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Investigating Yield, Yield Components and Some Qualitative Traits of Bulb in Iranian Improved Onion (*Allium cepa* L.) Red Rey Cultivar

Sayyedeh Mahsan Taghi Shokrgozar[1], Mohsen Khodadadi[2*], Vahid Abdossi[1], Vahid Zarrin Nia[1] and Ramin Hajianfar[2]

[1]Department of Horticulture, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[2]Vegetable Research Center, Horticulture Research Institute, AREEO, Karaj, Iran.

Authors' contributions

This work was carried out in collaboration between all authors. Author SMTS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MK collaborate on field research and guidance in the research protocol. Author VA managed the statistical analyses of the study. Author VZN managed the literature searches and author RH carry out Blab quality tests. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

The purpose of this two years research (2016-2017) conducted in Karaj is to investigate quantitative and qualitative traits of bulb in Red Rey Iranian improved onion ((*Allium cepa* L.) population Red Azarshahr as check in terms of increasing yield of bulb and qualitative traits especially in DM percentage. The improved population was achieved by the selection of superior bulbs, cultivation and its selfing and consequently the identification of the best families and conduction of open pollination between them. In April 2016, the improved population with basic population and Red Azarshahr improved cultivar (as a comparative cultivar as check) were evaluated in RCBD design at three replicate and the different traits were measured including total yield, bulb weight, bulb diameter, bulb height, number of bulb layers, the number of bulb centers,

**Corresponding author: E-mail: m.khodadaddi@areeo.ac.ir; kodadadi@yahoo.com;*

bulb firmness, dry matter of bulb, total sulfur content, total phosphorus content, total potassium content in bulb and the amount of bulb vitamin C. The results showed that the improved population was than basic population in various traits especially in bulb yield with 98.9 tons per hectare, but there was no superiority in improved population in proportion to basic population or check cultivar in qualitative traits of bulb particularly qualitative laboratorial characteristic (sulfur, phosphorus, potassium and vitamin C) except for dry matter percent and bulb firmness.

Keywords: Onion; Red Rey; improved population; yield, qualitative traits; bulb.

1. INTRODUCTION

The onion (*Allium cepa* L.), also known as the bulb onion or common onion, is a vegetable that is the most widely cultivated species of the genus *Allium*. The cultivated area of the onion in the world is 44.4 million hectares and the yield of it is 19.3 tons per hectare [1]. The cultivated area of onion in Iran was 70125 hectares and the yield of this crop was reported 33.96 tons per hectare [2].The origin of the onion crop is (*A. cepa*) from Central Asia, especially Iran [3]. The production of onion in Iran is generally carried out with the long day's populations and cultivars in autumn. Native population's traits are mainly undesirable due to genetic erosion and frequent cultivations in areas. The Rey population in Tehran and Alborz provinces is generally cultivated in about 1000 hectares.

Experimental results in which five morphotypes of Rey onion population with 18 morphotypes from three other important populations of Iran (Red Azarshahr, Rey Red and Zanjan Quli Qeseh) showed that all of the population of Rey's morphotypes, especially number 13, had the highest amount in terms of yield and dry weight [4]. It was also concluded that this population (Red Rey) is non-uniform in terms of time of bulb maturity and its bulb neck diameter is relatively thick [4].

Providing superior crop cultivars is not possible without achieving and using genetic diversity. The indigenous population in vegetables such as onion are always considered as an important treasury of gene in the process of breeding. The onion population has high heterozygosity which perpetuated through fertilization [5].

In order to maintain the desired traits, it is very important to make accurate selection of mother bulb in the seed production process. Improvement has been carried out for traits such as yield, uniformity, diseases resistance, adjustment to latitude and farming operation [6, 7]. Historically, in open pollinated plants, mass selection is the best method for breeding [5]. Also, good results can be obtained through recurrent selection [8, 9].Three synthetic varieties of onion have been produced in the USA from one series of self-pollinated lines with deep brown yellow color, large size bulb and high storability adjustable to conditions of New York City. Also, in the second series, six new varieties have been improved [10].

High heritability and generic efficiency for traits of bulb weight, leaf length, leaf number, bulb length and diameter were reported in Allium species [11,5,12]. Fasika et al. [13] assessed average to high heritability for single plant yield. also estimated high heritability for the rate of dry matter (30-80%), yield in hectare (63-79 %), soluble solid matters (24-74%) and mean bulb weight (64-68%) [13].

Mohanty estimated the medium to high heritability and the coefficient of genotype changes with average genetic yield during the investigation of 12 various onions within 4 years for neck diameter. Therefore, it can be take action to modify the population for such traits by conducting simple selection [14]. Moosavzadeh, et al. reported significant positive and negative correlation among characteristic of onion diameter, length of onion, length of leaf and number of leaf with yield of onion single plant. In this research, onion diameter had the most direct and positive effects on the yield of single plant of onion. Also, the length of bulb and leaf length had a relatively large direct effect on the yield of single plant of onion [4].

In the research conducted by Darabi, the improvement of Behbahan local population was conducted by using production method of OP cultivars in Behbahan Agricultural Research Center [15]. In the first year, storage characteristic of selected bulbs were investigated and then, two generations of self- fertilization were performed. After the end of improvement procedures, the most appropriate date for cultivation and plant density for improved

population was determined and the compatibility of this genotype investigated in south regions of Iran. Moreover, this genotype was assessed in cultivation condition. The results showed that if the date of cultivation being observed and the appropriate density of this genotype has high yield production potential (total and salable yield are 69.34 and 60.26 tons in hectare, respectively)and regarding the white color and high percentage of bulb dry matter, it can be good for storage. The characteristics of the above genotype are that it can be stored for a long time and is good from the standpoint of color and shape uniformity. In cultivation condition, from the viewpoint of total and marketable yield, the percentage of twinness and color purity had priority over population.

in the past years, various researches have been conducted in different fields in Red Rey Iranian population including the investigation of storage capability, the investigation of growth in the farm and the investigation of quantitative and qualitative characteristics of five Rey local populations with 18 bulb populations from East Azarbayjan, Zanjan and Khorasan Razavi. The results of this researches showed that this population has fairly high storage capability [16]. This population is more late maturity compared to Azarshahr and White Qom populations in term of growth period [17]. This population has yield superiority and dry matter percentage compared to Zanjan province population, but the neck diameter of Rey bulbs were significant high which will be improved in the present project.

The aim of this research is to reduce the diameter of the bulb neck and to make the onions more uniform in the Red Rey population.

2. MATERIALS AND METHODS

2.1 The First Part

The improvement of Red Rey Iranian cultivar has been conducted by breeding program on its base mass selection in Seed and Plant improvement institute of Karaj in a four year project (2012-2015).In first year, the possibility of seed production in 100 self-families was individualized in isolated cages after selecting 500 superior bulbs considering main traits of mass in term of type, shape and color.

In the next year, 100 families of onions were evaluated based on three important traits including yield, shape uniformity of bulbs and early maturity using RCBD in three replicates. Finally, 5 lines (6, 68, 94, 57 and 56) were selected. In the following program, by cultivation of bulbs in five superior families and conducting open pollination between them, the seed improved of Red Rey population has been achieved. The improved population with basic population (a part of seed in this population has been kept in gene bank) and check cultivar has been investigated in the second part of the following research.

2.2 Second Part

Spring and autumn 2016: the cultivation of improved population on the farm together with the basic population and Red Azarshahr improved cultivar, in RCBD design at three replicates. Eachplot has been made up of six lines each has five meters. The distance between rows and plants was 50cm and 10cm, respectively.

The crop was irrigated with drip Irrigation in this project based on water requirement and soil texture once in each five days. Fertilization was carried out on the basis of soil testing.

2.3 The Traits of this Experiment were Recorded as Follows

The bulb quantitative traits including yield with harvesting bulbs of middle rows of each plot, bulb weight, bulb diameter was determine using Vernier caliper in 30 random bulbs form each plot and bulb height with weight measurement and bulb center numbers with cutting in 10bulbs in each plot randomly.

2.4 The Bulb Qualitative Traits Including

Bulb firmness with FTO penetrometer model 11 with eight millimeter tip [18].

The amount of bulb mineral elements including total sulfur (preparation of ash and extract from dry matter and spectrophotometry), total phosphorus (preparation of ash and extract from dry matter and flame photometry) [19].

Bulb dry matter percentage: 50 g fresh matter has been cut and put in the oven with 72 centigrade temperature for 48 hours.

The amount of bulb vitamin C (with 2 and 6 titration DCIP) [20].

Conducting simple variance analysis and means comparison by using SAS software with Duncan's multiple range method in the level of 5%.

3. RESULTS

In Tables 1 and 2 , the results of simple variance analysis and mean comparisons of traits in Rey basic population, improved Red Rey population and Red Azarshahr improved cultivar has been shown.

3.1 Bulb Yield

In quantitative traits, yield as the most important trait showed a significant difference between the three genotypes. Mean yield was significant in all three populations at 1% level (Table 1).The bulb yield of the improved population was 69 tons per hectare and Azarshahr ranked second with 68 tons. However, these two population did not have a significant difference in yield, and the basic population had the lowest yield with 58 tons and was in a separate statistical group (Table 2).

3.2 Bulb Height and Diameter

The most important quantitative traits in the onion marketable are the length and diameter of bulb, as shown in the Table 1, the onion height at 1% level showed a significant difference among the genotypes of the experiment, and the diameter of the onions also showed a 5% difference in the statistical difference. As it is seen, the traits of bulb height did not differ significantly between the two basic and improved populations, and both were in the same statistical group. But Azarshahr population in this regard was placed in a separate statistical group and had the highest bulb height.The Red Azarshahr cultivar is a bit longer than Red Rey and it also has the higher ranking with 64.69 millimeter. According to Bulb heights, the diameter of bulb was also significantly different among the populations.The highest diameter of onion was Azarshahr with an average of 87 mm (in a separate statistical group).Also, the improved population with the diameter of 76 mm in the second place and the basic population with 64 mm were in the third place, which did not show any significant difference (Table 2).

3.3 Bulb Weight

The weight of onions affected by the size of height and diameter of bulb as well as the thickness of the bulb layer is considered as an important trait.It can be seen that this trait also has a significant statistical difference at 1% level under the influence of different genotypes (Table 1).By comparing the mean of onion weight, the results showed that Azarshahr genotype had the highest value of 175 g and the second one was improved population with 173 g of onion, although both were in a similar statistical group. The lowest is the base population with an average of 106 g (Table 2).

3.4 Number of Bulb Center

The number of central onions did not show any significant difference under the influence of different genotypes. In fact, this trait was not affected and the three genotypes were not significantly different (Table 1).There was no statistical difference between genotypes, but the comparison of the means showed that the highest amount of base population was 2.33 and the improved population and Azarshahr had the lowest value with 1.67 (Table 2).

3.5 Number of Bulb Layer

The number of bulb layers did not show any significant difference between genotypes (Table 1). Comparing the means as presented in Table 2, the highest value was for the improved population with the 9-layer value, and the two genotypes of the base and the azarshahr were also ranked 8 and 8.67, respectively.

3.6 Dry Matter of Bulb

The dry matter content of bulb in the three genotypes showed a significant difference at 5% level. As shown in Table 2, this trait was the highest in the improved population with 11.14% and was ranked in the statistical group a. Also, two genotypes of base and Azarshahr with 10.44 and 9.46 percent were in the next rank and in a separate statistical group.

3.7 Quantitative Trait

There is no significant difference in bulb quantitative traits like, total sulfur, total phosphorus, and total potassium (Table1). In

Table 1. The results of analysis variance in experimental genotypes

SOV	Df	Onion yield	Bulb height	Bulb diameter	Bulb weight	Number of bulb center	layer number of bulb	Bulb firmness	Total sulfur	Total phosphorus	Total potassium	Bulb dry matter	Neck diameter
Genotype	2	111.00**	146.53**	411.77*	4695.66**	0.44^{ns}	0.78^{ns}	0.67**	0.009^{ns}	0.0030^{ns}	0.027^{ns}	1.70*	28.94*
Block	2	5.33 ^{ns}	5.65^{ns}	27.82^{ns}	409.94*	0.44^{ns}	0.78^{ns}	0.07^{ns}	0.008^{ns}	0.0014^{ns}	0.012^{ns}	0.23^{ns}	1.99^{ns}
Error	4	5.33	6.24	40.05	40.48	0.78	0.28	0.02	0.006	0.0016	0.031	0.404	3.37
CV (%)		3.52	4.41	8.30	4.20	16.68	6.16	2.05	15.20	9.66	8.11	6.11	13.59

**, ** and ns are significant at 1%, 5% and non-significant respectively*

Table 2. Results of mean comparisons in traits (Duncan's multiple range test at 5% level)

Genotype	bulb yield (T/ha)	bulb height (mm)	Bulb diameter (mm)	bulb weight (g)	number of bulb center	layer number of bulb	bulb firmness (N/cm^2)	total sulfur (%)	total phosphorus (%)	total potassium (%)	bulb dry material (%)	neck diameter (mm)
Improved	69.68^{a}	50.98^{b}	76.49^{b}	173.50^{a}	1.67^{a}	9.00^{a}	7.60^{a}	0.47^{a}	0.447^{a}	2.210^{a}	11.14^{a}	10.92^{b}
basic	58.67^{b}	54.60^{b}	64.37^{b}	106.07^{b}	2.33^{a}	8.00^{a}	7.00^{b}	0.48^{a}	0.431^{a}	2.060^{a}	10.44^{b}	12.83^{a}
control	68.68^{a}	64.49^{a}	87.80^{a}	175.63^{a}	1.67^{a}	8.67^{a}	6.67^{c}	0.57^{a}	0.385^{a}	2.237^{a}	9.64^{c}	16.95^{a}

fact, there was no significant difference between improved population and base genotype and Azarshahr genotype.

3.8 Neck Diameter

The neck diameter in improved population has the top rank of with 10.92millimeter compared to basic population with 12.83 millimeter (**b** ranking). It means that the neck diameter has been shorten by improvement. In Red Azarshahr, the neck diameter has the most undesirable ranking, it means that **a**, with 16.95 millimeter. The onion neck must be closed and not thick, which would be an indication of inadequate ripeness.

3.9 Bulb firmness

Bulb firmness is a trait that has a significant difference ($P<0.01$) among treatments (Table 1). The results of the comparison of the means showed that the highest Bulb firmness was found in the improved Red Rey population with 7.6 Newton/cm2, and it showed a significant difference with other two genotypes (Table 2). Two genotypes of Red Rey base population and Azarshahr, respectively, with 7 and 6.67 Newton/cm2, were next ranked, which were also in separate statistical groups (Table 2).

4. DISCUSSION

Changes in the dry matter of bulb DM depend on many factors, for example, the amount of plant nutrition, the time it takes to stop irrigation, and the length of the plant's growth period. When the growth period is complete, more dry matter is transferred to the bulbs. In this research, there is a significant increase in percentage of bulb dry matter which is around 10.4 % in basic population in comparison with the improved population which is around 11.1 %. From the standpoint of bulb firmness, the improved population of Rey holding 7.6 N/cm2, show significant superiority in basic population of Rey and Azarshahr Red control cultivar. It can be said that the average increase of bulb dry matter in improved population in comparison to basic population were among the reasons for increasing of bulb tissue firmness.

Recently, there have been some research conducted on the mass selection in populations to increase of standard genes in Iranian mass such as Red Azarshahr [21] and White Qom [22], while in Rey Red mass, the result of this research is the same as the result of above mentioned researches especially from the standpoint of total yield average increase. The results of this research is not the same as the results of Darabi's research from the standpoint of traits such as storage capability. In the above-mentioned research, Behbahan white population, it was reported a mass holds high dry matter percentage which this matter caused to high storage capability. The execution of promotional project in Rey red improved mass cultivation areas, Alborz and Tehran provinces, is suggested for introduction and promotion of new population [15].

One of the important traits that is important in a marketability is the diameter of the bulb neck. The numerical value of this trait in the modified population was reduced by the corrective program. Brewester reported that neck-thickness is a physiological disorder that is influenced by seasons, sites and cultivars [23].

The onion yield has been increased in the improved population as mentioned. Genetic variability, character association pattern and direct and indirect effects of yield contributing characters are helpful in crop improvement [24].

Very few research has been done to estimate genetic parameters related to qualitative traits and onion dry matter [24]. Improvement onion has been more focused on performance, and if it is coupled with quality traits, it will have great results and will not only improve slightly, but will also be superior in quality. Information regarding genetic analysis of quality parameters like vitamin C, phenol and pyruvic acid contents of bulb is lacking [24].

One of the important attributes of product storage and handling capabilities is Firmness. This attribute is directly related to the reduction of losses. It is also important in mechanized harvesting. Therefore, it is necessary to consider this attribute in future corrective programs. Bulb firmness are good for minimizing the quality loss caused by different harvesting and post harvesting operations. The number of growing points, bulb size and shape, number of scales, scale thickness, and bulb firmness are important bulb quality characters in the fresh market and onion processing industry. In many studies, it has been shown that the bulb size with Firmness has a negative correlation, as the onion bulb larger, Firmness decreases [25].

Other research results showed that was a significant interaction between cultivar and storage time for weight loss [24].Other research results also showed that dry matter percentage in different cultivars was significantly different. The results of this study showed that the highest cultivar with dry matter was 15-18%. Also, the results showed significant relationship between cultivar and storage time under the influence of dry matter [26].

5. CONCLUSION

Finally, it can be concluded that the breeding program has a significant effect on important traits such as yield and dry matter and some qualitative traits and has been effective in improving these traits in the Red Rey population. It is suggested that new research be carried out in order to improve the qualitative characteristics of this population, for other attributes such as storage capability and bulb uniformity. It is also suggested that future research be carried out on qualitative traits such as taste and alike.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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