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Studies on Variability, Correlation and Path Analysis of Traits Contributing to Fruit Yield in Grapes

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The present investigation was conducted to estimate genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance (GA) along with correlations and path coefficients from the data collected on 20 grape cultivars during 2000-09. The high estimates of GCV and PCV recorded for bunch weight, berry weight, bunch number and fruit yield per vine indicated the presence of adequate genetic variation among the genotypes and suitability of these traits for further improvement by selection. High heritability estimates coupled with high genetic advances for these traits confirmed that these traits are under the control of additive gene action and phenotypic selection for their improvement will be effective. Fruit yield per vine showed significant positive association with bunch length, bunch width, bunch weight and bunch number while significant negative association of berry length, berry diameter and berry weight with acidity percentage indicated that improvement of these traits through selection will also improve quality of table grapes by reducing acidity. Number of bunches per vine had maximum direct effect on fruit yield per vine followed by bunch weight. Bunch length as well as bunch width contributed to fruit yield per vine indirectly via bunch weight. Hence, the number of bunches per vine and bunch weight are identified as key traits for developing high fruit-yielding cultivars of grapes.

Key Words: Fruit yield, GCV, Grapes, Path analysis, PCV

Introduction

Grape cultivation is one of the most remunerative farming enterprises in India. Grape is grown under a variety of soil and climatic conditions in three distinct agro-climatic zones namely sub-tropical, semi arid tropical and mild humid-tropical climatic regions in India. Punjab comes under sub-tropical region, which covers the North western plains corresponding to 28^{o} and 32^{o} N latitude. In South western Punjab, area under grapes has been reducing since last decade due to fluctuations in temperature, erratic rainfall and short shelf life. 'Perlette' is the only early ripening variety quite successful in this region, occupying more than 90% of total area under grapes, whereas, other varieties like Beauty Seedless, Thompson Seedless and Anab-e-Shahi are being cultivated in small areas. Punjab state has a great potential for grapes cultivation for table and wine purposes. Hence, the availability of a suitable high-yielding grapes cultivar is important for popularization among the growers. The breeding methodology for genetic improvement of fruit yield and its components depends upon the nature and magnitude of variability available for these traits. The estimation of genetic parameters such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (H^2) and genetic advance (GA) is helpful in making selections effective for improving base population. Effectiveness of selection will increase if the nature of interrelationships among different characters is understood. Path analysis further unravels the cause of such associations by determining direct and indirect contributions. Although Giridharan and Jindal (1995) studied correlation and path analysis for some physiological parameters, but very little information with respect to these aspects is available in this crop. Therefore, the present investigation was conducted to estimate genetic parameters along with correlations and path coefficients among the fruit yield and its components in grapes.

Material and Methods

The experimental material comprising 20 different cultivars *viz.*, Cardinal, Angur Early, Banqui Abyad, Khalili, Arkavati, Shadipur Local, Black Prince, Bharat Early, Madeliene Anguvine, Perlette, Arka Hans, Delight, Beauty Seedless, Rubi Red, Black Muscat, Tas-A-

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Ganesh, Arka Kanchan, Arka Shyam, Selection 7 and Lomanto were collected from different parts of India. All the cultivars were planted in randomized block design each with 3 replications at PAU, Regional Research Station, Bathinda, Punjab. The average rainfall at the experimental site was 400 mm, the annual maximum temperature was 31.5°C and annual minimum temperature was 16.9°C during fruiting season. The soil was sandy loam with pH (8.31), organic carbon (0.32%), electrical conductivity (0.24 dS/m), available N (212 kg/ ha), available P (21.5 kg/ha) and available K (357.0 kg/ ha). Three plants each, per replication of each cultivar, were grown at a spacing of 3 × 3 meters. Data were recorded on bunch length (cm), bunch width (cm), bunch weight (g), berry weight (g), berry length (mm), berry diameter (mm), total soluble solids (TSS %), acidity (%), bunch number and fruit yield (kg/vine) for nine years (2000-09). The genotypic and phenotypic coefficients of variation and heritability (in broad sense) were calculated after pooling of the data (Singh and Choudhary,1979) while genetic advances were estimated as per the procedure of Johnson *et al.* (1955). The path analysis was carried out following Dewey and Lu (1959).

Results and Discussion

The analysis of variance showed significant differences among the cultivars for all the 10 traits (Table 1). The high estimates (>35%) of PCV and GCV for bunch weight, berry weight, bunch number and fruit yield indicated the presence of adequate genetic variation among the genotypes and suitability of these attributes for further improvement by selection (Table 2). High heritability estimates (>90%) coupled with high genetic advance percentage (>70%), for bunch weight, berry weight, bunch number and fruit yield confirmed that these traits are under the control of additive gene action and phenotypic selection for their improvement will be effective. Wei *et al.* (2002) and Kumar *et al.* (2002) also observed berry weight to be under strong additive genetic control. High heritability estimates for berry weight, bunch weight and bunch number were also reported by Wei *et al.* (2003). The estimates of PCV and GCV for bunch width and acidity percent were low in magnitude yet these were close to each other indicating little effect of environment in the inheritance of these traits.

The phenotypic and genotypic correlation coefficients between different characters are presented in Table 3. Fruit yield per vine showed significant positive association with bunch length (0.2976), bunch width (0.3238), bunch weight (0.2706) and bunch number (0.6348), while significant negative association with total soluble solids (–0.2851). These traits also showed high correlation with fruit yield per vine at genotypic level indicating little effect of environment on the expression of such traits. Hence, improving bunch length, bunch width, bunch weight and bunch number seemed to improve fruit yield per vine. Berry length, berry diameter and berry weight showed significant positive association with each other but significant negative association with bunch number. It indicated that improvement of berry length, berry diameter and berry weight will reduce bunch number. Significant negative association of berry length, berry diameter and berry weight with acidity percentage indicated that improvement of these traits through selection will also improve the quality of grapes by reducing acidity.

Path coefficient analysis revealed that bunch number made maximum direct contribution to fruit yield per vine followed by bunch weight, berry length and bunch width. Bunch length as well as bunch width contributed to fruit yield per vine indirectly via bunch weight. Berry length, berry diameter and berry weight also contributed to fruit yield per vine via bunch weight. In view of high

Table 1. Pooled Analysis of variance of fruit yield and its components in grapes

Source	DF	Mean Square									
		Fruit yield (kg/vine)	Bunch length (cm)	Bunch width (cm)	Bunch weight (g)	TSS (%)	Acidity (%)	Berry weight (g)	Berry length (mm)	Berry diameter (mm)	Bunch number
Environment	8	601.92**	15.95**	18.05**	80352.5**	53.27**	2.33**	0.751	0.0695	0.0480	2865.4**
Block within Environment	18	5.18	9.00**	3.17	2314.2	36.23**	0.015	0.694	0.3028**	0.1595**	53.199
Genotype	19	1101.03**	113.57**	76.99**	318627.3**	33.37**	1.55**	21.65**	1.101**	0.9754**	16240.64**
Environment × Genotype	152	112.88**	11.03**	4.68**	21069.1**	5.12	0.137**	0.464	0.0317	0.0254	1268.21**
Pooled Error	342	6.015	5.04	2.34	3095.5	5.16	0.02	0.166	0.0494	0.0576	88.2718

Table 2. Genetic parameters for fruit yield and its components in grapes

Characters	Mean	PCV (%)	GCV (%)	Heritability (H2)	GA (%)
Bunch length (cm)	16.82	13.22	11.81	79.81	21.74
Bunch width (cm)	10.81	16.43	15.88	93.44	31.63
Bunch weight (g)	274.25	41.97	40.67	93.93	81.20
TSS (%)	16.60	8.08	6.90	72.99	12.15
Acidity (%)	1.05	23.93	23.26	94.47	46.58
Berry weight (g)	2.47	35.46	35.77	96.13	70.22
Berry length (mm)	1.71	12.52	11.65	86.61	22.34
Berry diameter (mm)	1.55	13.12	11.90	82.29	22.24
Bunch number	51.34	49.34	49.01	98.65	99.27
Fruit yield (kg/vine)	12.96	48.88	48.31	97.68	98.35

Table 3. Phenotypic (r_p) and genotypic (r_g) correlation coefficients of fruit yield and component characters in grapes

Characters	Bunch length (cm)	Bunch width (cm)	Bunch weight (g)	TSS (%)	Acidity (%)	Berry weight (g)	Berry length (mm)	Berry diameter (mm)	Bunch number	Fruit yield (kg/ vine)
Bunch length (cm)	1.000									
Bunch width (cm)	0.7632**									
	0.8898	1.000								
Bunch weight (g)	0.7049**	0.8660**								
	0.8415	0.9096	1.000							
TSS (%)	0.0152	0.1560	0.0330							
	0.1103	0.1875	0.0381	1.000						
Acidity (%)	-0.0793	-0.1641	-0.1589	-0.1111						
	-0.0817	-0.1609	-0.1576	-0.1328	1.000					
Berry weight (g)	0.3953**	0.3766**	0.4617**	-0.1902	-0.4050**					
	0.4108	0.3942	0.4791	-0.2004	-0.4120	1.000				
Berry length (mm)	0.3670**	0.4174**	0.5112**	-0.0790	-0.3452**	0.7948**				
	0.3298	0.4578	0.5775	-0.1103	-0.3810	0.8650	1.000			
Berry diameter (mm)	.4076**	0.3184*	0.4287**	-0.2936*	-0.3644**	0.9191**	0.6762**			
	0.4372	0.4234	0.5032	-0.2354	-0.4047	1.0102	0.8248	1.000		
Bunch number	-0.2658*	-0.3690**	-0.4197**	-0.4718**	0.2412	-0.2774*	-0.4731**	-0.1999		
	-0.3004	-0.3785	-0.4383	-0.5292	0.2580	-0.2829	-0.4947	-0.2374	1.000	
Fruit yield (kg/ vine)	0.2976*	0.3238*	0.2706*	-0.2851*	-0.0006	-0.0285	-0.0768	0.0066	0.6348**	
	0.3312	0.3361	0.2865	-0.3489	-0.0124	-0.0362	-0.1068	0.0144	0.6630	1.000

* Significant at 5% level ; ** Significant at 1% level of significance

Table 4. Path analysis coefficient of fruit yield versus component characters in grapes

Characters	Bunch length (cm)	Bunch width (cm)	Bunch weight (g)	TSS (%)	Acidity (%)	Berry weight (g)	Berry length (mm)	Berry diameter (mm)	Bunch number	PCC* with Fruit yield (kg/vine)
Bunch length (cm)	0.1346	0.1745	0.2794	0.0016	0.0134	-0.1449	0.1109	0.009	-0.281	0.2976
Bunch width (cm)	0.1027	0.2287	0.3433	0.0164	0.0277	-0.1381	0.1262	0.0071	-0.3901	0.3238
Bunch weight (g)	0.0949	0.198	0.3964	0.0035	0.0268	-0.1693	0.1545	0.0095	-0.4437	0.2706
TSS (%)	0.002	0.0357	0.0131	0.1049	0.0188	0.0697	-0.0239	-0.0065	-0.4988	-0.2851
Acidity (%)	-0.0107	-0.0375	-0.063	-0.0116	-0.1689	0.1485	-0.1043	-0.0081	0.225	-0.0006
Berry weight (g)	0.0532	0.0861	0.183	-0.0199	0.0684	-0.3666	0.2403	0.0204	-0.2933	-0.0285
Berry length (mm)	0.0494	0.0955	0.2026	-0.0083	0.0583	-0.2914	0.3023	0.015	-0.5002	-0.768
Berry diameter (mm)	0.0549	0.728	0.1699	-0.0308	0.0615	-0.337	0.2044	0.0222	-0.2113	0.0066
Bunch number	-0.0358	-0.0844	-0.1664	-0.0495	-0.0407	0.1017	-0.143	-0.0044	1.0572	0.6348

Bold figures are direct effects, *PCC stands for phenotypic correlation coefficient; Residual effect: 0.0850

indirect contribution of different traits through bunch weight, this trait will be most effective for selection of high-yielding cultivars of grapes. Although bunch number influenced fruit yield per vine, slightly negatively via different traits, yet in view of it's very high direct effect upon fruit yield per vine, selection for this trait can also be relied upon for improving fruit yield.

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