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Participatory variety evaluation and selection of improved onion (*Allium cepa* L.) varieties for bulb yield under supplementary irrigation condition at Basketo Special District, Southern Ethiopia

Gezahegn Fikre Ergicho [1, 2, *] and Teshale Wube Hogago [1, 3]

[1] *Southern Agricultural Research Institute (SARI), Arba Minch Agricultural Research Center (AMARC), P.O.BOX. 2228, Arba Minch, Ethiopia.*
[2] *Vegetable crops research division, SARI, AMARC P.O. BOX. 2228, Arba Minch, Ethiopia.*
[3] *Source Technology Transfer and Multiplication division, SARI, AMARC, P.O. BOX. 2228, Arba Minch, Ethiopia.*

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Abstract

Onion is one of the most important vegetables and high economic crops, but grown by a few small-scale farmers in Basketo special district (woreda). Likewise, productivity of the crop in the district is very low. Lack of improved onion varieties and the use of inappropriate agronomic practices are among the major factors that limit the productivity of onions in the study area. Hence, this study was conducted at Basketo special woreda in 2019 and 2020 cropping seasons under supplementary irrigation to evaluate adaptability and to select high yielding onion varieties using farmers' selection criteria. The experiment consisted of five improved onion varieties, namely; Adama red, Bombay red, Nafis, Adama Red, Robaf and Nasik Red and arranged in Randomized Complete Block Design in three replications. The results revealed that onion varieties exhibited differential performance in the two cropping seasons in the study area. Accordingly, Nasik red variety gave the highest bulb weight, marketable and total bulb yield (13.23 and 1.75 t/ha) and took a short period for bulb maturity compared to other onion varieties in the two cropping seasons. On the other hand, variety Bombay red produced 11.7 and 11.3 t/ha during the year. However, variety 'Nafis' was also selected by the farmers through their criteria. Therefore, onion varieties Nasik red (129.9Q/ha) and Nafis (106.1 Q/ha) are selected and recommended for the onion growers in the study area for better bulb yield.

Keywords: Bulb weight; Nasik red; Onion varieties; Participatory variety selection; Yield related traits

1. Introduction

Onion (*Allium cepa* L.), which belongs to the family Alliaceae, is one of the most important vegetable crops grown in many countries of the world [1]. The bulbs of onion are the most economically important part and commonly used as flavoring, seasonings or as vegetables in stews and as a result, it becomes a popular crop among both producers and consumers (Best, 2000). In Ethiopia, onion is widely produced by smallholder farmers mainly under irrigation condition as a source of income [2]. The production of onion in the country is increasing from time to time [3] due to its high economic value in the lowland areas of Ethiopia where there is irrigation water access.

According to the Central Statistical Agency of Ethiopia [3], the total area covered by onion in Ethiopia was 36,373.48 hectares during the 2019/20 cropping season with the total production of273,858.98 tons [3]. The production of onion covered 2253 hectares of land with a total production of 19,286.3 tons in the Southern Nations, Nationalities and Peoples' (SNNP) regional state during the 2019/2020 cropping season. The average bulb yield of onions is not more 8 t ha^{-1} both at national and regional levels [3], which is by far lower than the world average bulb yield (20 t ha^{-1}) of onions

* Corresponding author: Gezahegn Fikre; Email:fikregezahegn@gmail.com

[4]. Basketo Special district is one of the potential areas of SNNP regional state for onion production and the district is gifted with the suitable agro-ecology, land and irrigation water availability for crop production. The current productivity of onion is very low compared to the immense potential of the country and Basketo Special district have. Onion production in Ethiopia in general and in Basketo Special District in particular is constrained by many factors [5], of which lack of improved onion varieties and poor agronomic practices are the major problems that limit onion productivity.

Participatory variety selection (PVS) is a powerful tool that involves farmers and other stakeholders to help orient breeding programs and to improve variety adoption [6]. It also assists plant breeders to develop technologies that fit into a specific production niche and the farmers' needs [7]. Participatory variety selection can speed up the selection and fast-track the dissemination processes. In addition, it will eliminate a number of unacceptable varieties and save money and time [8]. An adoption of improved onion technology will provide an opportunity for improvement of productivity and creation of employment especially for jobless youths and women in the production areas and it brings farming diversification and income source to the producers of the respective district. In order to introduce and provide the improved onion varieties for the producers of Basketo special woreda, the adaptability and yield performance of the varieties must be evaluated and selected by participating farmers. Therefore, this study was conducted to evaluate adaptability and performance of recently released onion varieties and select high yielders using farmers' selection criteria.

2. Material and methods

2.1. Description of the Study Site

This experiment was conducted in Basketo special woreda, Southern Nations, Nationalities and Peoples' Regional State of Ethiopia for two consecutive cropping seasons (2019 and 2020). The altitude of the study area is about 883 meters above sea level with an average rainfall of 1200mm. The soil type of this site is clay loam. Geographically, the study site is located between $6^0$21'01''N latitude and $36^0$32'50''E longitude with an average temperature of 21.5^{0}C.

2.2. Experimental materials

Five improved onion varieties, namely; Adama red, Bombay red, Nafis, Adama Red (standard check), Robaf, and Nasik Red were used in the study. The seeds of these varieties were obtained from Melkasa Agricultural Research Center.

Table 1 Description of onion varieties used in the study

Variety	Maturity (days)	Total soluble solids (%)	Bulb size (g)	Bulb yield (t/ha)
Adama Red	110-130	10-13	60-80	35
Bombay Red	<120	9-11	85-100	30
Nasik Red	90-110	10-18	85-100	30
Nafis	90-100	10-18	100-130	40
Robaf	--	--	--	--

Source: [9]

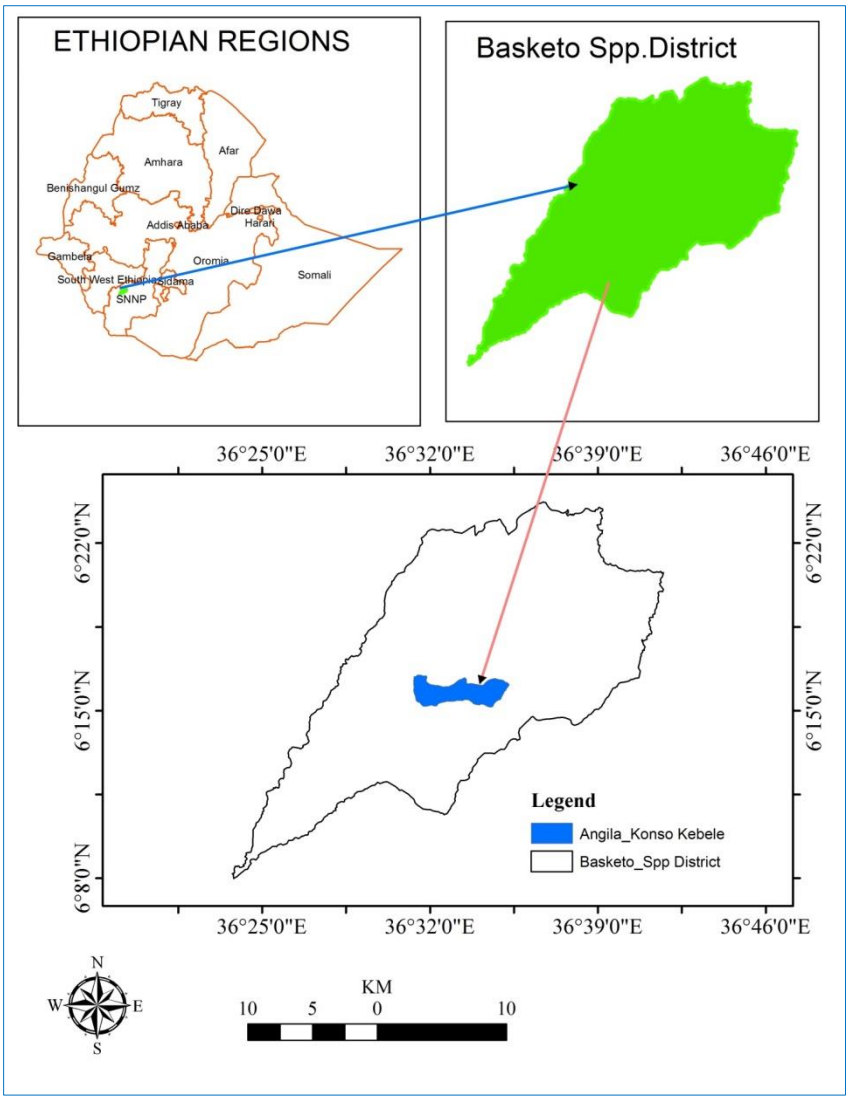

Figure 1 Map of the study area

2.3. Farmers' Selection and Participatory Evaluation

In this study, 20 onion growers were selected from the districts with the help of development agents. Training was given to the farmers to create general awareness about the experiment. Group discussion and debates were made to observe and clear contradictory ideas on the issue like farmers' preferences, criteria for evaluation, and characteristics of good onion varieties. Evaluation criteria were set by farmers' prior to evaluation as; vegetative performance, bulb size, bulb shape, bulb color, market preference, and tolerance to disease. According to the farmers, good onion varieties should have the following characteristics; vigorous and uniform, free from disease, higher in yield, red color, and medium to large bulb size with oval shape. Therefore, the varieties were evaluated by the farmers using these criteria and analyzed using pair-wise and matrix ranking.

2.4. Experimental design, field management and data collection

A field experiment was laid out in a randomized complete block design with three replications. At four leaf stage, seedlings were transplanted in a plot of 3.2m x 2m. Each plot consists of eight rows with 3.2 meters long. Spacing between rows and plants was 40cm and 20cm, respectively. Nitrogen fertilizer at the rate of 46 kg ha^{-1} was applied by split application method in the form of urea, first half during transplanting, and the remaining half at 45 days after transplanting. NPS at the rate of 200 kg ha^{-1} was applied during transplanting. All recommended agronomic practices were applied and harvesting was done at the appropriate maturity stage (90% top down) of the varieties. Data on plant height, number of leaves, days to maturity, bulb diameter, bulb weight, and bulb yield (marketable, unmarketable, and total) were collected.

2.5. Statistical Analysis

The mean values of all parameters of the field data were subjected to analysis of variance (ANOVA) using SAS software [10], version 9.2. Least significant difference (LSD) procedure was used to compare differences between treatment means.

3. Results and Discussion

3.1. Growth and Phenological Parameters

3.1.1. Number of leaves per plant

Fully developed leaves of five randomly selected plants were counted from the middle rows of each experimental plot at physiological maturity and the average was computed. Leaf number was significantly influenced by varieties in both years. The highest leaf number (13.7) was obtained from variety Nasik red which is statistically similar to with varieties Adama red and Bombay red, while the lowest (9.7) was from variety Robaf (Table 2). The difference in leaf number might be due to the genetic differences of the varieties, which governs the overall growth performance of the variety although it is determined by other climatic and edaphic factors [11]; [12] and [13].

3.1.2. Plant height

Table 2 shows the plant height of some varieties of onion grown in Basketo special district during 2019-2020. Variety Nasik red showed the highest plant height of 60.0 cm, which is not differed significantly from other varieties except Adama red which had the shortest (54.0 cm). The genetic make of the varieties could be the possible reason for this variation in plant height. However, all tested varieties had not shown significant difference in the 2020 cropping year. Similarly, [13] and [12] observed differences in plant height amongst onion genotypes.

3.1.3. Days to maturity

The results indicated that the lowest number of days to reach maturity was required by variety Nasik red (115 days) which is statistical at par with the varieties, Bombay red and Nafis, and was found earlier compared to other varieties in both cropping years in the study area. Significantly maximum days to maturity (127.67 days) were recorded in variety Adama red (standard check) in the 2019 cropping year. However, variety Robaf took the longest time (130.0 days) in 2020 to attain maturity. Early maturity is an important trait for escaping the drought season, and it could be the transfer of photosynthetic materials from leaves to bulbs that facilitate the growth rate of onions. This causes early initiation of bulb, early maturity, and early harvesting. The more number of days taken for maturity might be due to less photosynthesis, resulting in more time to complete the vegetative growth. These results are in conformity with the findings of [14] and [15].

Table 2 Performance of onion varieties in terms of growth and phenological parameters evaluated at Basketo Special district in 2019 and 2020 cropping seasons

Varieties	Plant height (cm)		Number of leaves		Days to maturity	
	2019	2020	2019	2020	2019	2020
Adama red	54.0b	60.0	12.33a	10.6b	127.67a	126.67b
Bombay red	57.3a	59.0	12.70a	13.3a	116.6c	126.33b
Nasik red	60.0a	58.0	13.70a	9.33b	115.0c	121.0bc
Nafis	59.3a	54.7	10.30b	13.0a	117.0c	120.33c
Robaf	59.7a	55.3	9.70b	12.0a	121.33b	130.0a
Grand mean	58.1	57.5	11.73	11.7	120.6	124.67
LSD (0.05)	3.2	NS	1.80	1.62	9.1	5.71
CV(%)	2.9	5.3	7.90	7.35	4.9	2.41

Source: Field experiment data taken during 2019-2020 cropping years

3.2. Yield components

3.2.1. Bulb diameter

From the mean comparison table, bulb diameter was not significantly (P<0.05) affected by the varietal effect in 2020 cropping season; which, however, it had not significantly affected in the year of 2019 (Table 3). In 2020 cropping year, a slightly bigger bulb of 16.7 cm diameter was recorded in varieties Adama red, Bombay red, and Robaf which was statistically similar. However, the least bulb diameter (14.0 cm) was noticed by Nasik red in the second year. The result is in agreement with the findings of [16] who reported the lowest bulb diameter for the variety Nasik red.

3.2.2. Bulb weight

Bulb weight is significantly affected by the varieties evaluated in 2019 and 2020 cropping years. The highest bulb weight was recorded by the variety Nasik red in both years which is statistically not significant with variety Nafis. During 2019, the largest bulb of 45.75 g weight was observed in the case of variety Nasik Red followed by Nafis (42.2.0 g) and Adama red (40.25 g) while the smallest bulb was noticed by variety Robaf (35.6 g) (Table 3). Although Nasik red exhibited a better bulb weight (43.21 g) in 2020 cropping year, all tested varieties showed a considerable decrease in bulb weight during the 2020 cropping season. The variation in bulb weight among varieties might also be due to the genetic differences of the varieties, which govern the overall performance of the variety although it is determined by other climatic and edaphic factors [17]; [11].

Table 3 Performance of onion varieties evaluated at Basketo Special district in terms of some yield components during 2019 and 2020 cropping seasons

Varieties	Bulb diameter (cm)			Bulb weight (g)		
	2019	2020	Mean	2019	2020	Mean
Adama red	13.3	16.5a	14.9	40.25^{ab}	38.30bc	39.27
Bombay red	14.0	16.7a	15.35	37.50^{b}	38.00bc	37.75
Nasik red	14.0	14.3b	14.15	45.75^{a}	43.10a	44.43
Nafis	12.5	16.3ab	14.4	42.20^{ab}	40.70ab	41.45
Robaf	13.6	16.7a	15.15	35.67^{b}	34.00c	35.35
GM	13.7	16.7		40.52	38.9	
LSD	NS	2.24		9.0	5.1	
CV	8.7	7.6		11.8	6.9	

Source: Field experiment data taken during 2019-2020 cropping years

3.2.3. Bulb yield of onion varieties

Onion varieties evaluated at the Basketo Special District showed significant variation in terms of marketable, unmarketable, and total bulb yield. Accordingly, the maximum marketable and total bulb yield was obtained from Nasik red in the two cropping seasons (2019 and 2020), whereas the lowest marketable and total bulb yield was observed in Nafis variety during the 2020 cropping season. Nasik red and Nafis varieties gave minimum unmarketable bulb yield in 2019 cropping season without significant variation among each other. Variations observed in bulb yield of onions among the varieties might be due to the genetic differences that exhibited differential performance in terms of growth and yield related traits, which determine the bulb yielding potential of the specific variety. The inconsistency of the climatic conditions of the area might contribute to the variation of the varietal performance across growing seasons. These results are in agreement with the findings of [17], [18], [19] and [20] who reported that different onion varieties perform differently under different locations and climatic conditions.

Table 4 Performance of marketable, unmarketable, and total bulb yield of onion varieties evaluated at Basketo Speccial district in 2019 and 2020 cropping seasons

Varieties	Marketable bulb yield (Q/ha)			Unmarketable bulb yield (Q/ha)			Total bulb yield (Q/ha)		
	2019	2020	Mean	2019	2020	Mean	2019	2020	Mean
Adama red	106.67	112.16ab	109.42	12.25bc	41.67a	26.96	110.0ab	107.0b	108.5
Bombay red	114.17	101.07ab	107.62	18.17ab	8.30c	13.24	95.0b	117.0ab	106.0
Nasik red	112.26	113.33a	112.79	0.59c	25.00b	12.79	132.3a	127.5a	129.9
Nafis	110.00	89.17b	99.59	0.50c	25.00b	12.75	120.5ab	91.6b	106.1
Robaf	111.67	106.67ab	109.17	26.83a	8.30c	17.57	103.3b	107.0b	105.2
GM	110.96	105.0.0		12.75	21.65		112.23	107.0	
LSD	NS	2272.0		14.30	2.03		27.6	24.0	
CV	10.4	11.5		59.5	4.98		13.1	11.9	

Source: Field experiment data taken during 2019-2020 cropping years

3.3. Farmers' Preference

Farmers' perceptions on the performance of onion varieties were tested at Basketo special woreda and analyzed using matrix and pair-wise ranking. The evaluated varieties performed well as the farmers' criterion. As a result, the majority of participant farmers in the district have shown good interest to produce improved onion varieties. After discussion and debate, farmers ranked the varieties based on their preference and degree of satisfaction by giving the values 1-5 [21]. Matrix ranking results showed that the overall means for all performance indicators/preference criteria were higher for Nasik red during 2019 and 2020 cropping years (4.0 and 3.71 respectively), followed by Nafis (3.57 and 3.29) (table 5). On the other hand, the least preferred and with low performance according to farmers' preference criteria was variety Robaf.

Table 5 Matrix ranking of onion varieties based on criteria selected by farmers at Basketo special woreda (n=20) during 2019-2020

Evaluation Criteria	2019					2020				
	Adama red	Bombay red	Nasik red	Nafis	Robaf	Adama red	Bombay red	Nasik red	Nafis	Robaf
Earliness	2	3	4	4	2	3	2	4	4	2
Disease tolerance	2	3	4	4	1	1	3	4	2	3
Bulb color	3	4	4	3	3	3	4	4	3	3
Bulb size	3	4	4	2	3	4	4	3	3	2
High yielder	3	1	4	4	2	3	4	4	3	3
Bulb uniformity	2	2	4	4	2	2	2	3	4	2
Market preference	3	4	4	4	3	3	4	4	4	3
Total score	18	21	28	25	16	19	23	26	23	18
Over all mean	2.57	3	4	3.57	2.29	2.71	3.29	3.71	3.29	2.57
Over all rank	4	3	1	2	5	4	2	1	2	5

Rank: 5= very good, 4= good, 3= average, 2= poor and 1 = very poor; **Source:** Primary data taken from participating respondents during 2019-2020 cropping years

Table 6 Pair wise ranking on the overall preference of farmers toward different onion varieties at Basketo special woreda

	2019						2020					
	Adama red	**Bombay red**	**Nasik red**	**Nafis**	**Robaf**	**Rank**	**Adama red**	**Bombay red**	**Nasik red**	**Nafis**	**Robaf**	**Rank**
Adama red	1					3	1					3
Bombay red	Adama red	1				5	Bombay red	1				2
Nasik red	Nasik red	Nasik red	1			1	Nasik red	Nasik red	1			1
Nafis	Nafis	Nafis	Nasik red	1		2	Adama red	Bombay red	Nasik red	1		3
Robaf	Adama red	Bombay red	Nasik red	Nafis	1	4	Robaf	Bombay red	Nasik red	Robaf	1	3

Source: Primary data taken from participating respondents during 2019-2020 cropping years

4. Conclusion

Onion is the most important vegetable that generates income for the small-scale farmers of Basketo special district who mainly cultivate the crop under supplementary irrigation. However, the production and productivity of onions in the study area is challenged by many factors. Lack of improved onion varieties is among the major factors that limit the productivity of the crop in the study area. Therefore, this study was conducted in 2019 and 2020 cropping seasons using supplementary irrigation to evaluate the adaptability of onion varieties and select high yielding onion variety for the study area by using farmers' selection criteria. The results revealed that growth parameters, phonological traits, yield, and bulb yield were significantly affected by the onion varieties. Nasik red variety showed better growth performance and earlier in days to bulb maturity compared to other onion varieties in the two cropping seasons (2019 and 2020). Moreover, the highest bulb weight (44.43g), marketable (112.78 Q/ha) and total bulb yield (129.9 Q/ha) were obtained from variety Nasik red in both cropping seasons. Therefore, from the result of this study, it can be concluded that production of onion by using varieties 'Nasik red' and 'Nafis' could increase the productivity of the crop in the Basketo Special District based on their average performance over the years and improve the livelihood of the farmers.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares that there is no competing interest.

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