



Correlation and path analysis studies in onion (*Allium cepa*) genotypes

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ABSTRACT

The present study was carried out at the experimental farm of the Department of Vegetable Sciences, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the winter (*rabi*) season of 2019–20 and 2020–21 to study the genetic variability, correlation and path studies in 30 different genotypes of the onion (*Allium cepa* L.) crop. All genotypes reflected a wide and significant spectrum of variability for all the traits under study. Genotypes UHF-ONI-13, UHF-ONI-15 and UHF-ONI-16 outperformed other genotypes in terms of yield and other critical horticultural characteristics. The magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters. The phenotypic and genotypic coefficients of variability were high for doubles/deformed bulbs, moderate for leaf length, plant height, average bulb weight, bulb yield per plot and per hectare. High heritability along with high to moderate genetic gain was observed for doubles/deformed bulbs, leaf length, plant height, average bulb weight, bulb yield per plot and bulb yield per hectare, which suggested that improvement can be achieved through simple selection. Bulb yield had significant and positive correlation with average bulb weight, equatorial diameter, plant height, polar diameter, days to harvest and days to 50% neck fall. Path analysis showed that bulb weight, equatorial diameter, bulb shape index, neck thickness, total soluble solids, plant height and leaf length had a positive direct effect on bulb yield

Keywords: Correlation, Genetic variability, Path analysis, Yield

Onion (*Allium cepa* L.) is one of the most important bulbous vegetable crop which belongs to the family alliaceae having chromosome number $2n=16$. According to Vavilov (1951), Central Asia is the primary center of origin. The near east and mediterranean region are considered its secondary center of origin. In India, it occupies an area of 1.64 million hectare (mha) with the production of 26.83 million tonnes (mt) and productivity is 16.36 tonnes/ha (Anonymous 2021). Onion is a crop that may be cultivated in diverse climatic conditions, i.e. low temperature areas of temperate region, warm locations of tropical and subtropical regions (Kale 2013). The crop is annual for bulb production and biennial

for seed production (Parmar *et al.* 2018). In India, the winter (*rabi*) onion is grown at a very wide scale in comparison to rainy (*khari*) crop. It has been designated as an essential commodity by the Indian government (Singh *et al.* 2018).

The high variation in genetic components can be seen due to cross-pollinated nature of onion crop. The extent of genetic variability present in a crop is of great importance for its improvement as the efficiency of selection mainly depends on it. It is essential to comprehend the nature and types of relationships among bulb yield components using correlation and path analysis in order to identify suitable breeding approaches for bulb yield improvement. Yield is a complex trait that is regulated polygenically. As a result, selecting superior genotypes based only on yield performance is ineffective. Hence, the knowledge of correlation between the traits is important, which indicate the involvement of the traits. However, correlation studies alone do not provide comprehensive information on the interrelationships of the traits for which path analysis is applied (Singh *et al.* 2018). In agriculture, plant breeders have used path analysis to help them classify characteristics that can be used as selection criteria to increase crop yield. In this study, efforts were made to study the direct and indirect influences of some key yield components among themselves and to yield through path analysis.

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MATERIALS AND METHODS

Location and traits: The present study was carried out at the research farm of Department of Vegetable Sciences, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during winter (*rabi*) season of 2019–20 and 2020–21. The experiment consisted of 30 onion genotypes, including the check cultivar Nasik Red to find out the genetic variability, correlations and path coefficient analysis. The experiment was laid out in a Randomized Complete Block Design (RCBD) in a plot size 1.5 m × 1.0 m with 3 replications at spacing of 15 cm × 10 cm. The standard cultural practices as recommended in the “Package of Practices for Vegetable Crops” were followed for raising a healthy crop of onion (Anonymous 2014). The data were recorded for 16 characters, viz. plant height (cm), number of leaves per plant, leaf length (cm), neck thickness (cm), polar diameter (cm), equatorial diameter (cm), bulb shape index, bulb skin colour, days to 50% neck fall, days to harvest, dry matter (%), total soluble solids (°B), doubles/deformed bulb (%), average bulb weight (g), bulb yield per plot (kg) and bulb yield per hectare (q).

Statistical analysis: As suggested by Panse and Sukhatme (1967), statistical analysis was performed on the mean values obtained from the 10 competitive plants for different horticultural traits that were randomly selected from each genotype in each replication. The variables of genotypic and phenotypic coefficients were computed according to the Burton and Devane (1953) while broad

sense heritability as per Burton and De-Vane (1953) and Allard (1960). Method given by Johanson *et al.* (1955) used to calculate the genetic gain expressed as per cent of population mean. The genotypic and phenotypic correlations calculated as per Al-Jibouri *et al.* (1958) in which total variability bifurcated into replications, genotypes and error. Both correlation coefficients i.e. genotypic and phenotypic used in finding out their direct and indirect contribution towards yield per plot. Dewey and Lu (1959) method was used to work out the direct and in direct paths.

RESULTS AND DISCUSSION

The analysis of variance indicated significant difference among the genotypes for all the characters studied, which represents the presence of good deal of variability in the genotypes. Dhotre *et al.* (2010), Lakshmi (2015) and Deepanshu and Singh (2020) also recorded adequate variability in their genetic materials. For both the years, the interactions of genotypes and years were non-significant, implying performances of the genotypes were almost identical irrespective of the change in years.

Genetic variability: Estimates of phenotypic and genotypic coefficients of variability, heritability, genetic advance and genetic gain for different traits are presented in the Table 1. The magnitude of phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the characters. The difference between the values of PCV and GCV were very less for most of the traits like neck thickness (0.2), polar diameter (0.07),

Table 1 Estimates of phenotypic and genotypic coefficients of variability, heritability, genetic advance and genetic gain for different traits in onion crop

Trait	Coefficient of variability (%)		Heritability (%)	Genetic advance	Genetic gain (%)
	Phenotypic	Genotypic			
PH (cm)	17.19	16.81	95.58	16.22	33.84
NLPP	8.31	8.00	92.77	1.20	15.88
LL (cm)	17.02	16.60	95.20	12.84	33.37
NT (cm)	12.49	12.29	96.85	0.33	24.92
PD (cm)	9.72	9.65	98.73	0.91	19.76
ED (cm)	9.22	9.14	98.38	0.93	18.68
BSI	11.32	11.19	97.74	0.21	22.80
DT 50% NF	5.53	5.38	94.80	15.59	10.79
DH	5.15	5.03	95.49	15.48	10.13
DM (%)	11.06	10.84	95.95	3.05	21.87
TSS (°B)	12.98	12.43	91.71	3.73	24.52
D/DB (%)	34.98	31.73	82.28	3.14	59.28
ABW (g)	19.50	19.38	98.80	24.90	39.68
Bulb yield per plot (kg)	20.98	20.94	99.63	2.58	43.05
Bulb yield per hectare (q)	20.98	20.94	99.63	137.65	43.05

PH, Plant height; NLPP, Number of leaves per plant; LL, Leaf length; NT, Neck thickness; PD, Polar diameter; ED, Equatorial diameter; BSI, Bulb shape index; DT 50% NF, Days to 50% neck fall; DH, Days to harvest; DM, Dry matter; TSS, Total soluble solids; D/DB, Doubles/deformed bulbs; ABW, Average bulb weight.

Table 2 Phenotypic and genotypic coefficients of correlation among different traits

		PH	NLPP	LL	NT	PD	ED	BSI	DM	TSS	D/DB	DT 50% NF	DH	ABW	YPP
PH	P	1.00	0.62*	0.95*	0.55*	0.52*	0.39*	0.12	-0.44*	-0.56*	-0.06	0.60*	0.62*	0.73*	0.72*
	G	1.00	0.66*	0.97*	0.57*	0.53*	0.40*	0.11	-0.46*	-0.61*	-0.07	0.63*	0.66*	0.75*	0.73*
NLPP	P		1.00	0.64*	0.71*	0.46*	0.22*	0.21*	-0.45*	-0.30*	-0.12	0.58*	0.57*	0.56*	0.57*
	G		1.00	0.69*	0.75*	0.48*	0.22*	0.22*	-0.47*	-0.34*	-0.12	0.60*	0.59*	0.59*	0.59*
LL	P			1.00	0.57*	0.55*	0.33*	0.19	-0.43*	-0.55*	-0.04	0.58*	0.60*	0.69*	0.68*
	G			1.00	0.59*	0.57*	0.34*	0.19	-0.46*	-0.61*	-0.04	0.62*	0.63*	0.72*	0.70*
NT	P				1.00	0.34*	0.42*	-0.06	-0.36*	-0.50*	-0.103	0.48*	0.47*	0.67*	0.69*
	G				1.00	0.34*	0.43*	-0.06	-0.37*	-0.53*	-0.13	0.50*	0.50*	0.69*	0.70*
PD	P					1.00	0.23*	0.64*	-0.56*	-0.32*	-0.36	0.28*	0.28*	0.65*	0.64*
	G					1.00	0.24*	0.64*	-0.57*	-0.34*	-0.41	0.28*	0.29*	0.66*	0.64*
ED	P						1.00	-0.59*	-0.29*	-0.28*	-0.19	0.37*	0.40*	0.74*	0.75*
	G						1.00	-0.59*	-0.30*	-0.30*	-0.19	0.37*	0.41*	0.75*	0.75*
BSI	P							1.00	-0.21*	-0.01	-0.18	-0.08	-0.10	-0.04	-0.06
	G							1.00	-0.22*	-0.02	-0.23*	-0.08	-0.10	-0.05	-0.07
DM	P								1.00	0.55*	0.07	-0.52*	-0.49*	-0.58*	-0.59*
	G								1.00	0.57*	0.05	-0.54*	-0.51*	-0.59*	-0.61*
TSS	P									1.00	-0.00	-0.57*	-0.58*	-0.51*	-0.50*
	G									1.00	-0.00	-0.60*	-0.61*	-0.53*	-0.52*
D/DB	P										1.00	0.20	0.21*	-0.30*	-0.33*
	G										1.00	0.23*	0.24*	-0.35*	-0.37*
DT 50% NF	P											1.00	0.95*	0.51*	0.50*
	G											1.00	0.97*	0.52*	0.51*
DH	P												1.00	0.53*	0.51*
	G												1.00	0.55*	0.53*
ABW	P													1.00	0.99*
	G													1.00	0.99*
YPP	P														1.00
	G														1.00

*Significant at 5% level; P, Phenotypic coefficients of correlation; G, Genotypic coefficients of correlation; PH, Plant height; NLPP, Number of leaves per plant; LL, Leaf length; NT, Neck thickness; PD, Polar diameter; ED, Equatorial diameter; BSI, Bulb shape index; DM, Dry matter; TSS, Total soluble solids; D/DB, Doubles/deformed bulbs; DT 50% NF, Days to 50% neck fall; DH, Days to harvest; ABW, Average bulb weight; YPP, Yield per plot.

equatorial diameter (0.08), average bulb yield (0.12), bulb yield per plot (0.04), reflecting that the characters are less affected by the environment. Chattopadhyay *et al.* (2013), Khosa and Dhatt (2013) and Parmar *et al.* (2018) also reported similar results. High PCV and GCV were exhibited by doubles/deformed bulbs (34.98% and 31.73%). Dhotre *et al.* (2010), Chatto *et al.* (2018) and Parmar *et al.* (2018) also reported high PCV and GCV for doubles/deformed bulbs. Moderate PCV and GCV were observed for plant height (17.19% and 16.81%), average bulb weight (19.50% and 19.38%) and bulb yield per plot (20.98% and 20.94%). Sharma *et al.* (2017) reported moderate PCV and GCV for plant height, equatorial diameter, leaf length and average bulb weight. Chatto *et al.* (2018) also reported moderate PCV and GCV for plant height, bulb weight and yield. Low PCV and GCV were recorded for days to harvest (5.15% and 5.03%), number of leaves per plant (8.31% and 8.00%), equatorial diameter (9.22% and 9.14%), polar diameter (9.72% and 9.65%), dry matter (11.06% and 10.84%) and total soluble solids (12.98% and 12.43%). Pyasi and Tiwari (2016) also reported low PCV and GCV for number of leaves per plant, polar and equatorial diameter of the bulb and days to harvest. Sharma *et al.* (2017) also reported low PCV and GCV for dry matter and total soluble solids.

Heritability and genetic gain: Genetic coefficient of variation does not indicate amount of heritable variation; hence, estimation of heritability needs to be made. High heritability was observed for all the characters under study, which varies from 82.28–99.63%, indicating that a large proportion of phenotypic variance was attributable to genotypic variance and traits were less influenced by the environment. Similar results were also observed by Lakshmi *et al.* (2015), Solanki *et al.* (2015) and Chatto *et al.* (2018). Genetic gain values ranged from 10.13–59.28%. Maximum genetic gain was recorded for doubles/deformed bulbs (59.28%). Dhotre *et al.* (2010), Mohapatra *et al.* (2017), Parmar *et al.* (2018) and Bal *et al.* (2019) also reported similar results. Moderate genetic gain was recorded for average bulb weight (39.68%), bulb yield per plot (43.05%) and bulb yield per hectare (43.05%). Khosa and Dhatt (2013) and Deepanshu and Singh (2020) observed moderate genetic gain for average bulb weight. However, days to harvest (10.13%) and number of leaves per plant (15.88%) exhibited low genetic gain. Singh and Dubey (2011) also observed low genetic gain for polar and equatorial diameter, number of leaves per plant and neck thickness. Chatto *et al.* (2018) observed similar results for number of leaves, polar diameter, neck thickness and equatorial diameter.

Genetic advance: High value of heritability accompanied with high genetic gain observed for doubles/deformed bulbs. Mohapatra *et al.* (2017), Parmar *et al.* (2018) and Deepanshu and Singh (2020) also estimate similar results. High heritability with moderate genetic gain recorded for average bulb weight and bulb yield per plot and per hectare, which suggests the possibility of improvement through simple selection. Lakshmi *et al.* (2015) and Deepanshu and Singh (2020) also observed similar results for average

bulb weight. However, characters like days to 50% neck fall and neck thickness exhibited high heritability coupled with low genetic gain.

Correlation studies: The genotypic correlation coefficients were greater than phenotypic correlation coefficients for all the traits under study, which lead to strong inherent association among characters (Table 2). This indicated that the environment played a little impact in the manifestation of the characteristics under investigation. Bulb yield had a positive and significant correlation with average bulb weight (0.99 and 0.99), equatorial diameter (0.75 and 0.75), polar diameter (0.64 and 0.64), and days to 50% neck fall (0.50 and 0.51) at both genotypic and phenotypic levels. While, yield had negative and significant correlation with dry matter (-0.59 and -0.61), TSS (-0.50 and -0.52) and doubles/deformed bulbs (-0.33 and -0.37). Bal *et al.* (2019) found to have positive and significant correlation of yield with polar diameter and days to maturity. Esho *et al.* (2019) also reported significant positive correlation of the yield with the number of leaves per plant while negative with per cent doubles/deformed bulbs. While, Deepanshu and Singh (2020) observed positive and significant correlation of yield with plant height, leaf length, bulb diameter and average bulb weight.

Path analysis: The examination of path analysis indicated that maximum direct positive effect on bulb yield was imposed by average bulb weight (0.869) followed by equatorial diameter (0.129), bulb shape index (0.118), neck thickness (0.097), total soluble solids (0.048), plant height (0.032) and leaf length (0.032). Similar results were also reported by Dhotre *et al.* (2010), Lakshmi *et al.* (2015), Solanki (2015), Nikhil *et al.* (2016) and Singh *et al.* (2018). Whereas, maximum negative direct effect on yield was recorded by polar diameter (-0.151) followed by dry matter (-0.107), doubles/deformed bulbs (-0.054), number of leaves per plant (-0.047), days to 50% neck fall (-0.015) and days to harvest (-0.004). Results demonstrates the approximate values of direct and indirect effects of various traits on bulb yield (Table 3). The residual effect at the genotypic level was minimal (0.0069), indicating that the maximum number of independent variables was used in this study on the dependent variable. In present study, average bulb weight exhibited high positive and direct effect and significant positive correlation with the bulb yield followed by equatorial diameter. As a result, these characteristics should be taken into account while choosing genotypes to increase yield.

The genetic variability studies through phenotypic and genotypic coefficients of variability, heritability, genetic advance and genetic gain represent the presence of good deal of variability in the genotypes for all the characters studied.

Environmental influence was very less as it was evident by narrow gap between genotypic and phenotypic coefficients of variation. Correlation studies at both the genotypic and phenotypic levels revealed that genotypic correlation coefficients were greater than phenotypic correlation coefficients. As far as path analysis is concerned,

Table 3 Estimates of direct and indirect effects of different traits on yield

Trait	PH	NLPP	LL	NT	PD	ED	BSI	DM	TSS	D/DB	DT 50% NF	DH	ABW	GCCYPP
PH	0.032	-0.031	0.031	0.056	-0.080	0.052	0.013	0.049	-0.029	0.004	-0.010	-0.003	0.651	0.734*
NLPP	0.021	-0.047	0.022	0.073	-0.072	0.029	0.026	0.051	-0.016	0.007	-0.009	-0.003	0.513	0.595*
LL	0.031	-0.032	0.032	0.057	-0.086	0.044	0.022	0.049	-0.029	0.002	-0.009	-0.003	0.625	0.703*
NT	0.018	-0.035	0.019	0.097	-0.051	0.056	-0.007	0.040	-0.025	0.007	-0.008	-0.002	0.596	0.704*
PD	0.017	-0.022	0.018	0.033	-0.151	0.031	0.076	0.062	-0.017	0.022	-0.004	-0.001	0.578	0.641*
ED	0.013	-0.011	0.011	0.042	-0.036	0.129	-0.070	0.033	-0.014	0.010	-0.006	-0.002	0.655	0.755*
BSI	0.004	-0.010	0.006	-0.006	-0.097	-0.076	0.118	0.024	-0.001	0.012	0.001	0.000	-0.041	-0.066
DM	-0.015	0.022	-0.014	-0.036	0.087	-0.039	-0.026	-0.107	0.027	-0.003	0.008	0.002	-0.515	-0.609*
TSS	-0.020	0.016	-0.019	-0.051	0.052	-0.038	-0.002	-0.061	0.048	0.000	0.009	0.003	-0.460	-0.524*
D/DB	-0.002	0.006	-0.001	-0.012	0.062	-0.024	-0.027	-0.006	0.000	-0.054	-0.004	-0.001	-0.304	-0.368*
DT 50% NF	0.020	-0.028	0.020	0.049	-0.043	0.049	-0.010	0.058	-0.029	-0.012	-0.015	-0.004	0.454	0.508*
DH	0.021	-0.028	0.020	0.048	-0.044	0.053	-0.012	0.055	-0.029	-0.013	-0.015	-0.004	0.475	0.528*
ABW	0.024	-0.028	0.023	0.067	-0.100	0.098	-0.006	0.064	-0.026	0.019	-0.008	-0.002	0.869	0.993*

PH, Plant height; NLPP, Number of leaves per plant; LL, Leaf length; NT, Neck thickness; PD, Polar diameter; ED, Equatorial diameter; BSI, Bulb shape index; DM, Dry matter; TSS, Total soluble solids; D/DB, Doubles/deformed bulbs; DT 50% NF, Days to 50% neck fall; DH, Days to harvest; ABW, Average bulb weight; and GCCYPP, Genotypic correlation with yield per plot. Residual effect=0.00695 and Diagonals figures represent the direct effects.

genotypic path analysis has maximum direct positive effect on bulb yield which was imposed by average bulb weight. In terms of yield and other important horticultural traits, genotypes UHF-ONI-13, UHF-ONI-15 and UHF-ONI-16 outperformed other. These studies will assist the breeders in making effective selection for enhancing the production, leading to the development of superior varieties with higher yield potential in onion. This study also demonstrated that the availability of variability in onion offers promising opportunities for crop enhancement in the near future.

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