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Influence of Bulb Treatment and Spacing Patterns on Yield and Quality of Onion (*Allium cepa* var. C*epa*) Seed at Humbo Larena, Southern Ethiopia

Ashenafi Woldeselassie*, Helen Teshome and Tibebu Simon
Department of Horticulture, College of Agricultural Sciences, Wolaita Sodo University, Ethiopia
*E-mail: ashehel@yahoo.com

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 both the main as well as the interaction effects of bulb treatment and spacing patterns did not influence the number of days required for emergence, 1000 seed weight, and physical purity. Days to 50% flowering was significantly influenced by bulb treatments but not spacing patterns. The main effects of both bulb treatment and spacing significantly influenced, plant height, number of umbels per plant, umbel diameter, seed weight per umbel, standard germination, vigour Index I and vigour index II. Bulb treatment and spacing interacted to significantly influence percent stand count, number of flowering stalks per plant, and 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

1. 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 effects of bulb treatment and spacing patterns on seed yield and seed quality of onion is the objective of the study presented in this paper.

2. 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 gross size of each plot was 2.6 x 3 m = 7.8 m^2. Net plot sizes differed according to the spacing. Thus, for S1, it was 2.5 m × 3.0 m = 7.5 m^2; for S2, it was 2.4 m x 3.0 m = 7.2 m^2; for S3, it was 2.4 m x 3.0 m = 7.2 m^2; for S4, it was 2.5 m x 3.0 m = 7.5 m^2. There were 7, 6, 6 and 5 plant rows per plot, making the total number of 150, 120, 90 and 75 plants per plot for the different spacing treatments of S_1, S_2, S_3 and S_4 respectively. 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 $1/3^{rd}$ 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 $2/3^{rd}$ 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 days to emergence, days to 50 % flowering, days to maturity, % stand count, plant height, number of flower stalks per plant, umbel number per plant, umbel diameter, weight of seeds per umbel, seed yield per hectare, seed purity, 1000 seeds weight, 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

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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.

3. Results and Discussion

3.1. Days to 50% flowering

The number of days required to reach 50% days to flowering was significantly ($P < 0.01$) affected by the main effect of bulb treatment but not to spacing patterns. Plants grown from whole bulbs flowered significantly earlier (68.50) than plants grown from cut or topped bulbs treated with ash or those treated with the fungicide (Table 2). Plants grown from fungicide-treated cut bulbs required a significantly higher number of days to reach the stage of growth of 50% flowering may be attributed to the healthier and more prolonged vegetative growth of the plants as observed during the growth period. This result is also in agreement with that of Rashid and Singh (2000) reported that topped bulb had more vigorous sprouting. The result that spacing did not affect days to flowering is consistent with the finding of Kanwar *et al*. (2000) that differences in population density did not lead to significant effect on days to flowering and maturity.

3.2. Plant height (cm)

Bulb treatment and spacing patterns significantly ($P < 0.05$) affected plant height. The tallest (83.37 cm) and the shortest (76.92 cm) plant height were obtained from fungicide-treated topped bulbs and whole bulbs, respectively. And also the tallest (83.03 cm) and the shortest (76.87 cm) plant height were recorded from single row spacing 50 x 20 and from double row spacing 50 x 30 x 20, respectively (Table 2). The significant increase in plant height in response to treating the topped bulbs with the fungicide and planting in lowest population density could be attributed to the potency of the chemical in killing fungal pathogens or rot organisms, thereby preventing the occurrence of diseased plants and lesser competition for nutrients, light, and moisture. Similarly, Asare-Bediako *et al.,* (2007) reported that Benlate (a fungicide) completely inhibited rot pathogens growth in yam (*Dioscorea alata* Poir**)**. And also Khan *et al.* (2002), who reported that various plant spacing, resulted in varied plant heights, with the densest planting leading to growth of shorter plants due to high competition among plants for growth factors

3.3. Stand count (%)

The interaction effects of bulb treatment and spacing patterns significantly ($P < 0.05$) affected stand count percentages .The highest (97.07 and 92.83) stand count percentages were recorded from the interaction of planting fungicide-treated cut (topped) bulbs at the single-row spacing of 50 x 20 cm and 40 x 20 cm, respectively. The lowest (39.18 and 43.90) stand count percentages were recorded from planting whole bulbs at the two double row spacing of 60 x 30 x 20 cm and 50 x 30 x 20 cm, respectively (Table 3). This effect could be attributed to interplant competition among plants for space, light, moisture, and nutrients at the higher population densities. Consistent with the results of this study, Higgins (1968) reported that in the narrow intra-row spacing, smaller plants were crowded out and they disappeared. Corroborating the results of this study, research conducted by Henderson *et al.,* (2000) on grain amaranth revealed that reduced plant competition and plant mortality were observed at the lower plant population densities.

3.4. Number of flower stalks per plant

The interaction effects of bulb treatment and spacing patterns significantly ($P < 0.05$) affected number of flower stalks per plant. The highest(16.50) number of flower stalks per plant was, recorded from the interaction effect of planting fungicide-treated cut bulbs at the sparsest plant population density 50 x 20 cm and the lowest (10.03) number was recorded from the interaction effect of planting the whole bulbs at double row spacing 60 x 30 x 20 cm (Table 4). This effect could be due to onion plants grown from fungicide-treated bulbs at the wider spacing of 50 x 20 cm may have endured lower competition among flower stalks for growth resources, thereby having increased number of flower stalks over plants grown in the other treatment combinations. This result is concurrent with the findings of Ogundana (1971), who reported that yam tubers treated with fungicides such as Benlate and Captan were reported to be free from fungal rots. The number of flower stalks per plant might also be enhanced by the effects of bulb topping (cutting) as well as that of chemicals. This suggestion is supported by Rashid and Singh (2000) who reported that bulb topping should be practiced to enhance vigorous sprouting.

3.5. Number of umbels per plant

Bulb treatment and spacing patterns significantly ($P < 0.01$) affected the number of umbels per plant. The highest (8.2) and the lowest (4.71) number of umbels per plant were recorded from fungicide-treated topped bulbs and whole bulbs, respectively. And also the highest (7.23) and the lowest (4.95) number of umbels per plant were recorded from single row spacing 50 x 20 and from double row spacing 50 x 30 x 20, respectively

(Table 5).The production of significantly higher umbel numbers from cut and fungicide-treated cut bulbs may be attributed to the growth of more shoot primordia in cut-and fungicide-treated bulbs due to removal of apical dominance as well as due to the protection provided by the plants by the fungicide against fungal pathogens and rot organisms. In line with this the decrease in the number of umbels produced per plant in response to the narrower spacing (high-density planting) may be ascribed to mutual shading and possibly stiffer competition for light as well as other growth factors among the onion plants. This result is consistent with the finding of Asare-Bediako *et al*. (2007) who reported that plants raised from Benlate (fungicide)-treated minisetts of yam (Dioscorea alata Poir) were more vigorous than those raised from minisetts sterilized only with distilled water. And also Ali *et al*. (1998) reported that wider plant spacing resulted in the production of larger number of umbels per plant where narrower plant spacing led to the production of decreased number of umbels per plant due to poor nutrient translocation to the plant and disease severity.

3.6. Umbel diameter (cm)

Bulb treatment and spacing patterns significantly ($P < 0.05$) affected umbel diameter. The widest (6.48 cm) and the lowest (5.39 cm) umbel diameter were recorded from fungicide-treated cut bulbs and whole bulbs, respectively. And also the widest (6.25 cm) and the lowest (5.47) umbel diameter were recorded from single row spacing 50 x 20 and from double row spacing 50 x 30 x 20, respectively (Table 5). This may be due to the Fungicide-treated bulbs against fungal pathogens, which may have encouraged growth of healthy and vigorous plants with wider umbels and by plants grown at the wider spacing may be linked to lesser competition among the onion plants for growth factors. This result is consistent with the finding of Asare-Bediako *et. al.* (2007) who stated that yam tubers were treated with Benomyl as a protective and eradicant fungicide with systemic activity and effective against a broad range of fungi. Similarly, Asaduzzaman *et al.* (2012) who reported the lowest umbel diameter at closer spacing and the highest at wider spacing.

3.7. 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.

3.8. 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

3.9. Germination test (%)

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.

3.10. 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.

3.11. 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.

4. 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. However, the values of seed quality parameters obtained in response to planting fungicide-treated topped bulbs at the double-row spacing of 50 x 30 x 20 cm and 60 x 30 x 20 cm, at which the highest seed yields were obtained, would meet the seed quality standards. Ash-treated topped bulbs planted at the double-row spacing produced the next higher onion seed yield and quality.

5. References

Abdul-Baki, A.A. and J.D. Anderson, 1973. Vigour determination in soybean by multiple criteria. *Journal of Crop Science*. 13: 630-633.

Ali, N., M.A. Baloch, S.A. Hussain and N. Ali, 1998. Study on the effects of planting space and bulb size on seed production in onion crop. Sharhad *Journal of Agriculture* 14(6): 563-568.

Asaduzzaman, M.D., M.D. Mahmudul Hasan, M.D. Mainul Hasan, M.D. Moniruzzaman, 2012. Quality Seed Production of Onion (Allium Cepa L.): An Integrated Approach Of Bulb Size and Plant Spacing. *Journal of Agricultural Research*. 50(1):119-128.

Asare-Bediako, E., F.A. Showemimo, Y. Opoku-Asiama and D.H.A.K. Amewowor, 2007.Improving Sprouting Ability of White Yam Minisetts (*Dioscorea alata* Poir) Var Pona and Dente Using Different Disinfectants and Protectants in Sterilized Saw Dust. *Journal of Applied Sciences. 7: 3131-3134.*

Brewster, J.L, 1994. Onions and other vegetable Alliums. CAB International, Wallingford, UK, 236 p.

CSSE (Crop Science Society of Ethiopia), 2006. Farmers' participatory onion seed production in the Central Rift Valley of Ethiopia: achievement, constraints and its implication for the national seed system. Conference summary, The Conference of the Crop Science Society of Ethiopia, 11, Addis Abeba (Ethiopia), 26-28 Apr 2004.

Dawit A., A. Deressa, L.Dessalegne, and C. Anchala., 2004. Domestic vegetable seed production and marketing. Research report. No 57. EARO, Addis Ababa. 29p.

EARO, 2004. Directory of Released Crop Varieties and their Recommended Cultural Practices. Ethiopian agricultural research organization. Addis Ababa. Pp. 26

Geremew A., T. Abdisa, K. Tolosa and A.Chali, 2010. Effect of intra-row spacing on yield of three onion (Allium cepa L.) varieties at Adami Tulu Agricultural Research Centre (mid rift valley of Ethiopia). *Journal of Horticulture*. 2(1): 007-011.

Hailu G., T. Simon and M. Tora., 2011. Participatory evaluation of shallot (*allium cepa* var.aggregatum) varieties and bulb size effect on yield and yield traits in wolaita zone, southern ethiopia.A research project submitted to wolaita Soddo University.Pp. 67

Henderson, T.L., B.L. Johnson and A.A. Schneiter, 2000. New crops row spacing, plant population, and cultivar effects on grain amaranth in the Northern Great Plains. *Agronomy Journal*. 92: 329-336.

Higgins, J.J., 1968. Vernonia anthelmintica: A potential seed oil sources of epoxy acid, I. Phenology of seed yield. *Agronomy Journal*. 60: 55-58.

Jones, H. A. and L.K. Mann, 1963. Onions and their Allies. London, Leonard Hill. pp 7-128

Kanwar, J.S., B.S. Gill and S.S. Bal, 2000. Response of planting time and density to onion seed yield and quality. Seed Research. 28(2): 212-214.

Khan, H., M. Iqbal, A. Ghaffoor and K. Waseem, 2002. Effect of various plants spacing and different nitrogen levels on the growth and yield of onion. *Journal Biological Science*. 2:545–7.

Lemma D. and S. Aklilu, 2003. Research Experiences in Onion production. Research Report No. 55. Ethiopia Agricultural Research Organization, Addis Ababa, Ethiopia.
Lemma D., S. G/Mariam, and E. Herath, 1994. Seed production studies on vegetables, pp. 276-282. Proceedings of the Second National Horticultural Workshop of Ethiopia. Addis Ababa, Ethiopia.
Norman, A.G., 1963. Competition among crops and pasture plants, Adv in Argon. 15:1-14.
Ogundana, SK., 1971. The post-harvest decay of yam tubers and its preliminary control in Nigeria. Biodeteroration of materials (Eds.) A.N. Walter and E.H. Hueck Van Plas, Vol. 2: 481-492.
Patil, J.G., V.R. Shelar and S.K. Shinde, 1993. Effect of irrigation intensity on seed yield and components of seed in onion seed crop India. Onion Newsletter for the Tropics, 4:40- 42.
Rashid, M.A. and D.P. Singh, 2000. A Manual on vegetable seed production in Bangladesh: 1st ed. AVRDC-USAID-Bangladesh Project-Horticulture Research Centre, Bangeladesh Agricultural Research Institute Joydebpur, Gazipur 70, BANGLADESH, pp 117.
Raymond A.T. George. 2009. Vegetable Seed Production. 3rd Edition, Cab International., UK. Pp 320.
Singh, K.P., Y.S. Malik, and S. Lal, 1985, Effect of stickling, planting and spacing in radish seedcrop. Seed Research. 13:1. pp 176-179.
Yohannes A., 1987. Current activities, recommendation and future strategies of onion research in Ethiopia. pp. 358-370. In: Burba, J.L., and C.R., Galmarini (eds), 1994. Proceedings of the 19th National crop improvement conference. Addis Ababa, Ethiopia, 22 26,April 1988, Institute of Agricultural Research.

Table 7. 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. Main effects of bulb treatment and spacing arrangements on days to 50% flowering and plant height in onion seed production of variety Bombey red

Treatment	Days to 50% flowering	Plant height (cm)
Bulb treatments		
Whole bulb	68.50b	76.92b
Cut bulb	68.58b	77.85b
Ash-treated cut bulb	68.83b	79.66b
Fungicide-treated cut bulb	71.08a	83.37a
F-test	**	*
LSD (5%)	1.071	3.279
Spacing (cm)		
50 x 30 x 20	69.58	76.87c
60 x 30 x 20	69.33	77.36bc
40 x 20	69.17	80.53ab
50 x 20	68.92	83.03a
F-test	Ns	*
LSD (5%)	1.071	3.279
CV (%)	1.9	4.9

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

Table 3. Interaction effect of bulb treatment and spacing patterns on percent plant stand count in onion seed production of variety Bombey red.

	Stand count (%)			
	Bulb treatment			
Spacing (cm)	Whole bulb	Cut bulb	Ash-treated cut bulb	Fungicide-treated cut bulb
50x30x20	43.90fg	50.67ef	55.79de	76.64b
60x30x20	39.18g	59.92de	62.38cd	79.34b
40 x 20	71.95bc	74.08b	77.08b	92.83a
50 x 20	81.38b	81.26b	81.06b	97.07a
F-test	*			
LSD (B x S) (5 %)	4.897			
CV (%)	8.4			

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

Table 4. The interaction effect of bulb treatment and spacing patterns on the number of flower stalks per plant and seed yield per ha of variety Bombay red onion seed.

Number of flower stalks plant^{-1}				
	Bulb treatment			
	Whole bulb	Cut bulb	Ash-treated cut bulb	Fungicide-treated cut bulb
Spacing (cm)				
50 x 30 x 20	10.67efg	11.33c-g	10.00g	11.70c-g
60 x 30 x 20	10.03fg	11.90c-f	11.67c-g	12.87bcd
40 x 20	11.00d-g	12.10b-e	13.87b	12.90bc
50 x 20	12.83bcd	12.80bcd	12.77bcd	16.50a
F-test		*		
LSD (B x S)		0.938		
CV (%)		9.2		
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 5.The main effects of bulb treatment and spacing arrangement on number of umbels per plant, umbel diameter, and seed weight per umbel of variety Bombay red onion seed.

Treatment	Umbel no. plant^{-1}	Umbel diameter (cm)	Seed weight umbel^{-1} (g)
Bulb treatment			
Whole bulb	4.71c	5.39b	2.25c
Cut bulb	5.43bc	5.55b	2.29bc
Ash-treat.cut bulb	5.93b	5.76b	2.39b
Fung.-tr. cut bulb	8.20a	6.48a	2.83a
F-test	**	*	**
LSD (5%)	0.982	0.5485	0.1298
Spacing (cm)			
50 x 30 x 20	4.95b	5.47b	2.18c
60 x 30 x 20	5.01b	5.49b	2.40b
40 x 20	7.08a	5.96ab	2.44b
50 x 20	7.23a	6.25a	2.74a
F-test	**	*	**
LSD (5%)	0.982	0.5485	0.1298
CV (%)	19.4	11.4	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 at 5% level of significance

Table 6. The main effect of bulb treatment and spacing patterns on germination percent, vigour index I and vigour Index II in onion variety Bombey red seed.

Seed quality			
	Germination perc.(%)	Vigour Index I	Vigour Index II
Bulb treatment			
Whole bulb	85.42b	998c	1.71b
Cut bulb	86.00b	1025bc	1.72b
Ash-treated bulb	88.50b	1067ab	1.77b
Fung.-treated bulb	93.08a	1121a	1.86a
F- test	*	**	*
LSD (5%)	3.903	57.38	0.0781
Spacing (cm)			
50 x 30 x 20	83.92c	933c	1.68c
60 x 30 x 20	87.67bc	1035b	1.75bc
40 x 20	89.58ab	1094a	1.79ab
50 x 20	91.83a	1150a	1.84a
F-test	*	**	*
LSD (5%)	3.903	57.38	0.0781
CV (%)	5.3	6.5	5.3

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

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