Influence of planting date and bulb size on yield and quality of onion (Allium cepa L.) seed production

Teshome Ashagrie, Derbew Belew and Amsalu Nebiyu

Cogent Food & Agriculture (2021), 7: 1908656
Influence of planting date and bulb size on yield and quality of onion (Allium cepa L.) seed production

Teshome Ashagrie¹*, Derbew Belew² and Amsalu Nebiyu²

Abstract: Constraints are reported for the low productivity and quality of onion seed production in Ethiopia. Therefore, a field experiment was conducted at Kobo sub-center research station and Libso investment farm to study the influence of planting date and onion bulb size on yield and quality of onion seed. The experiment was laid out in Randomized Complete Block Design with three replications and involved three levels of onion bulb sizes and four levels of planting dates. The results of the study revealed that significant interactions between planting date and mother bulb size on seed yield (ton ha⁻¹), germination percentage, seed vigor index I and seed vigor index II. The highest seed yield (2.8 tons ha⁻¹) was recorded from large onion bulbs of a size planted at Kobo early—October. Planted onion bulbs early-October increased seed yield (ton ha⁻¹ by 21.7%) than planted early-November. Regarding onion bulb size, large bulbs increased seed yield (ton ha⁻¹ by 40%) than the small bulbs. The highest (97.3) germination percentage was recorded from large onion bulbs planted at Kobo in early-October. Therefore, for the production of better yield and quality of onion seeds, early-October planting and large onion bulbs (4.1–5 cm) can be recommended in the study areas and other similar agro-ecology areas of the country.

Subjects: Agriculture; Crop Science; Statistics for the Biological Sciences

ABOUT THE AUTHORS

Teshome Ashagrie is a researcher and staff of Sirinka Agricultural Research Center of Amhara Agricultural Research Institute, Ethiopia. He has experienced in conducting field experiments in different horticultural crops. Currently, he is a PhD candidate in Horticulture at Jimma University College of Agriculture and Veterinary medicine, Jimma, Ethiopia. His research interest is on horticultural crops, especially on vegetable breeding and agronomy.

Dr. Derbew Belew is a teaching and research staff (Professor of Horticulture) at Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia. His research interest is Agronomy-physiology, focusing mainly on vegetable and fruit crops and published widely.

Dr. Amsalu Nebiyu is teaching and research staff (Associate Professor) at Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia. His research interest is soil fertility and nutrient management, cropping systems intensification, legume-cereal integration.

PUBLIC INTEREST STATEMENT

Onion is an important vegetable crop which has been produced in Ethiopia for its daily uses and economic benefits. Unlike other bulb crops, the onion is propagated by seeds. The onion seed in Ethiopia is either imported or produced by informal seed producers. However, the quality is low, and the supply is largely inadequate. Therefore, the experiment was carried out including three onion bulb sizes and four planting dates. The highest seed yield (2.8 tons ha⁻¹) was recorded from large onion bulbs planted at Kobo. However, the lowest (1.2 tons ha⁻¹) seed yield was recorded from small onion bulbs planted at Libso. Onion bulbs planted in early-October increased seed yield (ton ha⁻¹ by 21.7%) than those planted early-November. Large bulbs increased seed yield (ton ha⁻¹ by 40%) than the small bulbs. According to this investigation onion seed production, needs high intention for the production of better yield and quality of onion seeds.
Keywords: Onion; planting date; bulb size; quality seed

1. Introduction

Onion (Allium cepa L.) is one of the bulb crops belonging to the family Alliaceae. It is an important bulb crop in the world and significantly important in the daily Ethiopian diet. It is also an extremely essential crop for increasing the income of producers and traders (Lemma & Shimeles, 2003). Regarding area coverage, worldwide 5,039,908 hectares of land and 96,773,818 tons and in Africa 953,123 hectares of land and 12,453,010 tons of dry onion bulbs were produced annually (FAOSTAT, 2019). In Ethiopia, a total area of 28,185 hectares of land was under onion production with total annual bulb production of 262,478 tons with productivity of 9.1 tons ha⁻¹ (CSA, 2019). This indicates the productivity of onion in Ethiopia (9.1 tons ha⁻¹) is far below the world average (18.8 tons ha⁻¹). Even if the productivity is low, the area under onion is gradually increasing mainly due to its high profitability per unit area, ease of production, and the expansion of small-scale irrigation areas throughout the country (Olanli & Fikre, 2010). In addition, increased awareness of the nutritional and health importance of the crop have resulted in increase demand for quality onion seed (Amsalu et al., 2014). In most of the time, the demand for onion seed is supplied by the informal seed sector. However, there are problems related to inadequate seed supply, increment of onion seed price, poor quality seed which returns poor germination percentage. Under a favorable condition, the shelf life of onion seed is one year. Due to these problems, farmers started onion seed production in different parts of the country (Olanli & Fikre, 2010).

Onion seed yield and quality are influenced by many factors like cultivar, soil, climate, season, production method, bulb size, date of planting and plant density. The determination of the best combination of these can be used to improve onion seed production and quality (Asaduzzaman et al., 2012). The effect of planting date and bulb size on onion seed production and its significant effects on both productivity and quality was studied and reported by several scholars in different parts of the world. The effect of different planting dates on onion seed production in Bangladesh was done, and October 30th was recommended as the best planting date (UD-Deen 2008). Similarly, November 15th was identified as the best planting date for onion seed production in the Borga region of Bangladesh (Mollah et al., 2015). In Iran, the best planting dates for onion seed production were from September 22 to October 6 and from October 21 to November 5 for onion varieties Texas Early Grano 502 and Germez Iranshoh, respectively, with mean minimum and maximum temperature of 21.48 and 9.09 C, respectively (Mehri et al., 2015). Studies in Central Ethiopia showed that onion seed production is best if mother bulbs are planted in September and October, which helped to align the time of flowering during the months of January and February, during cooler and drier months (Olanli & Fikre, 2010).

Bulb size determines the vigor of the reproductive phase and the number of reproductive shoot initials. This is directly related to the number of seed stalks and subsequent seed yield. Various onion bulb sizes were tested for seed production potential at Melkassa for three seasons in order to determine the optimum size for high seed yield and quality. Large bulbs in excess of 4.1 cm diameter produced vigorous umbels of above 5 cm diameter; a large number of flowers stalks (as many as 360/100 m²) and with almost double the seed yield (695 kg/100 m²) of bulbs of ware—size (Lemma & Shimeles, 2003). According to (Mohammad and Gaafar, 2015) significant variations due to different bulb size were observed in respect of seed yield ha⁻¹. The large size bulb produced the highest number of seeds 1563.33 kg ha⁻¹ which was followed by medium size bulbs 1383.33 kg ha⁻¹ and small size bulbs produced the lowest number of seeds 1193.33 kg ha⁻¹. The study areas are high potential for vegetable crop production including onion. Therefore, this study was conducted to identify the effects of planting date and bulb size on onion seed yield and quality at Kobo and Libso, Northeastern Amhara, Ethiopia.

2. Materials and methods

2.1. Description of experimental areas

The study was carried out at Kobo sub-center research station and Libso investment farm from September 2018 to April 2019 under irrigation. Kobo is located 571 km from Addis Ababa at 120...
08°21′ N and 39°38′ 21° E at an altitude of 1500 m.a. Figure 1 shows that the long-term mean annual rainfall of the area is 510.6 mm with a maximum and minimum temperature of 31°C and 15.1°C, respectively. Libso is located at 11°33.21′ 59″ N and 39°39.32′ 17″ E at an altitude of 1630 m and far from 475 km north of the capital city, Addis Ababa. The long-term mean annual rainfall of the area is 848 mm with a maximum and minimum temperature of 30°C and 11.6°C, respectively (EAMSC, 2019).

2.2. Experimental material
Onion variety ‘Bombay Red’ was obtained from Melkasa Agricultural Research Center to proceed the study. The cultivar was released by Melkasa Agricultural Research Center. Its area of production is from 700 to 2000 m above sea level, and the seed yield potential of the cultivar is 1.3–2 tons ha⁻¹ (Lemma & Shimeles, 2003).

2.3. Experimental design, treatments and Agronomic Practices
The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and treatments involved three levels of mother bulb size viz., small (2–3 cm), medium (3.1–4 cm), and large (4.1—5 cm) and four levels of planting dates; early-October (October 5), mid-October (October 15), late—October (October 25) and early-November (November 5). The planting material was harvested and stored for two months in a shaded storage house on wooden shelves. The bulbs, very small and large, damaged, twins or splits and diseased were discarded. For final planting bulbs, these free from insect, disease and mechanical injuries were measured from 2 to 5 cm (small to large) size by using a caliper.

The experimental field was plowed by a tractor. Large clods were broken down in order to bring the land to be leveled. After the land was prepared, the layout was done. The ridges and plots were prepared manually. The distance between plots and blocks was 1 m and 1.5 m, respectively. One day before planting the field was irrigated to moist the soil, and the next day the selected bulbs were planted according to the trial plan. Planting was done in single rows 50 cm between water furrows, 30 cm between rows on the bed and 20 cm between plants in the rows. There were 36 plots corresponding to 12 treatment combinations. The amount of fertilizer per plot was calculated from the amount of fertilizer per hectare. The granules of urea fertilizer were placed in rows along the onion plants 5 cm away from the plants and covered with a 5 cm thick soil.

Figure 1. Mean monthly temperature (°C) and rain fall (mm) at Kobo and Libso Northeastern Amhara, Ethiopia during the trial period. Source: East Amhara Meteorological Service Center annual report. Kombolcha (2019).
The plots were irrigated at the interval of 4–5 days during the first phase of active growth of the plants. Later, the irrigation gap was increased to a seven-day interval. In each application, the amount of water was at field capacity. Cultivation was done manually, and the field was kept free of weeds during the growing period. For the control of onion thrips insecticide selecon was used. All other agronomic practices were applied uniformly for all the plots as per the recommendation made for the crop.

2.4. Sampling and Data Analysis
The harvesting of umbels in the net plot area was done by a sharp sickle at the maturity of the umbel per each plot. The umbels were dried on canvas and threshed by hand. The seeds were separated from stalks and other debris by winnowing and the chaff seeds were separated from well-filled seeds by soaking seeds in water filled in buckets. The floating seeds were discarded as chaffy seeds because they are hollow, unable to sink in water while the sinking ones are considered well filled and viable. The sinking seeds were drained and dried under shade, weighted and recorded as seed weight per plot after being adjusted to 8% moisture content. Finally, quality tests (germination percentage, seed vigor index I and II) were carried out. The data were checked for all ANOVA assumptions. Analysis of variance was done using SAS 9.4 statistical software. Means were compared by using the least significant difference (LSD) test at 5% probability level.

3. Results and discussion

3.1. Growth parameters

3.1.1. Plant height
Location, bulb size, planting date, and interaction effect of bulb size by planting date were significantly (P < 0.0001) affected plant height. However, there was non-significant effect on the interaction effect of location by bulb size, location by planting date and location by bulb size by planting date. The tallest plant height (95.3 cm) was recorded from large bulb size planted at Kobo on early-October and the shortest plant height (82.9 cm) was recorded from medium bulb size planted at Libso on early-October (Table 1). The increase in plant height could be mainly due to early planting which might have provided plants with a relatively cooler period compared to the latter plantings, and larger bulbs had enough reserve food to support the growth of plants which resulted in the maximum plant height. This result agrees with the findings of Nag and Oishimaya (2017) who reported that plant height could be affected by onion bulb size and planting date. In addition, Khodadodi and Hassanpannah (2012) indicated that the planting date of onion bulbs had a significant effect on plant height.

4. Number of leaves per plant
The location, bulb size, planting date, and interaction effect of bulb size by planting date were significantly (P < 0.0001) influenced on the number of leaves per plant. But, there was non-significant on the interaction effect of location by bulb size, location by planting date and location by bulb size by planting date. The highest number of green leaves per plant (53) was recorded from large bulb size planted at Kobo and the least was from small bulb size (23) planted at Libso on the same planting date of early—October (Table 1). As bigger bulbs contain more sprouting initials and reserve food material, they might have been responsible for producing more leaves than smaller ones. This result is in conformity the results of Asaduzzaman et al. (2012), Hussain et al. (2001), and Islam (2002) who reported maximum number of green leaves per plant from large bulbs.

5. Number of flower stalks per plant
The main effect of bulb size and planting date was significantly (P < 0.0001) affected the number of flower stalks per plant. However, there was a non-significant effect on the main effect of location and interaction effect of location by bulb size, location by planting date, bulb size by planting date and location by bulb size by planting date. The highest number of flower stalks per plant (11) were recorded on large bulb size planted at Libso on early—November, while the least number of flowers stalks (6) were recorded on small bulb size planted at Libso on early—October (Table 1). Large bulb sizes, increased number of flower stalks by (59.4%) as compared to the small bulb sizes.
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 flower stalks per plant. This result is in agreement with the findings of various scholars (Asaduzzaman et al., 2012; Hussain et al., 2001) revealed that the number of flower stalks per plant was significantly high in large-sized bulbs while the minimum in small-sized bulbs.

6. Fifty percent flowering date
Planting date and the interaction effect of bulb size by planting date were highly significantly (P < 0.0001) influenced on 50% flowering date. Besides, main effects of location and bulb size were significantly (P < 0.001) affected. However, there was a non-significant effect on the interaction effect of location by bulb size, location by planting date and location by bulb size by planting date. Large bulbs planted at Libso on early—October flowered early (72.6 days), while the longest days to attain 50% flowering were recorded from medium bulb size planted at Libso on mid-October (94.6) days (Table 1). This might be the reason that in early planting there was low temperature which might have contributed to the enhancement of 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. Anisuzzaman et al. (2009) reported that planting date had a marked influence on the number of days required for 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.

Mean values in column followed by the same letter are not significantly different at \( P < 0.05 \).

Where, \( L = \) Location, \( BS = \) Bulb size \( PD = \) planting date, \( PH = \) plant height, \( NLPP = \) number of leaves per plant, \( NFSP = \) number of umbel stalks per plant, \( 50\% FD = 50\% \) flowering date, \( SD = \) standard deviation, \( LSD = \) least significant difference, \( CV = \) coefficient of variation in percent.

6.1. Yield and yield component parameters

7. Umbel diameter

Bulb size, planting date, and their interaction effect of bulb size by planting date were significantly \( (P < 0.0001) \) affected umbel diameter. Nevertheless, there was a non-significant effect on the interaction effect of location by bulb size, location by planting date, bulb size by planting date and location by bulb size by planting date. The maximum umbel diameter \((6.7 \text{ cm})\) was recorded from a small bulb size planted at Kobo in mid-October. But, the least \((4.9 \text{ cm})\) was recorded from a large bulb size planted at Libso on early—November (Table 2). This might be due to less number of umbels and less competition in small bulb sizes than in large bulb sizes. Afterwards, the maximum umbel diameter was recorded in small bulb sizes. This result contradicts with other researchers regarding bulb size. However, in relation to the planting date in agreement with different scholars. Pati et al. (1993) reported earliness to have a significant effect on the umbel diameter. El-Helaly and Karam (2012) also reported that the maximum diameter of the umbel was obtained with early planting. Asaduzzaman et al. (2012) revealed that plants from large bulbs produced the highest umbel diameter, while the smallest bulb size produced the lowest bulb size.

8. Number of seeds per umbel

The number of seeds per umbel was significantly \((P < 0.0001)\) affected by the main effect of bulb size, planting date, and their interaction effect of bulb size by planting date. However, there was a non-significant effect on the main effect of location and interaction effect of bulb size by planting date, location by planting date and location by bulb size by planting date. The highest number of seeds per umbel \((1362.6)\) was recorded from a small bulb size planted at Kobo in early-October. Nevertheless, the lowest number of seeds \((846)\) was obtained from a small bulb size planted at Libso on early—November (Table 2). There was \((61\%)\) change in the number of seeds per umbel regarding planting date and location. The variation in the number of seeds per umbel might be due to flower abortion caused by high temperature, lack of efficient pollinators of the flowers in the umbel, shortage of nutrition which is caused by high competition and death of the weak florets in the umbel. The delayed planting resulted in poor plant growth and delayed bolting. Moreover, high temperature at the flower stalk forming stages might have reduced the number of seeds per umbel.

Mean values in column followed by the same letter are not significantly different at \( P < 0.05 \).

Where, \( L = \) Location, \( BS = \) Bulb size, \( PD = \) Planting date, \( UD = \) umbel diameter, \( NSPU = \) number of seeds per umbel, \( SD = \) Standard deviation, \( LSD = \) least significant difference, \( CV = \) coefficient of variation in percent.

9. Seed weight per umbel

Location, bulb size, planting date, and interaction effect of location by bulb size, location by planting date, bulb size by planting date and location by bulb size by planting date were highly significantly \((P < 0.0001)\) influenced on seed weight per umbel. The maximum seed weight per umbel \((5.4 \text{ g})\) was obtained from a large bulb size planted at Kobo in early October. However, the least \((1.6 \text{ g})\) was recorded from a small bulb size planted at Libso on early—November (Figure 2). There was \((42\%)\) change in seed weight per umbel in relation to the planting date and location. 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 flowering and seed set. This result is contradict with El-Aweel and Ghobashi (1999), El-Helaly and Karam (2012), and
Table 2. Effects of location, bulb size and planting date on umbel diameter, number of seeds per umbel, and standard deviation of each variables

| Lo      | Treatments | Variables |
|---------|------------|-----------|
|         | BS | PD | UD  | SD   | NSPU  | SD    |
| Kobo    |    |    |     |      |       |       |
|         | Large | O5 | 6.3abc | 0.04 | 1306.3bc | 16.443 |
|         | O15 | 6.2cdrf | 0.2 | 1137.3fg | 32.8 |
|         | O25 | 5.6ik | 0.26 | 1026.0j | 9.53 |
|         | N5  | 5.2 mi | 0.12 | 1004.3j | 9.29 |
| Medium  | O5  | 6.6ab | 0.15 | 1315.0bc | 13.23 |
|         | O15 | 6.0hghi | 0 | 1163.3ef | 12.58 |
|         | O25 | 5.9ghi | 0.03 | 1122.3gh | 21.12 |
|         | N5  | 5.7ghi | 0.06 | 1013.3j | 12.58 |
| Small   | O5  | 6.7a  | 0.06 | 1362.6a  | 12.50 |
|         | O15 | 6.6ab | 0.24 | 1248.3d  | 22.55 |
|         | O25 | 5.7ijk | 0.1 | 1094.0x  | 64.21 |
|         | N5  | 6.3bcde | 0.57 | 858.3x  | 14.43 |
| Libso   | O5  | 6.1defghi | 0.09 | 1282.0cd  | 7.54 |
|         | O15 | 6.1cd  | 0.2 | 1115.6ghi | 17.92 |
|         | O25 | 5.4i  | 0.27 | 1009.0j  | 10.53 |
|         | N5  | 4.9m  | 0.12 | 1002.3j  | 24.21 |
| Medium  | O5  | 6.4abcd | 0.26 | 1335.0abc | 8.66 |
|         | O15 | 5.9ghij | 0.09 | 1146.6fg  | 13.61 |
|         | O25 | 5.5ij  | 0.13 | 1076.6d  | 52.29 |
|         | N5  | 5.4i  | 0.15 | 993.0j  | 7.54 |
| Small   | O5  | 6.4abcd | 0.09 | 1346.0abc | 10.53 |
|         | O15 | 6.4abcd | 0.15 | 1199.0a  | 15.09 |
|         | O25 | 5.6i  | 0.25 | 1111.6f  | 57.95 |
|         | N5  | 6.1defg | 0.63 | 846.0a  | 18.24 |
| LSD (5%)|    | 0.3  | 41.9 |
| CV (%)  |    | 3.8  | 2.2 |

Asaduzzaman et al. (2012), regarding bulb sizes. However, there is in agreement with planting dates who reported that the maximum seed weight per umbel was recorded on an early planting date. The contradiction might be due to the difference in the cultivar of the onion.

10. Thousand seed weight
Location, bulb size, planting date, and interaction effect of location by bulb size, location by planting date, bulb size by planting date and location by bulb size by planting date were highly significant (P < 0.0001) effect on thousand seed weight. The heaviest seed (4 g) was recorded in both bulb sizes planted at Kobo in all planting dates and at Libso in some cases while, light seed (2 g) was obtained from bulb size large, medium and small planted on early—November and early—October (Figure 3). There was a 50% change in thousand seed weight due to the difference in location. The reason for increasing the seed weight may be due to the difference in the planting date, i.e., these bulbs planted early had got a suitable increment to increment their seeds. This result is conformity with the findings of El-Aweel and Ghobashi (1999), who reported significant increase of thousand seed weight with planting date. El-Helaly and Karam (2012) also reported planting date to have a significant effect on thousand seed weight.

LSD (5%) = 0.2 CV (%) = 3.5
Figure 2. Effects of location, planting date and bulb size on onion seed weight per umbel.

\[ \text{LSD (5\%) = 0.2 } \quad CV (\%) = 3.5 \]

Where, Ko = Kobo, Li = Libso; L = Large, M = Medium, S = small, O5 = October 5, O15 = October 15, O25 = October 25, N5 = November 5; SWPU = seed weight per umbel

\[ \text{LSD (5\%) = 0.2 } \quad CV (\%) = 0 \]

Where Ko = Kobo, Li = Libso; L = Large, M = Medium, S = small, O5 = October 5, O15 = October 15, O25 = October 25, N5 = November 5; SWPU = seed weight per umbel

11. Seed yield ton per hectare
Location, bulb size, planting date, and interaction effect of location by planting date and bulb size by planting date were highly significant \( (P < 0.0001) \) affected seed yield tones ha\(^{-1}\). However, there was non-significant effect on the interaction effect of location by bulb size by planting date. The highest seed yield was obtained from large bulb size planted at Kobo on early—October (2.8 tons ha\(^{-1}\)) followed by large bulb size planted at Kobo on mid—October (2.5 t ha\(^{-1}\)) while the least (1.2 tons ha\(^{-1}\)) was recorded from small bulb size planted at Libso on early—November (Figure 4). The difference in seed yield 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 a large number of seed heads and, consequently, increasing seed yield tons ha\(^{-1}\). 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 date and the highest seed yield were obtained from large onion bulbs with early planting while, the lowest seed yield was obtained from
Figure 3. Effects of location, planting date and bulb size on thousand seed weight of onion.

\[ \text{LSD (5\%)} = 0.2 \quad \text{CV (\%)} = 0 \]

Where, Ko = Kobo, Li = Libso; L = Large, M = Medium, S = small, O5 = October 5, O15 = October 15, O25 = October 25, N5 = November 5; TSW = thousand seed weight.

small mother bulbs with late planting. In addition, the result is in accordance to the findings of Ali et al. (2015), Mollah et al. (2015), and Debasish et al. (2016), who reported that the large size bulb produced the higher seed yield per hectare.

\[ \text{LSD (5\%)} = 0.1; \text{CV (\%)} = 3.7 \]

Where Ko = Kobo, Li = Libso; L = Large, M = Medium, S = small, O5 = October 5, O15 = October 15, O25 = October 25, N5 = November 5; SY = seed yield

11.1. Quality parameters
12. Germination percentage

Germination percentage was significantly (P < 0.0001) affected by the main effect of bulb size, planting date, and interaction effect of bulb size by planting date. However, there was a non-significant effect on the main effect of location and interaction effect of location by bulb size, location by planting date and location by bulb size by planting date. Large bulb size planted at Kobo in early-October gave the highest (97.3) germination percentage followed by medium bulb size planted at Kobo and large bulb size (96) planted at Libso on early—October. However, medium bulb size planted at Libso on early-November gave the lowest (67) germination percentage (Table 3). Increase germination percentage might be due to high food reserves present in a large bulb which, in turn, might supply nutrient to the seeds and early planting also resulted in producing quality seed. This result is conformity with the following authors. Muktadir et al. (2001) reported
higher seed germination percentage from larger mother bulbs. El-Helaly and Karam (2012) also conclude that planting date had a significant effect on seed germination and the highest percentage of seed germination was obtained by early planting. Asaduzzaman et al. (2012) 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.

13. Seed vigor index I and II

Bulb size, planting date, and interaction effect of location by planting date and bulb size by planting date were highly significantly (\(P < 0.0001\)) affected seed vigor index I. However, there was a non-significant effect on location by bulb size. The maximum seed vigor index I value (1334.1) was recorded from medium bulb size planted at Kobo in early October followed by large bulb size planted at Kobo on the same planting date. However, the lowest value (591.5) was obtained from a medium bulb size planted at Libso on early—November (Table 3). Seed vigor index II was significantly (\(P < 0.001\)) affected by the interaction effect of bulb size by planting date. However, there was a non-significant effect on the main effect of location, bulb size, planting date, and interaction effect of location by bulb size. Location by planting date and location by bulb size by planting date. The maximum seed vigor index II value (18.4) was recorded from a large bulb size planted at Kobo on mid—October followed by a medium bulb size planted at Kobo in early-October. However, the lowest value (6.7) was obtained from a medium bulb size planted at Libso on early—November (Table 3). The difference in seed vigor might be due to the quality differences of seed lots which were caused by the planting date. This finding was related to that of Malik et al. (1999), who reported highest seed vigor index with early planting.
Table 3. Effects of location, bulb size, and planting date on germination percentage, seed vigor index I, seed vigor index II and standard deviation of each variables

| Lo      | Treatments | BS | PD | GP | SD  | SVI | SD  | SVII | SD |
|---------|------------|----|----|----|-----|-----|-----|------|----|
| Kobo    | Large      | O5 | 97.3<sup>a</sup> | 1.5 | 1271.9<sup>a</sup> | 34.2 | 9.7<sup>cdef</sup> | 0.2 |
|         |            | O15 | 92.0<sup>cd</sup> | 2   | 1153.6<sup>bc</sup> | 67.8 | 18.4<sup>a</sup> | 0.4 |
|         |            | O25 | 86.0<sup>i</sup> | 1   | 1117.9<sup>cde</sup> | 37.2 | 8.6<sup>cdef</sup> | 0.1 |
|         |            | N5  | 77.3<sup>gh</sup> | 3.1 | 1086.8<sup>cdef</sup> | 5.9  | 10.2<sup>cdef</sup> | 4.6 |
| Medium  | O5         | 96.0<sup>ab</sup> | 2   | 1206.5<sup>ab</sup> | 52.5 | 15.9<sup>ab</sup> | 5.3 |
|         | O15        | 84.0<sup>f</sup> | 2   | 1066.8<sup>ab</sup> | 37.1 | 8.4<sup>cdef</sup> | 0.2 |
|         | O25        | 92.0<sup>cd</sup> | 2   | 1334.1<sup>a</sup> | 40.9 | 12.2<sup>cde</sup> | 5.3 |
|         | N5         | 70.6<sup>i</sup> | 1.2 | 904.4<sup>i</sup> | 19.5 | 7.1<sup>ef</sup> | 0.1 |
| Small   | O5         | 90.6<sup>de</sup> | 2.3 | 1127.4<sup>cde</sup> | 40.1 | 12.1<sup>cde</sup> | 5.4 |
|         | O15        | 76.6<sup>gh</sup> | 1.2 | 943.1<sup>hi</sup> | 31.5 | 10.2<sup>cdef</sup> | 4.3 |
|         | O25        | 75.3<sup>hi</sup> | 4.2 | 949.2<sup>hi</sup> | 54.6 | 10.2<sup>cdef</sup> | 5.0 |
|         | N5         | 79.0<sup>g</sup> | 1   | 955.9<sup>hi</sup> | 34.1 | 10.5<sup>cde</sup> | 4.7 |
| Libso   | Large      | O5  | 96.0<sup>ab</sup> | 1   | 1139.2<sup>c</sup> | 39.6 | 12.8<sup>bc</sup> | 5.5 |
|         | O15        | 93.0<sup>abc</sup> | 1   | 1038.4<sup>g</sup> | 19.9 | 9.3<sup>cdef</sup> | 0.1 |
|         | O25        | 86.3<sup>f</sup> | 0.6 | 938.3<sup>fi</sup> | 53.0 | 11.5<sup>cde</sup> | 4.9 |
|         | N5         | 78.3<sup>gh</sup> | 2.5 | 762.7<sup>h</sup> | 40.9 | 7.8<sup>cde</sup> | 0.3 |
| Medium  | O5         | 95.3<sup>abc</sup> | 1.5 | 1143.7<sup>c</sup> | 38.0 | 19.1<sup>ab</sup> | 0.3 |
|         | O15        | 87.0<sup>f</sup> | 2   | 1029.5<sup>g</sup> | 46.9 | 8.7<sup>cdef</sup> | 0.2 |
|         | O25        | 90.6<sup>de</sup> | 1.5 | 1024.3<sup>g</sup> | 20.5 | 9.1<sup>cdef</sup> | 0.2 |
|         | N5         | 67.0<sup>h</sup> | 2   | 591.5<sup>h</sup> | 1.9  | 6.7<sup>f</sup> | 0.2 |
| Small   | O5         | 87.3<sup>ef</sup> | 2.5 | 1004.2<sup>gh</sup> | 24.6 | 8.7<sup>cdef</sup> | 0.3 |
|         | O15        | 76.0<sup>gh</sup> | 2.6 | 878.6<sup>l</sup> | 15.2 | 7.6<sup>def</sup> | 0.3 |
|         | O25        | 73.0<sup>f</sup> | 4.3 | 654.8<sup>l</sup> | 50.5 | 7.3<sup>cdef</sup> | 0.4 |
|         | N5         | 78.6<sup>gh</sup> | 2.5 | 789.3<sup>h</sup> | 29.1 | 7.8<sup>cde</sup> | 0.3 |
| LSD (5%)|            |     | 3.5 |     | 62.5 |     | 5.1  |     |
| CV (%)  |            |     | 2.5 |     | 3.7  |     | 29.6 |     |

Mean values in the column followed by the same letter are not significantly different at P < 0.05. Where Lo = Location, BS = Bulb size, PD = Planting date, GP = germination percentage, SVI I = seed vigor index I, SVII II = seed vigor index II, SD = Standard deviation, LSD = least significant difference, CV = coefficient of variation in percent.

14. Conclusions
The current study was conducted to identify the effects of planting date and mother bulb size on onion seed yield and quality. The finding showed significant differences among planting date and mother bulb size for most yield and quality parameters. The maximum seed yield (2.8 tons ha<sup>-1</sup>) was recorded from a large bulb size planted at Kobo on early—October while the least (1.2 tons ha<sup>-1</sup>) from small bulbs planted at Libso on early—November. In terms of germination percentage, the highest (97.3) was obtained from a large bulb size planted at Kobo on early—October, whereas the lowest germination percentage (67.0) was from a medium bulb size planted at Libso on early—November. From the findings of this study, it could conclude that appropriate planting date with accurate bulb size could be practiced to increase the yield and quality of onion seed production. Therefore, onion seed producers in the study areas should be encouraged to plant onion bulbs in early—October with (4.1–5 cm) bulb size to produce better yield and quality of onion seed.
Acknowledgements
We would like to thank Amhara Regional Agricultural Research Institute and Agricultural Growth Program (AGP II) for funding the study.

Funding
The authors received no direct funding for this research.

Author details
Teshome Ashagrie1
E-mail: teshu34@gmail.com
Derbew Belew2
Amsalu Nebiyu3
1 Sirinka Agricultural Research Centre, P.O.Box 74, Sirinka, Ethiopia.
2 Jimma University, College of Agriculture and Veterinary Medicine, P.O. Box 307, Jimma, Ethiopia.

References
Ali, M. A., Hossain, M. M., Zakaria, M., Naznin, A., & Islam, M. M. (2015). Effect of bulb size on quality seed production of onion in Bangladesh. Int. J. Agron. Agri. Res., 6(4), 174–180.
Amsalu, A., Afari-Sefa, V., Bezabih, E., Fekadu, F. D., Tesfaye, B., & Milkesso, T. (2014). Analysis of vegetable seed systems and implications for vegetable development in the humid tropics of Ethiopia. Int. J. Agric. For., 4(4), 325–337.
Anisuzzaman, M., Ashrafuzzaman, M., Ismail, M. R., Uddin, M. K., & Rahim, M. A. (2009). Planting time and mulching effect on onion development and seed production. Afr. J. Biotechnol., 8, 412–416.
Asaduzzaman, M., Mainul, M., Mahmudul, M. H., Moniruzzaman, M., & Mohammad, H. K. H. (2012). Effect of bulb size and plant spacing on seed Production of onion (Allium cepa L.). Bangladesh J. Agril. Res., 37(3), 405–414. https://doi.org/10.3329/ bjar.v37i3.12084
CSA. (2019). The federal democratic republic of Ethiopia central statistical agency agricultural sample survey. In SBA statistical bulletin. Addis Ababa.
Debashis, M., Santra, P., Maity, T. K., & Basu, A. K. (2016). Quality seed production of onion (Allium cepa L.) cv. Sukhsoag as influenced by bulb size and date of planting. Agri. Res. Tech., 2(3), 1–6.
El-Aweel, M. A. T., & Ghabash, A. A. (1999). Seed production in onion as influenced by dates of planting in the Sultanate of Oman. Assiut, J. Of Agric. Sci., 30, 43–53.
EAMSC. (2019). East amhara meteorological service center annual report. Kombolcha, Ethiopia.
El-Helaly, M. A., & Karam, S. S. (2012). Influence of planting date on the production and quality of onion seeds. Journal of Horticultural Science & Ornamental Plants, 4(3), 275–279.
FAOSTAT (2019). Food and agricultural organization of the united nations. https://www.fao.org/faostat/en/#data/QC.
Hussain, S. W., Ishtiaq, M., & Hussain, S. A. (2001). Effects of different bulb sizes and planting dates on green leaf production of onion (Allium cepa L.). J. Biol. Sci., 8, 433–439.
Islam, K. S. (2002). Control of growth cycle of onion for high yield and quality seed production. PhD. Thesis, Bangladesh Agricultural University.
Khodadadi, M., & Hassanpanah, D. (2012). The effects of planting date and mother bulb size and quantitative and qualitative seed traits of onion red variety. Int. J. Agric. Res.Rev., 2, 324–327.
Lemina, D., & Shimeles, A. (2003). Research experiences in onions production. Research report No. 55, EARO p. 52.
Malik, Y. S., Singh, N., & Neha, B. K. (1999). Effect of planting time, bulb cut pinching of bolt treatment on yield and quality of onion seed. Vegetable Sci., 26, 143–145.
Mehri, S., Foradi, B. R., & Kashi, A. K. (2015). Influence of planting date on some morphological characteristic and seed production in onion (Allium cepa L.) cultivars. Agric Sci Dev., 4(2), 19–21.
Mohammed, A.E, Gaafar, M. E. (2013). Some Quality Characters of Six Sudanese Onion Cultivars. International Journal of Research in Agricultural Sciences, 2(2), 2368–1997.
Mollah, M. R. A., Ali, M. A., Ahmad, M., Hassan, M. K., & Alam, M. J. (2019). Effect of bulb size on the yield and quality of true seeds of onion. European J. Biotech Biosci., 3(7), 23–27.
Muktadir, M. S., Farooque, A. M., Rahim, A. M., & Hossain, M. M. (2003). Yield and quality of onion seed as influenced by the planting time and bulb size. Bangladesh J. Seed Sci. Technol., 5, 47–52.
Nag, S., & Oshimaya. (2017). The top onion producing countries in the World. World Atlas. worldatlas.com/articles/the-top-onion-producing-countries-in-the-world.html. https://www.agriculturenigeria.com/product/crop-production/horticulture/onion/ 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.
Olani, N., & Pikre, M. (2010). Onion seed production techniques: A manual for extension agents and seed producers. FAO.
Patil, J. G., Shelar, V. R., & Shinde, S. K. (1993). Effect of irrigation intensity on seed yield and components of seed in onion seed crop in India. Onion Newsletter for the Tropics, 4, 40–42.
Vianney, M. T. W., Albert, R., & Zoumbiess, T. (2011). Effects of seasons of bulb and seed production on the early bolting of onion (Allium cepa L.) cv violet de Galami. Journal of Applied Biosci., 40, 2652–2658.
