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Character association and path coefficient studies in Rabi onion (*Allium cepa* L.)

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Abstract

The present investigation was conducted to assess variability, heritability, genetic advance, correlation, path coefficient and genetic divergence among forty-three onion genotypes during the Rabi season at AICRP on Vegetable Crops, Department of Horticulture, MPKV, Rahuri. The experiment was conducted in a Randomized Block Design with two replications. Analysis of variance revealed significant differences among the genotypes for all the twelve quantitative characters studied. The highest GCV and PCV were observed for bolting percentage, followed by double bulb percentage and average bulb weight. High heritability coupled with high genetic advance as percent of mean was observed for neck thickness, TSS and total bulb yield per plot, indicating the predominance of additive gene action and scope for direct selection. Total bulb yield per plot showed positive association with plant height, neck thickness, days to 50 percent neck fall, days to harvest, average bulb weight, polar diameter and equatorial diameter. Path analysis revealed the highest positive direct effect of plant height followed by average bulb weight, while days to harvest and polar diameter exhibited moderate positive direct effects on bulb yield. Genetic divergence analysis grouped the genotypes into four clusters, with the maximum inter-cluster distance between Clusters I and IV. Based on overall performance, RVC 24-38, RVB 24-27, RVB 24-25, RVA 24-01 and RVC 24-48 were identified as promising genotypes. These genotypes may be utilized as potential breeding material for developing high-yielding and disease-tolerant onion cultivars.

Keywords: Onion, genetic variability, heritability, correlation, path analysis, genetic divergence

Introduction

Onion (*Allium cepa* L.) is an important bulb vegetable crop belonging to the family Alliaceae and is widely cultivated for its use as a vegetable, spice and flavouring ingredient. It possesses considerable nutritional, medicinal and economic importance and is an essential component of the Indian diet. India is the second-largest producer of onion after China, with Maharashtra being the leading onion-producing state, contributing 39.81 percent of the country's production, followed by Madhya Pradesh with 17.41 percent during 2022-23. The crop has substantial domestic demand and export potential and plays an important role in the agricultural economy. Therefore, improvement in bulb yield, quality and desirable horticultural traits is essential for enhancing onion productivity and profitability.

The success of any crop improvement programme largely depends on the magnitude of genetic variability available among the breeding material. Evaluation of genotypic and phenotypic variability, heritability and genetic advance is therefore essential for identifying superior genotypes and determining the effectiveness of selection. Since bulb yield is a complex quantitative trait influenced by several component characters and environmental factors, knowledge of the association between yield and its contributing traits is important for efficient selection. Correlation analysis determines the direction and degree of association among characters, whereas path coefficient analysis separates these relationships into direct and indirect effects. Genetic divergence analysis further assists in identifying genetically diverse parents for utilization in hybridization programmes. Thus, the combined assessment of variability, heritability, genetic advance, correlation, path coefficient and genetic divergence among 43 onion genotypes provides a useful basis for identifying promising genotypes and improving bulb yield and other desirable traits.

Materials and Methods

The investigation was conducted on 43 onion (*Allium cepa* L.) genotypes obtained from the AICRP on Vegetable Crops, Mahatma Phule Krishi Vidyapeeth, Rahuri, during the Rabi season. The experiment was laid out in a Randomized Block Design (RBD) with two replications. Observations were recorded on five randomly selected plants from each genotype in each replication for twelve quantitative characters viz., plant height, number of leaves per plant, neck thickness, days to 50 percent neck fall, days to harvest, average bulb weight, polar diameter, equatorial diameter, bolting percentage, double bulb percentage, total soluble solids and total bulb yield per plot. The data recorded for individual characters were subjected to analysis of variance appropriate to Randomized Block Design as suggested by Panse and Sukhatme (1967) [13]. The genotypic and phenotypic coefficients of variation were estimated, while heritability in broad sense and genetic advance as percent of mean were calculated to assess the magnitude of genetic variability and expected response to selection. The correlations among different characters at genotypic (g) and phenotypic (p) levels were estimated as suggested by Searle (1961) [14]. To determine the direct and indirect contribution of different characters towards bulb yield, path coefficient analysis was carried out using genotypic correlations as suggested by Dewey and Lu (1959) [12]. Genetic divergence among the genotypes was estimated using Mahalanobis D² statistics and the genotypes were grouped into clusters by Tocher's method.

Results and Discussion

Correlation

Correlation analysis provides useful information on the strength and direction of association among yield and its contributing characters and thereby assists in identifying suitable selection criteria. In the present investigation, genotypic correlation coefficients were generally higher than the corresponding phenotypic correlations, indicating a stronger inherent genetic association among the traits with comparatively lower environmental influence. At the genotypic level, total bulb yield per plot showed significant positive association with plant height, neck thickness, days required for 50 percent neck fall, days to harvest, average bulb weight, polar diameter and equatorial diameter. In contrast, significant negative associations were observed with number of leaves per plant, bolting percentage and total soluble solids, while double bulb percentage showed a negative and non-significant association with bulb yield. At the phenotypic level, total bulb yield exhibited significant positive associations with plant height, neck thickness, days to harvest, average bulb weight, polar diameter and equatorial diameter, whereas days required for 50 percent neck fall showed a positive but non-significant association. Significant negative associations were observed between bulb yield and bolting percentage and TSS. Plant height, neck thickness, average bulb weight and bulb diameters also showed favourable associations with several yield-related traits. The positive association of bulb yield with average bulb weight, plant height and bulb dimensions indicates their importance in improving productivity, while the negative association of yield with bolting percentage suggests the adverse effect of bolting on bulb production. Similar associations among yield and its component characters have been reported by Degewione *et al.*, Hossain

et al., Mahanthesh *et al.*, Pujar *et al.*, Raghuvanshi *et al.*, Sahu *et al.*, Mesenbet and Walle (2018) [6], Ranjan *et al.* (2024) [7] in onion and related bulb crops.

Path analysis

Correlation coefficient alone does not provide adequate information about the relative contribution of individual characters towards yield, as the observed association may arise through both direct and indirect effects. Therefore, path coefficient analysis as proposed by Dewey and Lu (1959) [12] was employed to partition the correlation coefficients into direct and indirect effects and to identify the characters contributing to total bulb yield per plot. Path analysis revealed considerable variation in the magnitude and direction of direct effects of different characters on bulb yield. Plant height exhibited the highest positive direct effect (0.804), followed by average bulb weight (0.689), days to harvest (0.236) and polar diameter (0.203). TSS (0.154) and number of leaves per plant (0.035) showed low positive direct effects. In contrast, neck thickness (-0.293), days required for 50 percent neck fall (-0.274), bolting percentage (-0.168), equatorial diameter (-0.144) and double bulb percentage (-0.005) exhibited negative direct effects on total bulb yield per plot.

Plant height showed a significant positive genotypic correlation with total bulb yield per plot (0.867) and also exhibited the highest positive direct effect (0.804), indicating its important contribution towards yield. Its association with yield was further supported by positive indirect effects through equatorial diameter (0.454), days to harvest (0.402), average bulb weight (0.338), neck thickness (0.337) and days required for 50 percent neck fall (0.331). Average bulb weight also exhibited a significant positive genotypic correlation with yield (0.780) along with a high positive direct effect (0.689), and its association was supported by positive indirect effects through neck thickness, equatorial diameter, days to harvest and plant height. Days to harvest and polar diameter showed significant positive correlations with yield (0.579 and 0.310, respectively) and positive direct effects (0.236 and 0.203), indicating their favourable contribution towards bulb yield. Among the remaining characters, neck thickness, days required for 50 percent neck fall and equatorial diameter showed significant positive correlations with total bulb yield per plot despite having negative direct effects, suggesting that their positive association with yield was mainly influenced by indirect effects through other characters. Bolting percentage exhibited a significant negative correlation (-0.639) and negative direct effect (-0.168) on yield, indicating its adverse influence on bulb productivity. Number of leaves per plant and TSS also showed significant negative correlations with yield (-0.364 and -0.757, respectively), although their direct effects were positive but low. Double bulb percentage recorded a non-significant negative correlation (-0.258) and a negligible negative direct effect (-0.005). Overall, the results indicated that plant height and average bulb weight were the most important characters owing to their high positive direct effects and significant positive association with bulb yield. Similar importance of yield-contributing characters and their direct and indirect effects on onion bulb yield has also been reported by Trivedi *et al.* (2006) [8], Mahanthesh *et al.* (2007) [2], Marey *et al.* (2012) [9], Basha and Lakshmi (2018) [10], Yogita *et al.* (2023) [11] and Ranjan *et al.* (2024) [7].

Table 1: Analysis of variance (ANOVA) for twelve characters of onion

Sr. No.	Character	Mean Sum of Squares		
		Replication	Treatment	Error
1.	Plant height (cm)	22.114	8.830**	3.031
2.	Number of leaves/plant	0.168	0.132**	0.242
3.	Neck Thickness (cm)	0.001	0.044**	0.007
4.	Days required for 50% neckfall	7.860	45.224**	14.956
5.	Days to harvest	22.512	40.115**	12.416
6.	Average Bulb weight(g)	4.070	588.829**	215.156
7.	Polar diameter (cm)	0.0823	0.214**	0.031
8.	Equatorial diameter(cm)	0.008	0.266**	0.031
9.	Bolting (%)	0.359	1.623**	0.547
10.	Double bulb (%)	0.095	0.168**	0.131
11.	TSS(°Brix)	0.006	13.680**	0.253
12.	Total bulb yield (kg/plot)	6.372	52.905**	10.423

* and ** indicate significant at 5% and 1%

Table 2: Estimates of Genotypic Correlation for twelve characters of onion

	Plant height (cm)	No. of leaves	Neck Thickness (cm)	Days required for 50% neck fall	Days to harvest	Average bulb weight (g)	Polar diameter (cm)	Equatorial diameter (cm)	Bolting (%)	Double bulb (%)	TSS (°Brix)	Total Bulb Yield (kg/plot)
Plant height (cm)	1.000	0.118	0.418**	0.413 **	0.500**	0.420**	0.090	0.565**	-0.264	0.334*	-0.599**	0.867**
No. of leaves/plant		1.000	0.080	0.402**	0.407**	0.352*	0.175	-0.189	-0.273	-0.525**	-0.143	-0.364 *
Neck Thickness(cm)			1.000	0.264	0.380*	0.997**	0.123	0.421**	-0.457**	0.103	-0.240	0.762 **
Days required for 50% neck fall				1.000	0.977**	0.320*	0.093	0.258	0.043	0.109	-0.137	0.399 **
Days to harvest					1.000	0.514**	0.164	0.391**	-0.092	-0.043	-0.272	0.579 **
Average bulb weight (g)						1.000	0.236	0.517**	-0.669**	-0.527**	-0.561**	0.780 **
Polar diameter (cm)							1.000	0.510**	-0.209	0.048	-0.479**	0.310 *
Equatorial diameter (cm)								1.000	-0.485**	0.183	-0.782**	0.635**
Bolting (%)									1.000	0.691**	0.567**	-0.639**
Double bulb (%)										1.000	0.166	-0.259
TSS (°Brix)											1.000	-0.757**
Total Bulb Yield (kg/plot)												1.000

*, ** Significance at 5% and 1% level, respectively

Table 3: Estimates of Phenotypic Correlation for twelve characters of onion

	Plant height (cm)	No. of leaves	Neck Thickness (cm)	Days required for 50% neck fall	Days to harvest	Average bulb weight (g)	Polar diameter (cm)	Equatorial diameter (cm)	Bolting (%)	Double bulb (%)	TSS (°Brix)	Total Bulb Yield (kg/plot)
Plant height(cm)	1.000	0.030	0.331**	0.111	0.186	0.215*	0.002	0.324**	-0.149	0.044	-0.433**	0.548**
No. of leaves/plant		1.000	-0.068	-0.029	-0.079	0.089	-0.154	-0.086	-0.068	0.031	0.083	0.013
Neck Thickness(cm)			1.000	0.130	0.227*	0.489**	0.139	0.277*	-0.266*	0.028	-0.233*	0.504**
Days required for 50% neck fall				1.000	0.954***	0.105	0.079	0.286 **	-0.026	0.095	-0.059	0.181
Days to harvest					1.000	0.205	0.133	0.353**	-0.043	0.087	-0.157	0.313**
Average bulb weight (g)						1.000	0.082	0.41***	-0.280**	0.024	-0.379**	0.798**
Polar diameter (cm)							1.000	0.430***	-0.140	0.119	-0.419**	0.217*
Equatorial diameter (cm)								1.000	-0.366**	0.169	-0.693**	0.513**
Bolting (%)									1.000	0.0300	0.416**	-0.328**
Double bulb (%)										1.000	0.029	0.031
TSS (°Brix)											1.000	-0.615**
Total Bulb Yield (kg/plot)												1.000

*, ** Significance at 5% and 1% level, respectively

Table 4: Estimates of Genotypic direct (Diagonal) and indirect effects (above and below diagonal) of various yield and yield components

	Plant height (cm)	No. of leaves/plant	Neck thickness (cm)	Days required for 50% neck fall	Days to harvest	Average bulb weight (g)	Polar diameter (cm)	Equatorial diameter (cm)	Bolting (%)	Double bulb (%)	TSS (°Brix)	Correlation value of Total Bulb Yield (kg/plot)
Plant height(cm)	0.804	0.0950	0.337	0.331	0.402	0.338	0.073	0.454	-0.213	0.268	-	0.867 **
No. of leaves/plant	0.004	0.035	0.003	0.014	0.014	0.012	0.006	0.007	-0.009	0.018	-0.005	-0.364 *
Neck thickness(cm)	-0.123	-0.023	-0.293	-0.077	-0.111	-0.295	-0.036	-0.123	0.134	-0.030	0.070	0.762 **
Days required for 50% neck fall	-0.113	-0.110	-0.072	-0.274	-0.267	-0.088	-0.025	-0.071	-0.012	-0.030	0.038	0.399 **
Days to harvest	0.118	0.096	0.090	0.231	0.236	0.121	0.039	0.092	-0.022	-0.010	-0.064	0.579 **
Av. bulb weight (g)	0.290	0.243	0.694	0.221	0.354	0.689	0.163	0.356	-0.461	-0.363	-0.387	0.780 **
Polar diameter (cm)	0.018	0.036	0.025	0.019	0.033	0.048	0.203	0.104	-0.043	0.010	-0.097	0.310 *
Equatorial diameter (cm)	-0.081	-0.027	-0.060	-0.037	-0.056	-0.074	-0.073	-0.144	0.070	-0.026	0.112	0.635 **
Bolting (%)	0.044	0.046	0.077	-0.007	0.015	0.112	0.035	0.081	-0.168	-0.116	-0.095	-0.639**
Double bulb (%)	-0.002	-0.003	-0.0005	-0.0006	0.0002	0.003	-0.0002	-0.0009	-0.003	-0.005	-	-0.258
TSS (°Brix)	-0.092	-0.022	-0.037	-0.021	-0.042	-0.086	-0.074	-0.120	0.087	0.025	0.154	-0.757 **

Residual effect: 0.151 *, ** Significance at 5% and 1% level, respectively

Conclusion

The present investigation revealed substantial genetic variability among the forty-three onion genotypes, as indicated by significant differences for all the twelve characters studied. The genotypic and phenotypic coefficients of variation indicated considerable variability, with higher estimates observed for bolting percentage, double bulb percentage and average bulb weight. High heritability coupled with high genetic advance was observed for neck thickness, TSS and total bulb yield per plot, suggesting the predominance of additive gene action and greater scope for improvement through direct selection. Total bulb yield showed significant positive associations with important growth and bulb characters, particularly plant height, neck thickness, average bulb weight, polar diameter and equatorial diameter, indicating their usefulness as selection criteria for improving bulb yield.

Path coefficient analysis revealed that plant height exerted the highest positive direct effect on total bulb yield per plot, followed by average bulb weight, while days to harvest and polar diameter also showed favourable direct effects. Genetic divergence analysis indicated considerable diversity among the genotypes, providing useful material for future breeding programmes. Based on overall performance, yield potential and desirable characteristics, RVC 24-38, RVB 24-27, RVB 24-25, RVA 24-01 and RVC 24-48 were identified as promising genotypes for utilization in onion improvement programmes. Among these, RVC 24-38 and RVB 24-27 also showed comparatively lower pest and disease incidence, indicating their potential as useful sources for developing high-yielding and disease-tolerant onion cultivars.

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