Genetic variability, heritability and genetic advance in white onion (*Allium cepa*L.) for growth, bulb yield, quality and its component characters

Abstract

The present investigation on "Genetic variability, heritability and genetic advance in white onion (*Allium cepa*L.) for growth, bulb yield and its component characters" was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, during the late*kharif* season of 2023-2024. The study was undertaken to evaluate the variability present among the late*kharif* genotypes and predict the results for hybridization programme. Twenty-six genotypes of onion were used for the experiment. Results indicated substantial phenotypic variability across the genotypes, with traits such as marketable yield (t/ha) showing high genotypic and phenotypic coefficient of variation (GCV and PCV). Broad-sense heritability estimates ranged widely, emphasizing genetic control for traits like polar diameter (cm) and marketable yield (t/ha). Genetic advance, as a percentage of mean, highlighted significant annual gains in fresh weight of plant (g) and average weight of bulb (g).The findings underscore the potential for onion improvement through selective breeding strategies targeting traits with high heritability and genetic advance. This research contributes valuable insights into enhancing onion productivity and quality traits crucial for sustainable agricultural practices and global food security.

Keywords: Onion, Variability, Heritability, Genetic advance

Introduction :

Onion (*Allium cepa*L.) is one of the important culinary vegetable belongsto family *Alliaceae*, having chromosome number 2n=16. It is a native of South West-Asia, from where it spread all over the world.The crop is mainly grown for local consumption and for export purposes.In the world, onion being the third most valuable vegetable after potato and tomato, and it is grown in more than140 countries by covering an area of 54.8 lakh hectares with production of 1045.54 lakh tons and productivity of 23.06 t/ha, (Anon., 2020). Among the cultivated *Alliums*in India onionis a prominent export-oriented vegetable and forms the world's second largest producer after China. In India, it is being cultivated in an area of 1.43 million hectares, producing 26.09 million tonnes with a productivity of 18.23 tonnes per hectare (Anon., 2021).The major onion growing states are Maharashtra, Madhya Pradesh, Karnataka,Rajasthan, Bihar and Odisha. The Karnataka state standssecondpositioninarea(2.49 lakhhectare)andthird positioninproduction (20.49 lakh tonnes).Themajor onion growingdistricts in the state are Vijayapura, Chitradurga,Bagalkot,Gadag, Ballary, DharwadandHaveri (Anon., 2022).

Variability in genotypes for yield and its component parameter is the primary factor to consider during selection. Any effective hybridization programme for varietal improvement is primarily dependent on the selection of parents with high variability, so that the desired character combination can be selected to improve quality and also increasing yield production. Furthermore, understanding heredity is critical for selection-based improvement as it indicates the transmissibility of a character to subsequent generations (Hulagannavar *et al.*, 2017). The use of genetically divergent parents in crop improvement is expected to give desirable and superior segregates. This could be achieved by crop improvement.

Material and Methods

The present investigation on "Genetic variability, heritability and genetic advance in white onion (*Allium cepa*L.) for growth, bulb yield and its component characters" was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during late*kharif*2023-24. Twenty-six genotypes were collected from different institutions and geographical diverse locations and evaluated using randomized complete block design (RCBD) consisting three replications. Five plants were selected randomly from each replication and data were recorded for the characters *viz.,* plant height (cm), number of leaves per plant, leaf length (cm), neck diameter (cm), fresh weight of plant (g), dry weight of plant (g), dry matter content of plant (%), equatorial diameter (cm), polar diameter (cm), bulb index, ten bulb weight (g), average weight of bulb (g), total yield (kg/plot),total yield (t/ha), marketable yield (t/ha), harvest index (%), number of rings per bulb, purple blotch incidence(%), TSS (°Brix), reducing sugar (%), non-reducing sugar (%), total sugar(%) and pyruvic acid (μ moles/ g). Analysis of variance was computed as per the procedures given by Panse and Sukhatme (1961) and genetic parameters such as mean, range, genotypic and phenotypic characters were analysed as suggested by Burton (1953). Heritability and genetic advance were worked according to Johanson*et al*. (1955).

Results and Discussion

The nature and degree of genetic variability is one of the most important aspects of any breeding effort. Knowledge of multiple variability characteristics considerably enhances the ability to forecast the degree of variability present in a given set of genetic material, including general mean, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), range, genetic gain, and broad sense heritability.PCV and GCV estimates were calculated for all of the observed characteristics. The coefficients of variability are characterized as low, moderate, or high, and they are useful in identifying the level of genetic variability among genotypes and predicting the results of hybridization programs. Heritability is an extremely important parameter for breeders since it indicates how well a genotype may be identified based on its phenotypic expression. Studying genetic improvement with heredity is more important for evaluating the true impacts of selection because heritability alone is insufficient. Genetic factors such as heritability, genotypic coefficient of variation, phenotypic coefficient of variation, and genetic advance (GA) as a percentage of mean were estimated for various onion genotype traits.

The data presented in table. 1 indicates the existence of wide range of phenotypic variability in experimental material. The estimates of PCV were higher than corresponding GCV for all characters studied which indicated that the apparent variation is not only due to genotypes but also due to the influence of environment.The higher estimates of GCV and PCV were recorded formarketable yield (t/ha) (GCV=36.15 %; PCV=37.02 %). Moderate estimates of GCV and higher estimates PCV was registered forPyruvic acid (µ moles/g) (GCV=19.25 %; PCV=20.80 %). Moderate estimates of GCV and PCV was registered forPolar diameter (cm) (GCV=18.47 %; PCV=18.86 %).Moderate estimate of PCV and lower estimate of GCV was found in the traits Leaf length (cm) at 30 DAT (GCV=9.96 %; PCV=12.08 %),Lowest GCV and PCV were recorded fornumber of rings per bulb (GCV=5.56 %; PCV=7.94 %).

The higher estimates of GCV and PCV for above characters indicates the existence of sufficient variability among the genotypes for these characters. Thus, simple selection could be helpful for further improvement. The similar outcome of results was recorded byGurjar and Singhania (2006), Chattoo*et al.* (2015), Priyanka*et al.* (2017), Amir *et al.* (2023) and Hulagannavar*et al.* (2023).

Table 1. Mean coefficient of variation, heritability (broad sense), genetic advance and genetic advance as per cent of mean of various character of white onion genotypes

Characters	Mean	Range		Variance		Co-efficient of variance		Heritability (Per cent)	Genetic advance (%)	Genetic advance as per cent of mean (Genetic Gain) (%)
		Min.	Max.	Genotypic	Phenotypic	Genotypic	Phenotypic			
X_1	59.22	44.88	67.68	12.31	23.57	5.92	8.19	52.22	5.22	8.82
X_2	10.62	7.91	12.18	0.46	0.73	6.40	8.05	63.15	1.11	10.48
X_3	53.13	40.18	63.47	14.24	24.04	7.10	9.22	59.80	5.98	11.26
X_4	1.15	0.75	1.43	0.01	0.02	11.50	12.79	80.93	0.24	21.32
X_5	85.81	47.61	127.09	369.68	412.94	22.40	23.68	89.52	37.47	43.67
X_6	11.62	6.74	17.92	7.03	7.89	22.81	24.17	89.08	5.15	44.36
X_7	13.60	11.91	15.87	0.64	0.93	5.89	7.11	68.63	1.36	10.06
X_8	5.68	3.05	7.44	0.93	1.07	17.03	18.30	86.64	1.85	32.66
X_9	4.63	2.12	5.97	0.73	0.76	18.47	18.86	95.90	1.72	37.26
X_{10}	0.81	0.67	0.98	0.002	0.004	6.26	8.15	59.09	0.08	9.92
X_{11}	65.25	29.55	103.25	316.54	343.73	27.26	28.41	92.09	35.17	53.89
X_{12}	19.20	6.72	32.25	35.87	38.33	31.18	32.23	93.60	11.93	62.15
X_{13}	17.06	4.05	28.99	38.02	39.89	36.15	37.02	95.32	12.40	72.70
X_{14}	75.22	61.50	87.26	18.30	28.83	6.68	7.13	63.48	7.02	9.33
X_{15}	7.49	6.03	9.07	0.17	0.35	5.56	7.94	48.97	0.60	8.01
X_{16}	13.49	8.78	17.59	2.14	3.32	10.84	13.51	64.47	2.42	17.94
X_{17}	2.82	2.05	4.09	0.15	0.20	13.91	16.21	73.66	0.69	24.60
X_{18}	5.96	4.35	8.15	0.42	0.64	10.86	13.43	65.47	1.08	18.11
X_{19}	3.90	2.27	5.32	0.56	0.65	19.25	20.80	85.64	1.43	36.70
X_{20}	23.24	9.48	41.92	61.36	65.23	33.70	34.75	94.06	15.64	67.34

Note: X_1-Plant height (cm) at harvest, X_2- No. of leaves per plant at harvest, X_3-Leaf length (cm) at harvest, X_4-Neck diameter of bulb (cm), X_5-Fresh weight of plant (g), X_6-Dry weight of plant (g), X_7- Dry matter content of plant (%), X_8-Equatorial diameter (cm), X_9-Polar diameter (cm), X_{10}-Bulb index, X_{11}- Average weight of bulb (g), X_{12}-Total yield (t/ha), X_{13}-Marketable yield (t/ha), X_{14}-Harvest index (%), X_{15}-Number of rings per bulb, X_{16}- TSS (°Brix), X_{17}-Reducing sugar (%), X_{18}-Total sugar (%), X_{19}-Pyruvic acid (µ moles/g),X_{20}-Purple blotch incidence (%).

As the genotypic coefficient of variation does not furnish complete details to determine the variations that are heritable nature. Hence, the heritability estimate become inevitable as this governs the variations due to genetic factors. This heritability helps for direct selection of characters, one should concentrate on these traits which are possessing high heritability. In addition to this, Burton (1952) proposed that the GCV along with heritability estimates will provide the clearer image of the improvement to be expected by phenotypic selection. The heritability in broad sense comprises both additive and non-additive gene effects (Hanson *et al.*, 1956).

The estimates of heritability (broad sense) ranges from 48.97 to 95.90 % for various characters under investigation (Table 1)Heritability was maximum for polar diameter (cm) (95.90 %) followed bymarketable yield (t/ha) (95.32 %), purple blotch incidence (%) (94.06 %), total yield (t/ha) (93.60 %), average weight of bulb (g) (92.09 %), fresh weight of plant (g) (89.52 %), dry weight of plant (g) (89.08 %), equatorial diameter (cm) (86.64 %), pyruvic acid (µ moles/g) (85.64 %), neck diameter of bulb (cm) (80.93 %), reducing sugar (%) (73.66 %), dry matter content of plant (%) (68.63 %), total sugar (%) (65.47 %), TSS (°Brix), (64.47 %), harvest index (%) (63.48 %), number of leaves per plant at harvest(cm) (63.15 %), leaf length at harvest(cm) (59.80 %), bulb index (59.09 %) and plant height at harvest(cm) (52.22 %). While, low estimates of heritability had found for number of rings per bulb (48.97 %).In this regard earlier studies alsoreported significant heritability forvarious parameter among onion genotypes (Dhotre e*t al*., 2010; Sharma *et al.*, 2017; Srivastav *et al*., 2017 and Manjunathagowda*et al.*, 2021).

Genetic advancement is described as an annual rise in performance of a certain characteristic or an annual intensification of that particular trait's performance.The highest genetic advance was recorded for fresh weight of plant (g) (37.47 %)and average weight of bulb (g) (35.17 %). While,moderate values of genetic advance were recorded forpurple blotch incidence (%) (15.64 %), marketable yield (t/ha) (12.40 %) and total yield (t/ha) (11.93 %) and Low estimates of genetic advance was recorded for harvest index (%) (7.02 %), leaf length at harvest (cm) (5.98 %), dry weight of plant (g) (5.15 %), plant height at harvest(cm) (5.22 %), TSS (°Brix) (2.42 %), equatorial diameter (cm) (1.85 %), polar diameter (cm) (1.72 %), pyruvic acid (µ moles/g) (1.43 %), dry matter content of plant (%) (1.36 %), number of leaves per plant at harvest (cm) (1.11 %),total sugar (%) (1.08 %), reducing sugar (%) (0.69 %), number of rings per bulb (0.60 %), neck diameter of bulb (cm) (0.24 %), and bulb index (0.08 %).%). Similarly, Dhotre*et al*. (2010), Hosamani *et al.* (2010) and Hulagannavar*et al.* (2023) also showed variations of genetic advance forvarious parameteramong the onion genotypes.

The data elicited on genetic advance as per cent of mean(genetic gain) showed maximum value for marketable yield (t/ha) (72.70 %), purple blotch incidence (%) (67.34 %), total yield (t/ha) (62.15 %),average weight of bulb (g) (53.89 %),dry weight of plant (g) (44.36 %) and fresh weight of plant (g) (43.67 %). While, moderate values of genetic advance as per cent of mean was noticed for polar diameter (cm) (37.26 %) followed by pyruvic acid (µ moles/g) (36.70 %), equatorial diameter (cm) (32.66 %), reducing sugar (%) (24.60 %), neck diameter of bulb (cm) (21.32 %), total sugar (%) (18.11 %), TSS (°Brix) (17.94 %), leaf length at harvest (cm) (11.26 %), number of leaves per plant at harvest(cm) (10.48 %) anddry matter content of plant (%) (10.06 %) and lowest values of genetic advance as per cent of mean was registered for harvest index (%) (9.33 %),bulb followed by index (9.92 %),plant height at harvest (cm) (8.82 %), and number of rings per bulb (8.01 %)(Table 1).In parallel to our investigation, earlier studies alsoreported the significant difference in genetic advance as per cent of mean among the different onion cultivars for various parameters (Manjunathagowda*et al.*, 2021; Singh *et al.*, 2021; and Hulagannavar*et al.*, 2023).

Conclusion

Significant genotypic and phenotypic differences were observed for all the traits under study. High genotypic coefficient of variation was recorded for yield indicating presence of ample amount of variability and less influence of environment on their expression. From the present investigation, the above genetical parameters like high heritability estimates coupled with genetic advance were registered for the characters like marketable yield (t/ha), and total yield (t/ha). It reveals the presence of additive gene action in expression of these traits and are more definitive for potential direct selection these traits.

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