (32.49) was measured at 8 x 30.

Leaf Width: The analysis variance showed a significant difference in leaf width on the garlic plant as influenced by intra-row spacing at P<0.05 (Appendix 3). Treatment one (8 x 25 cm plant spacing) gave the lowest leaf width (1.69), while the highest leaf width (2.54) was obtained from treatment four (14 x 25 cm plant spacing) recorded (table 1). Nevertheless, the other treatment was statistically similar, but there was a numerical difference between them; this could be explained by the fact that wider plant spacing showed less competition for resources, which led to larger leaves developing; this result was consistent with the findings of Abeba T, et al. [19]. Specifically, treatment one (planted with 0 cm plant spacing) recorded the lowest leaf width (0.73), while treatment five (planted with 20 cm plant spacing) recorded the highest leaf width (1.99).

Leaf number per plant: The experiment's findings showed that, in terms of the number of leaves per plant, there is a significant difference (p<0.05) between the treatments (Appendix 4). Compared to other intra-row spacings, the 14 x 25cm intra-row spacing considerably enhanced the number of leaves (P<0.05). Generally speaking, the number of leaves increases with the width of the intra-row spacing (Table 1). That means the highest leaf number per plant (15.067) was recorded from treatment four (planted with 14 x 25cm spacing between plants), whereas the lowest leaf number per plant (10.80) was recorded from treatment one (planted with 8 x 25 cm spacing between plants). This could be partly owing to the fact that wider-spaced plants develop more axillary branching than plants spaced at closer spacing, which results in a larger leaf number per plant. This result is in agreement with the findings of Martha Mebratu [18] who founded the highest leaf number per plant (6.36) at 10 x 30cm spacing between plants and the lowest leaf number per plant (6.31) at 8 x 30 cm spacing between plants.

Effect of Intra Row spacing on Yield and Yield Components of Garlic

Number of Cloves per Bulb: In terms of the number of cloves per bulb, the ANOVA result showed a significant difference (p<0.05) between treatments (Appendix 5). The range of cloves per bulb was found to be 15.43 to 20.30 (Table 1). The plot with the plant spacing of 12 x 25 cm in Table 1 had the fewest cloves per bulb (15.43) while the plot with the maximum number of cloves per bulb (20.30) was planted with 14 x 25 cm plant spacing.

Bulb Weight (gm): The result of the ANOVA indicates that there was a significant difference (p<0.05) among treatments with reference to bulb weight (Appendix 6). The results showed that bulb weight increases with an increase in row spacing. The bulb weight ranges from 60.33 to 75.33 grams. Greater bulb weight (75.33) was noted in the plot planted with 14 x 25 cm plant spacing, and less bulb weight (60.33) was recorded in the plot planted with 12 x 25cm plant spacing (Table 1). The result justified the fact that an increment in intra-row spacing increased the bulb weight of the plant. This research finding is in line with the findings of Darabi, et al. [20], who reported that increasing the distance between rows and plants decreased the total bulb yield but increased the mean bulb and clove weights. Consequently, spacings of 14 x 25 and 12 x 25 cm gave the largest total bulb production and the lowest mean weights of bulbs, respectively [21-24].

Treatment	PH	LL	LW	LN/P	NCB	BW
8cm	65.773^{a}	49.180^{a}	1.693^{d}	10.80^{d}	18.67^{ab}	67.67^{b}
10cm	63.187^{b}	47.868^{b}	1.953^{c}	12.20^{c}	20.30^{a}	54.67^{d}
12cm	61.587^{bc}	47.40^{bc}	2.23^{b}	13.67^{b}	15.43^{c}	60.33^{c}
14cm	60.89^{c}	46.467^{c}	2.540^{a}	15.068^{a}	17.63^{bc}	75.33^{a}
LSD (0.05)	1.63	1.07	0.16	1.06	2.37	4.905
CV %	1.3	1.13	3.76	4.1	8.21	5.04

Table 1: Effect of Intra Row spacing on growth, yield and yield components of Garlic.
Where: PH=Plant height, LL=Leaf length, LW=Leaf width, LN/P=Leaf number per plant, NCB= Number of cloves per bulb, BW=Bulb weight

Summery & Conclusion

Garlic (*Allium sativum L.*) is a monocotyledonous aromatic plant belonging to the Alliaceae family and genus Allium. The production of garlic in Ethiopia is generally low as compared to other growing countries. This is due to several variables such the absence of proper disease-free seeds (Cloves), inappropriate agronomic procedures, i.e., sowing time, seed rate, and both intra- and inter-row spacing. Therefore, the main purpose of this study was to identify the effect of intra-row spacing on the growth, yield, and yield components of garlic. Our field experiment involves three replications with four treatments (8cm, 10cm, 12 cm, and 14cm).

The results of the intra-row spacing used in the study showed significant variation among the different treatments. The highest results were shown in the treatment (14*25). Highest leaf number per plant (15.068), leaf width (2.540), and bulb weight (75.33) were recorded at 14 cm spacing compared to other parameters. According to the ANOVA result, leaf number per plant, leaf width, and bulb weight were significantly affected by intra-raw spacing. Generally, the wider the plant spacing, the better the growth performance of the garlic plant. However, the yield-related parameters are good indicators of yield. Thus, those treatments, which are bulb weight and number of cloves per bulb, showed better performance and also suggest a positive relationship with increasing plant spacing statistically.

In conclusion, garlic growers in the study area may produce more yield with a plant spacing of 14*25 because all parameters showed a significant difference as compared to other treatments. Especially Due to the better results (2.540), (15.068), and (75.33) for the leaf width, leaf number per plant, and bulb weight, respectively, that are recommended in this study, but to tell the result for the grower with full confidence, it requires a cost-benefit analysis.

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