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PARTICIPATORY SELECTION OF ONION (*ALLIUM CEPA* L.) VARIETIES IN THE LOWLANDS OF NORTH SHEWA, CENTRAL ETHIOPIA

Natnael Girma*, Zerihun Kebede, Abdu Yassin, Alemayehu Ayele, Tigist Firew, Damtew Aragaw, Fiseha Desalegne, Teklemariam Ayele

Amhara Regional Agricultural Research Institute, Debre Birhan Agricultural Research Center, Debre Birhan, Ethiopia

Abstract. Onion is an economically and nutritionally important vegetable crop grown worldwide and in Ethiopia as well. Even though the production and the cultivated area of the crop is increasing in Ethiopia, its productivity is much lower than the global productivity. Though its productivity is being constrained by many factors lack of adaptive and high yielding varieties contributes the largest share for its lower productivity. Hence in order to select adaptive and high yielding varieties that are preferable by the onion producing farmers, participatory evaluation of four improved onion (*Allium cepa* L.) varieties (i.e. Bombey red, Adama red, Nafis and Nasik red) was carried out during the 2016 and 2017 main rainy seasons at Efratana gidim woreda in North Shewa Zone of Central Ethiopia. The treatments were laid out in a Randomized Complete Block Design and replicated four times. The collected agronomic data was subjected to analysis of variance at 5 % significance level using SAS statistical software version 9.1. Farmers' preference for those varieties was also assessed based on pair-wise selection attributes set by onion producing farmers. On the combined ANOVA, only plant height, trunk diameter and equatorial diameter have shown statistically significant variation ($p<0.05$) between the varieties. Nasik red was the longest variety at 47.30 cm, while Nafis was the shortest at 42.60 cm. Variety Nasik red had the largest trunk diameter of 1.18 cm while variety Nafis had the smallest trunk diameter of 0.87 cm. The biggest bulb equatorial diameter, 5.53 cm, was found from the Variety Adama red, while the lowest bulb equatorial diameter, 4.59 cm, was recorded from the variety Nasik red. Moreover, the farmers have selected Adama red variety as their first preference. In general, using both the agronomic performance of the varieties and farmers' preference, Adama red variety has been recommended for Efratana gidim and other locations which have similar agro-ecological conditions with the testing environment.

Keywords: *Adama red, Onion, Variety, Pairwise ranking, Participatory.*

****Corresponding Author:*** *Natnael Girma, Amhara Regional Agricultural Research Institute, Debre Birhan Agricultural Research Center, Po. Box 112, Debre Birhan, Ethiopia, e-mail: natigrima66@gmail.com*

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1. Introduction

Onion (*Allium cepa* L) is one of the important bulb crops belonging to the genus *Allium* and the family *Alliaceae* (Asfaw & Eshetu, 2015). Following tomatoes, onion is the second most popular vegetable being produced worldwide (Agidew, 2018). Onion is valued for its distinct pungency and forms an essential ingredient for flavoring varieties of dishes. In Ethiopia, onion is considerably an important vegetable and used for the seasoning of many dishes and most commonly for the local stew. It is preferred over the local shallot because of its high yield potential per unit area, availability of desirable cultivars for various uses, ease of propagation by seed, high domestic and export markets in fresh and processed forms (EAA, 2021).

In Ethiopia, onion is a recently introduced vegetable that became known in the early 1970s (Muluneh *et al.*, 2019). The production of the crop is rapidly increasing and

has spread throughout the country, being cultivated under both irrigated as well as rain-fed conditions in different agro-climatic regions (Sara *et al.,* 2015). In 2017/18 main cropping season 31,637 hectare of land was covered with onion production and 2,938,875.85 quintal of onion was produced (CSA, 2018). Currently, it has changed the livelihoods of many farmers in the rift valley, including the low land areas of Kewot and Effrata districts of North Shewa, Amhara region. Subsequently, most farmers are engaged in this business and presently it is taking over most of the irrigable land and farmers are producing onion in two harvests from October to June in these areas (Lemma & Shimelis, 2003).

Although the total production and the cultivated area under onion production is increasing over time, the crop's productivity is by far lower than the global productivity (Olani & Fikre, 2010). Lack of improved onion cultivars, inappropriate agronomic practices and little-given attention to the crop are the main reasons for this lower productivity in the country. Though a number of improved cultivars were released by Melkassa agricultural research center and incorporated into the farming system of the country, most of the smallholder growers are still using the planting material which has been obtained from their local markets, from semi-formal seed producers and informally imported seed which are inferior in yield, easily susceptible to diseases and insect pests and non-adapted to wider agro-ecologies (Muluneh *et al.,* 2019). Therefore, the study was intended to evaluate the adaptability and yield potential of improved onion varieties in the study area through participatory variety selection and ensure their acceptability by farmers.

2. Material and Method

Description of the study area

The field experiments were carried out during the 2016 and 2017 main rainy seasons at Efratana gidim woreda, yemlowiha kebele Farmers training center (FTC), which is located at 10.35° Latitude and 39.97° Longitude and an altitude of 1490 meters above sea level. The site has a distance of around 140 km and 270 km from Debre Birhan and Addis Ababa, respectively. The mean annual temperature for Efratana gidim woreda is 21.7 ^{o}C, while the mean annual rainfall is 1085 mm. The soil of the experimental areas represents a heavy clay-textured Nitosol. Moreover, these areas are characterized by bimodal rainfall systems which mostly had an erratic or irregular distribution. Cereals like long maturing sorghum varieties and tef are the predominantly grown crops, whereas cattle and goats are the major livestock with natural pasture (grazing) and crop residues are the popular feed sources.

Experiential procedure, Data Collection and Analysis

The Performance of four released onion varieties, namely Bombey red, Adama red, Nafis and Nasik red which were brought from Melkasa Agricultural Research Center were evaluated for their adaptability, yield potential and reaction to disease and insect resistance for two seasons (2016-2017). The detailed agro-morphological description of these varieties is described in Table 1.

The tested varieties were laid out in a randomized complete block design (RCBD) with four replications. Seedlings of all varieties were raised on well-prepared seed beds. The experimental plots were prepared by a traditional oxen-drawn plow. After 45 days, uniform and vigorous seedlings of each variety were selected and transplanted on

August 7 in 2016 and on August 2 in 2017 to a well-prepared field on a plot size of 2.6 m wide and 2.5 m long on a ridge of 40 cm width with 20 cm and 10 cm spacing between rows and plants, respectively. A spacing of 1 meter between plots and 1.5 meter between replications was kept for cultural practices.

Table 1. Characteristics of released/ recommended onion cultivars in Ethiopia

Characteristics	Adama red	Bombey red	Nasik red	Nafis
Leaf Color	Medium Green	Dark Green	Deep Green	Deep green
Leaf Arrangement	Erect	Medium	Erect	Erect
Bulb Size (g)	60-80	85-100	85-100	100-130
Bulb Shape	Flat Globe	Flat Globe	Globe	Globe
Bulb Skin Color	Dark Red	Light Red	Medium	Medium Red
Bulb Flesh Color	Reddish white	Reddish white	Reddish	Reddish white
Maturity (Days)	110-130	<120	90-110	90-100
TSS (%)	10 To 13	9 To 11	10 To 18	10 To 18
Dry Bulb (t ha^{-1})	35	30	30	40

Source: (Asfaw & Eshetu, 2015)

Synthetic fertilizer of NPS 121 kg ha^{-1} and Urea 100 kg ha^{-1} was applied. The full dose of NPS fertilizer was applied once during planting, whereas the Urea fertilizer was applied in two splits: half at the time of transplanting and the remaining half 45 days after transplanting. For the control of thrips, *Selecrone 720 EC* (1 liter per 150 liters of water per hectare) was sprayed at the vegetative stage. Based on the infestation of the weed, hand weeding and hoeing were employed properly and uniformly for the entire plot. In both years after the cessation of rainfall, supplementary furrow irrigation was applied per seven-day intervals.

Agronomic data such as plant height, number of leaf, trunk diameter, marketable bulb yield, unmarketable bulb yield, average bulb weight, equatorial diameter, and longitudinal diameter, were collected from the central four rows and subjected to ANOVA at a 5 % significance level using SAS statistical software version 9.1. All significant treatment means were compared using the Least Significant Difference (LSD) test.

Farmers' selection and participatory evaluation of the varieties

In 2017, field-day was organized by inviting Woreda level Agriculture experts and farmers to facilitate future promotion works and acquire farmers' perceptions *(i.e., their selection criteria and varietal preferences).* With this notion, eighteen onion growing farmers were selected with the help of development agents and general awareness about the experiment was given. Then, farmers were given the chance to discuss and share ideas on issues like their preferences, criteria for evaluation and characteristics of good onion varieties. Prior to evaluation, the farmers had set the criteria to be used for differentiating the varieties. Farmers were first identifying and list of attributes which was very important for them to select adapted varieties and gave weight for attributes according to their importance. Finally, the varieties were evaluated by the farmers using these criteria and analyzed using pair-wise ranking and matrix.

3. Result and Discussion

Agronomic Performance of the varieties

In 2016, the individual environment analysis of variance has indicated the presence of statistically significant difference between the tested varieties only in plant height and unmarketable bulb yield (Table 2) and the varieties were statistically differed only in trunk diameter and bulb equatorial dimeter in 2017 (Table 3). The combined ANOVA for agro-morphological traits of onion varieties showed the presence of a statistically significant ($p \leq 0.05$) difference only on plant height, trunk diameter, and equatorial diameter (Table 4). Dadi *et al.*, (2022), also reported significant variation between onion varieties in desirable yield related traits in variety adaptation trial conducted in different agro-ecologies of Ethiopia which is due to the genetic difference of these verities. The detailed varietal differences of these traits were discussed below in Table 5.

Accordingly, the highest plant height (47.3 cm) was recorded from Nasik red while the shortest plant height was observed from Nafis (42.6 cm) and Adama red (43.71 cm) varieties. Varieties Nasik red and Bombey red had the largest trunk diameter of 1.18 cm and 1.11, respectively. On the contrary Nafis had the smallest trunk diameter of 0.87 which is statistically similar with that of Adama red (0.91 cm). The biggest bulb equatorial diameter of 5.53 cm was found from the variety Adama red while the lowest bulb equatorial diameter of 4.59 cm was recorded from the variety Nasik red. A similar finding was reported by (Rahel & Tolessa, 2018) as the size (i.e. length and diameter) differences of the onion bulb is highly influenced by varietal differences.

Generally, the difference in yield of any crop varieties including that of onion depends on the genetic make-up of the genotypes, climate, crop husbandry practices and their interactions. Though it was not statically significant, the highest total bulb yield (33.65 t ha^{-1}) and (33.06 t ha^{-1}) was obtained from Nafis and Adama red varieties, respectively. The lowest total bulb yield of 28.82 t ha^{-1} was obtained from Nasik red variety. The result of this study is in agreement with the findings of (Rahel & Tolessa, 2018) who obtained the highest total bulb yield (36.28 t ha^{-1}) from the variety Nafis than other varieties. (Gezahigne & Awoke, 2021), have also reported the absence of a statistically significant variation in bulb yield of these varieties in Southern Ethiopia.

Farmer Preference of the Varieties

Participation of farmers on technology evaluation would help in getting feedback about the technologies and identifying existing constrain. Moreover, farmers' participation in the variety selection process has a paramount role to identify farmers' preferred traits and in promoting the technologies. In this regard, a field day was organized in 2017 on maturity stage of the crop to select farmers' preferred varieties and achieve the objective of the experiment by participating researchers, experts, the head of the district agricultural development office, extension agents, and farmers. To select the best performing variety, the farmers had set bulb color, split bulb, bulb yield, earliness, and bulb size as the major selection attributes. Then, based on their order of importance, the pre-identified selection attributes have been prioritized by the farmers themselves as illustrated in Table 6.

Table 2. Mean performance of onion varieties at Ataye, 2016

No.	Varieties	PH	NL	TD	MBY	UNMBY	AWB	BEDM	BLDM
1	Nasik	43.20ab	9.90	1.15	24.54	0.43 b	55.22	5.23	4.74
2	Bombey red	43.77a	11.00	1.29	26.84	0.26 b	60.38	5.52	4.74
3	Nafis	40.35bc	9.95	0.92	31.31	0.85 a	70.44	5.55	4.87
4	Adama red	39.82c	10.00	0.90	29.92	0.24 b	67.33	5.42	4.72
	LSD	3.16	2.63	0.25	75.08	0.23	16.89	0.65	0.34
	Mean	41.78	10.21	1.06	28.15	0.45	63.34	5.43	4.76
	CV	4.74	16.15	14.76	16.67	32.58	16.67	7.48	4.53

*PH=Plant height in cm, NL = Number of leaf, TD = Trunk diameter in cm, MBY = Marketable bulb yield ton per hectare, UNMBY = Unmarketable bulb yield ton per hectare, AWB = Average bulb weight, BEDM = Bulb equatorial diameter in cm, BLDM = Bulb longitudinal diameter in cm. * and ** indicates significance at the 5 and 1 % level respectively. NS stands for not significant*

Table 3. Mean performance of onion varieties at Ataye, 2017

No.	Varieties	PH	NL	TD	MBY	UNMBY	ABW	BEDM	BLDM
1	Nasik	51.40	9.00	1.21 a	31.28	13.66	70.40	3.96 b	4.28
2	Bombey red	46.30	10.75	0.94 b	31.70	17.47	71.32	5.21 a	4.82
3	Nafis	44.92	9.50	0.81 b	32.80	22.71	73.95	4.69 ab	4.64
4	Adama red	47.62	10.75	0.89 b	34.40	15.44	77.40	5.64 a	5.28
	LSD	5.37	2.77	0.19	70.20	15.79	12.39	1.05	1.47
	Mean	47.56	10.00	0.96	32.56	17.32	73.27	4.87	4.75
	CV	7.06	17.32	12.42	13.47	44.17	13.47	13.51	19.32

*PH=Plant height in cm, NL = Number of leaf, TD = Trunk diameter in cm, MBY = Marketable bulb yield ton per hectare, UNMBY = Unmarketable bulb yield ton per hectare, AWB = Average bulb weight, BEDM = Bulb equatorial diameter in cm, BLDM = Bulb longitudinal diameter in cm. * and ** indicates significance at the 5 and 1 % level respectively. NS stands for not significant*

Table 4. ANOVA of mean square values of yield and yield related traits of onion varieties at Ataye, 2016-2017

Source of variation	Mean square							
	DF	PH	NL	TD	BEDM	BLDM	ABW	TBY
Year	1	266.81^{**}	0.91^{ns}	0.08^{*}	2.46^{*}	0.001^{ns}	787.57^{*}	25918.01^{*}
Variety	3	32.20^{*}	2.85^{ns}	0.19^{**}	1.35^{*}	0.33^{ns}	180.98^{ns}	4197.70^{ns}
Replication	3	4.22^{ns}	2.70^{ns}	0.04^{ns}	0.35^{ns}	0.04^{ns}	53.32^{ns}	1075.83^{ns}
Year*Variety	3	14.66^{ns}	0.89^{ns}	0.06^{*}	0.85^{ns}	0.39^{ns}	46.54^{ns}	781.71^{ns}
Error	18	7.60	2.89	0.02	0.30	0.45	104.53	2059.39

*DF: degree of freedom, PH=Plant height, NL = Number of leaf, TD = Trunk diameter, BEDM = Bulb equatorial diameter, BLDM = Bulb longitudinal diameter, ABW = Average bulb weight, TBY = Total bulb yield. * and ** indicates significance at the 5 and 1 % level respectively. NS stands for not significant*

Table 5. Mean performance yield and related traits of onion varieties at Ataye, 2016-2017

Varieties	PH	NL	TD	BEDM	BLDM	ABW	TBY
Nasik red	47.30[a]	9.40	1.18[a]	4.59[b]	4.51	62.8	28.82
Bombey red	45.02[ab]	10.93	1.11[a]	5.36[a]	4.78	65.9	30.28
Nafis	42.60[b]	9.70	0.87[b]	5.12[ab]	4.75	72.2	33.65
Adama red	43.71[b]	10.42	0.91[b]	5.53[a]	5.00	72.4	33.06
Mean	44.7	10.10	1.01	5.15	4.76	68.30	31.45
LSD	2.89	1.77	0.14	0.57	0.70	10.70	4.77
CV	6.17	16.7	13.7	10.62	14.04	15.10	14.43

PH=Plant height in cm, NL = Number of leaf, TD = Trunk diameter in cm, BEDM = Bulb equatorial diameter in cm, BLDM = Bulb longitudinal diameter in cm, ABW = Average bulb weight, TBY = Total bulb yield ton per hectare. Means with the same letters in a column are not significantly different.

Then after, the farmers identified the varieties which they like most based on the allover mean of preset selection attributes (Table 7). According to the summary matrix rating, Adama red had the highest overall mean of the ranks (3.19) for all performance indicators. Farmers chose this variety because it has the best bulb color and size for the market, as well as its minimal split bulb producing nature.

Table 6. Pair-wise ranking of attributes for onion variety evaluation at Ataye, 2017

Attributes	Bulb color	Split bulb	Bulb Yield	Earliness	Bulb size	Scores	Rank
Bulb color		Bulb color	Bulb color	Bulb color	Bulb color	4	1
Split bulb			Split bulb	Split bulb	Split bulb	3	2
Bulb Yield				Bulb Yield	Bulb size	1	4
Earliness					Bulb size	0	5
Bulb size						2	3

Table 7. Farmers preference ranking matrix of onion varieties at Ataye, 2017

Varieties evaluated	Farmers selection attributes						
	Bulb color	Split bulb	Bulb yield	Earliness	Bulb size	Mean	Rank
Nasik red	2.4	2.7	2.4	1.7	2.2	2.28	3
Bombey red	1.3	1.5	1.67	2.67	2.01	1.83	4
Nafis	2.6	2.05	3.4	3.1	2.2	2.67	2
Adama red	3.7	3.7	2.5	2.4	3.67	3.19	1

4. Conclusion

Onion is an important bulbous vegetable grown worldwide including Ethiopia. Ethiopia has a great agro ecological potential for onion production throughout the year. Though onion is a recently introduced vegetable in Ethiopia due to its many advantages it has become highly preferred over the local shallot by the farmers. Despite a number of improved cultivars were released by Melkassa Agricultural Research Center, farmers in Efratanagidm woreda are still using onion cultivars which are not checked for their adaptability, disease reaction and yield potential for their specific location. Therefore with the objective of selecting adaptive and high yielding varieties that are preferable by the onion producing farmers, participatory evaluation of four improved onion varieties was carried out during the 2016 and 2017 main rainy seasons. The result of this study

indicated that though there is no statistically significant difference in the total bulb yield, varieties Nafis and Adama red has given the higher bulb yield. Moreover, Adama red was a highly preferred variety by the farmers in Efratana gidim Woreda. Therefore, based on both agronomic performance of the varieties and farmer's preference, Adama red variety of onion has been recommended for production in Efratana gidim woreda and other similar agro-ecologies to get higher bulb yield with better market preference.

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