Agriculture, Forestry and Fisheries
2024, Vol. 13, No. 5, pp. 167-174
https://doi.org/10.11648/j.aff.20241305.15

SciencePG
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Research Article

Effect of Intra Row Spacing and Nitrogen Fertilizer Levels on Yield of Shallot in Mulo District, Ethiopia

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Abstract

The shallot is one of the important alliaceous crops cultivated in many tropical countries. It is an important horticultural crop used to flavor the local stew "wot" and a source of income for farmers in Ethiopia. However, the productivity of shallot is low at study area due to various limiting factors such as low soil fertility, plant population and lack of improved agronomic practices. A field experiment was conducted to investigate the effect of intra-row spacing and nitrogen fertilizer levels on growth, yield and quality of shallot at Mulo District, Oromia Regional state, Ethiopia during 2021/22 off season. The treatments consisted of four intra-row spacing (5, 10, 15 and 20) cm and four levels of nitrogen fertilizer (0, 50, 100 and 150) kgNha^{-1} tested in a randomized complete block design with three replications. Data on shallot yield was collected. The interaction effect of intra-row spacing and nitrogen fertilizer influenced the marketable yield, unmarketable yield, bulb weight, bulb fresh weight, bulb dry weight, dry matter and total yield. As a result, the treatment combination of 150kgha^{-1} nitrogen and 15cm intra-row spacing yielded the highest net benefit of shallot (Eth-Birr 1,012,274), followed by the treatment combination of 150kgha^{-1} nitrogen and 20 cm intra-row spacing. In conclusion, the above findings indicated that the combined application of 150kgNha^{-1} with 15 cm spacing can improve shallot growth and productivity in the Mulo district area. However, more research needs to be done in different seasons and locations, taking into account the application rate of nitrogen fertilizer and different intra-row spacing, to generate more reliable information.

Keywords

Interaction Effect, Marketable Yield, Net Benefit, Nutrient

1. Introduction

The shallot is one of the important crops that belong to the Alliaceae family which includes other plants such as chives, leeks, garlic and onions. It was believed that the common onion is originated from central Asia and the shallot is native to Asia Minor [1]. It is very similar to common onion; unlike the common onion, which has a large single bulb, it produces clusters of several bulb splits (2 to 20 bulb lets) [2]. Farmers prefer shallots for their better tolerance to disease, shorter growth cycle and drought stresses and longer storage life than the common onion and for their distinct flavor that per-

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Received: 13 March 2024; **Accepted:** 13 April 2024; **Published:** 26 September 2024

sists after cooking.

The production of shallot was obtained 36,366t from 2970ha with an average yield of 12.24tha-1, which is lower as compared to the world average of 21.37tha-1 produced. The production and productivity of shallot in Ethiopia is constrained by several factor such as pests and diseases, coupled with a low level of improved agricultural technology, recurrent droughts decreases in soil fertility levels, different cultural practices and inappropriate spacing.

Farmers in the study area apply broadcast and zero of fertilizers to shallot. Due to this reason, it is necessary to identify nitrogen fertilizer levels for each area and production system to improve productivity of shallot. And also farmers in the study area use only very close spacing, which is easily suitable to disease and low production. Too low and too high application of nitrogen has great effect on growth and yield of shallot.

Strategies for increase bulb yield and quality of shallot should aim at proper application of essential fertilizers like nitrogen that meet the demand of the crop. At the same time, selecting spacing to better suited to nitrogen fertilizer rate. So far, little research was done on application nitrogen fertilizer levels and intra row spacing on shallot for increase growth and yield. It is given this information, it is crucial to conduct a thorough study into the effects of using nitrogen-based application fertilizer and intra row spacing on shallot yield. Thus, this study was initiated to assess the performance of existing shallot spacing with different nitrogen fertilizer levels for yield of shallot. To evaluate the effect of intra-row spacing and nitrogen fertilizer levels on shallot yield in the study area.

2. Materials and Methods

Description of the Study site. The experiment was conducted at Mulo district, North Shewa, Oromia, Ethiopia, during the 2021/22 off-season cropping. Mulo is 31 km from the north of Addis Ababa and is geographically located at about 9°04' 60.0" N latitude and 38°13' 00.0" E longitude at an altitude of 2315 meters above sea level. The minimum temperature of 6-10 ℃ and maximum temperature of 18-23℃. The mean annual temperature is 15.36℃, with a mean minimum of 8℃ in December and a maximum of 22.9℃ in February and May. The soil of the experimental site was characterized by well-drained clay loam with sand (21% sand, loam 21%, and 58% clay) with a pH of 6.

Description of the Experimental Materials: Improved shallot variety called ‘DZSHT-005 obtained from Debre Zeit Agricultural Research Center (DZARC) was used as planting material for the experiment. ‘DASHT-005 ' was released by DZARC during 2019. The variety is high yielding and well adapted to the agro-ecology of the study area. Urea was applied as a source of nitrogen and which was bought from Mulo agricultural bureau.

Treatment and Experimental Design: The treatment were two factors, namely, four levels of N fertilizer application rates (0, 50, 100, and 150 kgNha-1) and four level of intra-row spacing (5, 10, 15 and 20 cm) combined in a factorial (4 x 4) randomized complete block design arrangement and replicated three times per treatment. Thus, there were 4x4=16 treatment combinations, which accounted for 48 experimental plots. The experimental setup was four levels of nitrogen fertilizer (0, 50, 100, and 150 kgNha-1) and four level of intra-row spacing (5, 10, 15 and 20 cm) combined in a factorial (4 x 4) randomized complete block design arrangement and replicated three times per treatment. Thus, there were 4x4=16 treatment combinations, which accounted for 48 experimental plots.

Experimental Procedure: the experimental field was cleared and ploughed using oxen and the plots were leveled manually. N was applied in the form of urea to the assigned plots of planting which is the source of mineral nutrient is varied depending on treatment was applied as side dressing on planting time. DZSHT-005 was planted in well-prepared rows per bed in January, 2021/22. And later on, other agronomic practices were kept uniform for all treatments as recommended and adopted for the location.

Data Collection and analysis: Yield and quality data were collected. The collected data were statistically analyzed using analysis of variance (ANOVA) and the treatment means were separated using List Significance difference (LSD) at 5% probability level. Five plants were labeled from each plot from four interior rows excluding the border rows. All yield and quality data were collected from sample plants. All data were collected when it was fully covered space 110 days after planting.

3. Results and Discussion

Yield Components and Bulb Yield of Shallot

Bulb length

The interaction of nitrogen and intra-row spacing had a highly significant (p<0.001) on bulb length. The bulb length of shallot increased consistently as the rate of nitrogen application increased, the highest value 5.41cm obtained from the application of nitrogen at 150kgha^{-1} and intra row spacing of 20cm (Table 1). However, which was statistical similar 15cm combination with 150kgNha-1. The growth of a wider bulb length in shallot at higher nitrogen levels could be attributed to the availability of adequate growth resources due to less competition, which allows the bulb to collect more includes available for storage, resulting in a longer bulb. Furthermore, larger bulb length in shallot with high nitrogen application rate and wider space may be linked to nitrogen promoting nature in cell elongation, above ground vegetative growth and synthesis of more chlorophyll to impart dark green color of leaves, which may be linked to an increase in dry matter production and translocation to the bulb. However, the growth of a shorter bulb length in shallot at nil nitrogen levels and closer intra row spacing could be attributed to the availability of insufficient growth resources due to high competition, which prevents the bulb from collecting as many nutrients for photosynthetic, storage and above ground vegetative growth, resulting in a shorter bulb length.

Hordofa et al. [3] Reported that increasing the rate of nitrogen significantly increased bulb diameter, indicating that nitrogen promotes growth of bulbs. The lowest value 2.95cm was recorded bulb length at nil application of nitrogen and intra row spacing of 5cm (Table 1). The current result is supported by the finding of [4] who stated that higher bulb diameter was achieved for the wider plant spacing as compared to the closer spacing of onion.

Bulb diameter

The interaction of nitrogen application fertilizer and intra row spacing had a highly significant (p<0.001) effect on bulb diameter. Application of highest rate of nitrogen (150 kg ha-1) on plants spaced at widest intra row spacing (15cm) recorded the highest bulb diameter as indicated in (Table 1). However, which was statistical similar 20cm combination with 150kgNha-1. The development of wider bulb diameter of shallot at higher nitrogen could be attributed to the availability of sufficient growth resources due to less competition that enable the bulb to accumulate more assimilates available for storage and result in higher bulb diameter. Increased nitrogen supply may have accelerated vegetative development and carbohydrate synthesis, resulting in carbohydrate translocation to bulbs and larger shallots. [5] Reported that increasing the rate of nitrogen significantly increased bulb diameter, indicating that nitrogen promotes growth of bulbs.

On other hand, the nitrogen fertilizer rates and smaller intra-row spacing of 5 cm produced the narrowest average bulb diameter (Table 1). This could be because plants grown with the shortest spacing received less soil water, nutrients and solar radiation with high interplant competition, allowing for lower foliage growth and, as a result, bulb expansion, resulting in lower bulb diameter. The finding was consistent with this of [6] also reported that application of nitrogen fertilizer up to 136kgha^{-1} significantly improved the weight of onion bulbs.

Average bulb weight

The interaction effect of nitrogen fertilizer rate application as well as intra row spacing had a highly significant (p<0.001) on average bulb weight. The highest average bulb weight 72gha-1 was recorded at treatment with the highest rate of nitrogen (150kgNha-1) and wider intra-row spacing (15cm). The increased average bulb weight with increasing intra-row spacing could be attributed to less competition with widely spaced plants, resulting in heavier bulb weight per plant. This could be related to an increase in dry matter production and distribution to the bulb. Furthermore, this could be due to an increase in bulb size and weight in response to nitrogen application, which could have increased photosynthesis and, as a result, enhanced growth and expansion of vegetative growth overall. The mean bulb weight was found to be absolutely and strongly associated with bulb length and diameter in this study, indicating that nitrogen fertilization increased bulb weight. This could be due to an increase in bulb size and weight in response to nitrogen application, which could have increased photosynthesis and, as a result, enhanced growth and expansion of vegetative growth as a whole, eventually partitioning significantly higher carbohydrates to the bulbs at maturity and less competition with widely spaced plants.

On other hand, the lowest average bulb weight 24.85gha-1 was recorded at treatment combination of nil nitrogen rates and narrower intra row spacing of 5cm. This could be attributed to high competition with closely spaced plants, resulting in smaller bulb weight per plant. The highest average bulb weights were recorded at treatment combination of highest rate of nitrogen and wider intra-row spacing while the lowest average bulb weight was recorded at treatment combination of nil rate of nitrogen rate and narrower intra-row spacing [7].

Bulb fresh weight

The interaction effect of nitrogen application rate as well as intra row spacing had highly significant (p<0.001) influence on bulb fresh weight. The highest bulb fresh weights of shallot were recorded at treatment combination of highest rate of nitrogen (150kgNha-1) and wider intra-row spacing 15cm (Table 1). The reason for maximum fresh bulb weight at wider spacing could be explained by plants grown at the greatest spacing receiving more soil water, nutrients and solar radiation with less interplant competition, promoting vigorous growth and larger-sized bulbs with increased bulb weight. Furthermore, the maximum fresh weight of bulb in the highest nitrogen dose could be that increased nitrogen supply in plants improved vegetative growth and accelerated greater carbohydrate synthesis, causing carbohydrates to be translocated from leaves to storage organs or bulbs, resulting in increased bulb fresh weight.

While, the application of nil nitrogen fertilizer in kilogram per hectare with intra row spacing of 5 cm resulted in the lowest bulb fresh weight (26.00g), but which was statistically similar to the application of nil nitrogen fertilizer in kilogram per hectare with intra row spacing of 10cm. The reason for minimum fresh bulb weight lower nitrogen supply in plants and narrowest plant spacing high competition between plan density and nil fertilizer, so less enhanced vegetative growth and accelerated carbohydrate synthesis because individual plants received less soil water, nutrients and solar radiation under less interplant competition, causing carbohydrates to be translocated from leaves to storage organs or bulbs, thereby decreasing fresh bulb weight. Generally, as nitrogen increased with space in further it decreased bulb fresh weight. These finding is consistent with this of [8], who found that increasing the rate of nitrogen fertilizer.

Bulb dry weight

The interaction effect of Nitrogen rate and intra row spacing was highly significant (p< 0.01) on bulb dry weight at 105^{0}C with 60hr. The combination of application nitrogen

150kgha-1 and at intra row spacing 20 cm resulted in the highest bulb dry weight (11.08g), but it was statistically similar to the applications of nitrogen rate 150kgha-1,100 kgha-1 and intra row spacing of 15cm, 20cm respectively. The reason for highest bulb dry weight, due to high photosynthetic area in reaction to nitrogen fertilization and in wider intra row spacing may have increased assimilate production and partitioning to the bulbs, resulting in increased bulb dry weight.

On the other hand, applying nitrogen rate at a nil of in kilogram per hectare and intra row spacing 5 cm resulted in the lowest 5.7g bulb dry weight, but it was statistically similar to applying nil nitrogen in kgha^{-1} and at intra row spacing of 10cm and 15cm. The bulb dry weight increased from 5.7g to 11.08g as the intra-row spacing increased from 5 cm to 20cm. This could be because closer spacing between plants resulted in high competition for nutrients, moisture and light, reducing the amount of assimilate produced and stored in the bulbs, resulting in lower bulb dry weight. [9] Reported that, as intra-row spacing increased from 5 cm to 20cm, the bulb dry weight was also increased from 6.98 g to 9.33g.

Percentage of dry matter content

The interaction effect of nitrogen and intra row spacing had highly significant (*p*<0.01) on dry matter content in percentage. The application of nitrogen at a rate of 150kgha^{-1} combination within intra row spacing of 20 cm resulted in the highest percentage of dry matter content 10.73 % (Table 1). This could be as application of nitrogen rate increased with intra row spacing has an important function in all living tissues of the plant, promoting bulb formation and the translocation of nutrients from leaf to bulb, which raises the percent dry matter content. However, the application of nil nitrogen rates in kgha-1 and intra row spacing of 5 cm resulted in the lowest percentage of dry matter content (5.1%), which was statistically equal to the nil nitrogen with 10cm and 15cm. The reason, due to the application of a nil nitrogen rate with closer intra row spacing not encouraging bulb formation and the translocation of nutrients from leaf to bulb and high competition between plants, which lowers the percent of dry matter content.

Table 1. *Interaction effects of nitrogen fertilizer and intra row spacing on shallot parameter.*

Treatment		**Yield Components**					
S	**N**	**BL**	**BD**	**ABW**	**BFW**	**BDW**	**BDM (%)**
5	0	2.95^{i}	3.07^{k}	24.85^{m}	26.00^{i}	5.70^{f}	5.10^{i}
5	50	3.12^{h}	3.19^{j}	36.16k	36.00^{h}	6.16^{ef}	6.76^{h}
5	100	3.38^{g}	3.42^{i}	46.13^{i}	48.00^{g}	6.25^{ef}	7.48^{gh}
5	150	3.54^{f}	3.56^{h}	51.21^{g}	52.67^{f}	6.30^{ef}	9.32^{cd}
10	0	3.03^{hi}	3.13^{jk}	30.95^{i}	28.00^{i}	5.71^{f}	5.14^{i}
10	50	3.61^{f}	3.23^{j}	48.83^{h}	48.00^{g}	6.16^{ef}	7.54^{fgh}
10	100	4.01^{e}	4.58^{e}	64.86^{e}	71.67^{e}	6.26^{ef}	8.89^{de}
10	150	5.17^{b}	4.73^{d}	67.85^{c}	113.33^{bc}	8.48^{c}	10.62^{ab}
15	0	3.11^{h}	3.36^{i}	34.95^{k}	33.67^{h}	5.78^{f}	5.25^{i}
15	50	3.540^{f}	3.60^{gh}	52.01^{g}	55.00^{f}	6.65^{e}	7.95^{fg}
15	100	4.83^{c}	4.88^{c}	66.21^{de}	103.00^{d}	9.88^{b}	9.55^{cd}
15	150	5.40^{a}	5.45^{a}	72.00^{a}	118.67^{a}	11.05^{a}	10.46^{ab}
20	0	3.12^{h}	3.68^{g}	38.37^{j}	36.00^{h}	5.92^{ef}	6.98^{h}
20	50	3.51^{f}	4.06^{f}	56.11^{f}	69.33^{e}	7.57^{d}	8.31^{ef}
20	100	4.67^{d}	5.22^{b}	66.56^{cd}	110.33^{c}	10.58^{a}	9.85^{bc}
20	150	5.41^{a}	5.45^{a}	69.86^{b}	117.67^{ab}	11.08^{a}	10.73^{a}
CV (%)		2.00	1.50	1.80	4.20	6.50	6.10
LSD (5%)		0.13	0.10	1.51	4.65	0.81	0.82

Note: LSD=least significant difference, CV= Coefficient of variation, HI=harvest index, BL=bulb length, BD=bulb diameter, ABW=average bulb weight, BDW=bulb dry weight, BDM=bulb dry matter

3.1. Harvest Index

The interaction effect of nitrogen as well as intra row spacing was extremely significant (p<0.001), on the harvest index. The harvest index increased dramatically as the rate of nitrogen application increased in tandem with the increasing rate of intra-row spacing. Thus, nitrogen application at a rate of 150kgha^{-1} with a 15 cm intra-row spacing resulted in the highest yield index, followed by nitrogen application at a rate of 150kgha-1 with a 10cm intra-row spacing (Table 2). Highest harvest index due to the presence of more leaves, wider leaves and wider pseudo stems at greater spacing. It could be linked to the occurrence of higher leaf length, leaf diameter and plant height at the application of 150kgNha-1 and 15 cm intra-row spacing, which may have resulted in high above ground biomass and marketable bulb yield having a higher harvest index.

The harvest indices were lowest for shallot plants that had no nitrogen application and had intra-row spacing of 5cm, 10cm and 20cm. The results showed that nitrogen rate grown with narrow intra-row spacing had a lower harvest index. This could be because the presence of shorter leaf and plant heights, as well as thin leaf diameters in close spacing, reduced above ground biomass and resulted in lower harvest index. It could possibly be related to the occurrence of lower leaf length, leaf diameter and plant height in the 0kgNha-1 and 5 cm intra-row spacing in treatment combination, which may have resulted in less above ground biomass and lower marketable bulb yield having a lower harvest index.

3.2. Biomass Bulb Weight

The interaction effect of nitrogen and intra row spacing was extremely significant (p<0.001) influenced dry total biomass yield. The biomass yield increased theatrically as the rate of nitrogen application increased in bike with the increasing rate of intra-row spacing. Thus, nitrogen application at a rate of 150kgha-1 with 20cm intra-row spacing resulted in the highest biomass, followed by nitrogen application at a rate of 150kgha-1 with 15cm intra-row spacing.

However, plants treated with nil kgNha^{-1} and spaced 10cm apart produced the lowest dry total biomass yield. The increase in total dry biomass yield in response to the increasing rate of nitrogen fertilizer and wider intra-row spacing may be probably associated with the nitrogen supply, which enhances the vegetative growth of plants like leaf number, leaf diameter, leaf length and plant height which contribute for improved rate of photosynthesis and assimilate production in the vegetative part. Plants grown at the widest spacing produced the highest dry total biomass yield possibly due to less competition among them for growth resources. Supporting the current study, [10] reported that higher values of shoot and bulb dry weight leads to higher in dry total biomass of onion in wider spacing.

3.3. Marketable Bulb

The interaction effect of nitrogen fertilizer rate and intra row spacing had been highly significant (p<0.001) influenced by the marketable bulbs. The highest 34.06tha-1 marketable bulb yield of shallot was recorded at treatment combination of 150kgNha^{-1} and 15 cm intra-row spacing but, further increase of intra row spacing beyond 15cm did not increase the yield (Table 2). The reason for highest marketable bulb yield due to the height, leaf number per plant, and leaf length increased with increasing spacing in the current study, a greater number of plants per unit area with an adequate supply of nitrogen increased marketable bulb yield. Furthermore, the influence of high application nitrogen and widest intra row spacing highest in the marketable yield of the shallot bulb, this could be attributed to more received nitrogen and low competition playing a more important role in plant protein and hormone formation; thus, having a good marketable bulb helps.

On the other hand, plants spread out at narrowest (5cm) intra-row spacing without nitrogen (0kgha-1) recorded lowest marketable bulb yield of shallot 14.58tha-1 which was statistically similar to nil nitrogen in kgha-1 and intra row spacing at 10cm. The reason for the lowest marketable bulb yield was due to short plant height, leaf number per plant and leaf length decreasing with closer spacing, as well as a lower number of plants per unit area with nil supply of nitrogen. The marketable bulb yield of shallot per unit area is related to the total number of plants per unit area and yield contributing parameters in addition to the performance of individual plants. These findings are consistent with the findings of other researchers who found that maximum onion bulb yield was obtained with treatment combinations of narrow intra-row spacing and optimal nitrogen fertilizer levels. [11] Also demonstrated that the highest marketable bulb yield of onion was recorded at treatment of 82kgNha^{-1}.

3.4. Unmarketable Bulb

The interaction effect of nitrogen rate as well as intra row spacing highly significant (p<0.001) influenced unmarketable bulb yield of shallot. The highest 2.21tha^{-1} unmarketable bulb yield of shallot was recorded at treatment combination of nil nitrogen in kilogram per hectare and intra-row spacing of 5cm (Table 2). Because there were more plants per unit area, closer plant spacing enhanced competition for growth factors, resulting in a lower number of undersized bulbs and a higher unmarketable bulb yield.

However, the application of nitrogen at the rate of 150kgha-1 with intra row spacing at 15 cm resulted in the lowest 0.45tha-1 (Table 2). The lower unmarketable yield in higher rate of nitrogen might be attributed to less competition for growth resources which results in larger bulbs which increased the proportion of the marketable bulb yield. In further, might be ascribed mainly to nitrogen deficiency and sub-optimal growth of plants which in turn resulted in weaker plants prone to disease and other biotic and abiotic stresses as well as low assimilate produced, resulting in lower size of bulbs. [12] Who reported highest unmarketable yield (39.52tha-1) and lowest total marketable yield from closest and widest intra-row spacing, respectively.

3.5. Total Yield

The interaction effect of nitrogen fertilizer rate as well as that of intra-row spacing highly significant (p<0.001) influenced the total bulb yield of shallot. Total bulb yield increased significantly in response to increasing the rate of nitrogen fertilizer application and wider intra row spacing (Table 2). The highest total bulb yield 34.51tha-1 was observed in the interaction effect of plants supplied with nitrogen at 150kgha^{-1} and planted at intra row spacing of 15cm. However, which was statistical similar with 20cm combination 150kgNha-1. The total bulb yield increased significantly in response to increasing the rate of nitrogen application of 150kgha-1 with the intra-row spacing of 15 cm in treatment combinations, which were started from zero nitrogen application but deeply when increasing wider space the yield was decreased. However, the increase occurred only up to at the intra-row spacing of 15cm, beyond, which the total bulb yield decreased.

The treatment combination of no nitrogen application fertilizer and 5cm intra row spacing, on the other hand, yielded the lowest overall bulb yields of 16.79tha-1(Table 2). Furthermore, this may be indicated that the increased nitrogen rate might have an inhibitory effect on bulb growth process which increased leaves development but reduced bulb initiation. Therefore, results of the present study clearly indicated that increasing shallot bulb total yield is possible up to a certain level of nitrogen fertilizer application rate. The study was in agreement with the findings of [13] who reported decrease of bulb yield at wider intra row spacing due to the insufficient number of plants grown per hectare.

The increased total bulb yield by high plant population could be explained due to the increased number of plants in the stand and consequently resulted in higher number of bulbs produced per unit area.

Table 2. *Interaction effects of spacing and nitrogen on yield.*

Treatment				**Yield**		
S	**N**	**HI**	**Biomass**	**Marketable**	**Unmarketable**	**Total yield**
5	0	57.77^{k}	25.24^{m}	14.58^{j}	2.21^{a}	16.79^{i}
5	50	63.68^{h}	28.62^{k}	18.23^{h}	1.94^{c}	20.16^{g}
5	100	70.92^{e}	31.25^{i}	22.16^{g}	1.85^{d}	24.00^{f}
5	150	77.76^{bc}	34.17^{g}	26.57^{e}	1.09^{e}	27.65^{d}
10	0	59.65^{j}	24.83^{m}	14.81^{j}	2.13^{b}	16.93^{i}
10	50	67.35^{g}	32.75^{h}	22.06^{g}	1.8^{d}	23.86^{f}
10	100	77.14^{c}	35.38^{f}	27.29^{e}	0.96^{f}	28.25^{d}
10	150	78.83^{b}	39.33^{c}	31.00^{c}	0.63^{i}	31.63^{b}
15	0	62.34^{i}	26.36^{l}	16.43^{i}	1.98^{c}	18.41^{h}
15	50	70.05^{ef}	36.3^{f}	25.20^{f}	1.13^{e}	26.33^{e}
15	100	78.22^{bc}	38.38^{d}	30.02^{cd}	0.85^{g}	30.87^{bc}
15	150	80.45^{a}	42.34^{b}	34.06^{a}	0.45^{j}	34.51^{a}
20	0	63.17^{hi}	30.19^{j}	19.07^{h}	1.95^{c}	21.02^{g}
20	50	68.88^{f}	35.26^{f}	24.29^{f}	1.09^{e}	25.38^{e}
20	100	75.05^{d}	39.15^{c}	29.38^{d}	0.73^{h}	30.11^{c}
20	150	74.51^{d}	44.02^{a}	32.80^{b}	0.57^{i}	33.37^{a}
CV (%)		1.14	0.80	3.10	2.90	2.90
LSD (5%)		1.33	0.43	1.23	0.65	1.25

Note: LSD=Least significant difference, CV= Coefficient of variation, BFW=bulb fresh weight

4. Conclusions

Shallot is one of the oldest cultivated crops and widely used around the world for its characteristic essence as a seasoning, condiment, spice, medicinal and agent food. It is a popular vegetable production in Ethiopia. Because Ethiopia has the ability to grow shallot crop all year long with a combination of small rains and bulb irrigation. However, farmers are producing the crop with very low rates of nitrogen fertilizer and without considering spacing especial depend on broadcasting, zero fertilizer and high plan density in study area. Proper nitrogen fertilizer applications and agronomic management have an undeniable contribution to increased crop yield, productivity and high acceptance of the market. As a result, the nitrogen fertilizer application rates and intra-row spacing were two important agronomic practices that influenced the yield and quality of Shallot bulbs. The optimal management of nutrients through fertilization is regarded as an essential component in a farming system, contributing significantly to the aspects of increasing soil fertility, productivity and crop quality. Furthermore, plant population influences interplant competition for growth factors like water, nutrients and sunlight, which influences plant growth and development if proper spacing is not used. As a consequence, both are necessary in shallot production because they affect shallot bulb development, yield, and quality. As a result, the optimal spacing and plant population are those that maximize yield, vegetable quality and farmer profits while minimizing expenses. Because of the impact of intra-row spacing and nitrogen fertilizer level on shallot yield and quality and to identify the appropriate intra-row spacing and nitrogen fertilizer rate that improves yield and quality as population grows.

In general, during the collection and analysis of data, nitrogen application at 150kgha^{-1} and intra row spacing of 15 cm produced the best results. Nitrogen and intra-row spacing had a significant impact on all yield and quality parameters. From this study, significantly taller plant height was obtained at the 150kg ha^{-1} nitrogen fertilizer rate and 20cm intra-row spacing.

Generally, the results showed that best performed best at combination of 150kgha^{-1} nitrogen fertilizer application within intra-row spacing of 15 cm shallot growth.

Acknowledgments: The authors give thanks to Wallaga University Shambu campus for funding the study, the Mulo district for giving labour and nitrogen fertilizer, for supplying the experiment site and the Beshoftu Agriculture Research Centre for providing the shallot variety. The authors of all cited sources have been acknowledged in the paper.

Abbreviations

g	Gram
ha	Hectare
Kg	Kilogram
N	Nitrogen
t	Tone

Data Availability

Available in the manuscript.

Funding

No funding received for this research.

Conflicts of Interest

The authors declare no conflicts of interest.

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