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Adaptability and yield performance evaluation of onion (*Allium cepa* L.) varieties in Jimma zone, Southwestern Ethiopia.

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ABSTRACT

Onions (*Allium cepa L.*) are the crucial vegetable crop used in treating number of diseases. The adaptation trial of three improved onion varieties (Nanthus, Adama red and Bombe red) with one local check was done in Jimma zone at Agaro Agricultural Research Sub-center which is trial site of Jimma Agricultural Research Center for two consecutive cropping seasons of 2016 and 2017 budget year using RCBD design with three replications. The analysis of different quantitative collected data, especially, marketable fruit numbers and marketable fruit weight detected significant differences among varieties with Bombe red performing well adapted and provided highest yield in both cropping seasons with the overall result yield performance of 71.51 tons/ha next to local varieties which provided 64.34 tons/ha of revealing well adapted and superiority of all marketable yield and inferior unmarketable yield. So, this variety recommended enhancing the production and productivities thereby boosting income generation of farmers and stabilizing market inflation is possible using this improved variety.

INTRODUCTION

Vegetable crops are the crucial in sustaining food security as well as economies of both developed and developing countries. There are number of vegetable crops grown in both rain fed and irrigation in Ethiopia (Emana et al., 2015). These crops are characterized by high yielder per unit of land with two or more production cycle. Vegetable crops accommodate number of crops including hot and sweet pepper, onion, tomato, cabbage, kale, broccoli, chilli, green bean (Emana *et al*., 2015;Chewaka, 2018). Production of these crops are indispensable for developing countries in many perspectives like fast maturing and filing time of food gaps, providing large amount of produces per unit area, and ability of cultivating throughout the year. Besides, the diverse agro-ecologies of the country enable production of diversified types of vegetable crops.

Among these crops, onion is rich with assimilable iron content used to treat anemia. It has also therapeutic value using in cold, coughs, effective in preventive heart attack, bronchitics and influenza (Tripathi and Lawande, 2006). Besides its food sources it serves as sources of work opportunity and income generation. Example; in 2013 Ethiopia exported 220,213 tons of vegetables and generated USD 438 million (Fufa, 2017).

In Ethiopia there were more vegetable technologies introduced and produced among which tomato is the oldest in Ethiopia. Additionally, the production area of vegetable crop is increasing from 80 ha to 833 ha in 1980 to 1993 and from 16578.72 ha to 22035.80 ha in 2006 to 2011 with demand from time to time. From 1993 up to 2011 the tomato production area increased to 5338ha with total production of 55635 Mg (Habtamu, 2017). Despite increasing of its production area, the productivity per unit area is very low (Nigussie *et al*., 2015). This made our farmers less beneficiaries from vegetable crops. Among vegetable crops, tomato is the chief with multi-function crop in consumption and selling.

In Ethiopia, demand of tomato is in increasing rate which is being imbalance with its production. For this reason, the price inflation became double fold as compared to the last decade. Despite climatic and soil condition of Ethiopia is suitable for large number of vegetable crops including tomato production, their productivity is very low. Concurrently, the total production and productivity of the crop 8 ton/ha is much less than worlds production (34 ton/ha) due to lack of improved varieties, poor production and management, insufficient educated person on the field and severe disease and insect pest (Binalfew *et al*., 2016; Alemayehu and Alemayehu, 2017).

In Jimma zone, the onion cultivation is at backyard level which is low yielder on limited lands. In addition, for markets in Jimma zone and surrounding, found at western and southwestern part of Ethiopia, the onion produces were transported from the rift valley areas where availability of irrigation facility and accessibility and closeness to agro-industry (Emana *et al*., 2015). On top of these, price inflation due to market chain with consumer population size requires immediate solution. To boost the productivity of the crop to satisfy the demand in required quantity and quality thereby increasing income sources of smallholder farmers and minimizing of malnutrition problem introducing of improved varieties and evaluating thereby selecting best variety is crucial. But, the agro-ecologies of the zone are suitable for cultivation of any types of horticultural crops including onion. Despite suitability of soil and climate of the areas, there were very few works done in introducing and evaluating adaptability of improved varieties of onion. That was why this experiment was designed with the objective to evaluate and select well adapted, high yielder onion varieties.

MATERIALS AND METHOD

Experimental site and duration

The trial was done at Agaro Agricultural Research sub-center which is testing site of Jimma agricultural Research center (JARC). The trial site is found at Southwestern part 397 km apart from capital city of Ethiopia. The study site located at 7''50'35- 7'' 51' 00'' N of latitude and 36''35'30''E longitude. The mean altitude and average annual temperature are 1650 masl and 20.4^{o}C respectively. The area receives average annual RF of 1616 mm (WeldeMichael et al., 2016). The experiment was done for two consecutive cropping season of 2016/17 and 2017/18. The experiment was conducted during dry season using supplementary irrigation. All managements like weeding, watering and earthing-up were done properly.

Experimental materials and design

There were four varieties including local materials were subjected to evaluation and these varieties were Nanthus, Adama red, Bombe red and local variety and these varieties were collected from national horticultural research coordinating center (Melkassa Agricultural research Center (MARC).

The experiment was conducted in randomized completely block design (RCBD) fashion with three replications. The experimental plot was designed in double row fashion where two rows were used on one ridge. Total of four ridges which include eight rows were used. Spacing of 30cm x 50 cm between rows and ridges were used respectively. Additionally, plants were spaced by 10 cm in which 30 plants accommodated per row and totally, 240 plants per plot were planted on total plot size of 3m x 2.70m.

Collected data and analysis

The onion was harvested at its appropriate maturity stage. Data was collected from the middle two ridges of four rows with net experimental area of 3m x 1.10m= 3.3m^2 which accommodated 120 plants per plot. Different yield and yield related data of onion such as:

- Average stand count at harvest (SCAH): plants from which yield and related data collected were counted from the three replications each and average of them was considered
- Average leaf length (LL): Ten representative plants were selected and leaf length were measured in centimeter using meter tape and the mean of the leaves length was taken
- Bulbs diameter (BlDr) (cm): diameters of marketable bulbs also from these representative trees was taken using caliper and the average diameter was used
- marketable bulbs weight (BlWt): The weight of marketable bulbs per plot was taken in kilogram and converted to tons per hectare
- Number and weight of unmarketable bulbs: Under sized and useless bulbils per plot from each replica were counted and weighted. The average of the three replicas was converted to quantal per hectare, where 10Qt is equals to 1 ton. These collected data were subjected to statistical analysis software (SAS) vers. 9.0. The mean separation of the varieties was done with least significant differences (LSD).

RESULTS AND DISCUSSION

In the first cropping season, significant variations were observed among varieties in all attributed parameters i.e average stand count at harvest per plot, average leaf length of selected plants, average bulbs diameter, average marketable yield number , average unmarketable yield numbers and average unmarketable yield weight and marketable yield weight. This result was disagreed with the result of Misgana and Awoke (2017) who suggested that non-significant variation observed among onion varieties tested at South Omo zone SNNPR Ethiopia. Similarly, in the second harvesting season highly significant variation among varieties detected except stand count at harvest and bulb diameter.

Stand count at harvest (SCAH) and Bulb size /diameter

In the first cropping year, the result revealed that there were significant differences among varieties based on stand count at harvest. Accordingly, the maximum numbers of onion plants observed per plot were 115.67 with variety Nanthus followed by local and Adama red with the average numbers stand count at harvest of 89.33 and 88 respectively. The minimum numbers of plants per plot were recorded with variety Bombe red (75.67).

As far as bulbs size concerned in the first cropping cycle, significant variations were observed among treatments where the largest bulbs size were recorded from Adama red (6.20 cm) and Nanthus (6.13 cm) varieties which were statistically similar followed by Bombe red (5.84cm) and local (5.15cm) varieties. Bulbs size is determined by spacing used and number of population per unit area. The narrow the spacing or the larger the numbers of plants per plot, the smaller the bulb size and vice versa to some extent (Guesh, 2015).

Marketable bulb numbers and weight per plot

Regarding marketable bulb numbers, in the first cropping season there were variation among varieties in which the large number of marketable bulbs recorded from Bombe red (55.67) followed by Nanthus (53.67) varieties and the least 39 bulbs number from Adama red. In this cropping season, there was no statistical difference observed in marketable yield weight among treatments. However, the maximum marketable fruit weight was recorded from Bombe red (64.35 t/ha) followed by Nanthus with the values of 50.61t/ha. But, the least marketable yield weight was recorded with Adama red variety 44.44 t/ha.

Regarding these parameters in the second year, there were significant variation also observed with Abombe red and local varieties provided largest marketable numbers and weight with average number of bulbs 64.67 and 78.69 t/ha and 60.33 numbers of bulbs and 81.82 t/ha respectively. The smallest numbers of bulbs of 30.67 and 44.33 with weight of 42.12 t/ha and 24.65 t/ha were recorded from varieties Nanthus and Adama red respectively.

When we evaluated the onion with highly populated per plot, the under sized unmarketable bulbs were highly recorded whereas the lower populated provided lower unmarketable yield. Additionally, during yield visual observation, uniform bulbs size observed from the onion with lower population than larger population. This agrees with the statement of Sara *et al*. (2015) densely populated onion plant produces smaller bulb size and lower bulb weight.

Unmarketable fruit number and fruit weight

In the first cropping season also, significant variation observed with unmarketable fruit number and fruit weight where the largest number were recorded with Adama red with average values of 23 followed by Nanthus and Bombe red which had statistically similar letter with the values of 18.66 and 17.00 respectively. Similarly, the variety detected variation statistically in unmarketable fruit weight where Adama red gave largest unmarketable fruit weight of 4.54 Qt/ha and the least was achieved with variety Bombe red of 1.88 Qt/ha. This might be due to the lower population per plot enhancing marketable yield increment.

Table 1. The summary of yield and related parameters of onion in the first cropping seasons (2016)

T.No	Varieties	SCAH	LL (cm)	BlSz (cm)	Mark no./plot	Mark wt (Qt/ht)	Unmark no/plot	Unmark wt (Qt/ha)
1	Nanthus	115.67^{a}	45.63 ^{a}	6.13^{a}	53.67^{a}	50.61^{b}	18.66^{b}	3.47^{b}
2	Adama red	88.00^{b}	41.80^{ab}	6.20^{a}	39.00^{b}	44.44^{b}	23.00^{a}	4.54^{a}
3	Bombe red	75.67^{c}	42.70^{ab}	5.84^{ab}	55.67^{a}	64.35^{a}	17.00^{bc}	1.88^{c}
4	Local	89.33^{b}	37.53^{b}	5.15^{b}	41.67^{b}	46.87^{b}	14.00^{c}	3.56^{b}
CV		4.72	9.20	8.27	7.85	11.64	8.64	7.82
LSD (5%)		8.85	7.70	0.96	7.45	12.96	3.12	0.56

*N.B: SCAH=stand count at harvest, LL=leaf length, BlSz= bulbs size/diameter, Markno/plot= marketable bulbs numbers per plot, Markwt(t/ha)=marketable bulbs weight in tons per hectare, Unmark no/plot= unmarketable numbers of bulbs per plot and Unmark wt (Qt/ha)= unmarketable weight of bulbs in Quintal hectare

Similarly, in the second cropping season, the same varieties Adama red and Nanthus were showed the maximum unmarketable fruit number and weight of 23.00 and 14.00 with 4.54 Qt/ha and 2.87 Qt/ha respectively. But, in the second season, though non-significant variation observed in stand count at harvest, bulbs diameter the maximum SCAH of 77.67 achieved from Adama red. Also maximum unmarketable yield were rendered from both Nanthus and Adama red with 3.97 Qt/ha and 3.31 Qt/ha respectively.

Table 2. The summary of yield and related parameters of onion in the second cropping seasons (2017).

T.No	Varieties	SCAH	LL (cm)	BlSz (cm)	Mark no./plot	Mark wt (t/ht)	Unmark no/plot	Unmark wt (Qt/ha)
1	Nanthus	60.00^{a}	52.07^{a}	5.13^{a}	30.67^{c}	42.12^{b}	14.33^{b}	5.17^{a}
2	Adama red	77.67^{a}	40.33^{ab}	4.413^{a}	44.33^{b}	24.65^{c}	23.00^{a}	3.49^{b}
3	Bombe red	73.00^{a}	38.27^{b}	4.723^{a}	64.67^{a}	78.69^{a}	8.00^{c}	1.27^{d}
4	Local	75.00^{a}	38.40^{b}	5.100^{a}	60.33^{a}	81.82^{a}	9.00^{c}	2.95^{c}
CV		14.00	15.69	18.55	5.83	9.29	15.32	6.42
LSD (5%)		19.97	13.25	17.84	5.83	0.058	4.16	0.408

*N.B: SCAH=stand count at harvest, LL=leaf length, BlSz= bulbs size/diameter, Markno/plot= marketable bulbs numbers per plot, Markwt(t/ha)=marketable bulbs weight in tons per hectare, Unmark no/plot= unmarketable numbers of bulbs per plot and Unmark wt (Qt/ha)= unmarketable weight of bulbs in Quintal hectare

The result of the second cropping season in marketable number and weight also showed significant variation except varieties Bombe red and local showed non-significant difference between them the largest yield weight of Bombe red next to local 64.67 fruit numbers with 78.69 t/ha for Bombe red and 60.33 fruit numbers with 81.82 tons/ha for local. Similar to the first cropping season, in the second cropping season, Adama red variety gave the lowest yield of 9 tons/ha.

To generalize the performance evaluation of these varieties the two years overall average yield of the traits were summarized as follow (table 3).

When the overall mean of the two years observed, the result was once again in both marketable fruit numbers and marketable fruit weight Bombe red and local variety showed the maximum yield numbers 60.17 and 51 with 71.51 Qt/ha and 64.34 Qt/ha respectively. But the lowest yield numbers and weight of 41.67 with 34.54 Qt/ha from Adama red and marketable numbers of 42.17 and 46.36 Qt/ha from Nanthus were recorded in that order. Contrary the lowest unmarketable number and weight also recorded from Bombe red and local varieties which showed statistically similar letter with values of 11.67 and 11.33 bulbs number and 1.57Qt/ha and 3.25Qt/ha respectively.

Table 3. Average combination of yield and related trait of the two years

T.No	Varieties	SCAH	LL	Mark. BlSz	Mark. no.	Mark. Wt	Unmark no	Unmark wt
1	Nanthus	87.83^{a}	48.85^{a}	5.57^{a}	42.17^{b}	46.36^{b}	16.33^{b}	4.32^{a}
2	Adama red	82.84^{ab}	41.06^{ab}	5.30^{a}	41.67^{b}	34.54^{b}	23.67^{a}	4.02^{ab}
3	Bombe red	74.33^{b}	40.48^{ab}	5.28^{a}	60.17^{a}	71.51^{a}	11.67^{c}	1.57^{c}
4	Local	82.16^{ab}	37.96^{b}	5.12^{a}	51.00^{ab}	64.34^{a}	11.33^{c}	3.25^{b}
CV		9.59	12.45	13.41	6.84	16.65	11.98	7.39
LSD (5%)		17.32	8.53	0.63	11.76	4.88	2.88	0.395

Similarly, in stand count at harvest and leaf length, Nanthus and Adama red showed superior where as non-significant variation observed in marketable bulb size. From the result also the longest average leaf length recorded from the highly populated onion varieties i.e the highest stand count at harvest which might be for light competition.

CONCLUSION AND RECOMMENDATION

Based on the result, the variety with highest stand count at harvest showed the tallest leaf length suggesting competition for light. But, due to varietal environment preferences, yield variation observed. Additionally, all varieties with highest number of stand count at harvest recorded the highest number and weight of unmarketable yield. Generally, variety Bombe red showed the greatest yield in all marketable parameters except for number of stand count at harvest and unmarketable yields detecting adaptability to the area. So, this variety is recommended for Agaro, its surrounding and areas with similar agro-ecologies.

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