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Effects of Planting Time and Mother Bulb Size on Onion (*Allium cepa* L.) Seed Yield and Quality at Kobo Woreda, Northern Ethiopia

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ABSTRACT

A field experiment was conducted at Sirinka Agricultural Research centre Kobo sub center research field during the 2012/2013 under irrigation condition with the objective of assessing the effect of different planting time (October 25, November 5 and November 15) and mother bulb sizes (2-3, 3.1-4 and 4.1-5 cm) on onion seed yield and quality. The study was conducted by using 3×3 factorial design with three replications. Data was collected on growth, yield and quality parameters and analyzed using SAS version 9.2 statistical software. The results of the study showed significant interactions between mother bulb size and planting time on days to 50% flowering, scape diameter (cm), seed yield per plant (g), seed yield per hectare (kg) and germination index. The maximum seed yield (1155.73 kg ha^{-1}) was obtained from large bulbs planted on October 25 while the least (75.15 kg ha^{-1}) from small bulbs planted on November 15. In terms of germination index, the highest (6.03) was obtained from the large bulbs planted on October 25, whereas the lowest germination index (3.37) was from small bulbs planted on November 15. Early planting on October 25 increased germination percentage by 39% than the last planting 15 November. Regarding mother bulb size, large bulbs increased germination percentage by 13.32% than the small bulbs. Correlation coefficient indicated that umbel diameter, seed number per umbel, seed weight per umbel and seed yield per plant were found to have positively and highly significantly correlated with seed yield per hectare. Therefore, based on the findings of the current study, early planting (October 25) of large bulbs (4.1-5 cm) can be used for high yield and better quality of onion seeds. Considering the above mentioned results, it would be advisable to further investgated the seed production potential of different onion types at different locations over years so as to come up with best recommendation. In addition, plant spacing, fertilizer rate and storage methods of onion seed could also be considered. Furthermore, the seed quality performance of imported and locally produced onion seeds could be investigated to promote the onion seed industry.

Key words: Mother bulb size, planting time, seed yield, seed quality, onion

INTRODUCTION

Onion (*Allium cepa* L.) is the most common member of the family Alliaceae and the widely grown herbaceous biennial vegetable crop with cross pollinated and monocotyledonous behavior having diploid chromosome number (2n = 16) (Bassett, 1986). Onion is different from the other edible species of Alliums for its single bulb and is usually propagated by true botanical seed. In

Ethiopia, onion can grow between 500 and 2400 m above sea level but the best growing altitude so far known is between 700 and 1800 m above sea level (Lemma *et al*., 1994). Suitable soil pH for onion ranges between 6.2 and 6.8 (Karim and Ibrahim, 2013). Onion contributes significant nutritional value to the human diet and has medicinal properties and is primarily consumed for its unique flavor or for its ability to enhance the flavor of other foods (Randle, 2000).

Seed production is a vital part in onion growing and is a highly specialized business requiring particular knowledge and training. Steady supply of good quality seeds is a pre-requisite for the successful accomplishment of high production of acceptable onions as fresh bulbs or as dehydrated either for local consumption or for export. The production of onion seed with high quality depends on a number of factors. The most important one includes storage methods, size of bulbs, planting dates and harvesting times. Moreover, onion seed production depends on the cultivar, location, growing season and adequate plant protection measures (Lemma and Shimeles, 2003). About 9,745.36 tones of onion seed was produced in the world in 2011 (FAO, 2013).

Lack of cool weather conditions to induce flowering is the main constraint of onion seed production in many tropical countries. As a result, many countries have to import onion seed from sub-tropics or temperate countries where the winter season provides the chilling requirement for flowering (Peters, 1990). Mother bulb size and planting time has marked influence on seed production in onion. Considering that an increase in size of bulb results in higher seed yield but large size bulbs if used will need a very high seed rate (Khokhar, 2009).

Kobo Woreda is one of the potential areas for vegetable production especially onion. Among different onion varieties, Bombey Red is the most widely used as a cash crop by the farmers in the area. In many areas of Ethiopia, the off season crop (under irrigation) constitutes much of the area under onion production. Since, with the establishment of Kobo Girana Valley Development Program (KGVDP), the farmers in Kobo area started vegetable production by using underground water irrigation system.

Earlier investigations conducted at Melkassa (Lemma and Shimeles, 2003) to determine optimum mother bulb sizes and planting time for onion seed production under Ethiopian condition. Those findings contributed much for the improved onion production until recent years. In order to fill the prevailing research gap, this study combining two important agronomic factors termed as planting time, mother bulb size and their interaction, was conducted under Kobo condition. With growing onion production demand in the Kobo area, in order to increase the quantity and quality seeds produced locally, reducing the cost of production for commercial seed and bulb producers and reducing dependence on seed import from abroad is becoming necessity. Therefore, this study was executed to assess the effect of different planting time and mother bulb size on seed yield and quality of onion under Kobo agro-climatic condition.

MATERIALS AND METHODS

Description of study area: The experiment was conducted from October 2012-April 2013 under irrigation condition at Sirinka Agricultural Research Center, Kobo sub-center research field, located at 570 km North of Addis Ababa at about 120 08' 21"N latitude and 39038'21"E longitude at an altitude of 1470 m.a.s.l. The long term mean annual rainfall of the area is 668 mm with a maximum and minimum temperature of 31 and 15°C, respectively.

Experimental material and design: Onion cultivar Bombay Red, obtained from Sirinka Agricultural Research Center, was used for this study. The experiment was laid out in 3×3 factorial design with three replications. Treatments consisted of three different mother bulb size (diameter); small (2-3 cm), medium (3.1-4 cm) and large (4.1-5 cm) and three planting time intervals (25 October, 5 November and 15 November). A plot size of 4×3.2 m (12.8 m^2) was used for each experimental unit. Treatments were randomly assigned to the experimental plots.

Experimental procedures: The experimental land was cleared and ploughed four times by oxen plough according to farmers' practice. The whole field was divided into three blocks each containing 9 plots. The onion bulbs were planted in rows with spacing of 50, 30 and 20 cm between water furrows, rows on the bed and plants in the rows, respectively. A distance of 1 and 1.5 m was maintained between unit plot and blocks, respectively. Each plot had six double rows (ridges) which consisted of (228 plants $plot^{-1}$). The middle four double rows were considered for recording the agronomic data. Bulbs of typical color and free from insect, disease and mechanical injuries were selected directly in the field from the harvest of 2012 growing period and were kept at room temperature upto first planting and were planted every ten days for successive dates of planting by keeping the rest of mother bulbs at room temperature. Mother bulbs were planted by hand three times at ten days interval, (October 25, November 5 and November 15). Starting from bulb planting upto harvesting time, all important agronomic practices like fertilization, weeding, cultivation, ridging and irrigation were practiced as per the recommendation (Lemma and Shimeles, 2003).

Statistical analysis: The data was checked for all ANOVA assumptions. Analysis of variance (ANOVA) and correlation were done using SAS Version 9.2 statistical software (SAS, 2008). Means were compared by using Least Significant Difference (LSD) test at 5% probability level.

RESULTS AND DISCUSSION

Growth parameters

Plant height (cm): Plant height was highly significantly ($p<0.01$) affected by bulb size and planting time but there was no interaction between the two factors (Table 1). The maximum plant height (79.83 cm) was produced from large mother bulb size. Planting time also significantly influenced plant height and the tallest plants (79.74 cm) were obtained from the first planting (25 October). The increase in plant height could mainly be due to early planting which might have provided plants with relatively cooler period compared to the latter two plantings and larger bulbs had enough reserve food to support growth of plants which resulted in the maximum plant height. This result agrees with the findings of Ud-Deen (2008) who reported that plant height could be affected by the mother bulb size and planting time. Khodadadi and Hassanpanah (2012) also reported the highest plant height from large mother bulb size. In addition, Malik *et al.* (1999) indicated that time of bulb planting had significant effect on plant height.

Number of leaves per plant: There was highly significant difference in the number of leaves counted among bulb sizes ($p<0.01$) but the interaction between the two factors was not significant. The highest number of green leaves per plant (33.5) was obtained from large bulb size and the least was from small bulb size (24.01) (Table 1). As bigger bulbs contain more sprouting (shoot) initials and reserve food material, they might have been responsible for producing more leaves than smaller ones. The result is in conformity with the results of Hussain *et al.* (2001), Islam (2002) and Asaduzzaman *et al.* (2012a), who reported maximum number of green leaves per plant from large bulbs.

Table 1: Effect of mother bulb size and planting time on plant height, number of leaves per plant, number of scapes per plant and scape height tested at Kobo

Treatments	Plant height (cm)	No. of leaves plant^{-1}	No. of scapes plant^{-1}	Scape height (cm)
Bulb size				
Large	79.83[a]	33.51[a]	6.65[a]	70.18[a]
Medium	70.63[b]	29.14[b]	5.37[b]	60.91[b]
Small	69.87[b]	24.01[c]	3.75[c]	60.70[b]
Planting time				
25 October	79.74[a]	29.30[a]	5.26[a]	69.63[a]
5 November	72.52[b]	28.87[a]	5.37[a]	63.01[ab]
15 November	68.08[b]	28.42[a]	5.17[a]	59.14[b]
LSD (5%)	5.67	1.85	0.59	5.63
CV (%)	7.73	6.44	11.23	8.82

Values in each column sharing same letter are not significantly affected at ($\alpha = 0.05$)

Number of scapes per plant: The number of scapes per plant significantly ($p<0.01$) decreased as the bulb size decreased. Planting time and its interaction with bulb size didn't significantly influence number of scapes per plant. Large bulb size gave significantly highest number of scapes per plant (6.65) (Table 1). Using large mother bulbs, increased number of scapes by 77% as compared to the small mother bulbs. This difference might be due to the superiority of large bulbs in terms of having more stored food which, in turn, might have produced more sprouts leading to more number of scapes per plant. This result is in agreement with the findings of various researchers (McDonald and Copeland, 1997; Hussain *et al*., 2001). Asaduzzaman *et al*. (2012a) also revealed that the number of scapes per plant was significantly high in the large sized bulb while the minimum in small sized bulb.

Scape height: Scape height significantly ($p<0.01$) varied with bulb size and planting time. Interaction of the two factors, however, didn't affect scape height. The maximum scape height (70.18 cm) was recorded from large bulb size, followed by medium (60.91 cm) and small (60.70 cm) bulb sizes. The tallest scape height (69.63 cm) was recorded from 25 October planting time, followed by 5 November (63.01 cm) and 15 November (59.14 cm) planting times (Table 1). This result is in line with the findings of El-Helaly and Karam (2012) who reported the longest scape from early planting. Farag and Koriem (1996) and Asaduzzaman *et al*. (2012a) also reported the tallest scape from large sized bulb while, the shortest scape from small-sized ones. In contrast to the results of the present study, Morozowska and Holubowicz (2009) reported no significant difference between scape heights. This might be due to difference in cultivar and environmental conditions of the experimental area.

Scape diameter: Scape diameter was influenced significantly ($p<0.05$) by the interaction of bulb size and planting time. The highest scape diameter was obtained from large bulbs planted from 25 October planting (1.09 cm). However, it was not significantly different from medium size bulbs planted on 25 October (1.02) and 5 November (0.94) (Table 2). This result is in conformity with the findings of Ashrafuzzaman *et al*. (2009), who reported the maximum scape diameter from large and medium-sized bulbs while lowest from the small size bulbs. El-Helaly and Karam (2012) also reported maximum scape diameter from early planting while the lowest values were recorded from delayed planting.

Table 2: Interaction effects of bulb size and planting time on scape diameter and days to 50% flowering tested at Kobo

Bulb size and planting time	Scape diameter (cm)	Days to 50% flowering
Large		
25 Otcober	1.09^{a}	69.00^{f}
5 November	0.74^{d}	74.00^{de}
15 November	0.68^{d}	79.67^{b}
Medium		
25 October	1.02^{ab}	73.00^{e}
5 November	0.94^{abc}	75.00^{cde}
15 November	0.83^{bcd}	77.00^{c}
Small		
25 October	0.77^{cd}	74.00^{de}
5 November	0.79^{cd}	75.67^{cd}
15 November	0.83^{bcd}	82.67^{a}
LSD (5%)	0.19	2.14
CV (%)	14.15	2.67

Values in each column sharing same letter are not significantly affected at ($\alpha = 0.05$)

Days to 50% flowering: Days to 50% flowering was significantly influenced ($p<0.01$) by the interaction of bulb size and planting time. Large bulbs planted on 25 October flowering early (69 days) while, the longest days to attain 50% flowering were recorded from small bulb size planted on 15 November (82.67 days) (Table 2). This might be the reason that in early planting there was low temperature which might have contributed for the enhancement bolting and flower stalk development and subsequent flower development while at late planting, the temperature increased which, in turn, might have delayed bolting and subsequent flowering and maturity. Large bulbs contributed to the plants by giving enough amount of reserved food. Anisuzzaman *et al.* (2009) reported that planting time had marked influence on the number of days required for emergence of 50% flowering and sometimes early maturing is good, as it can escape from bad weather and diseases. Vianney *et al.* (2011) reported that low temperatures lead to plants bolting.

Yield and yield component parameters

Umbel diameter (cm): Bulb size and planting time significantly ($p<0.01$) influenced umbel diameter. However, interaction of the two factors didn't affect umbel diameter. The maximum umbel diameter was recorded from large bulb size (5.8 cm) but was on par with the one obtained from medium sized bulbs (5.58 cm). The lowest umbel diameter (5.02 cm) was obtained from small bulbs. The maximum umbel diameter (6.01 cm) was also obtained from those planted on 25 October, followed by 5 November (5.57 cm) and 15 November (4.82 cm) (Table 3). This might be due to higher supply of food materials to the umbel by larger bulb size and early planting also created favourable environmental conditions for earliest flowering and subsequently large umbel size. Patil *et al.* (1993) reported earliness to have significant effect on the umbel diameter. El-Helaly and Karam (2012) also reported that the maximum diameter of umbel was obtained with early planting. Asaduzzaman *et al.* (2012b) revealed that plants from large bulbs produced the highest umbel diameter while the smallest bulb size produced the lowest diameter.

Number of seeds per umbel: Significantly highest (407.44) number of seeds per umbel was recorded in large bulb size while the lowest was obtained in small bulb size (324.22). Regarding planting time, the maximum (515.33) and the least (256.56) number of seeds per umbel were recorded from planted on 25 October and 15 November, respectively (Table 3). However, the

Table 3: Effect of mother bulb size and planting time on umbel diameter, No. of seed umbel^{-1}, weight of seeds per umbel and 1000 seed weight tested at Kobo

Treatments	Diameter of umbel (cm)	No. of seed umbel^{-1}	Weight of seeds umbel^{-1} (g)	1000 seed weight (g)
Bulb size				
Large	5.80^{a}	407.44^{a}	2.67^{a}	3.13^{a}
Medium	5.58^{a}	322.78^{b}	2.41^{b}	3.30^{a}
Small	5.02^{b}	324.22^{b}	1.80^{c}	3.31^{a}
Planting time				
25 October	6.01^{a}	515.33^{a}	3.16^{a}	3.24^{ab}
5 November	5.57^{b}	282.56^{b}	2.16^{b}	3.43^{a}
15 November	4.82^{c}	256.56^{b}	1.57^{c}	3.06^{b}
LSD (5%)	0.43	61.95	0.25	0.21
CV (%)	8.04	17.64	11.06	6.57

Values in each column sharing same letter are not significantly affected at (α = 0.05)

interaction between the bulb size and planting time was not significant. Early planting on 25 October increased seed number per umbel by 100% than the last planting 15 November. Regarding mother bulb size, large bulbs increased seed number per umbel by 26.23% than the small bulbs. In addition to bulb size and planting time, the variation in number of seeds per umbel might be due to flower abortion caused by high temperature, lack of efficient pollinators of all the flowers in the umbel, shortage of nutrition which caused high competition and death of the weak florets in the umbel. Delayed planting resulted in poor plant growth and delayed bolting, moreover, high temperature at scape forming stages might have reduced the number of seed per umbel.

Weight of seeds per umbel (g): Both bulb size and planting time showed significant ($p<0.01$) difference in weight of seed per umbel. However, there was no significant interaction. The maximum weight of seed per umbel (2.67 g) was obtained from planting of large bulbs. Regarding planting time, both had significant difference. The maximum seed weight per umbel (3.16 g) was recorded from 25 October planting time, whereas 5 November and 15 November planting time gave 2.16 and 1.57 g of seed, respectively (Table 3). The highest weight of seeds per umbel might be due to the larger bulb containing more food reserves which, in turn, produced more number of flowers and seeded fruits per umbel and early planting for the conducive temperature for both development growth of flowering and seed set. This result is in agreement with El-Aweel and Ghobashi (1999), El-Helaly and Karam (2012) and Asaduzzaman *et al*. (2012a), who reported maximum weight of seeds recorded from large mother bulbs and early planting time.

Thousand seed weight (g): Planting time significantly ($p<0.05$) affected thousand seed weight but bulb size, interaction of bulb size, planting time didn't affect thousand seed weight. The heaviest seed (3.43 g) was obtained from 5 November planting time. That was not significantly different from that recorded on 25 October planting. However, significantly lowest thousand seed weight (3.06 g) was obtained from 15 November planting (Table 3). The reason for increasing thousand seed weight may be due to difference in planting time, i.e., these bulbs planted in early had got suitable temperature to increment their seeds. This result is in conformity with the findings of El-Aweel and Ghobashi (1999), who reported significant increase of thousand seed weight with planting time. El-Helaly and Karam (2012) also reported planting time to have significant effect on thousand seed weight.

Seed yield per plant (g): There was significant interaction between bulb size and planting time significantly ($p<0.01$) seed yield per plant. The highest seed yield per plant (10.97 g) was obtained

Table 4: Interaction effects of mother bulb size and planting time on seed yield per plant tested at Kobo

Bulb size and planting time	Seed yield plant^{-1} (g)
Large	
25 October	10.97^{a}
5 November	7.63^{c}
15 November	6.27^{d}
Medium	
25 October	9.73^{b}
5 November	4.23^{e}
15 November	3.10^{ef}
Small	
25 October	5.77^{d}
5 November	3.80^{ef}
15 November	2.67^{f}
LSD (5%)	1.17
CV (%)	11.07

Values in each column sharing the same letter are not significantly affected at (α = 0.05)

from the large bulbs planted on 25 October, followed by medium bulbs planted on the same date (9.73 g). The lowest seed yield (2.67 g) was obtained from small bulb size planted on 15 November (Table 4). The difference in seed yield per plant might be due to the number of scapes per plant, number of umbels per plant and number of seeds per umbel caused by larger sized bulbs and due to cool temperature for flower development in early planting and subsequent favourable temperature could have increased the final seed yield per plant. This result agrees with the findings of Aminpour and Mortazavibak (2004), who reported higher onion seed yields from plants grown from bigger bulbs. Muktadir *et al*. (2001) also reported that different bulb sizes had significant effect on seed yield per plant which increased with increase in bulb size and planting time. Asaduzzaman *et al*. (2012b) also reported that seed yield per plant was significantly varied due to different bulb sizes. El-Helaly and Karam (2012) depicted that favorable planting time produced high seed yield with best quality.

Seed yield (kg ha^{-1}): Bulb size and planting time exhibited a very highly significant interaction ($p<0.001$) differences on seed yield per hectare. The highest seed yield was obtained from large bulb size planted on 25 October (1155.73 kg), followed by medium bulb size planted on the same date (983.8 kg) while, the least (75.15 kg) was obtained from small bulb size planted on 15 November (Fig. 1). The difference in seed per hectare might have been due to the relative large amount of food reserves stored in large bulbs which enhanced the production of healthy and vigorously growing plants with large number of seed head and consequently increasing seed yield per hectare. This result agrees with the findings of Ud-Deen (2008), who reported that onion seed yield per hectare could be affected by the mother bulb size and planting time and the highest seed yield were obtained from large mother bulb with early planting while, the lowest seed yield was obtained from small mother bulb with late planting.

Quality parameters

Germination percentage: Germination percentage was significantly affected by planting time ($p<0.01$) and bulb size ($p<0.05$) but no interaction effect. Large bulb size (90.78) and planting on 25 October (97.56) gave the highest germination percentage followed by medium bulb size (83.22)

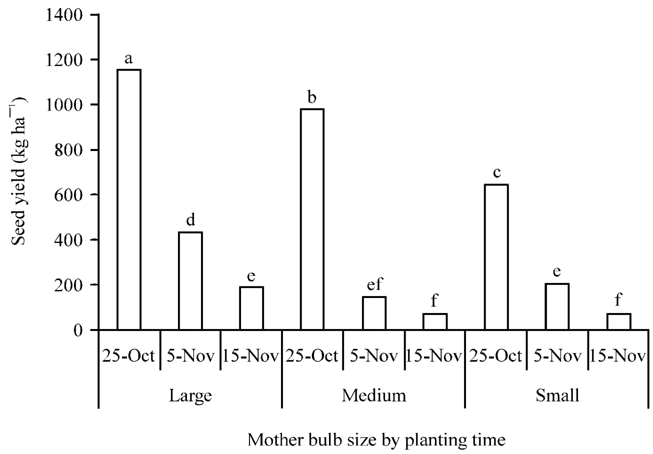

Fig. 1: Interaction effects of mother bulb size and planting time on seed yield (kg ha^{-1}) tested at Kobo, Means having the same letter on the top of bars are not significantly affected at (α = 0.05), LSD (5%) = 79.34 CV (%) = 10.18

Table 5: Effect of mother bulb size and planting time on germination percentage and seed vigor index tested at Kobo

Treatments	Germination (%)	Seed vigor index
Bulb size		
Large	90.78[a]	1235.3[a]
Medium	83.22[ab]	1195.8[a]
Small	80.11[b]	1070.1[a]
Planting time		
25 October	97.56[a]	1326.6[a]
5 November	86.44[b]	1178.5[ab]
15 November	70.11[c]	996.0[b]
LSD (5%)	8.13	228.0
CV (%)	9.61	19.5

Values in each column sharing same letter are not significantly affected at (α = 0.05)

and 5 November planting (86.44). Whereas, small bulb size (80.11) and late planting 15 November (70.11) gave the lowest germination percentage (Table 5). Early planting on 25 October increased germination percentage by 39% than the last planting 15 November. Regarding mother bulb size, large bulbs increased germination percentage by 13.32% than the small bulbs.

Increase in germination percentage might be due to high food reserves present in the large bulb which, in turn, might supply nutrient to the seeds and early planting also resulted in producing quality seed. Muktadir *et al.* (2001) reported higher seed germination percentage from larger mother bulbs. El-Helaly and Karam (2012) also concluded that planting time had significant effect on seed germination and the highest percentage of seed germination was obtained by early planting. Asaduzzaman *et al.* (2012b) also reported that seeds obtained from the largest sized bulb gave the highest germination percentage while those produced from the smallest bulbs showed the lowest germination percentage.

Seed vigor index: Seed vigor index was significantly affected by planting time ($p<0.05$). However, there was no significant effect on mother bulb size and interaction effect. The maximum seed vigor

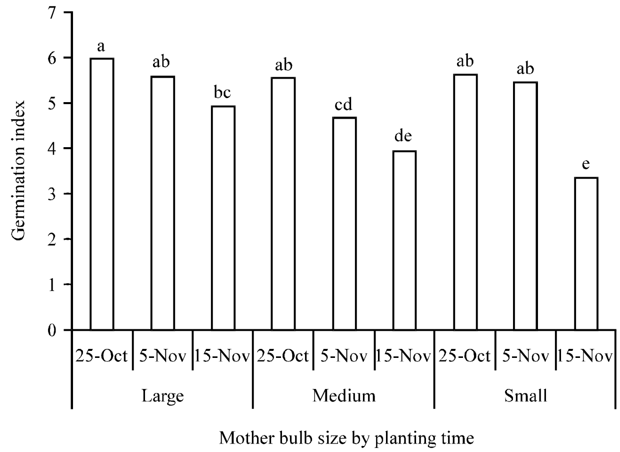

Fig. 2: Interaction effects of mother bulb size and planting time on germination index tested at Kobo. Means having the same letter on the top of bars are not significantly different at ($\alpha = 0.05$), LSD (5%) = 0.74 and CV (%) = 8.45

index values (1326.6) were recorded from planted on 25 October followed by 5 November (1178.5) and 15 November (996) (Table 5).

The difference in seed vigor index might be due to the quality differences of seed lots which was caused by planting time. This finding was related with that of Malik *et al.* (1999), who reported highest seed vigor index with early planting.

Germination index: Interaction of different bulb sizes and planting time significantly ($p<0.05$) influenced germination index. The highest value of germination index (6.03) was obtained from large bulb size planted on 25 October, whereas the lowest germination index (3.37) from small bulb size planted on 15 November (Fig. 2).

Higher value of germination index indicates the earlier germination and lower value indicates late germination. The difference in germination index might be due to the quality differences of seed lots which was caused by mother bulb size and planting time. Islam *et al.* (2009) reported that the germination index indicated the quality of the seed in jatropha seed study.

CONCLUSION

Onion is a high value and high income generating vegetable crop for most farmers or producers in Ethiopia. It is widely produced by small farmers and commercial growers and is mainly produced under irrigation condition. Planting time and mother bulb size are among the key factors that affect onion seed production. However, there are no research recommendations pertaining to planting time and mother bulb size with due consideration of the environmental condition of Kobo area. Therefore, the present study was conducted to assess the effects of different planting time and mother bulb size on onion seed yield and quality under Kobo agro-climatic condition. The finding showed significant differences among planting time and mother bulb size for most yield and quality parameters. The highest (1155.73 kg ha^{-1}) seed yield of onion was obtained from large sized mother bulbs planted on 25 October while, the least (75.15 kg ha^{-1}) from small bulbs planted on 15 November. From the finding of this study, it could be concluded that appropriate planting time with accurate mother bulb size could be practiced to increase the yield and quality of onion seed production. Onion seed producers in the study area should be encouraged to plant on 25 October with 4.1-5 cm mother bulb size to produce better yield and quality of onion seed. However, it could be advisable to further investigation of the seed production potential of different onion types at different locations over years so as to come up with best recommendation. In addition plant spacing, fertilizer rate and storage methods of onion seed could also be considered.

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REFERENCES

Aminpour, R. and A. Mortazavibak, 2004. Mother bulb size and planting pattern effects on seed quality and quantity of onion (*Allium cepa* L.) Cv. Texas early grano 502. Seed Plant, 20: 39-48.

Anisuzzaman, M., M. Ashrafuzzaman, M.R. Ismail, M.K. Uddin and M.A. Rahim, 2009. Planting time and mulching effect on onion development and seed production. Afr. J. Biotechnol., 8: 412-416.

Asaduzzaman, M., M. Hasan and M. Moniruzzaman, 2012a. Quality seed production of onion (*Allium cepa* L.): An integrated approach of bulb size and plant spacing. J. Agric. Res., 50: 119-128.

Asaduzzaman, M., M.M. Hasan, M.M. Hasan, M. Moniruzzaman and M.H.K. Howlander, 2012b. Effect of bulb size and plant spacing on seed production of onion (*Allium cepa* L.). Bangladesh J. Agric. Res., 37: 405-414.

Ashrafuzzaman, M., M.N. Millat, M.R. Ismail, M.K. Uddin, S.M. Shahidullah and S. Meon, 2009. Paclobutrazol and bulb size effect on onion seed production. Int. J. Agric. Biol., 11: 245-250.

Bassett, M.J., 1986. Breeding Vegetable Crops. AVI Publishing Co., USA., ISBN: 9780870554995, Pages: 584.

El-Aweel, M.A.T. and A.A. Ghobashi, 1999. Seed production in onion as influenced by dates of planting in the sultanate of Oman. Assiut J. Agric. Sci., 30: 43-53.

El-Helaly, M.A. and S.S. Karam, 2012. Influence of planting date on the production and quality of onion seeds. J. Hortic. Sci. Ornamental Plants, 4: 275-279.

FAO, 2013. FAO Statistical Yearbook 2013: World Food and Agriculture. Food and Agriculture Organization, Rome, Italy, ISBN-13: 9789251073964, Pages: 356.

Farag, I.A. and S.O. Koriem, 1996. Influence of size and cutting mother bulbs on yield and quality of onion seeds. Assiut J. Agric. Sci., 27: 97-106.

Hussain, S.W., M. Ishtiaq and S.A. Hussain, 2001. Effect of different bulb sizes and planting dates on green leaf production of onion (*Allium cepa* L.). J. Biol. Sci., 1: 345-347.

Islam, A.K.M.A., N. Anuar and Z. Yaakob, 2009. Effect of genotypes and pre-sowing treatments on seed germination behavior of Jatropha. Asian J. Plant Sci., 8: 433-439.

Islam, K.S., 2002. Control of growth cycle of onion for high yield and quality seed production. Ph.D. Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Karim, S.M.R. and N.R. Ibrahim, 2013. Effect of planting time, day length, soil pH and soil moisture on onion. Int. J. Biol. Pharm. Allied Sci., 2: 807-814.

Khodadadi, M. and D. Hassanpanah, 2012. The effects of planting date and motheral bulb size on quantitative and qualitative seed traits of onion red rey variety. Int. J. Agric.: Res. Rev., 2: 324-327.

Khokhar, K.M., 2009. Effect of set-size and storage temperature on bolting, bulbing and seed yield in two onion cultivars. Sci. Hortic., 122: 187-194.

Lemma, D. and A. Shimeles, 2003. Research experiences in onion production. Research Report No. 55, EARO, Addis Abeba, Ethiopia.

Lemma, D., Z. Yayeh, E. Hearth, T. Getachew and G. Asfaw, 1994. Variety development on vegetables. Proceeding of the 2nd National Horticultural Workshop of Ethiopia, December 1-3, 1992, Addis Ababa, Ethiopia, pp: 276-287.

Malik, Y.S., N. Singh and B.K. Nehra, 1999. Effect of planting time, bulb cut and pinching of bolt treatments on yield and quality of onion seed. Vegetable Sci., 26: 143-145.

McDonald, M.B. and L.O. Copeland, 1997. Seed Production: Principles and Practices. Chapman and Hall, New York, ISBN: 9780412075513, Pages: 749.

Morozowska, M. and R. Holubowicz, 2009. Effect of bulb size on selected morphological characteristics of seed stalks, seed yield and quality of onion (*Allium cepa* L.) seeds. Folia Horticulturae, 21: 27-38.

Muktadir, M.S., A.M. Farooque, M.A. Rahim and M.M. Hossain, 2001. Yield and quality of onion seed as influenced by the planting time and bulb size. Bangladesh J. Seed Sci. Technol., 5: 47-52.

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 in India. Onion Newsletter Trop., 4: 40-42.

Peters, R.J., 1990. Seed Production in Onion and other *Allium* Species. In: Onions and Allied Crop, Volume 1: Botany, Physiology and Genetics, Rabinowitch, H.D. and J.L. Brewster (Eds.). CRC Press, Boca Raton, FL., USA., ISBN-13: 978-0849363009, pp: 103-124.

Randle, W.M., 2000. Increasing nitrogen concentration in hydroponic solutions affects onion flavor and bulb quality. J. Am. Soc. Hortic. Sci., 125: 254-259.

SAS, 2008. SAS/STAT Version 9.2 User's Guide. SAS Institute Inc., Cary, NC., USA.

Ud-Deen, M.M., 2008. Effect of mother bulb size and planting time on growth, bulb and seed yield of onion. Bangladesh J. Agric. Res., 33: 531-537.

Vianney, M.T.W., R. Albert and T. Zoumbiesse, 2011. Effects of seasons of bulb and seed production on the early bolting of onion (*Allium cepa* L.) cv violet de Galmi. J. Applied Biosci., 40: 2652-2658.