Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.11, 2015

Effect of Spacing and Nitrogen Fertilizer on the Yield and Yield Component of Shallot (Allium ascalonium L.)

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Abstract
This research was conducted to study the interaction effect of different rate of nitrogen fertilizer and plant spacing on yield and yield components of shallot under Jimma condition, in the experimental field of College of Agriculture and Veterinary Medicine, Jimma University. Local variety of shallot was used with the three level of nitrogen (0kg/ha, 100kg/ha, 150kg/ha) and three intra-row spacing (10cm, 15cm, 20cm). The result of this field experiment indicated that, the interaction effect of 150gk/ha and 20cm spacing resulted highly significant plant height (30.33cm) ($p<0.05$). Nitrogen levels significantly affected the number of leaves per plant of shallot with the highest value (27.84cm) obtained from 100 kg N ha^{-1} ,so statistically significant($p<0.05$). There was no significant effect of interaction between nitrogen and intra-row spacing on leave number of shallot. Significantly largest stem diameter 0.63cm ($p<0.50$) was obtained from intra-row spacing of 20cm. But there was no interaction effect of nitrogen and spacing on the stem diameter of shallot. There was no interaction effect of nitrogen fertilizer and spacing on the bulb diameter of shallot. No significant difference was obtained with the interaction effect of nitrogen and spacing on shallot bulb weight. An increased N dose to 100$kgha^{-1}$ resulted in the increased yield of shallot bulbs to 30.2 tha^{-1} which was significantly different from 0$kgha^{-1}$ and 150$kgha^{-1}$($p<0.05$). From this finding the highest growth performance of plant which leads to increased yield could be using 150$kgha^{-1}$and spacing of 20cm.However the conclusive recommendation should be based on the results of repeated experiments.
Keywords: Shallot, Nitrogen, Spacing, Plant height, Leave number

1. Introduction

Shallot (*Allium ascalonium L.)*is an onion like plant that is originated from Western Asia. Shallot belongs to the family of alliaceae (Splittsstoesser, and Walter, 1990). This includes other plants such as chives, leeks, garlic and onions. The main differences between ordinary onions and shallots are that shallots grow in clusters with the separate bulbs being much smaller than regular onions, usually up to the size of a golf ball, which are attached at the base (UK foodonline.co.uk.2006).

This plant is similar to common onion but smaller. The bulbs when planted divides and produces more than two and up to 15 distinct small bulbs (cloves) which remain attached at the bottom in cluster or aggregated. Environmental response is tolerant to a wide range of soils with PH of six to seven loose, sandy soils with a high level of organic content are preferable. Plants are very tolerant to high temperature up to 30^{o}c and relatively high temperatures encourage bulb development in most cultivars. Most cultivars grow well at altitudes varying from sea level to 2500m. Large bulbs are formed in day length of twelve hours than of ten hours (Tindall, 1983).

Shallot is propagated by using bulb or segments as a planting material. Dry bulbs planted a spacing of 20cm between plants and 35cm between rows and one large or two small bulbs are planted in each hill. When planting, bulbs should be only half buried in the soil. They are best suited to cooler locations or winter cultivation. They require more frequent watering than do onions and maturity time is three months; although they can be picked for salad use earlier (William, 1991).

According to Tindal (1983), bulbs which are formed in clusters of four to eight can normally be harvested 60-100 days from planting by which time the leaves will have become yellow depending on the cultivar characteristics. Young bulbs, with green leaves, are also harvested for use in salads.

Shallot is the most widely cultivated and favorite vegetable crops in Ethiopia. Its use as a condiment for many local dishes has significant importance. Shallots are rather exacting in their soil requirements, a sandy loam being best. In Ethiopia, they are planted during the rainy season and the tops of the sets are cut before planting. Depending on the availability of water and the cultivars, it should be possible to raise more than one crop in growing season (Getachew and Asfaw, 2000). Shallot is an annual and several bulbs are rising from single parent bulb. The leaves are slightly flattened on upper surface, 7-20mm in diameter, up to 40cm in length. Flower born in umbels, cape up to 25cm in height, perianth segments 6, length4-6mm, green-white; stamens 6, short, alternation with parianth segments ovary superior, 3-locular and simple style. Fruit is a globular capsule, containing many seeds. The seeds are black, wrinkled at maturity, 6mm x 4mm and sickle shaped embryo. However, bulbs (cloves) are variable in shape, size and colour, covered with thin red scale leaves (H.D.Tindal, 1983).

Shallots contribute significant nutritional value to the human diet and have medicinal properties and are primarily consumed for their unique flavor or for their ability to enhance the flavor of other foods (Randle, 2000). On a global scale, shallot is a minor alliaceous crop. However, in many tropical countries the vegetative propagated shallot is cultivated as an important bulb crop. Shallot is a crop used as a main ingredient in most traditional Ethiopian cuisine. The shallot cultivated in Ethiopia is pungent red in colour, dry bulb type which is exclusively propagated by vegetative means. However, loss of bulb weight and quality are the principal problems encountered during post-harvest storage and transport of the shallot (Currah and Proctor, 1990).

Applications of 50kg N/ ha gave higher bulb yield per plant and per hectare than the control and the 200kgN/ ha but did not differ from the 100 and150kg N/ ha rates. The average of weight of bulb splits at 50 kg N/ ha was also significantly higher (9.9g).However average number of bulbs splits per plant of the 50kg N/ ha was not significantly different from all the other N rates (Pandey, 1991 and Sharma, 2008) showed continuous increase in the yield of shallot with increase in N rates beyond 50kg/ ha up to 200kg /ha. The shortage of further increase in yield with increase in N rate beyond 50 kg N/ ha might partially be attributed to the high soil N. Liu *et.al*., (2009) reported that N fertilizer had more pronounced effect on shoot length and sheath diameter of shallot but there is no significant difference in number of shoot per plant. The experiment further revealed that application of 50kg N/ ha in two splits is economically sound to gate the highest bulb yield of shallot. The rate of biological fixation of nitrogen is greatly dependent on soil and climatic conditions (Nyle. C, 1990).

Plant population is one of the factors that need to be optimized. The optimum use of spacing or plant population has dual advantage. It also avoids strong competition between plants for growth factor such as water, nutrient, and light. Conversely optimum plant population enables efficient use of available crop land without wastage (Zubelidia and Gases, 1977). Shallot is propagated by using bulb lets or segmented as planting materials. Dry bulbs planted at spacing of 20cm and 35cm between plants and inter-raw respectively in each hill. Age planting is advisable to ensure drainage. Environmental requirement such as adequate moisture, temperature, soil moisture, rain fall, appropriate irrigation, sandy loam soils, root emergency and the plant goes through a period of vegetable growth.

Resprouting of plants in the field due to unexpected rainfall at crop maturity poor storability and low selling price at pick harvest (about three times lower than during planting time) are also bottlenecks in shallot production. Shortages of different panting densities, the optimum for high production are not yet identified. Fertilizers which are optimums for high production are not yet determined in the view of crops exacting soil requirements, handling and storage problems. (Godfrey, et.al., 1987).

Spacing is frequently referred to as a limiting factor but in reality embraces two or more of factors already listed (Soffe, 1995). The competition occurs between plants of the same species and is termed as intra-specific competition. In extreme cases of crop plant growing in complete isolation, its individual yield gives an indication of the maximum yield possible per plant (Robin and Kamenetsky, R., 2002).

Close spacing of individual plants suffer much from competition and the crop may be impaired in too wide spacing; however, the yield per hectares may be reduced because of reduction in plant number and the plants become too large and/or wood for consumption, and weeds allow developing aggressively in the open space between crop plants.

The production of the shallot is highly related to agronomic and management practice. Because, inappropriate management and agronomic practice decrease the growth performance and yield of shallot. Among them, improper spacing and the rate of nitrogen fertilizer applications are among the factors which affect crop emergence, growth and yield of shallot.

Therefore, to solve these problem or increase growth performance and seedling emergence; research is required to carry out to analyze or to assess the influences of factors listed above. Hence the objective of this study was to determine the effect of spacing and nitrogen fertilizer for better yield of shallot and to determine the combination effect of nitrogen fertilizer rate and plant density on yield and yield component of shallot.

2. Materials and methods

2.1 Materials used

The materials used during our field work were Hoe, Fork, spade, Peg Note book, Pen Pencil, Calculator, Ruler Nitrogen fertilizer Sensitive balance, Rake, Water cane and Knife.

2.2 Methodology and procedure followed

2.2.1 Description of study area

The experiment was conducted at Jimma university college of Agriculture and Veterinary Medicine (JUCAVM) in 2013 under field condition and irrigation. JUCAVM was geographically located 335km south west of Addis Ababa at about 7^o, 33N latitude and 36^o, 57'E longitude at an altitude of 1700m.a.s.l. The mean maximum and minimum temperature were 28.8^{o}c and 11.4^{o}c respectively and the mean maximum and minimum relative humidity were 91.4% and 39.92% respectively. The mean rain fall of the area was 1500mm. The soil of the experimental site was well drained clay to silt soil and also the area was surrounded by some plants which are used as wind breaks. The area has slightly gentle slope which reduce erosion (BPEDOR, 2000).

2.2.2. Experimental design

Appropriate type of experimental design was selected on which the research trial was conducted. Accordingly, Randomized Complete Block Design (RCBD) was used. The number of combine treatment were 9, number of replication of the treatment were 3, distance between plot and row was 1m and 0.5m respectively, distance between plant where 10, 15 and 20 cm and area of each plot was $1m^2$. Identification of the place where each plot was located on the designed area to ensure which plots receive which treatment was fixed by using random number.

2.2.3. Field layout and randomization

The two factors (effect of different rate of nitrogen and plant density) were evaluated. Three levels of nitrogen rates (0kg/ha, 100kg/ha 150kg/ha) and three levels of plant density 10 cm, 15cm and 20cm were used and the treatments was combined. The combined treatments were replicated three times and RCBD design was used. The space between blocks (replications) was 1cm. The space between plots along the replication was 1m, and the space between sub plots the main plot was 0.5m. Net area=1m*27m=$27m^2$,Production area=14m*5m=$70m^2$.

There were 5 rows per plot. But the data was collected from the three (10% of the total plant /plot) most centrals of shallot plant on each plot and the left rows was considered as a border effect.

2.2.4. Experimental Procedures

During our field research work the following procedures were followed. Suitable site was selected, the soil nutrient content was analyzed, and the land was cleaned (unwanted materials and vegetables were removed). The area was measured by using trigonometric theorem and land digging and plot preparation according to the length and width recommended to the shallot production was done. Bulbs of local shallot were bought from Jimma market and cut by knife before planting and contacted with ash to facilitate sprouting and to produce many shoots. During cutting knife was disinfected by ethanol alcohol to prevent (reduce) microorganism infection. The bulb was planted with spacing (10cm, 15cm, 20cm) and three nitrogen level (0,100,150 kg/ha) and the space between row was 50cm. Watering was continued with the recommended rate of watering (day by day) until shallots finished its growth and development. Weeding the plot (bed) with the interval of a week was applied. Data was collected three times after eight weeks of sowing from five plants per plot and the result was interpreted and the result was discussed as follow.

2.3. Method of data collection

After eight weeks of sowing, the desired data was taken from the three rows of each plot randomly through measuring plant height; number of leaves per bulbs, stem diameter; weight of the bulb, and bulb diameter of the sample plant was used. The bulb weight was subjected to sensitive balance measurement.

2.4. Collected Data

The following parameters were studied:

Measuring Plant height (cm): Plant height for five randomly selected plants per plot was measured using ruler.

Counting number of leaves/bulb: The number of leaves per bulb for five randomly selected plants was counted.

Measuring stem diameter (cm): Stem diameter for five bulbs per plot was measured using ruler and tread.

Measuring of bulb diameter (cm): Bulb diameter for five randomly selected shallots per plot was measured using ruler.

Measuring Weight of bulb (gm): Bulb weight for five randomly selected shallots per plot was measured using sensitive balance.

Counting of bulb numbers (t/ha): Bulb number for five randomly selected shallots per plot was counted manually.

2.5. Data analysis

Data collected was subjected to analysis of variance (ANOVA) using SPSS package and the means separated by using Duncan multiple range test (DMRT) at 0.05 level of significant. Fcal was calculated from the data and a probability of committing type one error (alpha) of 0.5 or 5 % was used to calculate the tabulated value of F (Ftab).

2.6. Beneficiaries'

The end result of this research will be used by the farmers, state farms, institutions, researchers and any individuals.

3. Results and Discussion

Table: 1. Effect of nitrogen on the yield and yield component of shallot

parameter	Nitrogen (Kg/ha			
	0	100	150	**LSD (5%)**
Plant height (cm)	24.11a	24.77a	25.72a	3.53
Leaves No	19.17b	27.84a	20.11b	3.44
Bulb yield (t/ha)	18.78b	30.20a	27.10b	2.20
Bulb weight gm)	25.9a	24.36a	30.9a	3.20
Bulb diameter (cm)	3.99a	3.83c	3.90b	0.86
Stem diameter(cm)	0.577c	0.578b	0.61a	0.11

*Numbers with the same letter within the row means, they are statistically the same at 5% probability level.

Table: 2. Effect of intra-raw spacing on the yield and yield component of shallot

parameter	Intra-row spacing			
	10	15	20	**LSD (5%)**
Plant height (cm)	22.66bc	27.28ab	24.65ab	3.53
Leaves No	20.6a	20.57a	19.95a	3.44
Bulb yield (t/ha)	30.71a	28.5b	25.44c	2.20
Bulb weight gm)	26.26b	34.77a	26.11b	3.20
Bulb diameter (cm)	3.93b	3.62c	4.16a	0.86
Stem diameter(cm)	0.566b	0.566b	0.63a	0.11

*The numbers with the same letter within the row means, they are statistically the same at 5% probability level.

Table: 3. Effect of interaction between nitrogen and intra-row spacing on yield and yield component of shallot

N(Kg/ha	Intra-row spacing (cm)	Plant height (cm)	Leaves Number per plant	Bulb yield(t/ha)	Bulb weight (gm)	Bulb diameter (gm)	Stem diameter (cm)
0	10	26.26b	15.73c	23.4cd	26.23bc	4.00a	0.63ab
	15	18.73d	21.27b	24.53cd	24.93c	3.63a	0.53c
	20	22.47c	20.53b	28.4ab	27.60b	4.33a	0.50c
100	10	26.80a	21.13b	19.1de	26.00bc	3.66a	0.70a
	15	25.07a	20.53b	25.5bc	30.53a	3.33b	0.57b
	20	24.20a	23.87a	26.56abc	27.10b	4.10a	0.53c
150	10	24.73bc	20.26b	21.63d	26.57bc	4.13a	0.57b
	15	25.23bc	19.93b	30.26a	24.80c	3.50b	0.60ab
	20	30.33a	24.26a	28.17ab	21.70d	4.07a	0.67ab
LSD (5%)		1.35	2.13	3.36	2.24	0.65	0.10
CV		7.08	11.4	8.18	6.75		5.04

*Means within the same column followed by a common letter are not significantly different at $P \leq 0.05$; ns, **, Non-significant and significant difference at $P \leq 0.001$, respectively; LSD: Least significant difference; CV: Coefficient of variation: plant height, leave number, stem diameter, bulb diameter, bulb weight of bulb and bulb yield of shallot.

3.1 Plant Height

Nitrogen had no significant effect on plant height of shallot with the highest value 25.72 cm obtained from application of 150 kg N ha^{-1} (table1) which was not highly significant from 24.77cm which obtained from the application of 100 kg N ha^{-1} (Appendix 1).The highest plant height 27.28cm (Appendix 1) was obtained from intra-row spacing of 15cm followed by 24.65 cm with the spacing of 20cm. The shortest plants 22.66 cm was observed from 10 cm intra-row spacing. Closer spacing resulted in competition for nutrient and light thus resulting in plants that were short while the wider spaced plants had adequate space for their growth and development.

There was a significant effect of interaction between nitrogen and intra-row spacing on height of shallot. The interaction effect of 150gk/ha and 20cm spacing revealed highly significant plant height (30.33cm). So that application of 150 $kgha^{-1}$ and 20cm spacing is highly significant at ($p<0.05$) from the others treatments. This could be due to luxury consumption where enough nutrients were available thus preventing competition between plants in which my study in line with (Soffin, 1995), reported that the average plant height (42.1cm) was obtained with the application of 150kg/ha and spacing of 20cm. At 0 kg N ha^{-1} 15 cm intra-row spacing (Appendex1) was result shortest plant 18.73cm.

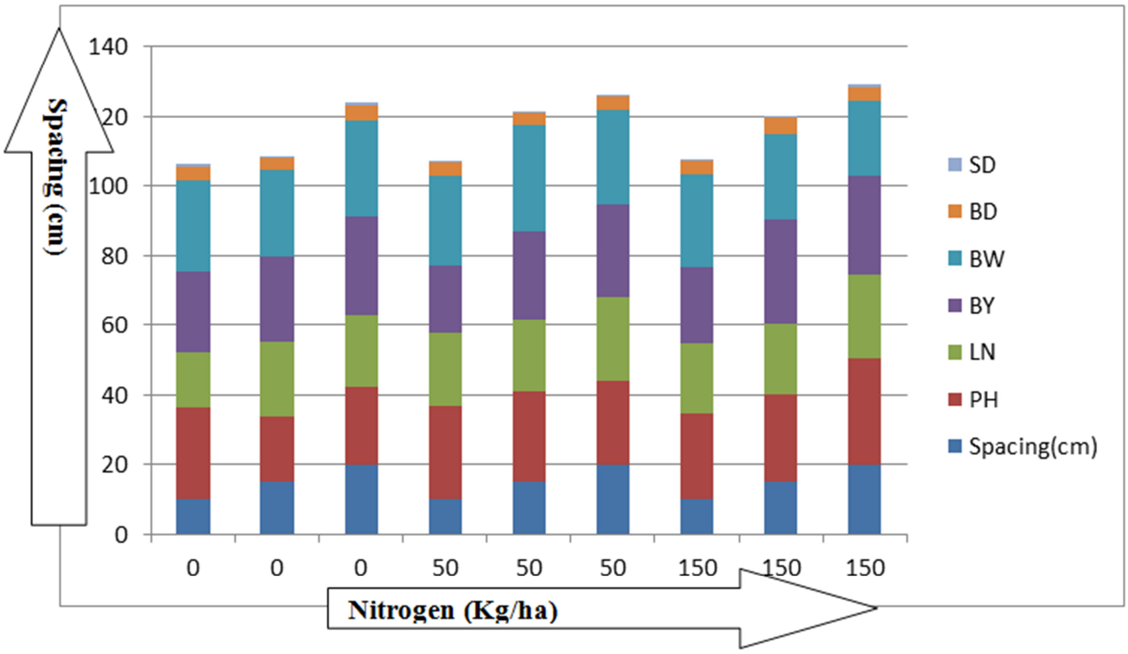
3.2 Number of Leaves per Plant

Nitrogen levels significantly affected the number of leaves per plant of shallot with the highest value (27.84cm) obtained from 100 kg N ha^{-1} ,so statistically significant at ($p<0.05$)(Appendex2)or table1.This also shows that, nitrogen played important role in leaf production via its role in vegetative growth. The effect of intra-row spacing on the leave number did not show high significance between the three treatments (Appendex2) or table 2. There was no significant effect of interaction between nitrogen and intra-row spacing on leave number of shallot. At 0 kg N ha^{-1} 10cm intra-row spacing were result small quantity of leaves per plant (15.73cm) which was numerically less than 24,26cm with 150 kgha^{-1} and 20cm spacing followed by 23.87cm at 100 kg N ha^{-1} and 20 cm spacing. So that at 100 kgha^{-1} ,150 kgha^{-1} and 20cm spacing had more leave numerically but not statistically different from other treatments (table3). The combination effect of nitrogen and spacing on shallot growth performance and yield had not showed significant differences among the treatments.

Nitrogen and intra-row spacing as well as their interaction, significantly affected, number of leaves, crop growth rate, individual bulb weight, bulb diameter and total bulb yield per hectare. Nitrogen at the rate of 100 or 150 kg N ha^{-1} gave the best results and was statistically the same in all the parameters measured(Aliyu et.al, 2008).The inter-action effect of nitrogen and spacing on the leave number of shallot was not showed significant different in my work among the treatments.

3.3 Stem Diameter

Nitrogen had significant effect on stem diameter of shallot with the highest value 0.61 cm obtained from application of 150 kg N ha^{-1} ($p<0.05$)(Appendex3). This clearly showed that nitrogen was mainly concerned with the vegetative growth of the plants. Numerically smallest stem diameter was obtained from application of 100kgha^{-1} .Significantly largest stem diameter 0.63cm ($p<0.05$) was obtained from intra-row spacing of 20cm (Appendex2). The thinner stem diameter 0.566cm was observed from 10 cm and 15cm intra-row spacing.



****SD (stem diameter), BD (bulb diameter), BW (bulb weight), BY (bulb yield), LN (leave number), and PH (plant height)**

Figure 1: Interaction effect of spacing and nitrogen on shallot growth and yield component

Closer spacing resulted in competition for nutrient and light thus resulting in plants that were thin while the wider spaced plants had adequate space for stem growth and development. There was no significant effect of interaction between nitrogen and intra-row spacing on the stem diameter of shallot (Appendex3). The smallest stem diameter was obtained at 0kgha^{-1} and spacing of 20cm numerically. While at 100 kg N ha^{-1}, 10cm intra-row spacing (table3) recorded the largest stem diameter from the rest of the treatments when compared with in them numerically in expanse of statistically. This could be due to happy consumption of nitrogen combined with good spacing of shallot.

3.4 Bulb Diameter

Nitrogen is significantly affected the bulb diameter of shallot. The largest bulb (3.99cm) was recorded from application of 0 kg N ha^{-1} which was statistically significance from the application of 100kgha-1 and 150kgha-1(Appendex4) or table 1. The minimum value in number for bulb diameter 3.83 cm was recorded from the100 kg N/ha (table1). This result showed that nitrogen is mainly play great role in reproductive parts of the plants.Intra-row spacing with 20cm had very significance difference (4.16cm)($p<0.05$)(Appendex4).Nitrogen significantly increased bulb diameter without affecting the bulb length. This result in line with the work of Nasreen et al. (2007) reported as significant increase in the diameter of bulbs due to the application of N 150kg/ha. The application of nitrogen had produced significance difference among the treatments.

Effect of interaction between nitrogen and intra-row spacing on bulb diameter of shallot did not show significant differences (Appendex3) or table 3.The bulb diameter of shallot under the condition of interaction effect had not variation between the treatments.

3.5 Shallot Bulb Yield

Bulb yield of shallot was statistically different or significantly affected by the application of nitrogen. An increased N doses to $100kgha^{-1}$ resulted in the increased yield of shallot bulbs to 30.2 tha^{-1} which was significantly different from $0kgha^{-1}$ and $150kgha^{-1}$($p<0.05$) (Appendex5). But further increase to 150kg N ha^{-1} did not increase the yield. The lowest bulb yield of 18.78 t ha^{-1} was recorded from the plot, where no N was applied (table1). Intra-row spacing of (10 cm) is significant from the others treatments yields (30.71 t ha^{-1}) which was significantly different from 28.5 t ha^{-1} recorded when 15 cm intra-row spacing was used (Appendex5). Spacing of 20cm recorded the lowest yield 25.44 t ha^{-1}.

There were no interaction effects of nitrogen and intra-row spacing on the bulb yield and yield components of shallot. (Appendex3). To sum up wider spacing reduced yield due to total reduction in the plants per hectare i.e. space is not fully utilized and lack of optimum fertilizer. (Aliyu et.al, 2008) reported that the yield of shallot at twenty and 25 cm intra-row spacing were found to have recorded the highest and statistically similar values. In this result the optimum yield of shallot bulbs (30.83 t ha^{-1}) was obtained from 15 cm intra-row spacing combined with 100 kg N ha^{-1}.But the combined effect of nitrogen and spacing on the shallot yield had no significant differences between the treatments.

3.6 Bulb Weight

Nitrogen application had significance differences on the bulb weight of shallot. The heaviest bulbs 30.9 gm at 150kg/ha which was statistically highly significances different ($p<0.05$) from 25.9 gm at 0kg/ha and 24.36gm at 100kg/ha. Therefore 150 kg N ha^{-1} is the most optimum technical dose for shallot bulb production. 0 kg N/ha and 100 kg N/ha produced the lowest values for bulb weight less than 30 gm due to the shortage of the nitrogen, which is an important element needed for proper growth and development of every plant including shallot(Appened6). Intra-row spacing had significant effect on the bulb weight of shallot with 15 cm spacing recorded highly significance difference(34.77cm) ($p<0.05$)(Appendix 6) of bulb weight than 10cm and 20cm spacing of the same numerical value of bulb weight(table2). These result indicated that shallot weight was increased with increased spacing. (Andre et.al, 2007) reported that average bulb weight of shallot increased with decreasing plant population. Likewise, in the present study, the lowest density (12.5plants/ m^2) produced the highest number of bulbs (9.6) and yield of bulbs (9.7-23) per plant which were significantly higher than the rest of plant density treatments.

There was no significant effect of interaction between intra-row spacing and N on the bulb weight of shallot (Appendex 6). This result indicated that further increased amount of nitrogen do not give larger bulb weight of shallot.

4. Summary and Conclusion

Shallot is an onion like plant that is originated from in Western Asia. Shallot is propagated by using bulb or segments as a planting material. Dry bulbs planted a spacing of 20cm between plants and 35cm between rows and one large or two small bulbs are planted in each hill. Shallot is the most widely cultivated and favorite vegetable crops in Ethiopia. In Ethiopia, they are planted during the rainy season and the tops of the sets are cut before planting. Depending on the availability of water and the cultivars, it should be possible to raise more than one crop in growing season. It is use as a condiment for many local dishes has significant importance. This research field was conducted to determine the optimum rate of nitrogen fertilizer rate and plant density on yield and yield component of shallot and the best combination of spacing and nitrogen fertilizer for better yield of shallot A field study was conducted to study the effect of different rate of nitrogen fertilizer and plant spacing on yield and yield components of shallot under Jimma condition, in the experimental field of College of Agriculture and Veterinary Medicine, Jimma University. Local variety of shallot was used with the three level of nitrogen (0kg/ha, 100kg/ha, 150kg/ha) and three intra-row spacing (10cm, 15cm, 20cm). The result of this field experiment indicated that, plant height was affected with different nitrogen level with the highest plant height 27.28cm was obtained from intra-row spacing of 15cm at 100kgha^{-1} and the shortest plants 22.66 cm were recorded from 10 cm intra-row spacing. The interaction effect of 150gk/ha and 20cm spacing resulted highly significant plant height (30.33cm) ($p<0.05$). Nitrogen levels significantly affected the number of leaves per plant of shallot with the highest value (27.84cm) obtained from 100 kg N ha^{-1} ,so statistically significant($p<0.05$). The effect of intra-row spacing on the leave number did not show high significance between the three treatments. There was no significant effect of interaction between nitrogen and intra-row spacing on leave number of shallot. Nitrogen had significant effect on stem diameter of shallot with the highest value 0.61 cm obtained from application of 150 kg N ha^{-1} (p,<0.05). Significantly largest stem diameter 0.63cm ($p<0.05$) was obtained from intra-row spacing of 20cm. The thinner stem diameter 0.566cm was observed from 10 cm and 15cm intra-row spacing but the was no interaction effect of nitrogen and spacing on the stem diameter of shallot. Nitrogen leves were not affecting the bulb diameter of shallot. Intra-row spacing with 20cm had very significance difference (4.16cm) ($p<0.05$) There were no interaction effect of nitrogen fertilizer and spacing on the bulb diameter of shallot. The heaviest bulbs 30.9 gm at 150kg/ha which was statistically highly significances different ($p<0.05$) from 25.9 gm at 0kg/ha and 24.36gm at 100kg/ha. Intra-row spacing had significant effect on the bulb weight of shallot with 15 cm spacing recorded highly significance difference (34.77cm) ($p<0.05$) of bulb weight but no difference was obtained with the interaction effect of nitrogen and spacing on shallot bulb weight. An increased N dose to 100kgha^{-1} resulted in the increased yield of shallot bulbs to 30.2 tha^{-1} which was significantly different from 0kgha^{-1} and 150kgha^{-1}($p<0.05$). Intra-row spacing of (10 cm) is significant from the others treatments yields (30.71 t ha^{-1}) which was significantly different from 28.5 t ha^{-1} recorded when 15 cm intra-row spacing was used. There was no significant different of interaction of nitrogen and spacing on shallot yield.

Generally, our results indicate that the interaction effect of nitrogen and spacing had no significance differences between the treatments except plant height showed the highest performances in all parameters or dependant variables at ($P<0.05$). This could be due to different factors related to increased growth in height and branches specially nitrogen and spacing which was favorable for shallot. In conclusion therefore, the easiest method of obtaining high growth performance of plant which leads to increased yield could be using 150kgha^{-1}and spacing of 20cm. These could be suggested to farmers; however the conclusive recommendation should be based on the results of repeated experiments. Moreover, emphasis should be given to optimum level of nitrogen and spacing under Jimma condition with further finding.

5. Acknowledgment

At the outset I would like to praise the everlasting Father and the Prince of love and peace **the Almighty God** who always let the bulk of unfinished work to be completed at a moment. I am grateful to my respected advisor Abraham Wolde, for his unreserved advice, guidance, and constructive criticism starting from the very commencement up to paper completion. Without his encouragement, insight and professional expertise, the completion of this work would not have been possible.

Many thanks should also extend to Jimma University College of agricultural and veterinary medicine for providing computer and internet service. In addition, I would like to express my sincere appreciation and gratitude to department of horticulture and plant sciences for preparing of this interesting course which will help me in my future career. Heartfelt thanks to many lecturers for their support during data analysis. I also thank all people who assisted me in one way or another during my study period.

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Abbreviations and Unit
Base quantity
Length
Name
Meter
Abbreviation
m

Mass	Kilogram	kg
Length	Centimeter	cm
Mass	tone	t
Area	Hectare	ha
Area	Square meter	m^2
Volume	Millimeter	mm
Height	Meter above sea level	m.a.s.l

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Appendices

Appendix 1: Analysis of variance (ANOVA) for plant height of shallot as influenced by plant spacing and N fertilizer

Source	Df	SS	MS	F_{cal}		Pvalue
Total	26	446.39				
Block	2	7.41	3.7	0.30		0.7477
Spacing	2	96.76	48.38	3.87		0.0427
Nitrogen	2	0.79	0.39	0.30		0.9687
SXN	4	141.22	35.31	2.28		0.00021
Error	16	122.4	19.7			
CV=14.22%						

Appendix 2: Analysis of variance (ANOVA) for leaf number per plant of shallot as influenced by plant spacing and N fertilizer

Source	Df	SS	MS	F_{cal}		Pvalue
Total	26	347.78				
Block	2	51.63	25.81	2.18		0.0460
Spacing	2	2.40	1.20	0.10		0.9041
Nitrogen	2	32.96	16.48	1.39		0.01779
SXN	4	70.89	17.72	1.49		0.2509
Error	16	189.88	11.86			
CV=16.91%						

Appendix 3: Analysis of variance (ANOVA) for stem diameter of shallot as influenced by plant spacing and N fertilizer

Source	Df	SS	MS	F_{cal}		Pvalue
Total	26	0.45				
Block	2	0.15	0.074	6.23		0.0100
Spacing	2	0.026	0.013	1.12		0.00519
Nitrogen	2	0.007	0.003	0.28		0.0401
SXN	4	0.07	0.018	1.53		0.2395
Error	16	0.19	0.011			
CV=18.56%						

Appendix 4: Analysis of variance (ANOVA) for bulb diameter of shallot as influenced by plant spacing and N fertilizer

Source	Df	SS	MS	F_{cal}		Pvalue
Total	26	26.83				
Block	2	9.94	4.97	6.64		0.0080
Spacing	2	1.34	0.67	0.90		0.000078
Nitrogen	2	0.11	0.055	0.07		0.9298
SXN	4	0.45	0.111	0.15		0.9609
Error	16	11.99	0.75			
CV=22.15%						

Appendix 5: Analysis of variance (ANOVA) for bulb yield of shallot as influenced by plant spacing and N fertilizer

Source	Df	SS	MS	F_{cal}		p value
Total	26	199.8				
Block	2	42.01	21.00	4.3		0.0313
Spacing	2	17.14	8.57	1.77		0.023
Nitrogen	2	41.53	20.76	4.28		0.0324
NXS	4	21.56	5.39	1.11		0.3850
Error	16	77.56	4.85			
CV=22.15%						

Appendix6: Analysis of variance (ANOVA) for bulb weight of shallot as influenced by plant spacing and N fertilizer

Source	Df	SS	MS	F_{cal}		pvalue
Total	26	461.76				
Block	2	184.16	92.3	9.0		0.0024
Spacing	2	1.120	0.56	0.05		0.000069
Nitrogen	2	38.84	19.42	1.89		0.028
NXS	4	73.05	18.26	1.78		0.1822
Error	16	164.14	10.25			
CV=12.29 %						

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