



Evaluation of Seed Production and Quality Performance of Onion (*Allium Cepa* L.) Varieties at Kulumsa in Arsi Zone South East Ethiopia

Nimona Fufa (Corresponding Author)

Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), P. O. Box 489, Asella, Ethiopia

Email: nimona.43@gmail.com

Fekadu Gebretensay

Debre Zeit Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), P. O. Box 489, Asella, Ethiopia

Dasta Tsagaye

Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), P. O. Box 489, Asella, Ethiopia

Demis Fikre

Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), P. O. Box 489, Asella, Ethiopia

Gizaw Wegayehu

Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), P. O. Box 489, Asella, Ethiopia

Awoke Ali

Kulumsa Agricultural Research Center, Ethiopian Institute of Agricultural Research (EIAR), P. O. Box 489, Asella, Ethiopia

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Abstract

Field experiment involving five improved onion (*Allium cepa* L.) varieties and carried out at Kulumsa Agricultural Research Center during the 2018 to 2019 cropping seasons under irrigated condition to identify the best performing variety for seed production to the target areas of Arsi Zone. The onion varieties included in the field experiment were (Nafis, Robaf, Nasic Red, Bombe Red, and Adama Red). The experimental design was a randomized complete block design (RCBD) with three replications. Phenological and growth parameters, seed yield, and yield components were studied. The result showed that Variety had a significant effect on most phenological and growth attributes as well as on yield attributes. The number of days to flowering and vigorously were significantly affected by variety; while plant height, days to booting and branch number was not significantly influenced by variety. Flower stalks height and diameter, number of umbel per plant, and umbel diameter also significantly affected by variety. Seed yield per umbel and mean seed yield per hectare also showed a significance difference among varieties. The highest seed yield per hectare (1415.89 kg/ha) was recorded from Adama Red and followed by Nafis variety, whereas Nasic red, Bombe red and Robaf show no significance difference among each other. Therefore, it can be concluded that use of the improved onion varieties such as Adama red and Nafis is advisable and could be appropriate for onion seed production in the test area even though further testing is required to put the recommendation on a strong basis.

Keywords: Growth parameters; Onion; Parameters; Seed yield; Varieties; Phonological.

1. Introduction

Onion (*Allium cepa* L.) is one of the most important vegetable crops commercially grown in the world. In one season bulbs are produced from seed and in the second season bulbs are replanted to produce seed. In Ethiopia, onion is one of the most important cash crops, which contributes to commercialization of the rural economy and creates many off-farm jobs [1, 2]. Onion seeds are well known to be highly perishable and poor in keeping quality and lose viability within a year, therefore it is essential to produce fresh seed every year and use the same for bulb production. One of the problems of onion production in the tropics is lack of seed which is true to type with high germination and vigor [3]. Onion is produced in many of the regions of Ethiopia. During the 2017/18 production year, the Oromia Region's onion production coverage was estimated about 13,669.5ha from which 1,033,485.45 tons of onion bulbs were produced with an average productivity of 7.56 tons ha⁻¹. Arsi Zone is one of the potential areas in Oromia regional state [4] and also in addition to bulb production; the area is suitable for onion seed production.

In Ethiopia the productivity of onion seed is much lower than other African countries [1]. The yield of onion seed in our country varies from 1000 - 1300 kg ha⁻¹ [5]; 75.15 - 1155.75 kg ha⁻¹ [6, 7] and 748.9-879.4 kg ha⁻¹ [8] and other countries ranged 828 - 1446 kg ha⁻¹ [9]. The area coverage and production across the country are

increasing from time to time and most of the recently released varieties accounts largest area coverage [10]. Despite an increase in the area of coverage, the productivity of onion variety in Ethiopia is much lower than the expected production level. The low productivity could be attributed to the limited availability of quality seeds and associated production technologies used among the others. Onion cultivars vary in their susceptibility to flower stalk development, depending on climatic conditions and their genetic background [11].

The overall seed production performances of the released onion varieties with the aim to play a significant role in solving the chronic seed shortage in the area and also in the country, and to exploit onion seed production and productivity capacity were not identified. Nevertheless, little information is available on onion seed production potential of varieties in the study area done on Nafis variety with fertilizer rates on seed production and quality [12]. Therefore, the presented study was designed to evaluate seed production potential of different varieties to come up with relevant recommendations that will help farmers for better onion seed production to the area.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Kulumsa Agricultural Research Center (KARC) which is located at 8°00' to 8°02'N and 39°07' to 39°10'E and an altitude of 2210 m a.s.l. in Oromia. KARC has a low relief difference with altitude ranging from 1980 to 2230 m. The agro-climatic condition of the area is wet with 81 mm mean annual rain fall and it is a uni-modal rainfall pattern with extended rainy season from March to September. However, the peak rainy season is from July to August. The mean annual maximum and minimum temperatures are 23.1 and 9.9°C, respectively. The coldest month is December whereas; May is the hottest month [13].

2.2. Experimental Materials and Bulb Production

Five released varieties of Onion; namely, Nafis, Robaf, Nasic Red, Bombe Red and Adama Red variety was used for the experiment. The seedlings were raised on seed bed at nursery site. After 45 days, seedlings were transplanted to the field for bulb production. Seedlings were transplanted with a recommended double row spacing of 40 cm × 20 cm × 5 cm [2]. All the recommended agronomic and crop protection practices such as cultivation, fertilization, weeding and fungicide/pesticide application were applied according to the national recommendations for onion. Once the onion is matured, bulbs were harvested and true to type bulbs which are healthy, well-shaped and size were selected for the experiment. Also, prior to planting, one fourth of the bulb tops were sliced off to promote sprouting [14].

2.3. Experimental Design and Procedure

The experiment was conducted under irrigation condition during the off-season using randomized complete block design (RCBD) with three replications. The sprouted onion bulbs were planted in double rows with spacing of 60, 40 and 20 cm between water furrows, rows and plants in rows, respectively [2]. Distances of 1 and 1.5 m were maintained between plots and blocks, respectively. A plot size of 3.2 m × 2.8 m (8.96 m²) was used for treatments. Each plot had four rows (ridges) which consisted of 112 plants. The middle double rows were considered for recording of data. Recommended amount of fertilizer (200kg/ha DAP & 100kg/ha Urea) were used, Urea as nitrogen source and NPS as phosphorous for each plot. The site was irrigated at the interval of three days during the first phase of active growth of the plant. Later, the irrigation gap was increased to seven days interval [2].

2.4. Data Collection and Measurement

Days to bolting: This was recorded as the number of days from date of planting up to when 50% of the plants in a plot produced flower stalk.

Days to 50% flowering: This was recorded as the number of days from date of planting up to when 50% of the flower stalks in each plot produced flowers.

Days to maturity: This was recorded as the number of days from date of planting up to when 50% of the plants in each plot matured or ready for harvest (when the seed colour changed to black or the capsule turned brown and started splitting).

vigorousity (1-9 scale): this parameter was taken subjectively by scale (1-9 scale)

Plant height (cm): This refers to the mean height of five randomly selected plants from the central rows from each plot. It was measured from the soil surface to the tip of the plant after development of umbels of the plant.

Flower stalk diameter (cm): This was measured for five randomly selected plants from the central rows from each plot at flowering stage and the average was calculated to record the parameter.

Flower stalk height (cm): measured for five randomly selected plants from the central rows from each plot at flowering stage and the average was calculated to record the parameter.

Number of flower stalks per plant: Numbers of flower stalks of the five randomly selected plants per plot from 4 double central rows was counted and the average calculated and recorded as the number of flower stalks per plant.

Number of umbels per plant: Numbers of umbels from the five randomly sampled plants was counted and the average calculated and expressed as the number of umbels per plant.

Umbel diameter (cm): This refers to the mean umbel diameter of the five randomly sampled plants in each plot. The diameter was measured using a ruler or a caliper two times measuring in two opposite direction (north-south and east to west).

Number of seeds per umbel: Five umbels were randomly taken from the five randomly sampled plants in each plot, dried, threshed and then counted to obtain number of seeds per umbel.

Seed yield per umbel (g): Five randomly sample umbels were harvested, dried, threshed to determine seeds weight per umbel and adjusted to a moisture content of 8%; the average weight of seed per umbel was calculated by dividing the total weight of seeds to number of the umbels.

Seed yield per plant (g): Five randomly sample plants were harvested, dried, threshed to determine seeds weight per plant and adjusted to a moisture content of 8%; the average weight of seed per plant was calculated by dividing the total weight of seeds to number of the plants.

Seed yield (kg ha⁻¹): The yield was estimated from seed yield per plot. The converted to hectares in kilograms.

1000 seeds weight (g): Sample of seeds from the bulk in each plot was taken and 1000 seeds were counted in seed counter machine and weighed using a sensitive balance and then adjusted to the moisture content of 8%.

Germination (%): One hundred seeds were placed on Petri dishes covered with filter paper and allowed to imbibe distilled water which was kept at room temperature until 15 days. The percent of germination has three replications using the total of 48 Petri dishes. A seed was considered germinated when the radicle protrusion attained approximately 1mm. Then percent germination was determined from counts of normal seedlings and the total seeds placed on Petri dishes. Percent of seed germination were done after harvest.

$$\text{Germination (\%)} = \frac{\text{Number of germinated seed}}{\text{Total seed}} \times 100$$

2.5. Data Analysis

The collected data were subjected to Analysis of Variance (ANOVA) using statistical analysis Software [15]. The mean separation was done using (LSD) test at 5% probability level and simple correlation was made to determine association of parameters by using Pearson analysis.

3. Results and Discussion

3.1. Phenology and Growth Parameters

Table-1. Mean values of phenology and growth parameters of five onion varieties evaluated for seed production at Kulumsa in 2018 to 2019 using irrigation

Treatments	Stalk formation date	Days to Bolting	50% flowering date	Vigourisity	Plant height	Seed maturity date	Number of flower Stalks per plant	Flower Stalk height (cm)
Nafis	56.33	65	84.33a	7.33a	88.6	167	6.4	68.6bc
Robaf	52.67	64	85a	5.67bc	83.83	172.67	7.47	65.47c
Nasic Red	54.67	58.33	80ab	6.5ab	89.47	167.33	6.8	73.93a
Bombe Red	47.67	54	74b	5c	83.2	155.67	7.4	68.47bc
Adama Red	53.33	59	77b	5.5bc	82.8	175	7.73	69.3b
LSD5%	12.609	8.167	6.6613	1.3202	7.365	16.627	1.2385	3.657
CV	12.65	7.22	4.42	11.69	4.57	5.27	9.19	3.31
Significance Level	ns	ns	*	*	ns	ns	ns	*

Means with no superscript letter within a column are not significantly different at 5% level of significance; * = significant at P < 0.05 probability level; ns =non-significant at P < 0.05 probability level; LSD = least significant difference; and CV = Coefficient of Variation

3.2. Stalk Formation Date

Days to stalk formation date was statistically non- significantly (P<0.05) affected by the variety. Bombay Red onion variety forms early (about 4 to 3 days earlier) when compared to others variety (Table 1). There was no significant difference among varieties, this mean that varieties cannot vary in their susceptibility to stalk formation date depending on climatic conditions and their genetic backgrounds to the area. Stack formation may be a problem of physiological nature and is undesirable for better production and onion varieties can differ in percentage of stack formation [16].

3.3. Days to Bolting

Days to bolting was statistically non-significantly (P<0.05) affected by the variety. Bombay Red onion variety bolted early (about 5 to 8 days earlier) when compared to the Nafis variety (65 days) (Table 1). Those onion varieties have no significant difference among varieties can vary in their susceptibility to bolting, depending on climatic conditions and their genetic backgrounds. In average the result confirmed with report of Getachew [8] days to bolting of Bombay red onion variety was between 63-67 days. In contrast differences of results to other findings in the number of days required for stalk formation could be due to the relatively cool climatic condition of the experimental site compared with Melkassa condition.

3.4. Days to 50% Flowering

Varieties showed significant difference on days to flowering. The longest (85) and earlier (74, 77) days to flowering was shown in Nafis and Adama red & bombe red respectively (Table 1). This indicated that Nafis took

longer days to flower while Bombe red and Adama red flowered earlier. Earliness or lateness in the days to 50% flowering might have been due to the inherited characters, early acclimatization to the growing area to enhance their growth and developments. This result was in agreement with the finding of Seleshi, *et al.* [17] who reported that days to flowering was significantly affected by the interaction effect of variety and location which could be due to the temperature of the growing area.

3.5. Vigourity (1-9 Scale)

Varieties showed significant ($P < 0.05$) difference between varieties on vigourity. Nafis variety was more vigorous (7.33) than Bombe red variety was the lowest, while others varieties were statistically non-significant difference among them (Table 1).

3.6. Plant Height (cm)

Plant height has no-significantly ($P < 0.05$) influence due to Varieties for onion seed production. The mean plant height of the onion varieties (55.23 cm) among the evaluated varieties at the locations (Table-1). There was no significant difference among varieties, this mean that varieties cannot produce significant difference on plant height depending on climatic conditions and their genetic backgrounds to the area. In concurrent to the present findings, Muhammad and Abdul [16], Islam, *et al.* [18] and Jilani, *et al.* [19] found significant genotypic variation among onion varieties in plant height.

3.7. Seed Maturity Days

Days to maturity were other growth parameters of seed onion. As indicated in Table 1, non-significant ($P < 0.05$) difference was observed on seed maturity days of different onion varieties for onion seed production. The longest and the earlier seed maturity days were observed on Adama red and Bombe red which is 175 days and 155.67 days respectively. The results indicate that, the traits are not affected by both genotype and environment.

3.8. Number of flower Stalks per Plant and Height (cm)

The number of flower stalks per plant was statistically non-significance ($P < 0.05$) difference between the varieties, this mean varieties were not affected by the environment and genotypes to produce flower stalk per plant. Varieties showed significant ($P < 0.05$) difference on flower stalk height. The Nasic red variety was the longest (73.93cm) and Robaf variety produce the shortest flower stalk (65.47cm) (Table 1). The number of flower stalks per plant varied from 1 to 15 per plant at Melkassa and the terminal number of 50-200 flowers produced per umbel of Adama Red variety depending on the number of shoots axis [2]. The result was in accordance with Tamrat [7] and Debashis, *et al.* [20] who found stalk heights for other cultivar of onion in the range of 76-93 cm which was similar to height recorded in the present study.

Table-2. Mean values of some growth and seed yield parameters of five onion varieties evaluated for seed production at Kulumsa in 2018 to 2019 using irrigation

Treatments	Flower Stalk Diameter (cm)	Number of Umbel per plant	Umbel Diameter (cm)	Number of seed per umbel	Seed Yield per umbel (g)	Seed Yield per plant(g)	Seed yield per hectare (kg ha ⁻¹)	1000 seed weight (g)	Germination rates %
Nafis	2.35a	8b	4.77b	724.7	1.76b	6.137	1157.17b	4.2	85.67
Robaf	2.33a	7.87b	4.98ab	601.7	1.45b	6.4	912.54c	4.06	84.67
NasicRed	2.34a	7.73b	5.56a	653.3	1.21b	7.04	1136.11b	4.49	85
BombeRed	2.02b	7.47b	4.58b	663	0.75b	8.627	1056.33bc	4.1	84
AdamaRed	2.01b	10.93a	5.18ab	763.5	2.82a	8.87	1415.89a	4.54	85.33
LSD5%	0.3132	2.4107	0.6407	161.81	1.0121	3.0474	223.04	0.692	10.232
CV	7	15.24	6.81	19.43	33.65	21.83	10.43	8.64	7.45
Significance Level	*	*	*	ns	**	ns	*	ns	ns

Means followed by the same letter or with no superscript letter within a column are not significantly different at 5% level of significance; * = significant at $P < 0.05$ probability level; ns = non-significant at $P < 0.05$ probability level; LSD = least significant difference; and CV = Coefficient of Variation

3.9. Flower Stalk Diameter (cm)

Flower stalk diameter was significantly ($P < 0.01$) influenced by varieties. Nafis, Robaf and Nasic variety were shows the highest about 2.3 cm flower stalk diameter, while Bombay Red and Adama Red onion variety shows the lowest in flow stack diameter. But Nafis, Robaf and Nasic were statistically non-significant between them (Table 2). This might be because of onion varieties may have different morphological and biochemical characteristics that affect the vegetative parts, as reported [16, 21].

3.10. Number of Umbel per Plant

Significant ($P < 0.05$) differences were observed between varieties on number of umbel per plant, due to the effect of varieties. Adama Red onion variety shows the highest (10.39) number of umbel per plant than other Varieties, while others all varieties show statistically the same number of umbel per plant (Table 2). Results on the number of umbels per plant also followed similar trend to the number of flower stalk per plant [16]. And also increase in NP fertilization, increases number of umbels and flower stalks per plant reported [7, 22].

3.11. Umbel Diameter (cm)

Umbel diameter was significantly $P (<0.05)$ affected by varieties. Nasic red gave the highest umbel diameter (5.56cm) followed by the Adama red variety (5.18cm) with no significant difference between the two means. The lowest umbel diameter was recorded from Bombe red variety (4.58cm) and interacted with the Nafis variety (Table 2). The performance of an onion cultivar mainly depends on the interaction of genetic makeup and environment [16].

3.12. Number of Seed per Umbels

The highest number of seed per umbel was recorded by Adama red (763.5) and Nafis (744.70) variety and this was statistically similar with other varieties, this means that the varieties show that non-significant ($P<0.05$) differences on number of seed per umbels, but this can affect directly the total seed production (Table 2). Results on the number of umbels per plant also followed similar trend to the number of flower stalk per plant. The number of seed per umbels produced by a single plant usually varies, depending on the number of branches formed on the shoot axis during vegetative growth [23].

3.13. Seed Yield per Umbel (g)

Seed yield per umbel was significantly ($P<0.05$) shows difference between the varieties. The highest significant seed yield per umbel was Adama Red variety (2.82g) than other varieties. This means that other varieties as Nafis, Robaf, Nasic red and Bombe red were statistically the same seed yield per umbel (Table 2). Seed yield per umbel increased linearly on cultivars with increases in set-size [16].

3.14. Seed Yield per Plant (g)

The effect of varieties showed the non-significantly ($P<0.05$) seed yield per plant, with no significant difference among them. The lowest seed yield per hectare was obtained from the plots with which did not vary significantly (Table 2). Onion cultivars varied significantly with respect to seed yield per plant due to genetic inheritance [21].

3.15. Seed Yield per Hectare (kg ha^{-1})

The seed yield showed significantly ($P<0.05$) affected by varieties. The highest significant seed yield ($1416.31 \text{ kg ha}^{-1}$) was observed by Adama Red variety. The least seed yield was obtained from Robaf variety, but statistically similar with other varieties without Adama red varieties (Table 2). Some of those parameters were directly correlated with the finding of Seleshi, *et al.* [17], seed yield were related with flowering characters like bolting period, umbel size, number of flower stalks/plant, flower stalk diameter and thousand seed weight had a direct positive influence on seed yield and these parameters are therefore recommended for selecting cultivars for high seed yield potential under Melkassa conditions. The current result was in accordance with the findings of Demis, *et al.* [12] on fertilizer application on Nafis Variety, the maximum seed yield per hectare was found from the combination application of N and P gave the highest seed yield ($1858.82 \text{ kg ha}^{-1}$) for onion seed.

3.16. Thousand Seed Weight

The highest 1000 seed weight was recorded by Adama red variety but statistically non-significant difference between other varieties. The lowest thousand seed weight was recorded from Nasic (Table 2). Cultivars varied significantly from each other with respect to leaf. A cultivar performs differently under diverse agro-climatic conditions and various cultivars of the same species grown even at the same environment often yield differently. Ali, *et al.* [24], also reported no significant variation in the weight of 1000 seeds among different varieties.

3.17. Germination Percentage

Germination percentage was statistically non-significantly $P (<0.05)$ affected by varieties. Bombe red variety gave the highest germination percentage of seeds (85.67%) followed by Adama red (85.33%) with no significant difference between the two means. The lowest germination percentage (64.67) was obtained from Nasic red (Table 2). Demis, *et al.* [12] reported that as the rate of phosphorus increased, percent of seed germination 30 days after harvest was increased on Nafis variety. And also application of fertilizers gave highest germination percentage of onion seeds compared to unfertilized treatment [8].

4. Conclusion

The results of this experiment indicated that the variety significantly affected by most of yield and yield contribution as flowering date, flower stalk height and diameter, number of umbel per plant, umbel diameter, seed yield per umbel and seed yield per hectare. The highest seed yield per plant (8.87 g) and per hectare (1415.89 kg/ha) was obtained from Adama red variety which was followed by Nafis variety (1157.17 kg/ha), this result was related with number of umbel per plant and also seed yield per umbel thus, Adama red variety was significant difference for those yield contributing parameters. On the other hand, the highest 1000 seeds weight (4.54 g) was also recorded from Adama red variety. Therefore, it can be concluded that use of the improved onion varieties of Adama red is advisable for onion seed production in the test area and also alternatively followed by Nafis variety which have high germination percentage with former variety.

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