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Prajwal Ghodeswar
M.Sc. Scholar, Department of Vegetable Science, Post Graduate Institute, Dr. PDKV Akola, Maharashtra, India

RS Wankhade
Assistant Professor of Horticulture, Agriculture Research Station, Dr. PDKV, Achalpur, Maharashtra, India

VS Kale
Professor, Department of Vegetable Science, Dr. PDKV, Akola, Maharashtra, India

Priti A Sonkamble
Associate Professor, Department of Genetics and Plant Breeding, Dr. PDKV, Akola, Maharashtra, India

SO Bawkar
Assistant Professor, College of Horticulture, Dr. PDKV, Akola, Maharashtra, India

Corresponding Author:
Prajwal Ghodeswar
M.Sc. Scholar, Department of Vegetable Science, Post Graduate Institute, Dr. PDKV Akola, Maharashtra, India

Genetic variability and heritability studies in red onion

Prajwal Ghodeswar, RS Wankhade, VS Kale, Priti A Sonkamble and SO Bawkar

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Abstract
A trial was conducted to assess genetic variability and heritability in red onion germplasm with a set of 45 genotypes in Randomized Block Design (RBD) with three replications at Instructional Farm of Vegetable Science, Department of Vegetable Science, Faculty of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* 2022-23. The analysis of variance revealed that mean square due to genotypes was significant for all traits. A wide range of variation was also observed for important yield components. The magnitude of PCV was higher than corresponding GCV for all the characters studied. Maximum GCV and PCV was observed for bolting and double bulb, while high heritability was observed for total yield/ha, days to maturity, average bulb weight, polar bulb diameter, bolting and bulb shape index. Genetic advance expressed as per cent of mean was high for total yield/ha, double bulbs and bolting. High heritability values along with high expected genetic advance over mean was noticed for the characters *viz.*, bolting and total yield/ha, suggested that the predominance of additive gene action indicating better scope for improvement of these traits by an effective selection programme.

Keywords: Onion, genotypes, genetic variability, yield

Introduction

One of the most significant bulb crops grown commercially for both domestic and international markets is the onion (*Allium cepa* L.). Its chromosome number is 2n=2x=16, and it is a member of the "Alliaceae" family. It is an essential ingredient in every kitchen, used as a condiment, spice, and vegetable to improve the flavor of various dishes. Green leaves, immature bulbs and mature bulbs of onion are used as vegetables and spices.

Onion is a highly cross-pollinated crop. It is annual for bulb production and biennial for seed production. A logical method to begin any breeding program is to survey variations in accessible materials. Genetic variability is the "sine qua non" of any such program. Selection is considered effective in a population with high heritable variability. To improve yield through selection, knowledge of the type and extent of variability in a population is a necessary prerequisite before commencing any breeding strategy. Genetic diversity and variability are critical components of every successful breeding program. Genetic variability in crops is a necessity for their importance because selection efficiency is mostly dependent on it. The success of phenotypic selection is determined by the degree to which genotypes' breeding value can be distinguished from their phenotypic expression. Heritability is a measure of how easily character traits can be passed down from parents to children. The idea of heritability plays an important role in identifying whether phenotypic differences between people are genetic or due to environmental influences. Genetic advance quantifies the expected benefit from population selection pressure. Heritability, along with genetic advance, provides the most accurate representation of selection efficiency. Lush (1940) [10] categorized heredity into broad and narrow senses. Broad sense heritability is the ratio of genotypic variance to phenotypic variance. This study was conducted to investigate the extent of genetic variability, genetic advance and heritability for bulb yield and its yield contributing characters among available genotypes of red onion.

Materials and Methods

The present investigation "Genetic variability and heritability studies in red onion" (*Allium cepa* L.) was carried out at Instructional farm of Vegetable Science, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* season of year 2022-2023. The material under study was constituted of 45 genotypes of onion which were collected from different institutes in a Randomized Block design with three replications. This study aimed to investigate the extent of genetic variability, genetic advance and heritability for bulb yield and its yield contributing characters among available genotypes of red onion. Five representative plants were selected randomly from each genotype and were tagged for identification and for recording observations on various traitsplant height (cm), number of leaves per plant, neck thickness (cm), bolting (%), days to maturity, polar bulb diameter (cm), equatorial bulb diameter (cm), bulb shape index, average bulb weight (g), TSS of bulb (%), double bulb (%) and total yield (t/ha). The meteorological data recorded at Meteorological Observatory, Department of Agronomy, Dr.PDKV, Akola. Recommended doses of manures and fertilizers were applied and spraying of insecticides and fungicides were given where ever felt necessary. Irrigation and other cultural operations were undertaken as and when required. The treatments (genotypes) were allotted randomly into blocks.

The genotypic coefficient of variation and phenotypic coefficient of variation were computed using the methods of suggested by Burton (1952) [3]. Heritability (broad sense), genetic advance (GA), and genetic advance as a percentage of the mean (GAM) were calculated following the techniques suggested by Robinson *et al.* (1949) [12].

Results and Discussion

The variability of distinct features among genotypes can be assessed using the general mean, genotypic coefficient of variation, and percentage of the mean. A wide variation in mean performance was observed among the genotypes for all characters under study (Table 1). Viz., traits plant height (cm), number of leaves, neck thickness (cm), bolting (%), days to maturity, polar bulb diameter (cm), equatorial bulb diameter (cm), bulb shape index, average bulb weight (g), TSS of bulb (%), double bulb (%) and total yield (t/ha). The values show highly significant differences for all characters under study, indicating a wide range of variation among genotypes. This suggests that there is lots of scope for improvement in this crop based on the evaluated characters. All of the characters under investigation showed a considerable range in their parents' mean performance. The level of variability for various features in different genotypes was quantified using range, general mean, genotypic coefficient of variation, phenotypic coefficient of variation, heritability, and expected genetic advance as a percentage of the mean (Table 2). The mean performance of genotypes demonstrated a large range of variability across all characters. The variation was highest for days to maturity with range of 104.67 to 114.67 days with mean of 109.40 days followed by average bulb weight 68.50 to 86.69 gm with mean of 79.31 gm, plant height 55.26 to 61.52 cm with mean of 58.58, total yield 29.92 to 47.52 t/ha with mean of 36.55 t/ha. This result is encouraging because the presence of high variability, among the traits has been an indication of better chance for improvement. Significant variability for various characters in onion have been reported by various workers viz. Hosamani *et al.* (2010) [8], Singh *et al.* (2017) [14]. The above findings were in broad conformity with the reports of these workers.

The results showed that the phenotypic coefficient of variation was greater in magnitude than the genotypic coefficient of variation for all characters, indicating the influence of the environment on their genetic expression. Highest genotypic and phenotypic coefficient of variation was observed for double bulb (243.413% and 347.589%) followed by bolting (163.414 to 201.522%) and moderate value of genotypic and phenotypic variation was observed in total yield per hectare (11.34% and 12.127%). However, low values of genotypic and phenotypic coefficient of variation observed for polar bulb diameter (6.355% and 7.68%), average bulb weight (5.87% to 6.954), total soluble solids (6.225% to 10.154%), equatorial bulb diameter (5.127% to 6.624%), number of leaves per plant (3.712%to 6.552%), days to maturity (2.744% to 2.999%), shape index (2.303% to 2.942%), plant height (1.894% to 4.048%), neck thickness (1.696% to 3.581%). Dhotre *et al.* (2010) [6] and Hosmani *et al.* (2010) [8] reported low PCV and GCV for number of leaves and TSS. Chattopadhyay *et al.* (2013) [5] also reported low PCV and GCV values for TSS, polar and equatorial diameter of the bulb. Khosa and Dhatt (2013) [9] and Dwivedi *et al.* (2017) [7] reported low PCV and GCV for number of leaves per plant, polar and equatorial diameter of the bulb and days to maturity. Low PCV and GCV for number of leaves per plant, days to harvest and polar diameter of the bulb was reported by Pyasi and Tiwari (2016) [11]. Sharma *et al.* (2017) [13, 14] also reported low PCV and GCV for total soluble solids. This shows that direct selection for these traits could significantly improve the ability to find superior onion genotypes. The differences between phenotypic and genotypic coefficients were very less, indicating that these features are least impacted by the environment and therefore phenotypic selection would be effective.

Table 1: Analysis of variance for fifteen characters in onion

S. No	Name of character/Source	Mean Sum of Square Replication	Treatment	Error
	D.F	**2**	**44**	**88**
1	Plant height @ 30 DAP(cm)	32.08	25.934**	11.671
2	Plant height @ 60 DAP(cm)	22.2	17.863**	8.437
3	Plant height @ 90 DAP(cm)	3.477	8.087**	4.391
4	No. of leaves/plant @ 30 DAP	0.128	0.224*	0.125
5	No. of leaves/plant @ 60 DAP	0.436	0.729*	0.432
6	No. of leaves/plant @ 90 DAP	0.305	0.797*	0.33
7	Neck thickness @ 30DAP (cm)	0.005	0.004**	0.002
8	Neck thickness @ 60DAP (cm)	0.005	0.006*	0.003
9	Neck thickness @ 90DAP (cm)	0.01	0.007**	0.004
10	Bolting (%)	1.156	15.085**	2.231
11	Days to maturity	1.867	28.782**	1.753
12	Polar bulb diameter (cm)	0.118	0.315**	0.042
13	Equatorial bulb diameter (cm)	0.123	0.252**	0.046
14	Bulb shape index	0	0.002**	0
15	Average bulb weight (g)	9.924	73.747**	8.743
16	Total soluble solids	0.414	2.386**	0.85
17	Double Bulb (%)	0.289	1.182**	0.304
18	Total yield t/ha	3.944	54**	2.466

*,** Significant at 5% (1.52) and 1% (1.80) levels, respectively

Heritability refers to the ratio of genotypic variance to phenotypic variance (or total variance). It is the heritable component of variation and a reliable predictor of character transmission from generation to generation. Thus, knowledge of heritability is vital for every crop improvement initiative. The high heritability character were total yield per hectare (87.448%), days to maturity (83.712%), average bulb weight (71.251%), polar bulb diameter (68.462%), bolting (65.755%), shape index (61.238%) and the moderate heritability character equatorial bulb diameter (59.892%), double bulb% (49.041%) total soluble solid (37.584%) and number of leaves per plant (32.097%) and low heritability character neck thickness (22.432%) and plant height (21.906%). Similar high heritability pattern was also observed by Lakshmi *et al.* (2015) [17] for average weight of the bulb and polar bulb diameter. Solanki *et al.* (2015) [15] has also reported similar findings for polar diameter and total yield. Similarly, Singh *et al.* (2017) [14] for average bulb weight, bulb yield per hectare, polar diameter. For polar diameter and yield has also reported by Chatto *et al*. (2018) [4]. Tripathy and Sahoo (2018) [16] had also reported the same results for bulb weight and yield

Expected genetic advance in percentage over mean was estimated for different characters and results are presented in Table 2. It was observed low in case of neck thickness (1.655%), plant height (1.827%), shape index (3.712%), number of leaves (4.332%), days to maturity (5.171%), total soluble solids (7.862%), equatorial bulb diameter (8.173%), medium in case of average bulb diameter (10.203%), polar bulb diameter (10.831%) and high for the total yield per hectare (21.845%),double bulbs% (351.147%) and bolting (272.974%). Similar results revealed by Anathan and Balkrishnamoorthy (2007) [1], Dhotre *et al*. (2010) [6], Bharti *et al.* (2011) [2], Chattopadhyay (2013) [5].

Table 2: Genetic parameters in respect of twelve quantitative traits in red onion Genotypes

Character	Range		Mean	GCV (%)	PCV (%)	Heritability% (h^2)	Genetic Advance	EGA in% of mean
	Min.	Max.						
Plant height @ 90 DAP	55.26	61.52	58.58	1.894	4.048	21.906	1.07	1.827
No. of leaves @ 90 DAP	9.67	12.13	10.64	3.712	6.552	32.097	0.461	4.332
Neck thickness@ 90 DAP	1.86	2.07	1.95	1.696	3.581	22.432	0.032	1.655
Bolting (%)	0.00	9.00	1.27	163.414	201.522	65.755	3.458	272.974
Days to maturity	104.67	114.67	109.40	2.744	2.999	83.712	5.657	5.171
Polar bulb diameter (cm)	4.01	5.34	4.75	6.355	7.68	68.462	0.514	10.831
Equatorial bulb diameter (cm)	4.45	5.67	5.11	5.127	6.624	59.892	0.418	8.173
Bulb shape index	0.86	0.97	0.93	2.303	2.942	61.238	0.034	3.712
Average bulb weight (g)	68.50	86.69	79.31	5.87	6.954	71.251	8.094	10.206
Total soluble solids	9.77	13.40	11.49	6.225	10.154	37.584	0.904	7.862
Double bulb (%)	0.00	3.00	0.22	243.413	347.589	49.041	0.78	351.147
Total yield t/ha	29.92	47.52	36.55	11.34	12.127	87.448	7.984	21.845

Conclusion
The analysis of variance revealed significant differences among 45 genotypes for all the characters under study. The high estimates of genotypic and phenotypic coefficients of variation were observed for bolting (%) and double bulb, which indicated the presence of sufficient variability for these traits in the accession studies. The high heritability observed in total yield/ha, days to maturity, average bulb weight, polar bulb diameter, bolting and bulb shape index. The high heritability with high genetic advance expressed as per cent mean were recorded for the traits *viz.*, bolting (%) and total yield (t/ha), which indicated the predominance of additive gene action and better scope for improvement of this characters for effective selection of genotypes.

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