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The Impact of Bulb Treatment and Spacing Patterns on Onion (*Allium Cepa* Var. C*epa*) Seed Yield and Quality at Humbo Larena, Southern Ethiopia

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Abstract

Field experiment was conducted at Humbo Larena, wolaita zone during the 2012/2013 dry season, to study the effect of bulb treatment and spacing patterns on seed yield and quality of onion in the semi-arid zone of Ethiopia. Treatments consisted of a factorial combination of four levels of bulb types [whole bulbs, cut (topped) bulbs, ash-treated cut (topped) bulbs, and fungicide-treated cut (topped) bulbs] and four levels of spacing patterns (50 x 30 x 20 cm, 60 x 30 x 20 cm, 40 x 20 cm, and 50 x 20 cm) laid out in randomized complete block design replicated three times. The onion variety known as Bombay Red was used as a test crop. Results revealed that the main effects of both bulb treatment and spacing significantly influenced, seed weight per umbel, standard germination, vigour Index I and vigour index II. However, bulb treatment and spacing interacted to significantly influence seed yield. The highest seed yield was obtained in response to planting fungicide-treated topped bulbs at the both double-row spacing. However, significantly higher values of all seed quality parameters were obtained from both single-row spacing.
Keywords: Onion (*Allium cepa* var. C*epa*), bulb treatment, spacing patterns, Ethiopia

Introduction

Onion *(Allium cepa* L.*)* is a recently introduced bulb crop in the agriculture commodity of Ethiopia and it is rapidly becoming a popular vegetable among producers and consumers (Lemma and Shimeles, 2003; Dawit *et al*., 2004). Onion (*Allium cepa* L.) is more widely grown in Ethiopia for local consumption and for flower export (Lemma and Shimeles, 2003). It is valued for its distinct pungency or mild flavour and also consumed universally in small quantities and used in many homes almost daily, primarily as a seasoning for flavouring of dishes, sauces, soup, and sandwiches in many countries of the world (Geremew *et al*., 2010).

Onion is one of the most important vegetable crops in Ethiopia which is used almost daily as a spice and vegetable in the local dish regardless of religion, ethnicity, and culture (CSSE, 2006). 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).

The vegetable production sector in Ethiopia relies mainly on imported seeds except the very limited ones such as hot pepper and Kale that has been traditionally produced. Most vegetables produced from imported seed do not perform very well due to poor germination and adaptability problems (Dawit *et al*., 2004). Onions are usually grown from seed, and flowering and seed production are important for crop production (Brewster, 1994). There are clearly enormous differences in average seed yields observed depending on genotype, locality, season, soil type, and method of seed production (Jones, 1963; Brewster, 1994).

The components of yield such as number of seed stalks per plant, flowers per umbel, umbel diameter and seed yield of onion depend on climatic and management factors such as time of planting, irrigation, fertilization, spacing, plant protection and other measures (Patil*et al.,* 1993;, Lemma *et al.,* 1994; Lemma and Shimeles 2003). As an important factor in determining seed yield of onion, plant spacing, varies from place to place as well as from variety to variety (Lemma and Shimeles, 2003). In addition, traditionally farmers cut off 1/3rd of the upper portions of mother bulbs before planting to encourage more sprouts per bulb and for early breakage of bulb dormancy, enhancing maturity and uniform flower stalk formation.

However, research in Southern Ethiopia as a whole and particularly at Wolaita zone has not yet recommended cutting and treating the seed bulbs before planting. Hence, it is vital to scientifically establish appropriate plant spacing and bulb treatment for maximizing onion seed yield and quality. Therefore, determining the impact of bulb treatment and spacing patterns on seed yield and seed quality of onion is the objective of the study presented in this paper.

Materials and Methods

Field experiment was conducted at Humbo Larena, Wolaita Zone, Southern Ethiopia. It is located at 6^0 49'N and 37^0 45'E and lies on an altitude of 1483 meters above sea level. The annual average temperature of the zone is 20^0C and the mean annual rainfall ranges from 1200 to 1300 mm. The rainfall has a bi-modal distribution pattern with small rains from March to May and long and heavy rains from June to September. The zone covers an area of 44,721 km^2 and found in the altitude range of 1500 – 2100 masl. (Hailu *et al*., 2011).

An improved onion variety named Bombay Red was used for the study. This variety was released in 1980 by Melkassa Research Centre. The variety is adapted to areas with altitudes ranging between 700-2000 m above sea level, and is cultivated using irrigation or as a rain-fed crop in the country. The onion variety is characterized by dark green leaf colour, medium leaf arrangement, mean bulb size of 85-100 g, flat globe bulb shape, light red bulb skin colour, reddish white bulb flesh colour, having a little less than 120 days of maturity, and high seed set (EARO, 2004).

The treatments consisted of planting bulbs that received four treatments [(whole bulbs cured for a week, cut (topped) bulbs cured for a week, cut (topped) bulbs rubbed with ash and cured for a week, and cut (topped) bulbs treated with a fungicide and cured for a week)] and four plant spacing patterns (50 x 30 x 20 cm double rows, 60 x 30 x 20 cm double rows, 40 x 20 cm single row, and 50 x 20 cm single row, designated as S1, S2, S3, and S4, respectively). The experiment was laid out as a randomized complete block design (RCBD) in a factorial arrangement, and replicated three times per treatment. Therefore, there were 4 x 4 = 16 treatment combinations, which amounted to 48 plots (experimental units) when replicated. The treatments were assigned to each plot within a block randomly. The plot size was 2.6 m x 3 m. A distance of 1 m was left between adjacent plots and a distance of 1.5 m was left between adjacent blocks. The total net area of all experimental plots required for the study was 816.4 m^2.

The bulbs were sorted for suitable size (medium/50-60mm diameter) and freedom from diseases as well as against early sprouts, split bulbs, and off types. The bulbs were then subjected to treatments except the ones to be used as a control (planting whole bulbs). The upper 1/3rd potions of the selected onion bulbs, other than the ones to be planted whole, were cut off using a sharp knife disinfected with alcohol. The lower 2/3rd portions of bulbs were rubbed with ash or a fungicide named Ridomil according to the planned bulb treatment. Rubbing with ash or the fungicide was done just immediately after the bulbs were cut off. The ash or Ridomil powder was rubbed on to the cut surfaces of the bulbs in the same thickness of approximately 1-2mm. After treating with the ash or the fungicide (rubbing the cut bulbs with ash or fungicide), the differently treated bulbs, including the whole bulbs, were spread on a mat placed on the floor under shade and cured for one week. Curing was done before planting and immediately after treating the mother bulbs. All bulbs were cured including the ones to be planted whole as well as the one subjected to the ash and fungicide treatments.

Prior to planting the bulbs, the selected experimental land was ploughed to a fine tilth, harrowed using a tractor and levelled and pulverised manually. A total of 48 experimental plots were laid out and the required numbers of ridges and rows were marked in each plot according to the spacing arrangements listed in Table 1. Planting the bulbs was done on 15 November 2012. The bulbs were planted at the specified spacing on ridges to the depth of about 5 cm and covered with soil. Fertilizer was applied at the rate of 92 kg N ha^{-1} and 138 kg P_2O_5 ha^{-1} using Urea and DAP (Diammonium Phosphate), respectively. All of the phosphorus fertilizer was applied in band along the rows just before planting the bulbs and covered with a 5 cm thick soil. The nitrogen fertilizer was applied in two splits, ½ at planting and the other ½ at flower initiation by placing the granules in rows along the onion plants 5 cm away from the plants and covering with a 5-cm thick soil. The plots were irrigated at the interval of 6 days during the first phase of active growth of the plant. Later, the irrigation gap was increased to 10 days' interval. Hoeing of the experimental plots was done manually and the field was kept free of weeds during the growth period until the canopies of the flower stalks covered the inter-row spaces. Chemicals named Selecron (3liter ha^{-1}), for the control of Thrips, Redomil (3kg ha^{-1})and Mancozeb (3kg ha^{-1}) were used for the control of downey mildew, and purple blotch, respectively.

Data were collected on weight of seeds per umbel, seed yield per hectare, germination percentage, seedling shoot length, seedling root length and seedling dry weight. From each plot, fifteen plants were randomly selected from the middle rows for collecting data to be expressed on plant basis. However, for collecting yield data, the remaining plants in the central rows of each plot were harvested, leaving aside all plants in the border rows as well as plants at both ends of each row. Therefore, the seed yield was calculated in kilograms per hectare in accordance with the spacing and the number of plants available in each net plot area. The seedling vigour index was calculated by adopting the formula suggested by Abdul-Baki and Anderson (1973) and expressed as in number.

Vigour index I

Seedling vigour index I = Germination (%) x [Seedling Root length + Shoot length (cm)]

Vigour index II

Seedling Vigour index II = Germination (%) x seedling dry weight (g)

Data were subjected to analysis of variance (ANOVA) procedure using (SAS, 2003). Differences between treatment means were separated using the Least Significant Difference (LSD) test at 5% level of significance.

Results and Discussion

Seed weight per umbel (g)

Bulb treatment and spacing patterns significantly ($P < 0.01$) affected seed weight per umbel. The highest (2.83 g) and the lowest (2.25 g) seed weight per umbel were recorded from fungicide-treated cut bulbs and whole bulbs, respectively. And also the highest (2.74 g) and the lowest (2.18 g) seed weight per umbel were recorded from single row spacing 50 x 20 and from double row spacing 50 x 30 x 20, respectively (Table 5). According to this finding, fungicide treated cut bulbs and wider plant spacing increased the seed weight per umbel. This may be ascribed to fungicide treated bulbs against fungal pathogens and less stiff competition among the individual flower stalks for nutrients and stored food than the completion occurring in among dense plants. Norman (1963) also reported that the higher seed weight per umbel obtained in response to planting at a wider spacing may be attributed to less competition among plants for growth factors.

Seed yield (Kg ha^{-1})

The interaction effects of bulb treatment and spacing patterns significantly ($P < 0.05$) affected seed yield. The highest (906.1 Kg ha^{-1}) seed yield was, recorded from the interaction effect of planting fungicide-treated cut bulbs at double row spacing 50 x 30 x 20 and the lowest (325.7 Kg ha^{-1}) was recorded from the interaction effect of whole bulbs at single row spacing 50 x 20 (Table 4). The data clearly revealed that planting fungicide-treated cut bulbs at the double-row spacing led to the production of the highest onion seed yield, followed by ash-treated topped bulbs and topped bulbs. In addition treating the cut bulbs with the fungicide may kill rot and/or pathogenic fungi, thereby removing any latent disease infection that may affect the growing plants. The result of the current study may have been associated with the accommodation of maximum number of plants per unit area in the closer spacing. The results of this study are consistent with Asare-Bediako *et. al.,* (2007) revealed that treating yam minisetts with a fungicide Benlate completely inhibited growth of rot pathogens. Raymond (2009) also stated that carrot seed yield increased with increased plant population density because more number of primary umbels that bore better seed yields were developed than tertiary and quaternary umbels that would produce lower seed yields

Germination Percentage (%)

Bulb treatment and spacing patterns significantly ($P < 0.05$) affected germination percentage. The highest (93.08 %) and the lowest (85.42 %) germination percentage were recorded from fungicide-treated cut bulbs and whole bulbs, respectively. And also the highest (91.83 %) and the lowest (83.92 %) germination percentage were recorded from single row spacing 50 x 20 and from double row spacing 50 x 30 x 20, respectively (Table 6). In general, seed germination percentage was enhanced in response to fewer occurrences of fungal pathogens and widening the spacing (lowering plant population density). This result is concurrent with that of Asaduzzaman *et al.*, (2012) who recorded the highest germination percentage (92.64 %) in response to the maximum spacing and a minimum germination percentage (83.85 %) in response to the minimum spacing.

Vigour Index I

Bulb treatment and spacing patterns significantly ($P < 0.01$) affected vigour index I. The highest number (1121) and the lowest number (998) vigour index I were recorded from fungicide-treated cut bulbs and whole bulbs, respectively. And also the highest number (1150) and the lowest number (933) vigour index I were recorded from single row spacing 50 x 20 and from double row spacing 50 x 30 x 20, respectively (Table 6). This also could be due to low competition among plants of low population (wide spacing) for the accumulation and partitioning of assimilate to seeds for vigour development. Similarly, Singh *et al*. (1985) reported that seedling vigour index was found to be better at a wider spacing compared to a narrower spacing.

Vigour index II

Bulb treatment and spacing patterns significantly (P < 0.05) affected vigour index II. The highest (1.86) and the lowest (1.71) vigour index II were recorded from fungicide-treated cut bulbs and whole bulbs, respectively. And also the highest (1.84) and the lowest number (1.68) vigour index II were recorded from single row spacing 50 x 20 and from double row spacing 50 x 30 x 20, respectively (Table 6). Generally, seed vigour Index II increased with increased spacing (decreasing plant population density). This could be attributed to lower competition among plants for growth factors for better development and accumulation of food source in the seed for next generation. Similarly, Singh *et al*. (1985) reported that seed quality attributes like test weight, germination percentage, and seedling vigour index were found to be better in response to planting at a wider spacing than narrower spacing.

Conclusion

The highest onion seed yield was obtained from planting fungicide-treated cut bulbs at the double-row spacing of 50 x 30 x 20 cm or 60 x 30 x 20 cm. And the lowest was obtained from planting whole bulbs. On the other hand, the highest values of seed quality parameters were obtained from the wider single-row planting and fungicide-treated cut bulbs. The lowest was obtained from whole bulbs at the narrower double-row spacing.

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Table 1. Treatment combination and plant population density

Treatment	Bulb type	Spacing	Plants m^{-2}	Plants ha^{-1}
T_1	Whole bulb	50x30x20 cm (S1)	20.00	200,000
T_2	Whole bulb	60x30x20 cm (S2)	16.66	166,666
T_3	Whole bulb	40x20 cm (S3)	12.50	125,000
T_4	Whole bulb	50x20 cm (S4)	9.720	97,222
T_5	Cut bulb	50x30x20 cm (S1)	19.44	194,444
T_6	Cut bulb	60x30x20 cm (S2)	16.66	166,666
T_7	Cut bulb	40x20 cm (S3)	12.50	125,000
T_8	Cut bulb	50x20 cm (S4)	9.720	97,222
T_9	Ash-treated cut bulb	50x30x20 cm (S1)	19.44	194,444
T_{10}	Ash-treated cut bulb	60x30x20 cm (S2)	16.66	166,666
T_{11}	Ash-treated cut bulb	40x20 cm (S3)	12.50	125,000
T_{12}	Ash-treated cut bulb	50x20 cm (S4)	9.720	97,222
T_{13}	Fungicide-treated cut bulb	50x30x20 cm (S1)	19.44	194,444
T_{14}	Fungicide-treated cut bulb	60x30x20 cm (S2)	16.66	166,666
T_{15}	Fungicide-treated cut bulb	40x20 cm (S3)	12.50	125,000
T_{16}	Fungicide-treated cut bulb	50x20 cm (S4)	9.72	97,222

For S_1 and S_2, the first number indicates the spacing between ridges (the double rows), the second number indicates the spacing between rows, and the third number indicates the spacing between plants; For S3 and S4, the first number indicates the spacing between the single rows and the second number indicates the spacing between plants.

Table 2. The interaction effect of bulb treatment and spacing patterns on seed yield per ha of variety Bombay red onion seed.

	Seed Yield (kg ha^{-1})			
	Bulb treatment			
Spacing (cm)				
50 x 30 x 20	673.1b	667.2b	720.5b	906.1a
60 x 30 x 20	670.4b	638.8bc	711.5b	898.0a
40 x 20	357.5ef	438.7def	483.1de	376.4def
50 x 20	325.7f	401.1def	513.8cd	385.8def
F-test	*			
LSD (B x S)	144.5			
CV (%)	15.1			

Means followed by the same letter are not significantly different at 5% level of significance. * = significant at 5% and 1% levels of significance; LSD = least significant difference at 5 % level of significance; B = Bulb treatment; S = Spacing; CV = Coefficient of variation

Table 3. The main effect of bulb treatment and spacing patterns on germination percent, vigour index I , vigour Index II and Seed weight umbel^{-1} (g) of onion variety Bombey red seed.

Treatments	Parameters'			
	Germination perc.(%)	Vigour Index I	Vigour Index II	Seed weight umbel^{-1} (g)
Bulb treatment				
Whole bulb	85.42b	998c	1.71b	2.25c
Cut bulb	86.00b	1025bc	1.72b	2.29bc
Ash-treated bulb	88.50b	1067ab	1.77b	2.39b
Fung.-treated bulb	93.08a	1121a	1.86a	2.83a
F- test	*	**	*	**
LSD (5%)	3.903	57.38	0.0781	0.1298
Spacing (cm)				
50 x 30 x 20	83.92c	933c	1.68c	2.18c
60 x 30 x 20	87.67bc	1035b	1.75bc	2.40b
40 x 20	89.58ab	1094a	1.79ab	2.44b
50 x 20	91.83a	1150a	1.84a	2.74a
F-test	*	**	*	**
LSD (5%)	3.903	57.38	0.0781	0.1298
CV (%)	5.3	6.5	5.3	6.4

Means followed by the same letter within a column are not significantly different at 5% level of significance; *, ** = significant at 5% and 1% levels of significance; LSD = least significant difference, CV = Coefficient of variation