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Effects of inter and intra-row spacing on the yield and yield attributes of onion *(Allium cepa L.)* under North Western zones of Tigray

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ABSTRACT

Onion is one of the most important high market value bulb crops cultivated commercially in most parts of the world. It is the most cultivated and high market value of vegetable crops in Tigray Northern Ethiopia. However, bulb yield of onion is limited due to improper use of plant spacing. Therefore, field experiment was conducted to determine the optimum planting spacing of Onion to maximize its productivity in 2015 and 2017 under irrigation conditions. Four different inter-row (20, 30, 40&50cm) and three intra-row (5, 10&15cm) spacing were used and laid out in randomized complete block design replicated three times. Bombey red variety was used as a testing variety. The current findings showed that plant height, bulb diameter, bulb weight, bulb length marketable bulb yield were significantly influenced by planting spacing. Accordingly, the tallest plant height and maximum marketable bulb yield were obtained from the narrower spacing. Therefore, 20 cm inter row and 5 cm intra row spacing is recommended for the growers to improve onion productivity in the study area.

Keywords: Inter, Intra, Onion, Spacing

INTRODUCTION

Onion (*Allium cepa L*) is an important bulb crop in Ethiopia. It is recently introduced and rapidly becoming popular among producers and consumers. It is widely produced by small farmers and commercial growers throughout the year for local use and export market (Lemma and Shimeles, 2003; Dawit *et al.*, 2004). Onion is used for flavoring or seasoning the food, both at mature and mature stages, besides being used as salad and pickle. It is important in the daily diets of human's in worldwide and Ethiopians as well (MoARD, 2005). Onion contributes significant nutritional value to the human diet and are primarily consumed for their distinctive flavor widely used in soups, meat dishes, salads, food dressings and sandwiches, medicinal purposes and is cooked alone as a vegetable. Its pungency is due to the presence of a volatile oil (Allyl propyl disulphide) (Malik, 1994).

The diverse agro-climatic conditions that prevail in the country provide the opportunity of producing onion bulb, seeds and cut flower for local use and export market (CSSE, 2006). Additionally, its higher yield potential, availability of desirable cultivars for various uses, ease of propagation by seed, high domestic (bulb and seed) and export (bulb, cut flowers) markets in fresh and processed forms is making the crop increasingly important in Ethiopia (Yohannes,1987).

In Ethiopia high potential to benefit from onion production, and the demand for onion is increasing from time to time for its high bulb yields, seed and flower production potential and its production is increasingly from time to time but not given as such high yield due to a number of constraints such as low fertility of soil, inappropriate fertilizer rate, lack of improved varieties, and poor management practices(Lemma and Shimelis, 2003).

The use of proper agronomic practice has an undoubted contribution in increasing crop yield. Transplanting Onion at recommended inter and intra row spacing increase productivity and has many advantages. It provides nutrient availability and avoids plant competition, allows root growth and development, enhances plant growth and lateral branch production. Additionally, it facilitates to carry out field operation (cultivation, weeding, hoeing, fertilizer application, better drain land and conduct crop protection activities). Optimum plant population enables efficient use of available crop land without wastage (Zubelidia and Gases, 1977).

However, in the country, intra-row spacing of 10 cm and inter-row spacing of 20 cm during transplanting to permanent field is used which was recommended before 20 years (FAO, 1995). But plant spacing as an important economic consideration in the production of onion should have to depend on type of variety (plant architecture, growth habit etc.), agro-ecology, production system etc. Therefore, for onion production, it is very difficult to give general recommendation to be applied uniformly in all agro ecologies of the country (UAAIE, 2001).

Onion is traditionally grown at the recommended spacing of 40 cm x 20 cm x 10 cm in Ethiopia (Lemma and Shimeles, 2003). However, spacing is an important factor for the production of onion since it affects both bulb yield and quality. Planting density greatly influences quality, texture, taste and yield of onion even within a particular variety (Saud et al., 2013). However, farmers in north western Tigray practiced different inter and intra row spacing for onion production. Therefore, the present study was initiated with the following objectives.

Objective

- To assess the effect of inter and intra-row spacing on growth and yield of onion; and
- To determine the optimum inter and intra row spacing on growth and yield of Onion production in

MATERIALS AND METHODS

The experiment was conducted during 2015-2016 under irrigation condition in Northwestern Zone of Tigray (Tselemti & M/zana) districts of Shire-Maitsebri (SMARC) experimental Stations.The experiment was laid out in 4*3 factorial arrangements using a Randomized Block Design (RCBD) with three replications and two factors which consists of 4 different inter row spacing: 20, 30, 40 &50cm and three different intra- row spacing 5, 10, & 15cm. Each plot contains Eight rows with different plot size of (2.8x1.6,2.8x2.4,2.8x3.2,2.8x4) and different number of plants per row which includes 56,28,19 plants for 5,10,&15cm intra row spacing's respectively.Onion variety 'Bombey Red' was used as planting material. The seeds of 'Bombay red' variety were raised on nursery site for about 40 days. Finally, seedlings were translated and planted at the prescribed between and within plant spacing. All management practices (ploughing, cultivation, watering, nursery and transplanting method, weeding and others) for the crop were applied uniformly as per the recommendation during nursery and filed conditions.

Method of Data Collection

All data relating to yield and yield components were collected from the central three rows by excluding plants from either end of the rows. For the purpose of crop data collection one (1) plant/row or six (6) plants/plot were selected randomly from each plot and observations on growth, yield and yield components of the crop such as: plant height, average leaf length, average leaf number, average neck thickness, average bulb length, diameter &yield were recorded.

Plant height (cm): Plant height was measured from the ground level up to the tip of the Longest leaf using ruler. Plant height of sex randomly selected plants were measured in the central rows of each plot at physiological maturity stage of the crop and the average was Computed.

Days to physiological maturity: It was registered on plot basis as the actual number of days from date of transplanting to when about 75% of the leaves fell down and 2/3 leaves had turned yellow

Number of leaves per plant: The number of fully developed leaves of six randomly selected plants was counted at the active green leaf stages and the average was computed to obtain number of leaves per plant.

Leaf length (cm): Leaf length was recorded as the average length of the longest leaves in six randomly selected plants at maturity.

Bulb diameter (cm): Bulb diameter was measured at right angles to the longitudinal axis at the widest circumference of the bulb of six randomly selected plants in each plot using veneer calliper (Saud et al., 2013) at harvest.

Bulb length (cm): Bulb length was the vertical average length of the matured bulb of six randomly selected plants in each plot which was measured by veneer caliper.

Bulb neck thickness (cm): The average neck thicknesses of six randomly selected plants in each plot were obtained by measuring the neck of bulbs at the narrowest point at the junction of bulb and leaf sheath using a veneer caliper.

Marketable bulb yield (t /ha): Marketable bulb yield was determined after discarding the unmarketable bulb, weight healthy bulbs and having nationally accepted marketable bulb weight of 60 g (Tegbew, 2011) at harvest in each plot and converted to t /ha.

Method of Data Analysis

All crop data collected in this study were subjected to two way statistical analysis of variance (ANOVA) following a procedure appropriate to factorial randomized complete block design as suggested by (Gomez and Gomez, 1984).When the treatment were significant, least significance differences (LSD) by Dunken's multiple range comparison were used for mean separation at p=0.05.

RESULTS AND DISCUSSION

In this study, data were collected for different quantitative characters to evaluate the influence of inter- and intra-row spacing on the yield and yield related traits of onion. The data were analyzed to know the degree of influence of inter- and intra-row spacing. Analysis of variance exhibited significant differences due to the main effects of inter & intra-row spacing on the growth parameters of onion (Table -3).

Plant Height

The analysis of variance showed that plant height was significantly ($P < 0.05$) affected by main effect of Inter & intra-row spacing (Table-3). Plants spaced at 30 cm were significantly taller (43.49 cm) than plants grown in other except 40 cm inter-row spacing. The lowest height was found in 20 cm inter row (41.53cm) & 5cm intra-row (41.43 cm) spaced respectively (Table-3). Height of plant can be considered as one of the indices of plant vigor and it depends upon vigor and growth habit of the plant. The result showed that the plants in wider spacing attained the higher height than the closer spacing. The increased plant height at wider inter & intra-row spacing might be due to the change in growth of plants with relatively less competition for growth factors such as mineral nutrients, solar radiation (sun light) and soil moisture. The finding of Khan *et al*. (2003) had confirmed that widest plant spacing of 10 cm produced significantly the highest plant height. This value was decreased as plant spacing reduced and ultimately significantly lowest value of this growth parameter was recorded in the closest intra-row spacing of 7.5 cm. Aliyu *et al.* (2008), and Sikder *et al.* (2010) also reported the closer inter & intra-row spacing resulted short plant height than wider plant spacing. Similarly, Tesfalegn (2015) reported that plant height of onion plants was significantly affected by inter &intra spacing of cultivars.

Table 1: Main effects of inter- and intra-row spacing on Bulb setting (BS), Bulb Maturity (BM) & plant height (Pht)

Treatments	Days to Bulb Setting	Days to Bulb Maturity	Plant height (Cm)
Inter row spacing(cm)			
20	68.06 b	122.5	41.53b
30	65.19 a	122.7	43.49a
40	65.00 a	123.0	43.36a
50	63.85a	122.6	42.74ab
LSD	2.200	ns	1.527
Intra-row spacing(cm)			
5	66.25 b	123.6b	41.43b
10	65.92b	123.0b	43.05a
15	64.40a	121.5a	43.86a
LSD	1.201	1.258	1.302
CV (%)	5.6	3.1	9.3

Bulb diameter

The analysis of variance result presented in (Table -5) showed that interaction effects inter and intra-row spacing had a significant ($P < 0.05$) influence on bulb diameter. The bulb diameter increased with the increase in inter and intra-row spacing. The highest bulb diameter (6.364 cm) and (6.172cm) was obtained at interaction of inter-row 50cm and intra-row spacing 15&10 cm respectively.

As inter and intra-row spacing increased, the bulb diameter was increased (Table-5). One of the probable reasons for decreasing in bulb size as inter and intra-row spacing decrease is reduced number of leaves per plant which intern negatively affect the amount of assimilation production. Other possible reason could be more severe competition for growth factors between neighboring plants. The trend of decreasing bulb diameter as inter and intra-row spacing decreased was in consistence with the results reported by Geremew *et al.* (2010) where the highest bulb diameter was recorded at intra-row spacing of 10 cm as compared to intra-row spacing of 8, 6 and 4 cm for Adama Red variety. Tendaj (2005) observed increment of bulbs diameter from about 14 to 47% as inter and intra-row spacing increased from 5 to 20 cm in shallot. The present finding was in agreement with many other authors who reported the larger bulbs of onion obtained in wider spacing of onion cultivars (Kantona *et al.,* 2003; Akoun, 2005; Hydar *et al*., 2007.

Bulb Length

Bulb length was significantly ($P < 0.05$) influenced by interaction effect of inter and intra-row spacing (Table -5). Significantly longest bulb length was recorded in plants spaced at 50 cm inter-row and 10 cm intra-row spacing which was measured (5.237cm) and not significant difference with inter row spacing 40 & 50 cm and intra row spacing 15cm which measured 5.184 & 5.171 cm respectively, while the smallest bulb length of 4.466 cm was obtained from plants spaced at 20 cm and 5cm inter and intra row spacing respectively (Table-5). The general trend was that as inter and intra-row spacing decreased so did the onion bulb length shorten. This might be due to the competition of plants for nutrients, light and moisture at narrow spacing which did not allow the bulbs to have more assimilates available for storage and thus resulted in smaller bulb length. The present finding is in agreement with the result reported byYemane *et al*. (2013) that, the highest bulb length was recorded at wider spacing compared to narrow spacing. Similar results were reported by Khan *et al*. (2003), and Hydar *et al*. (2007).

Bulb Neck thickness

The analysis of the data for bulb neck thickness revealed that both inter and intra-row Spacing had significantly ($P < 0.05$) effect on this parameter(Table-4). Significantly thicker bulb neck was observed in plants spaced in 50x15cm inter and intra row spacing than the other spacing. On the other hand, the lowest neck thicknes observed in 20cm inter row spacing which was statistically at par with the neck thickness under 30 and 40cm inter row spacing. The general trend observed was as the inter & intra-row spacing increased neck thickness was also increased(Table-4).The decrease in neck diameter in response to decreased in inter and intra-row spacing could be attributed to the availability of progressively lower amount of photosynthesis due to the increasing competition among plants for growth factors. Thick neck in onion is caused by the active onion growth that the neck did not become dormant and resulted to undifferentiated scales with high thickness at wider inter & intra-row spacing (Currah and Proctor, 1990). This indicated that thick neck in onion causes delay in bulbing and has a negative impact on bulb yield (Yemane *et al*., 2013).Gautam *et al*. (2006) observed that bulbs with thin necks store longer than bulbs with thick necks. Thick bulb necks take longer to dry after harvesting and provide a high risk for infection of post-harvest storage diseases such as bacterial soft rot (Bosekeng, 2012). Jilani (2004) also found bulbs of thick neck in plots of lowest planting density (20 plants m^2) while the plots of highest density (40 plants m^2) produced bulbs of thin neck diameter.

The present study is in agreement with the report of Sikder *et al*. (2010) that, the closest spacing significantly produced lower bulb neck thickness. This report was also similar with the reports of Dawaret *et al*. (2007) and Khalid (2009) that higher bulb neck thickness was observed in plants spaced at wider plant spacing, while the lowest in plants spaced at closer intra-row spacing.

Marketable Bulb Yield

The interaction effect of inter and intra-row spacing had significant effect ($P < 0.05$) on marketable bulb yield (Table -5). The highest marketable bulb yield of 36087Kg/ha was obtained from the narrow inter and intra row spacing from20cm inter row spacing and plants with 5cm intra-row spacing. As inter and intra row spacing decreased marketable bulb yield was increased. Similar to this finding Khalafalla (2001) reported that marketable yield was significantly increased with closer spacing over the wider spacing in potato. Geremew *et al.* (2010) reported intra-row spacing have effect on marketable yield. Yemane *et al*. (2013) also obtained the decreased marketable bulb yield as the intra-row spacing increased. Similarly, Guerra (1988) and Khan *et al*. (2003) also reported higher marketable bulb yield as the plant spacing decreased.

Table-4: Main effects of inter- and intra-row spacing on Bulb neck thickness

S/N	Trts	Inter row spacing(cm)	Intra row spacing(cm)	ABD(cm)	ABL(cm)	MY(Kg/ha)
1	T1	20	5	4.768e	4.466f	36087a
2	T2	20	10	5.245d	4.603ef	28871bc
3	T3	20	15	5.478cd	4.630def	26697bcd
4	T4	30	5	5.278d	4.773cde	31014b
5	T5	30	10	5.693bcd	4.772cde	26037cde
6	T6	30	15	5.886abc	4.894bcde	22743def
7	T7	40	5	5.373d	4.751cdef	27245bcd
8	T8	40	10	5.896abc	4.918bcd	24106de
9	T9	40	15	5.999ab	5.184ab	19053fg
10	T10	50	5	5.961abc	4.963abc	24412cde
11	T11	50	10	6.172ab	5.237a	21943ef
12	T12	50	15	6.364a	5.171ab	16527 g
Mean				5.68	4.86	25394
LSD(0.05)				1.122	0.647	10209.0
CV (%)				12.2	8.2	24.9

Table -5. Interaction effect of inter and intra-row spacing on onion Average bulb diameter (ABD), Average bulb length (ABL), and marketable fruit yield (MY)

Treatments	Bulb neck thickness
Inter row spacing(cm)	
20	1.148b
30	1.212b
40	1.233b
50	1.427a
LSD	0.1515
Intra-row spacing(cm)	
5	1.223b
10	1.221a
15	1.321a
LSD	0.0960
CV(%)	23.3

SUMMARY & CONCLUSION

Study was conducted in North western zone of Tigray determine optimum inter and intra-row spacing for maximum yield of onion. Factorial combination of four inter- row (20, 30, 40 and 50 cm) and three intra-row spacing (5, 10, and 15 cm) were laid out in a randomized complete block design (RCBD) with three replications. Different phonological and yield related traits were examined against the plant spacing combinations. Significant variations due to spacing were recorded in interaction effect on Bulb diameter, Bulb length, and Marketable Bulb yield. Moreover, the main effects of inter-row spacing caused significant variation on plant height and Bulb neck thickness wider inter- row spacing's brought about higher values for those parameters.

The highest marketable fruit yield per hectare (36087) was obtained from the interaction effect of treatments 5 cm intra-row spacing with 20cm inter row spacing. On the other hand, the lowest total marketable fruit yield per hectare (16527 kg) was recorded from the wider spacing (from treatment combination of 15 cm intra-row with 50 cm inter-row spacing). Therefore, 20 cm inter row and 5 cm intra row spacing is recommended for the growers to improve onion productivity in the study area.

CONFLICT OF INTEREST:

The Authors declare no conflict of interest.

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