Assiut Journal of Agriculture Science 53 (3) 2022 (118-134) *Website: http://ajas.journals.ekb.eg/*
ISSN: 1110-0486 / E-ISSN: 2356-9840 *E-mail: ajas@aun.edu.eg*

Original Article

Variability, Heritability, Association and Selection Response to Bulb Weight and Storability in Egyptian Onion

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DOI:10.21608/ajas.2022.134534.1136

Abstract

This study assessed the variability within and among populations of three Egyptian onion cultivars (Red Behari, Giza-6 Mohasan and Line-70) during storage at normal room temperature. Selection response was estimated towards improving storability of medium to large sized bulbs. The bulbs were checked at 45-d intervals to discard sprouted and disease infected bulbs. The histograms analyses suggested normally distributed initial data for bulb weight, diameter, and length. The estimated descriptive statistical parameters revealed appreciable differences among and within the analyzed onion populations. Bulbs of cv Giza-6 Mohasan and Line-70 were excluded after 135-d in storage as all their bulbs developed sprouts. Red Behari cv showed sprouting after 225 d. At this time, the histogram for Red Behari cv strongly skewed left as a result of small bulbs predominance. Only some medium sized bulbs remained. These bulbs may be useful for population improvement in cv Red Behari or crossed with other cultivars. The bivariate analysis for genetic and phenotypic associations showed high r values for bulb diameter and length with bulb weight during storage. These traits had a high genetic component as shown by heritability (H^2) and coefficient of variation (*cv*). It is concluded that genetic variation exists for improving storability in Egyptian adapted onion. Red Behari medium sized bulbs may be further improved for shelf life by within population selection or after crossing with Giza-6 Mohasan. Indirect selection for bulb weight may be applied using bulb diameter.

***Keywords**: Allium cepa, Breeding, Crop improvement, Descriptive statistical parameter, Histogram analysis*

Introduction

Onion (*Allium cepa* L.) is one of the most broadly cultivated vegetable crops in the whole world. It belongs to the family Alliaceae (2n = 2x = 16), and is ranked the second only after tomato in terms of importance (Sahoo *et al.*, 2017). It is an ancient crop that was cultivated in Egypt more than 5000 years ago (Brewster, 1994). It is

Received: 17 April 2022 / Accepted: 27 April 2022/ Published online: 1 August 2022

currently a main crop and Egypt is among the top producer as it was recorded the fourth main producer and exporter of onion (FAOSTAT, 2019)**.** Onion is grown for its fresh bulbs and as green plant. It is used for seasoning and flavoring the food, in addition to its use in pickles and salads. It is also used by the processing industry for dehydrating onion bulbs in the form of onion flakes and powder, which is in great demand in the world market. In this context, Egypt grew 82.146 hectare and production was 2.917.470 tons in 2019. Total onion bulb exports recorded 487,000 tons of them dehydrated onion was 12,970 tons (2.7%) and green onion 32,743 tons (6.7%). Bulbs of onions are rich in carbohydrates, minerals and nutrients (such as calcium, phosphorus and iron), protein, and vitamin C as well as its immense medicinal properties.

As an economically important main crop, onion has received the attention of researchers in Egypt especially in breeding (Shalaby, 1967; Ahmed and Ahmed, 1976; Abd El-Rehim 1994; Gamie 2000; Abo-Dahab 2006; Abo-Dahab *et al*., 2018). Breeding of onion is facing several limiting obstacles and have been mainly hindered by the out-breeding and biennial growth habit of the crop, as well as by the paucity of large sets of robust molecular markers (McCallum, 2007). The crop is biannual out-cross species, suffers inbreeding depression and severely deteriorate, and has a very big genome. Efforts, therefore, have been confined to population breeding emphasized on directional mass selection (Shalaby *et al.*, 1991; Abd El-Rehim 1994;Wall and Corgan, 1999; Mallor and Sales, 2012; Barakat and Hassan, 2021). Additional difficulty in breeding of onion is the locality in terms of need for specific day-length and the interaction of temperature and day-length to set bulbs. These conditions limit to some extent the germplasm exchange among different regions.

Smaller sized bulbs are usually stored better under room temperature than bigger ones However, average sized bulbs are desired. Previous studies have not stressed on this issue (Gamie 2000). Direct selection for bulb weight may be time consuming. The indirect selection utilizing another strongly correlated trait that is simple and easy to be visually selected would be helpful. Hence, it is useful to exploit the association between bulb weight and other more visually manageable traits. This study, therefore, was conducted to determine the phenotypic and genotypic correlations between bulb weight and its diameter and length in addition to assess heritability and selection response for these traits during storage under normal room conditions.

Materials and Methods

Plant material

The present investigation was conducted at the Agriculture Research Station, Faculty of Agriculture, Assiut University during 2020 and 2021. The studied onion material consisted of three cultivars (Red Behari, Giza-6 Mohasan, and Line-70). Onion seeds were sown in nursery on Sept. and 60-day-old plants were then transplanted 10 cm apart on both sides of 70 cm wide rows. Culture practices including fertilization were applied as recommended for production of bulb onion in Egypt (Hasan, 1991) Bulbs were harvested when showing 50% of tops fallen down (on May) and subjected to curing for 2-3 weeks in shade place. Random sample of bulbs were taken to use in storability assessment under normal room conditions where temperature ranged from 20.4 ± 1.4 to 34.8 ±1.9 and relative humidity ranged from 40.1±4.8 to 54.2±7.25.

Measurements

Data were recorded at 45-day interval for individually labeled and numbered bulbs. These data included bulb weight (initial weight), length and diameter. Bulbs showing sprouting and disease disorder were discarded. Weight loss percentage was calculated by dividing final weight of remained bulbs after the storage period (45 d) by the initial weight × 100. The experiment was laid out in a randomized complete-block (RCBD) design with three replicates.

Estimated genetic parameters

Histograms of frequency distribution and the basic statistical parameters characterizing the populations including the range, mean, variance, standard deviation (SD), standard error (SE), skewness and kurtosis were investigated. Based on the variance component (Steel and Torrie, 1980) relevant to RCBD design (Gomez and Gomez, 1984), genotypic and phenotypic variances (Vg and Vp) were estimated. Genotypic variance (δ^2g) = (MSg - MSe)/r and phenotypic variance (δ^2ph) = (δ^2g+δ^2e/r), where δ^2e**:** MSe /r, where MSg is the means square of genotypes, MSe is the means square of the residual (error), and r is the number of replicates; VP = VG + (MSe/r). The broad sense heritability was calculated as H^2 = Vg /Vp (Mather,1949) where Vg = (Vp – Ve). Phenotypic coefficient of variation (PCV) was calculated as described by Burton (1952) [(phenotypic variance)$^{1/2}$ / $\overline{x}$] ×100**)** Where, $\overline{x}$ is the grand mean of all genotypes. Genotypic coefficient of variation (GCV) = [(Genotypic variance)$^{1/2}$/ $\overline{x}$] ×100. Environmental coefficient of variation (ECV) = [(MSe)$^{1/2}$ / $\overline{x}$] ×100. Heritability values were categorized as follows: 0 – 30 % = low; 31 – 60 % = moderate; > 60 % = high (Robinson *et al.*, 1949). PCV and GCV were categorized according to Sivasubramanian and Menon (1973), into three levels (0 – 10% = low; 11% – 20% = moderate and > 20% = high.

The phenotypic correlation (r_p xy) = Cov p XY/δ̃p X* δp Y, where Cov p XY is phenotypic covariance of traits x and y, and δpX* δpY is the product of the square root of phenotypic variances of traits x and y, respectively. The genetic correlation (rg xy) = Cov g XY/δ̃g X* δg Y, where Cov g XY is genetic covariance between traits x and y, and δg X* δgY is the product of the square root of genetic variances of traits x and y, respectively (Miller *et al.*, 1958; Searle, 1961; Kashiani and Saleh, 2010).

Table 1. Expected mean squares according to randomized complete-block design

Source of variation	Degrees of freedom	Mean squares	Expectation of mean squares
Blocks	(r-1)	MSr	$\delta^2 e + g\sigma^2 r$
Genotypes	g-1	MSg	$\delta^2 e + r\delta^2 g$
Error	(r-1) (g-1)	MSe	$\delta^2 e$
Total	rg-1	----	----

δ^2g: genotypic variance; δ^2e: error variance; r: number of replications; g; number of genotypes

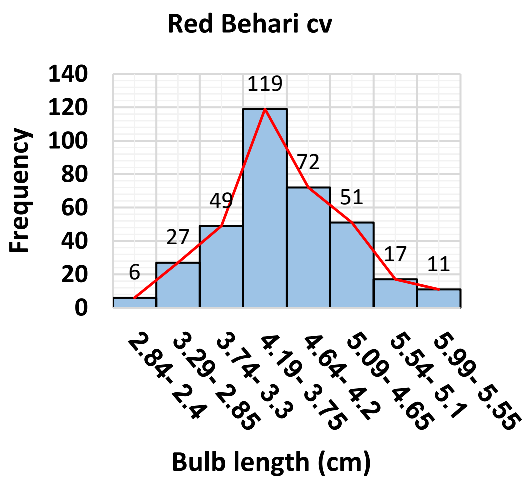
Expected selection response (R) was estimated (Falconer, 1996; Allard, 1999) as $R = I * h^2 * \delta P$, where i is standardized selection differential (tabulated for any given selected proportion for any trait that is normally distributed, so it is not specific for a trait or a population), h^2 is the heritability in broad sense and δP is the phenotypic standard deviation. The correlated response to selection was estimated as $Cry = i*HxHy*rg*\delta Py$, where i is the standardized selection differential for traits x, Hx and Hy are the square roots of heritability of traits x and y, rg is genetic correlation between x and y and δ̃P y is the phenotypic standard deviation for y (Falconer, 1996).

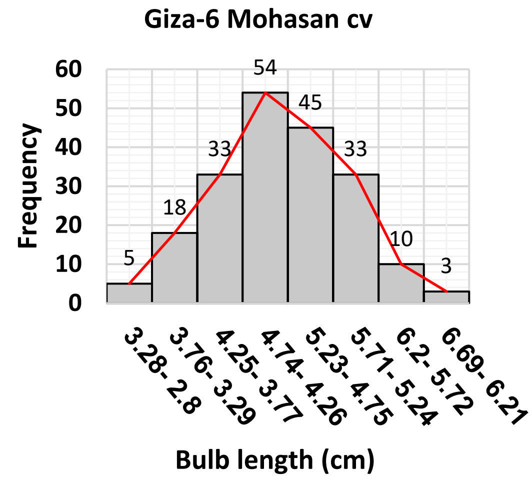
Results and Discussion

Histogram and descriptive statistical parameters analyses

Availability of genetic variability is a basic prerequisite for crop improvement through breeding. In this context, study of histograms for traits frequency distribution and determination of various first and second degree descriptive statistical parameters hold a prime importance in crop breeding. Here, a wide range and high level of variability was detected within and among the studied onion cvs in the initial bulb weight, length and diameter (Fig. 1 to 3). The coefficients of variation (*cv*) revealed a large portion of the total variation was controlled by genetic effects (Sivasubramanian and Menon, 1973). As shown in these Figure, histograms of the analyzed traits of the three cultivar populations in this study revealed a quantitative (continuous) nature of distribution. In this regards, the histogram is considered an effective graphical technique for presenting both the skewness and kurtosis of data set. Central tendency (means) and dispersion (variance and standard deviation) measures, in addition to, shape descriptors (skewness and kurtosis) are shown in Figures 1 to 7. Shape descriptors presented in Figures (1 to 3) for the 3 populations reveal no severe violation suggesting a nearly normal distribution of the studied initial bulb traits.

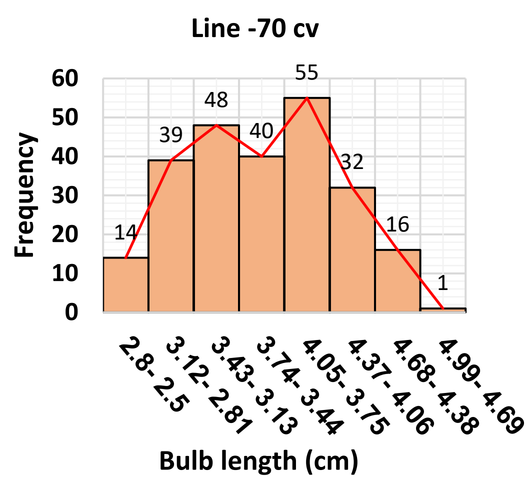
Initially, the cv Giza-6 Mohasan had the greatest average bulb weight and variance (Fig 3) while Initial bulb length and diameter were the greatest in cv Giza-6 Mohasan. Line-70 was the least in bulb length while cv Red-Behari was the least in bulb diameter. Histograms of bulb weight remained with slight changes from a storage period to another up to 135 d in storage (Fig. 3 to 6) (storage period is 45 d).





Parameters				
	Min.	Max.	Mean	Variance
	2.4	6.00	4.182	0.42
	SD	SE	Skewness	Kurtosis
	0.648	0.034	0.2429	0.0162

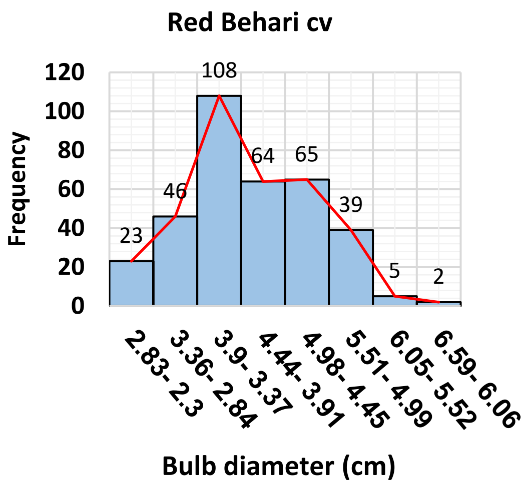
Parameters				
	Min.	Max.	Mean	Variance
	2.8	6.7	4.68	0.543
	SD	SE	Skewness	Kurtosis
	0.737	0.052	0.0759	-1.699



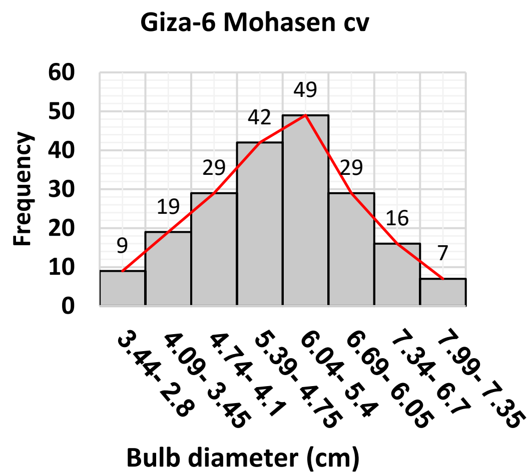
Parameters				
	Min.	Max.	Mean	Variance
	2.5	5.00	3.611	0.264
	SD	SE	Skewness	Kurtosis
	0.513	0.033	0.1013	-0.5577

Total cv 15.68 **Genetic cv = 12.74** **Environmental cv = 2.94**

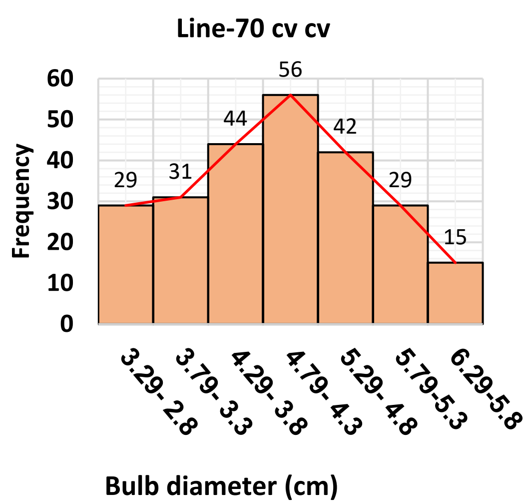
Figure 1. The histogram of frequency distribution for initial bulb length of three onion populations



Parameters				
	Min.	Max.	Mean	Variance
	2.3	6.6	4.045	0.632
	SD	SE	Skewness	Kurtosis
	0.795	0.042	0.2804	- 0.2339



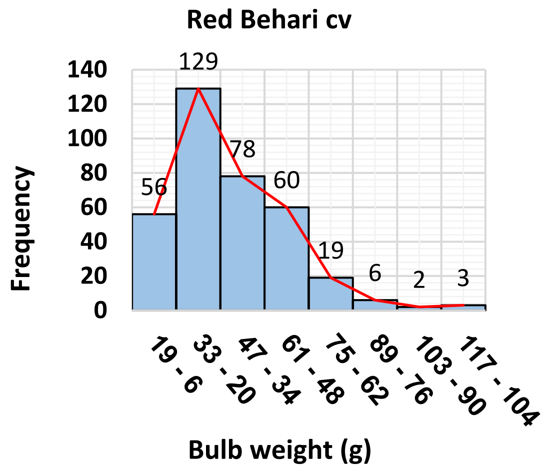
Parameters				
	Min.	Max.	Mean	Variance
	2.8	8.00	5.379	1.242
	SD	SE	Skewness	Kurtosis
	1.114	0.078	0.0024	-0.2838

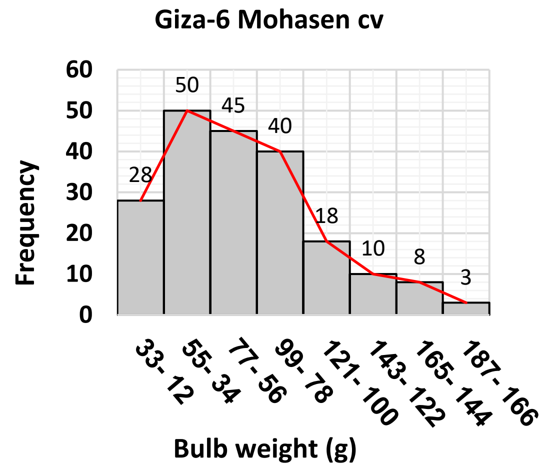


Parameters				
	Min.	Max.	Mean	Variance
	2.8	6.8	4.444	0.689
	SD	SE	Skewness	Kurtosis
	0.83	0.053	0.1116	-0.5577

Total cv = 20.37 **Genetic cv = 14.49** **Environmental cv = 5.88**

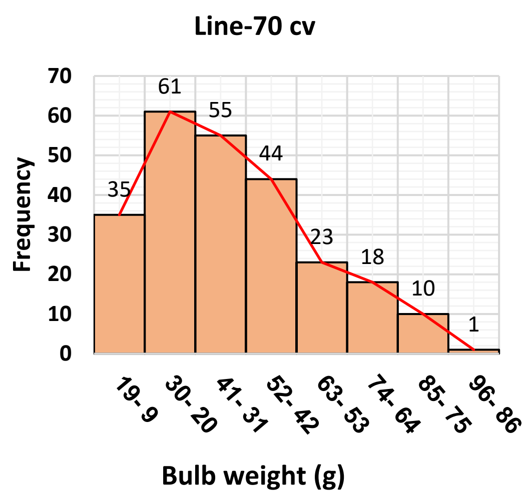
Figure 2. The histogram of frequency distribution for initial bulb diameter of three onion populations





Parame	Min.	Max.	Mean	Variance
	8.64	114.81	36.53	332.87
	SD	SE	Skewness	Kurtosis
	18.25	0.971	1.143	1.8325

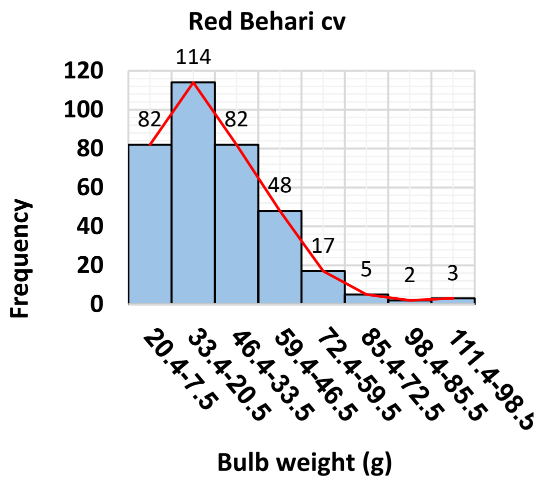
Parame	Min.	Max.	Mean	Variance
	13.3	187.2	72.396	1309.802
	SD	SE	Skewness	Kurtosis
	36.191	2.546	0.7814	0.3353



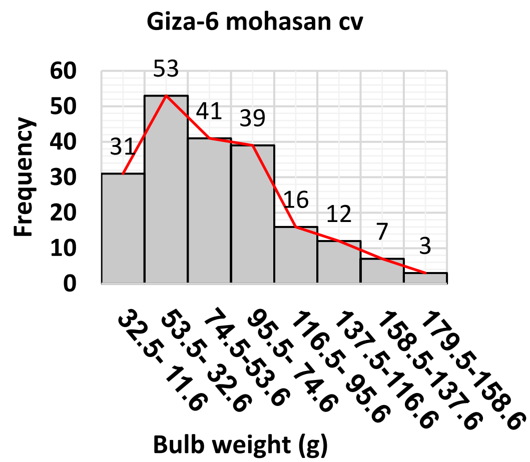
Parame ters	Min.	Max.	Mean	Variance
	12.08	94.24	39.218	323.169
	SD	SE	Skewness	Kurtosis
	17.977	1.144	0.6752	-0.1684

Total cv = 57.09 **Genetic cv = 39.48** **Environmental cv = 17.61**

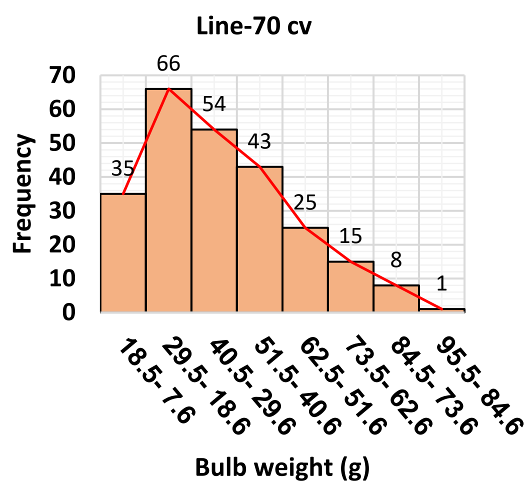
Figure 3. The histogram of frequency distribution for the initial bulb weight of three onion populations.



Parameters	Min.	Max.	Mean	Variance
	7.66	11.281	33.99	301.882
	SD	SE	Skewness	Kurtosis
	17.375	0.925	1.1597	1.9251



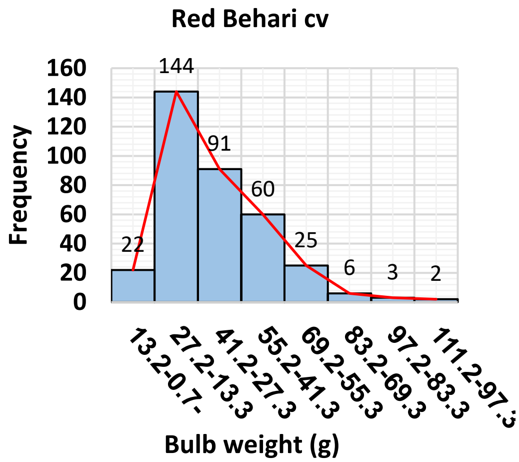
Parameters	Min.	Max.	Mean	Variance
	11.93	179.28	68.067	1192.884
	SD	SE	Skewness	Kurtosis
	34.538	2.43	0.8066	0.3669

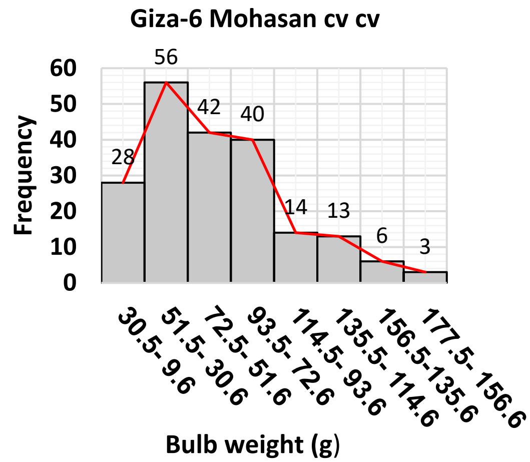


Parameters	Min.	Max.	Mean	Variance
	10.99	92.16	36.945	302.868
	SD	SE	Skewness	Kurtosis
	17.403	1.107	0.6988	-0.1325

Total cv = 57.82 **Genetic cv = 39.72** **Environmental cv = 18.10**

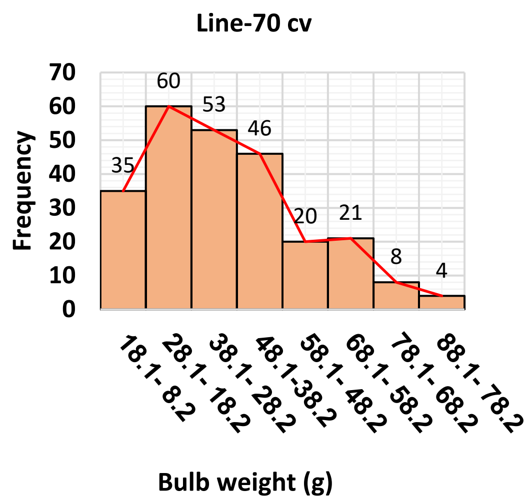
Figure 4. The histogram of frequency distribution for the bulb weight after 45d in storage under normal room temperature of three onion populations.





Parameters	Min.	Max.	Mean	Variance
	0.9	109.62	32.656	291.41
	SD	SE	Skewness	Kurtosis
	17.071	0.909	1.1346	1.8741

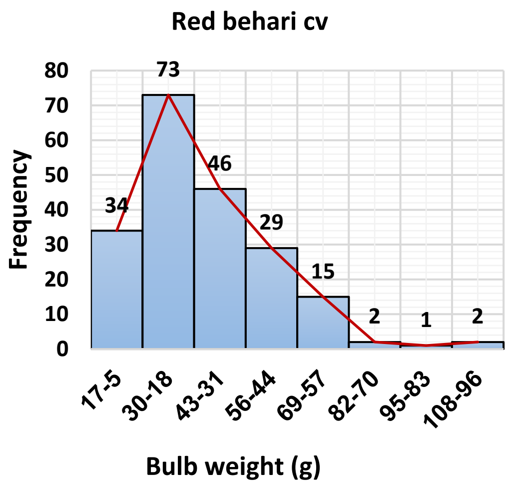
Parameters	Min.	Max.	Mean	Variance
	11.31	175.85	66.024	1145.31
	SD	SE	Skewness	Kurtosis
	33.842	2.381	0.8316	0.405



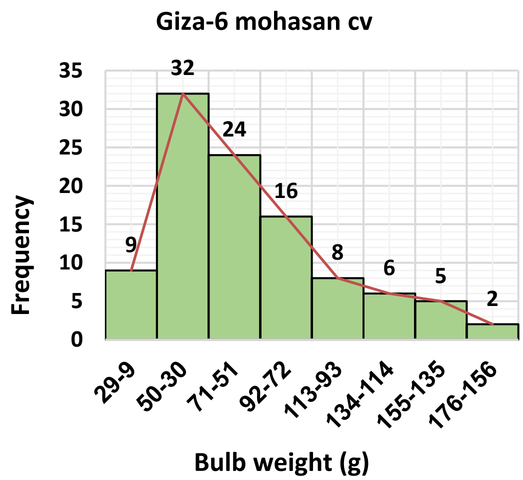
Parameters	Min.	Max.	Mean	Variance
	10.57	85.79	35.965	284.773
	SD	SE	Skewness	Kurtosis
	16.875	1.074	0.6745	-0.1992

Total cv = 58.05 **Genetic cv = 39.92** **Environmental cv = 18.13**

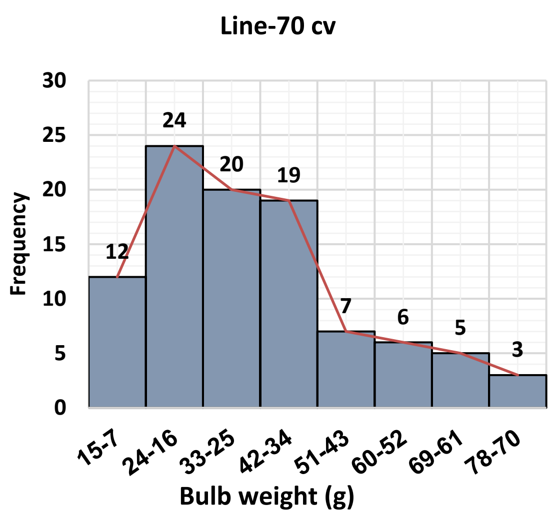
Figure 5. The histogram of frequency distribution for the bulb weight after 90 d in storage under normal room temperature conditions for three onion populations.



Parameters	Min.	Max.	Mean	Variance
	5.990	107.520	33.362	298.657
	SD	SE	Skewness	Kurtosis
	17.282	1.216	1.1266	1.8811



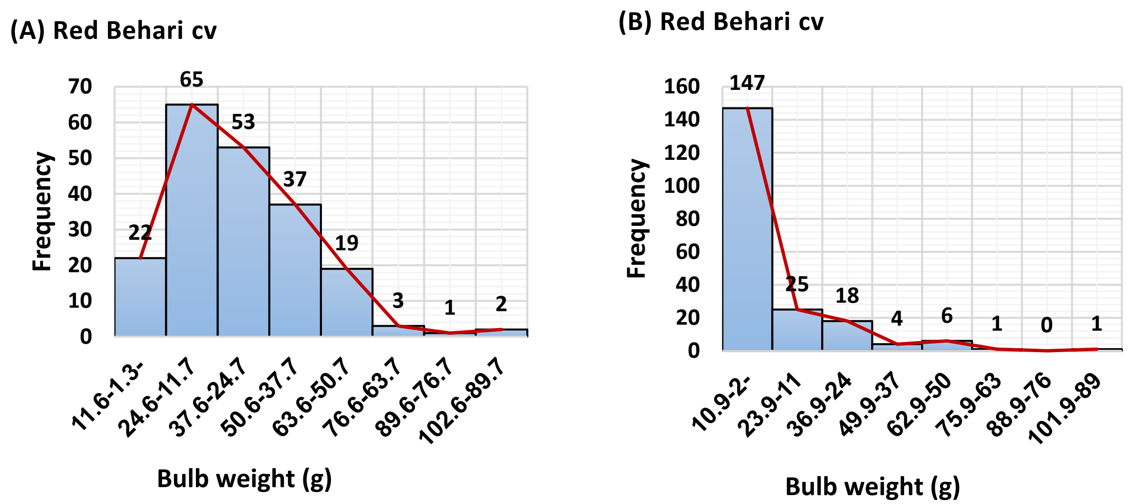
Parameters	Min.	Max.	Mean	Variance
	12.42	173.75	68.938	1293.885
	SD	SE	Skewness	Kurtosis
	35.971	3.562	0.9411	0.4178



Parameters	Min.	Max.	Mean	Variance
	9.57	75.64	33.02	260.026
	SD	SE	Skewness	Kurtosis
	16.125	1.646	0.7809	-0.077

Total cv = 73.17 **Genetic cv = 44.11** **Environmental cv = 29.06**

Figure 6. The histogram of frequency distribution for the bulb weight after 135 d in storage under normal room temperature conditions for three onion populations.



Parameters	Min.	Max.	Mean	Variance
	0	101.440	30.467	304.214
	SD	SE	Skewness	Kurtosis
	17.442	1.227	0.9197	1.5771

Parameters	Min.	Max.	Mean	Variance
	0	99.980	8.073	247.754
	SD	SE	Skewness	Kurtosis
	15.740	1.107	2.5038	7.5833

Figure 7. The histogram of frequency distribution for the bulb weight after 180 d (A) and 225 d (B) in storage under normal room temperature conditions for Red Behari cv.

This can be attributed to the reduced bulb discarding during this time period. However, all bulbs of Giza-6 Mohasan and Line-70 cvs developed sprouts then after and rejected. Further, bulbs of Giza-6 Mohasan and Line-70 cvs lost 4.77% and 15.8% of their weight, respectively. Bulbs of Red Behari cv continued in storage with no sprouting up to 180 d. Its bulbs lost 8.7% and 16.6% of their weight after 135 d and 180 d, respectively. Nonetheless, the graphical distribution of cv Red Behari (Fig. 7B) showed strong left skewness suggesting existence of reduced bulb number of larger weight. In other words, no viable variation remained for selection. The few bulbs of cv Red Behari that persisted the storage conditions (Fig. 7B) may be usefully employed in improving shelf life of bulb onion directly within its population or after crossing with Giza-6 Mohasan.

Heritability and Correlation

Heritability is of prime importance in plant breeding. Selection can only cause change when available variation is genetic and more precisely heritable variation. Heritability is an index used to quantify the extent to which a trait in a population alters by selection. The most useful result of heritability is that breeder can know how much of the phenotypic variation is due to each component (genotypic and environmental factors). The variation quantity that is genetic in origin can be expressed as the broad-sense heritability $H^2 = VG/VP$ or the percentage of phenotypic variation that is genetic. This could include dominance and epistatic variation. However, additive variation is more interested (expressed as narrow sense heritability;

$h^2 = VA/VP$). The h^2 is the proportion of phenotypic variance that is due to additive genetic effects. In the current assessment, the broad sense heritability was very high (Table 2E) suggesting a prime role of genetic factors in the expression of bulb weight during storage (Robinson, 1949).

Table 2. The phenotypic correlations (A, B and C) and genotypic correlations (D) and the broad sense heritability (E) for the studied bulb traits

(A) Red Behari cv

Phenotypic correlation (rp)

Trait[1]	W1	W2	W3	W4	L	D
W1		0.998	0.991	0.92	0.364	0.51
W2			0.996	0.923	0.362	0.509
W3				0.923	0.357	0.507
W4					-0.01	0.158
L						0.574
D						

(B) Line 70

Phenotypic correlation (rp)

Trait	W1	W2	W3	W4	L	D
W1		0.999	0.998	0.997	0.837	0.962
W2			0.999	0.998	0.84	0.96
W3				0.998	0.841	0.962
W4					0.861	0.962
L						0.772
D						

(C) Giza-6 Mohasan

Phenotypic correlation (r_p)

Trait	W1	W2	W3	W4	L	D
W1		0.99	0.998	0.996	0.837	0.958
W2			1	0.998	0.96	0.88
W3				0.998	0.953	1
W4					0.826	0.961
L						0.786
D						

(D) Genotypic correlations (r_g)

Trait	W1	W2	W3	W4	L	D
W1						
W2	1					
W3	0.99	0.99				
W4	0.9	1	1			
L	0.81	0.8	0.79	0.6		
D	0.98	0.97	0.98	1	0.64	

(E) Broad sense heritability

Bulb Diameter (D)	Bulb Length (L)	Bulb weight-4	Bulb weight-3	Bulb weight-2	Bulb weight-1	Trait
0.960	0.987	0.91	0.953	0.952	0.954	Heritability (H^2)

[1]W1 to W4 are initial bulb weight and bulb weight after storage for 45, 90, and 135 d; L = bulb length and D=bulb diameter;

Complex quantitative trait is controlled by many genetic and environmental effects and also its performance depends on other related traits (Ejara, 2017). Direct selection in such case may not be viable. Instead, indirect selection utilizing simple correlated traits (Ahmed and Kamaluddin, 2013). Pleiotropism can result in a genotypic correlation between two traits as one gene can affect several traits at the same time leading to correlation. Genetic correlations are heritable and they may provide the opportunity for simultaneous selection of many traits together (Falconer, 1996). It is suggested that conducting indirect selection can be performed when the genetic correlation coefficient values with the desired trait are higher than 0.50. The correlation coefficient is considered weak if its value is less than 0.50, moderate when ranges from ± 0.50 to ± 0.69, strong when varies between ± 0.70 and ± 0.89, and very strong when exceeding ± 0.90 (Robinson *et al.*, 1949). In the present study, both phenotypic and genotypic correlation coefficients were very strong amongst bulb weight during storage (Table 2). Except r_p in cv Red-Behari, the r_g and r_p showed strong association for bulb diameter with bulb weight during storage.

Genotypic correlation coefficients among studied traits (Table 2D), were comparatively similar or higher than the respective phenotypic ones and they had the same sign. Accordingly, there was a substantial influence of the genotypic factor on the expression of these traits (bulb diameter and weight). This is further supported by the high values of the heritability (Table 2E). It may be feasible and more practicable to utilize bulb diameter to select bulbs with greater weight and improved storability (Ambachew *et al*. 2015). This would be fully reliable especially if it is of higher heritability.

Table 3. The expected direct selection response and the expected correlated response for improved bulb weight under room temperature storage conditions in three Egyptian onion cultivars

Trait[1]	Response to direct selection Red Behari cv		Response to direct selection Giza-6 Mohasan cv		Response to direct selection Line-70 cv	
	5 %[2]	10 %[2]	5 %	10 %	5 %	10 %
W1	35.856	30.63	71.124	60.766	35.329	30.184
W2	34.074	29.1122	67.733	57.86	34.129	29.159
W3	33.513	28.6329	66.437	56.76	33.129	28.304
W4	32.39	27.67	67.43	57.61	30.22	25.82
L	1.3175	1.1257	1.498	1.280	1.043	0.891
D	1.5722	1.343	2.203	1.882	1.641	1.402
Trait	**Indirect selection Red Behari cv**		**Indirect selection Giza-6 Mohasan cv**		**Indirect selection Line-70 cv**	
	5 %	10 %	5 %	10 %	5 %	10 %
W1 - L	29.61	25.30	58.74	50.19	29.18	24.93
W1 - D	35.21	30.08	69.85	59.68	34.69	29.64
W2 - L	27.83	23.77	55.32	47.26	27.87	23.81
W2 - D	33.49	28.61	66.58	56.88	33.54	28.66
W3 - L	27.12	23.17	53.78	45.94	26.81	22.91
W3 - D	33.03	28.22	65.48	55.94	32.65	27.89
W4 - L	20.08	17.16	41.81	35.72	18.74	16.01
W4 - D	32.80	28.02	62.58	53.47	30.60	26.15

[1] W1 to W4 are initial bulb weight and bulb weight after storage for 45, 90, and 135 d; L = bulb length and D=bulb diameter; W1-L to W4-L are bulb weight selected indirectly using bulb length; W1-D to W4-D are bulb weight selected indirectly using bulb diameter.
[2] Selection intensity (i) at 5% = 2.06 and at 10% = 1.76.

Selection response for bulb weight and storability

The value of the genetic gain depends on the value of the selection differential (i.e., how much better than average the selected plants are) and heritability. Selection differential is influenced by variation (σ^2_p) in the population and the proportion (i) of the population that are being used for breeding. It is easier to find plant that performs much better than average when there is much variation in the population. Further, the larger the selected proportion, the less superior plants than the population average. As shown in Table (3), direct and correlated selection responses were consistently higher when selected 5% of the population of the studied cvs compared to 10%.

The selected proportion alone is not a very good representation of how much better than average the selected plants are. It needs to be evaluated in combination with the value of the variation. Therefore, the mean of the selected proportion is expressed in units of variation (the standard deviation).

In phenotypes that tend to be normally distributed the phenotypic value can be expressed as being how many standard deviations away from the population mean. We can use the selected proportion of plants and use properties of the normal distribution to determine the mean of the plants in that selected proportion, i.e., expressed in phenotypic standard deviations (the *selection intensity*). Obviously, the value of selection response to bulb weight decreases somewhat with advancing the selection periods (Table 3). This can be attributed to reduced variation available for selection as result to discarding of undesirable bulbs following each storage period. Bulb diameter seemed to be more efficient criterion for indirect selection of bulb weight in the different storage periods (Table 3).

Conclusions

Genetic variation exists for improving storability in Egyptian adapted onion. Red Behari medium sized bulbs may be further improved for shelf life by within population selection or after crossing with Giza-6 Mohasan. Bulb weight (primary trait) having an improved storability can be attained either by direct selection or indirect selection using bulb diameter (secondary trait).

Conflicts of Interest: There were no conflicts of interest between the authors.

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التباين والتوريث والارتباط والاستجابة للانتخاب لوزن البصلة وقابلية التخزين في البصل المصري

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الملخص

في هذه الدراسة تم تقييم التباين داخل وبين عشائر ثلاثة أصناف من البصل المصري (البحيري الاحمر والجيزة -6 محسن وسلاله -70) أثناء التخزين في درجة حرارة الغرفة العادية، وتم تقدير الاستجابة للانتخاب وذلك نحو تحسين قابلية تخزين الابصال المتوسطة إلى كبيرة الحجم، وكان يتم فحص الابصال كل 45 يوم للتخلص من الابصال المنبتة والمصابة بالأمراض. لقد دللت نتائج تحاليل المدرجات التكرارية ان البيانات الأولية لوزن البصلة وقطرها وطولها موزعة توزيعا طبيعيا، وكشفت المقاييس الإحصائية الوصفية المقدرة الى فروق عالية ملحوظة بين وداخل عشائر البصل التي تم دراستها. تم استبعاد ابصال الصنف جيزة-6 محسن والسلاله-70 بعد 135 يومًا من التخزين حيث حدث تزريع لجميع ابصالهما، وكانت البصلة قد فقدت 4.77% من وزنها في صنف جيزة-6 محسن، بينما فقدت 15.8% من وزنها في السلاله-70، هذا بينما أظهر الصنف البحيري الأحمر تزريعا بعد 225 يوم من التخزين وقد سجل عندها فقد في الوزن يقدر بمقدار 8.7 %، 16.6 % بعد 135 يوم و180 يوم على التوالي، لوحظ انحراف الرسم البياني بشدة إلى اليسار بعد 225 يوم تخزين نتيجة كثرة اعداد الابصال الصغيرة مع بقاء قليلا من الابصال المتوسطة الحجم. قد تكون هذه الابصال مفيدة لتحسين القدرة التخزينية للصنف البحيري الأحمر أو تحسين اصناف اخري عقب التهجين معها. لقد اظهر التحليل ثنائي المتغير للارتباط الوراثي والظاهري قيم ارتباط عالية لقطر البصلة وطولها مع وزن البصيلة أثناء التخزين بما يؤيد وجود مكون وراثي كبير وهذا يتضح ايضا من قيم معاملي التوريث والتباين المرتفعة. من هذه الدراسة نستنتج وجود اختلافات وراثيه كبيره وفعاله لتحسين القدرة لتخزين لأصناف البصل المصري ويمكن تربية ابصال متوسطة الحجم (كصفة أولية) للصنف البحيري الأحمر وذات قدره تخزينيه محسنة إما عن طريق الانتخاب داخل عشيرة للصنف البحيري الأحمر او عقب تهجينه مع جيزة-6 محسن ويمكن ان يكون الانتخاب غير مباشر باستخدام قطر البصلة (كصفة ثانوية).