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Research Article

Response of Garlic (*Allium sativum* L.) on Intra Row Spacing and NPS Ratio for Growth, Yield Components and Yield at Bench-Sheko Zone, South Western Ethiopia

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Abstract

The objective of this study is to identify the optimum Nitrogen, Phosphorus and sulfur and plant density for maximum production of garlic crop in the study area. Garlic is an important condiment and cash crop in Ethiopia. Low yield and productivity of the crop are the major characteristics of the crop in the country. The field experiment was composed of three intra raw spacing and four labels of NPS ratio, three levels of intra-row spacing with 5 cm, 10 cm and 15 cm laid out in a Randomized Complete Block Design replicated three times. Data pertaining growth, yield and yield-related parameters were collected and analyzed using SAS version 9.3. The result of the study revealed that almost all of the variables considered were significantly affected by the interaction between NPS ratio and intra-row spacing. As a result,, bulb length (4.71 cm), bulb diameter (3.7 cm), bulb weight (59.0 g), clove number per bulb (29.00), dry matter (37.13 %), marketable bulb yield (kg ha-1) (6715.87 kg ha-1), unmarketable bulb yield (kg ha-1) (607.67 kg ha-1), total bulb yield per hectare (kg ha-1) (7313.97 kg ha-1) and harvest index (57.93 %). The highest marginal rate of return of garlic (873.75 %) was obtained from the treatment combination of 19: 38: 7 labels of NPS ratio with wider intra row spacing (15 cm). The minimum marginal rate of return (-7,160.1 %) was recorded from the treatment combination of 0: 0: 0 labels of NPS ratio with medium intra row spacing (10 cm). The correlation analysis indicated that the relationship between marketable yield and all variables except unmarketable bulb yield and total bulb yield (where negative and significant) was positive and highly significant ($P<0.001$). According to the findings of this study, it can be concluded that applying 19: 38: 7 labels of NPS ratio combined with the wider intra row spacing (15 cm) helps to produce higher product in the study area. Because it was helps to produce higher marginal rate of return. Therefore, it is better to use 19: 38: 7 labels of NPS ratio combined with the wider intra row spacing (15 cm) for producing higher garlic product in the study area. But, since the current study was limited to a single season at a single location and varieties, it should be repeated across locations, seasons and varieties for comprehensive recommendation.

Keywords

Garlic, NPS Bulb, Spacing, Yield and Yield Component

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1. Introduction

Garlic (*Allium sativum* L.) is an important edible bulbous crop belonging to the family Alliaceae along with onion, shallot, leek and chives. Garlic has higher nutritive value than other bulbs crops [1]. It has higher nutritive value as compared to other bulbous crops and it is a rich source of carbohydrates (29 %), proteins (6.3 %), minerals (0.3%) and essential oils (0.1-0.4 %) and also contains fat, vitamin C and sulphur [13]. Garlic soils should be fertile, rich in organic matter, well drained and capable of holding adequate moisture. Soil pH ranging from 6.8-7.2 is generally for garlic production. According to Janet [11], soil pH below 5.0 can lead to the death of garlic plants.

Garlic is an important vegetable crop in the world as well as in Ethiopia. Total cultivated area in the world was 1,199,929 ha^{-1} with total production of 17,674,893 ton [14]. The world garlic cultivation was increased from 1,320,592 ha^{-1} in 2009 to 1,546,741 ha^{-1} of land in 2018 with total production of 22,072,428 and 28,494,130 ton respectively. In Ethiopia, garlic is one of the main vegetable crops cultivated for both consumption and medicinal purposes. However, in many parts of the country, garlic crop yields are low due to a number of constraints, among which lack of balanced nutrient supply, diseases, and moisture stress are the major ones [16]. The low performance of garlic production both at the country level and regional level can be accounted to the traditional production practices employed by smallholder farmers. One of these practices involve poor application of fertilizer in terms of NPS ratio and plant density and also lack of evidences on how much to apply for agronomic optimum. Although some farmers are using chemical fertilizers, the rate of application is by far below the national blanket recommendation which is about 105 kg N ha^{-1} and 92 kg P ha^{-1} for garlic production (Ethiopian Institute of Agricultural Research [5]. The Ethiopian Ministry of Agriculture has recently introduced a new compound fertilizer (NPS) instead of DAP, containing nitrogen (N), phosphorous (P_2O_5), and sulfur (S) with a ratio of 19 %, 38 %, and 7 %, respectively Ethiopian agriculture [5]. And Therefore, the target of this study will be evaluating the constraints of farmer`s garlic production practices and evaluating the response of garlic to the newly introduced fertilizer blend NPS in the study area in order to contribute to horticultural development accomplishments of the country. In addition the yield of garlic at Semen Bench District can be statistically improved by using N: P_2O_5: S fertilizer.

The situation is even more challenging for researchers and farmers to understand the impact and identify optimum agronomic and economic threshold of the newly introduced NPS fertilizer that contains sulfur. Conversely, there is limited information about effects of NPS on growth and yield of garlic for growers and researchers in Bench Sheko Zone, South Western Ethiopia. Therefore, this investigation is initiated to evaluate the plant density and the different NPS rates on growth and yield of garlic. There is shortage of information on specified plant density and NPS rate for garlic crop production in Bench-Sheko Zone and in general Ethiopia in particular that will be greatly help to increase garlic production. Considering the importance of garlic as one of the potential vegetable crops for both domestic consumption and export, it is imperative to increase its productivity along with application of appropriate plant density and NPS rate. Depending on the above fact the present study was proposed for the following objective.

1.1. General Objective

To identify the optimum Nitrogen, Phosphorus and sulfur and plant Spacing for maximum production of garlic crop in the study area.

1.2. Specific Objective

1. To evaluate the response of plant density and NPS rate on yield and yield component of garlic in the study area.
2. To assess current farming practices and synthesize major potential and constraints in farmer`s garlic production practices.

2. Result and Discussion

The analysis of variance indicated that all yield and yield component variables were significantly influenced by intra row spacing, NPS ratio and their interaction. Hence, the results are presented and discussed below.

Average bulb length (P<0.001) were very highly significantly affected by the interaction between Intra row spacing and NPS ratio. The highest bulb length (4.71 cm) were recorded from the treatment combination of 19: 38: 7 levels of NPS ratio with wider intra row spacing (15 cm), followed by (4.62) with treatment combination of 19: 38: 7 levels of NPS ratio with medium intra row spacing (10). Whereas, the minimum bulb length (2.2 cm) was recorded from the treatment combination of 0: 0: 0 levels of NPS ratio with closer intra row spacing (5 cm) (Table 1). Increased 19: 38: 7 levels of NPS ratio with wider intra row spacing (15 cm) are likely attributable to more nutrition, food reserve, space, and moisture availability, resulting in reduced competition for available growth resources. The increment in bulb length and diameter at increased NPS ratio and intra-row spacing might be attributed to the positive effect of higher vegetative growth which was obtained by applying higher labels of NPS ratio and at wider spacing availability of adequate nutrients, light, and moisture for bulb growth and development and less completion between plants for growth resources.

Many researchers indicated that bulb length and bulb width of garlic were highest at wider intra-row spacing. As reported by [13], by using Tsedey 92 variety they found the highest bulb length (4.49 cm) and bulb diameter (5.02 cm) at maximum intra row spacing (12.5 cm) relative to small intra row spacing (5 cm).

Bulb diameter of garlic were very highly significantly (P<0.0001) influenced by the interaction of intra row spacing and NPS ratio. The highest average bulb diameter (3.7 cm) was obtained from the treatment combination of 19: 38: 7 NPS ratio and wider spaced plants (15 cm), followed by a treatment combination of 9: 19.5: 3.5 NPS ratio and wider spacing (15 cm) (3.4 cm). The minimum average bulb diameter (0.1 cm) was recorded from the treatment combination of 0: 0: 0 NPS ratio and closer spacing (5 cm) (Table 1). In general, the highest bulb diameter was recorded from the wider intra row spacing and 19: 38: 7 NPS ratio, while, decreases in spacing showed a decreasing trend in bulb diameter. This might be the result of competition between plants for nutrition, water, NPS and light source. This result is in line with the finding of [10] As regards N-doses, increased bulb diameter (3.34 cm) was recorded by using 180 kg N, which was statistically similar with 240 kg and 180 kg N ha^{-1} showing 2.91 and 2.96 cm diameter of bulbs, respectively. Maximum, but non-significant bulb dia (3.13 cm) was obtained in Shah Alam variety against the lowest (2.58 cm) recorded in Dera Local [10]. Interactive studies showed that 180 kg N induced maximum improvement in bulb size (3.76 cm) of Shah Alam variety. Whereas, 0 kg and 60 kg N ha^{-1} gave smallest bulb diameter in Peshawar Local which was 2.06 and 2.09 cm, respectively. Because of the gaining of high space, with the increase in intra row spacing, average bulb diameter of the onion plants increased [10]. The data recorded from Axum Agricultural Research Center shows that, the plant spaced at 12.5 cm intra row spacing produced the highest bulb diameter [16, 6].

Very highly significant (P<0.0001) effect of intra row spacing and 19: 38: 7 labels of NPS ratio was observed on bulb weight. A higher value (59.0 g) of this variable was recorded from the treatment combination of 19: 38: 7 labels of NPS ratio with wider intra row spacing (15 cm), followed by (56.2 g) a treatment combination of 9: 19.5: 3.5 labels of NPS ratio with medium intra row spacing (10 cm). The minimum bulb weight (30.0 g) was recorded from the treatment combination of 0: 0: 0 labels of NPS ratio with close intra row spacing (5 cm). This could be attributed to the presence of significant nutrients in 19: 38: 7 labels of NPS ratio and 9: 19.5: 3.5 labels of NPS ratio, as well as broader intra row spacing for vegetative plant growth, which results in a positive correlation with bulb weight. This result is in agreement with [9] the bulb weight was significantly affected by plant spacing. Bulb weight increases as row spicing increases. The weight of the bulb varies from 74.66 and 99.33 g. A plot planted with 20 cm plant spacing had more bulb weight, while a plot planted with 10 cm plant spacing had less bulb weight. The growth, yield and economic potential of garlic were increased in response to the combined application of 92 kg N + 40 kg P + 30 kg S ha^{-1} with a benefit cost ratio of 6.44: 1 on Andosols and 138 kg N + 40 kg P + 60 kg S ha^{-1} with a benefit cost ratio of 5.86: 1 on Vertisols [4]. the higher bulb yields obtained from Andosols at 92 kg N + 40 kg P ha^{-1} along with 30 or 60 kg S ha^{-1} exceeded the one obtained from the same soil in the control plot by about 112% and 123%, respectively [4]. Statistical evaluations showed that average bulb weight was significantly affected by NPS fertilizer (P < 0.05). The highest average bulb weight was recorded in the (57: 114: 21 kg/ha NPS fertilizer) as 39.44 g which was 29 % higher than 28.0 %. The results also showed that increasing the rate of NPS fertilizer increased the average bulb weight. This might be because the highest nitrogen, phosphorus, and sulfur contribute to the metabolic process such as the formation of nucleic acids, phospholipids, coenzymes, and chlorophyll which in turn enhances the bulb weight of garlic plants [2]. This study was in agreement with the finding of [8] who reported that higher bulb weight was achieved by the application of 78.75- 69-12.7 kg ha^{-1} NPS. Onion bulb weight was highly significantly (P≤0.01) influenced by the application of different NPS fertilizer rates. That is, maximum bulb weight (198.83 g) was obtained from onion plants supplied with 105: 119.6: 22 kg ha^{-1} N: P_2O_5: S fertilizer rate which was about 50.1% bigger than the bulb weight obtained from non-fertilized plants. The bulb weight obtained from was, however, similar with those bulbs obtained from onion plants supplied with 136.5: 119.6: 22 kg ha^{-1} of N: P_2O_5: S fertilizer rate [15].

Table 1. *Interaction effect of NPS ratio and intra row spacing on bulb length, bulb diameter, bulb weight, clove number per bulb and dray mater, of garlic at Semen Bench District during the production periods of 2021/22.*

Treatments		Variables				
NPS (%)	Spacing (cm)	Bulb length (cm)	Bulb diameter (cm)	Bulb weight (g)	Clove number	Dray Mater (%)
	5	2.20^{f}	2.01^{f}	36.0^{g}	5.7^{h}	16.80^{j}
0: 0: 0	10	2.40^{e}	2.04^{f}	40.0^{ef}	7.0^{gh}	17.10^{j}
	15	2.50^{e}	2.42^{e}	57.0^{b}	7.3^{g}	17.40^{j}

Treatments		Variables				
NPS (%)	Spacing (cm)	Bulb length (cm)	Bulb diameter (cm)	Bulb weight (g)	Clove number	Dray Mater (%)
	5	2.67^{d}	2.04^{f}	38.7^{f}	12.0^{f}	20.20^{i}
4.5: 9.75: 1.75	10	2.70^{cd}	2.07^{f}	56.0^{b}	15.7^{e}	21.20^{h}
	15	2.80^{c}	2.81^{cd}	59.0^{a}	19.0^{d}	22.63^{g}
	5	2.80^{c}	2.07^{f}	39.3^{f}	18.0^{d}	25.47^{f}
9: 19.5: 3.5	10	3.07^{b}	2.71^{d}	56.2^{b}	22.7^{c}	28.43^{e}
	15	3.136^{b}	2.98^{c}	54.3^{c}	28.0^{a}	30.87^{d}
	5	3.10^{b}	3.0^{c}	41.0^{e}	18.3^{d}	32.13^{c}
19: 38: 7	10	4.62^{a}	4.20^{b}	52.7^{d}	25.0^{b}	35.30^{b}
	15	4.71^{a}	4.50^{a}	59.0^{a}	29.0^{a}	37.13^{a}
LSD $_{(0.05)}$		0.11	0.25	1.30	1.59	0.73
CV (%)		2.13	5.40	1.70	5.45	1.71

Where: LSD=Least Significant Difference and CV=coefficient variation

The interaction effect of intra row spacing and NPS ratio was very highly significant (P<0.0001) affected clove number per bulb. The highest average clove number per bulb (29.0) was obtained from the treatment combination of 19: 38: 7 labels of NPS ratio with wider intra row spacing (15 cm), which is statically similar with the treatment combination of 9: 19.5: 3.5 labels of NPS ratio and wider intra row spacing (15 cm), followed by the treatment combination of 19: 38: 7 labels of NPS ratio with medium intra row spacing (25.0). The minimum average clove number per bulb (5.7) was recorded from the treatment combination of 0: 0: 0 labels of NPS ratio with closer intra row spacing (5 cm) (Table 1). This might be attributed to 19: 38: 7 labels of NPS ratio have adequate food reserves for better bulb development and garlic planted at wider spacing tend to intercept lighter and suffer less competition for nutrients, hence establish better individual bulb characteristics and produced more clove number per individual stands. The study is similarly with study of [17] maximum clove number per bulb at relatively wider spacing was recorded at 12.5 cm intra row spacing.

The interaction effect of intra row spacing and NPS ratio was significantly (P<0.001) affected dry matter. The treatment combination of 19: 38: 7 labels of NPS ratio with wider intra row spacing (15 cm), (37.13 %) of dry matter, followed by (35.30%) a treatment combination of 19: 38: 7 labels of NPS ratio with medium intra row spacing (10 cm). The minimum average dry matter (16.80 %) was recorded from the treatment combination of 0: 0: 0 labels of NPS ratio with closer intra row spacing (5 cm) (Table 1). This might be due to the higher equatorial width of the bulbs produced in 19: 38: 7 labels of NPS ratio and wider spacing.

The interaction effect of intra row spacing and NPS ratio was very highly significantly (P<0.0001) affected marketable bulb yield. The highest average marketable bulb yield (6715.87 kg ha^{-1}) was obtained from the treatment combination of 19: 38: 7 labels of NPS ratio with medium intra row spacing (10 cm), which is similar with treatment combination of 19: 38: 7 labels of with wider intra row spacing (6715.20 kg ha^{-1}) followed by the treatment combination of 9: 19.5: 3.5 labels of NPS ratio with medium intra row spacing (6713.97 kg ha^{-1}). The minimum average marketable bulb yield (6702.00 kg ha^{-1}) was recorded from the treatment combination of 0: 0: 0 labels of NPS ratio with closer intra row spacing (5 cm) followed by the treatment combination of 9: 19.5: 3.5 labels of NPS ratio with closer intra row spacing (6706.37 kg ha^{-1}) (Table 1). Garlic could have varied yield potential under different agro-ecological settings due to the effects of labels of NPS ratio, plant density and environment interaction on the formation of bulbs that develops from the interplay between plant density and the environment.

This result is in line with the findings of [3] the highest marketable bulb yield of onion was recorded at treatment combination of 82 kg ha^{-1} N and 4 cm intra-row spacing. On the other hand, onion plants spaced at widest intra-row spacing without nitrogen recorded lowest marketable bulb yield of onion. The closer intra row spacing and application of optimum rate of nitrogen leads to highest number of bulbs with marketable size. Although plant height, number of leaves per plant and leaf length increased with increasing spacing in the present study, higher number of plants per unit area with enough supply of nitrogen increased marketable bulb yield. These observations of increased marketable yield at 19: 38: 7 labels of NPS ratio and wider spacing might be due to the presence of the higher amount of initial reserved food material in the 19: 38: 7 labels of NPS ratio which enhanced more cell division and cell elongation and less completion for growth resources at wider spacing resulting in vigorous plants that yielded larger bulbs than the medium and smaller ones.

The interaction effect of intra row spacing and NPS ratio was very highly significantly (P<0.0001) affected unmarketable bulb yield. The highest average unmarketable bulb yield was obtained from the treatment combination of 4.5: 9.75: 1.75 labels of NPS ratio with closer intra row spacing (5 cm) (607.67 kg ha^{-1}), followed by treatment combination of 0: 0: 0 labels of NPS ratio with small intra row spacing (5 cm) (607.37 kg ha^{-1}). The minimum average unmarketable bulb yield was recorded from the treatment combination of 19: 38: 7 labels of NPS ratio with wider intra row spacing (15 cm) (573.67 kg ha^{-1}) followed by treatment combination of 9: 19.5: 3.5 labels of NPS ratio with wider intra row spacing (15 cm) (575.63 kg ha^{-1}) (Table 2). This result is consistent with [12, 16, 8, 7] the increase in the intra row spacing unmarketable bulb yield of onion decreased significantly. The highest yield is produced at 2.5 cm intra row spacing. Even though almost all researches concluded as the narrowest spacing to produce highest unmarketable yield their conclusion on the spacing type are different [16].

Table 2. *Interaction effects of NPS ratio and intra row spacing on marketable bulb yield, unmarketable bulb yield, and total bulb yield per hectare and harvest index of garlic at Semen Bench District during the production period of 2021/22.*

Treatments		Variables			
NPS (%)	Spacing (cm)	Marketable bulb yield (kg ha^{-1})	Unmarketable bulb yield (kg ha^{-1})	Total bulb yield (k g ha^{-1})	Harvest index (%)
0: 0: 0	5	6702.00^{h}	607.37^{a}	7309.40^{a}	29.30^{i}
	10	6710.20^{e}	590.57^{b}	7300.80^{bc}	31.30^{hi}
	15	6711.33^{cd}	578.73^{c}	7290.07^{ed}	32.30^{h}
4.5: 9.75: 1.75	5	6702.63^{h}	607.67^{a}	7310.30^{a}	45.40^{fg}
	10	6710.50^{de}	590.57^{b}	7301.10^{b}	44.40^{g}
	15	6711.80^{c}	578.73^{c}	7290.50^{ed}	45.40^{fg}
9: 19.5: 3.5	5	6706.37^{g}	606.03^{a}	7312.40^{a}	47.40^{ef}
	10	6713.97^{b}	579.73^{c}	7293.70^{bcd}	49.70^{de}
	15	6713.93^{b}	575.63^{c}	7282.90^{e}	50.20^{cd}
19: 38: 7	5	6708.50^{f}	605.47^{a}	7313.97^{a}	52.27^{c}
	10	6715.87^{a}	576.97^{c}	7292.83^{cd}	55.27^{b}
	15	6715.20^{a}	573.67^{c}	7288.87^{ed}	57.93^{a}
LSD $_{(0.05)}$		0.87	6.08	8.20	2.60
CV (%)		0.09	0.61	0.07	3.40

Where: LSD=List significant deference and CV %=coefficient variation

The interaction effect of intra row spacing and NPS ratio was very highly significant (P<0.001) affected yield per hectare. The highest average total bulb yield per hectare was obtained from the treatment combination of 19: 38: 7 labels of NPS ratio with closer intra row spacing (5 cm) (7313.97 kg ha^{-1}) statically similar with treatment combination of 9: 19.5: 3.5 labels of NPS ratio (7312.40 kg ha^{-1}) with closer intra row spacing (5 cm). The minimum average total bulb yield per hectare (7282.90 kg ha^{-1}) was recorded from the treatment combination of 9: 19.5: 3.5 labels of NPS ratio with wider intra row spacing (15 cm) (Table 2) statically similar with treatment combination of 19: 38: 7 labels of NPS ratio (7288.87 kg ha^{-1}) with wider intra row spacing (15 cm) spacing. The result was similar to that [2] highest yield (14.91 ton ha^{-1}) was recorded from (57: 114: 21 kg/ha NPS) which was 65% higher than. (19: 38: 7 kg/ha NPS) and (28.5: 57: 10.5 kg/ha NPS) were not statistically different when they are compared to each other. This could be due to the beneficial effect of higher vegetative growth achieved by applying 19: 38: 7 labels of NPS ratio, which could lead to the formation of larger bulbs and higher yield. This might be because 19: 38: 7 labels of NPS ratio have relatively more reserve food for an emerging shoot to utilize and rapidly establish itself and efficiently utilize growth resources during the growing season compared to 0: 0: 0 labels of NPS ratio with relatively less reserve food. An increase in bulb yield at closer spacing was also reported by [17] where they observed maximum yield at 5 cm intra row spacing relative to wider spacing using Tsedey 2 garlic variety. This increment of total yield at closer spacing might be attributed to the increase in plant population per unit area.

The interaction effect of intra row spacing and NPS ratio was very highly significant ($P<0.001$) affected yield harvest index. A higher value (57.93 %) of harvest index was recorded from the treatment combination of 19: 38: 7 labels of NPS ratio with wider intra row spacing (15 cm), followed by (55.267 %) a treatment combination of 19: 38: 7 labels of NPS ratio with medium intra row spacing (10 cm). The minimum harvest index (29.30 %) was recorded from the treatment combination of 0: 0: 0 labels of NPS ratio with close intra row spacing (5 cm) this were statically similar with (31.300) 0: 0: 0 labels of NPS ratio with medium intra row spacing (10 cm) (Table 2). Wider intra row spacing and 19: 38: 7 labels of NPS ratio to 9: 19.5: 3.5 labels of NPS ratio could have reduced plant number, leaf length, and plant height that lowering the aboveground biomass and resulting in a higher harvest index. Which could explain the higher harvest index seen at wider spacing and 19: 38: 7 labels of NPS ratio, on the other hand, may have a lower harvest index due to a higher number of leafs and leaf width, which increase aboveground biomass and raised the harvest index. This excessive vegetative development harms the division of take in towards the bulbs. This result is inclined with [17] the main effect of intra row spacing significantly affected the harvest index of garlic plants. Intra row spacing of 5 cm gave the highest harvest index of 50.41 %, while the lowest harvest index of 35.69 % was obtained at the wider intra-row spacing of 12.5 and the existence of shortest leaf length and plant height which lowered aboveground biomass and resulting in a higher harvest index, could explain the higher harvest index found at tight spacing [17]. Furthermore, the higher harvest index at a wider intra-row spacing of 15 could be attributed to a higher number of leaves, longer leaf length, and diameter at wider intra-row spacing. Leaf number, leaf width, number of cloves per bulb, bulb weight, marketable bulb yield, and total bulb yield all have a positive and significant impact on harvest index.

3. Summary and Conclusion

The result of the study revealed that almost all of the variables considered were significantly affected by the interaction between NPS ratio and intra row spacing. As a result, maximum days to maturity, (116.0 days), leaf number (12.0), leaf width (2.7 cm), bulb length (4.71 cm), bulb diameter (3.7 cm), bulb weight (59.0 g), clove number per bulb (29.00), dry matter (37.13 %), marketable bulb yield (6715.87 kg ha^{-1}), were obtained by applying 19: 38: 7 labels of NPS ratio with medium intra row spacing (10 cm) and total bulb yield per hectare (7313.97 kg ha^{-1}) were obtained by applying 19: 38: 7 labels of NPS ratio with closer intra row spacing (5 cm), harvest index (57.93 %) were obtained by applying 19: 38: 7 labels of NPS ratio with wider intra row spacing (15 cm) even though statistically

Correlation analysis indicated that the relationship between marketable yield and all variables except unmarketable bulb yield and total bulb yield (where negative and significant) was positive and highly significant ($P<0.01$).

According to the findings of this study, it can be concluded that applying 19: 38: 7 labels of NPS ratio combined with the wider intra row spacing (15 cm) helps to produce higher product in the study area. Because it was helps to produce higher marginal rate of return. Therefore, it is better to use 19: 38: 7 labels of NPS ratio combined with the wider intra row spacing (15 cm) for producing higher garlic product in the study area.

But, since the current study was limited to a single season at only one location, it should be repeated across locations, and season for complete recommendation.

Abbreviations

CV	Coefficient Variation
DAP	Die Ammonium Phosphate
EIAR	Ethiopian Institute of Agricultural Research
LSD	List Significant Deference
NPS	Nitrogen Phosphors and Selphors

Author Contributions

Mandefro Gebre Hibstu is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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