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Variability, interrelationship and path coefficient studies in watermelon

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ABSTRACT

Genetic variability, heritability, genetic advance, correlation and path coefficient of yield and attributing traits were studied in twenty watermelon genotypes. The variance analysis for fourteen quantitative characters showed that genotypes differ significantly among them for all characters under study indicating great variability among the genotypes selected. High heritability and high genetic gain were observed for weight of 100 seeds, seeds fruit^{-1}, yield plant^{-1} and fruit weight. Studies on correlation and path analysis indicated that genotypic correlations were higher than phenotypic level in general. The yield plant^{-1} had positive and significant correlation with fruit polar diameter, fruit weight, number of fruits plant^{-1} and seeds fruit^{-1} at both phenotypic and genotypic levels. The path coefficient analysis revealed that number of fruits plant^{-1} and fruit weight had positive direct effect on yield plant^{-1}. Hence, selection based on these characters will be effective for improvement of high yielding genotypes in watermelon.

Key words: *Citrullus lanatus*, heritability, correlation, path analysis.

INTRODUCTION

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] is an economically important crop of the family Cucurbitaceae grown throughout the world. In India, it is cultivated in an area of 81,000 ha with a production of 18.27 lakh tonnes (GOI, 5). The watermelon fruit is 93% water, with small amounts of protein, fat, minerals and vitamins. The major nutritional components of the fruit are carbohydrates (6.4 g/100 g), vitamin A (590 IU) and lycopene (4,100 µg/100g). Flesh colour is an important trait of watermelon which determines consumer acceptability. Lycopene, an anticarcinogenic compound imparts colour to red fleshed watermelon. Lycopene may help reduce the risk of certain cancers, such as prostate, pancreas, and stomach. The lycopene content of the new dark red watermelon cultivars is higher than that in tomato, pink grapefruit or guava (Wehner, 10). Watermelon fruits make a delicious and refreshing dessert, especially esteemed in hot weather. They have served as an important source of water in the Kalahari Desert and other arid areas of Africa. The rind may be pickled or candied. Roasted seeds are eaten in the Orient and the Middle East, and some Chinese cultivars used for this purpose have been bred to have very large seeds (Robinson and Decker-Walters, 14). Genetic variation is an essential prerequisite for any crop improvement programme (Said and Fatiha, 16). To initiate any effective selection programme, the information on the nature and the magnitude of variability present in genetic stocks, heritability and genetic advance is of considerable importance for a breeder. Correlation studies between yield and its components and their relative contribution to yield will be of great value in planning and evaluating breeding programme. Path analysis facilitates the partitioning of correlation coefficient into direct and indirect effects on yield and other attributes. Genetic information related to yield improvement in watermelon is limited (Kumar and Wehner, 11). Therefore, an attempt was made in the present investigation to estimate the extent of variability, heritability, genetic advance, correlation and path analysis by utilizing 20 watermelon genotypes.

MATERIALS AND METHODS

The present experiment was carried out at Department of Olericulture, College of Agriculture, Vellayani, Kerala Agricultural University during 2015-16. The site was located at 08 ^{0} 25`53.7`` N and 76 $^{0}$ 59`15.8`` E at an altitude of 29 m above mean sea level. The experimental material consisted of twenty genotypes from public and private sectors including three commercial cultivars viz., Sugar Baby from IARI, Arka Muthu and Arka Manik from IIHR, Bengaluru. The experiment was laid out in randomized block design with three replications. Seedlings were raised in portrays and twelve days old seedlings were transplanted at a spacing of 2m × 1m. Recommended cultural practices were adopted for proper growth and stand of the crop. The observations were recorded on fifteen traits from five randomly selected competitive plants

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from each genotype and replication. The data were subjected to analysis of variance as per procedure described by Panse and Sukhatme (12). Heritability, genetic advance and genetic gain were calculated according to the formulae of Johnson *et al.* (8). The correlation coefficients were calculated as per Al-Jibouri *et al*. (1) and path coefficient analysis by Dewey and Lu (4).

RESULTS AND DISCUSSION

The mean sum of squares was highly significant for all traits indicating the presence of wide range of variability in the genotypes (Table 1). The range of variation was high for number of seeds fruit^{-1} followed by days to first harvest, fruit polar diameter, days to first male flower, days to first female flower, weight of 100 seeds and yield plant^{-1} indicating variability of the genotypes used in the present study. This would help in selecting the best genotypes from existing collection. Rind thickness and number of fruits per plant, however, recorded low value indicating minimum variation and less scope for selection.

Coefficients of variation are better indices for comparison of characters with different units of measurements. In the present study, even though phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the characters, only a slight difference was observed between them (Table 2). This revealed greater stability of the characters against environmental fluctuation, thus the selection based on phenotypic performance will be reliable. A major portion of PCV was contributed by GCV for most of the characters suggesting that the observed variation was mainly due to genetic factors. This similarity between PCV and GCV was reported earlier by Prasad *et al*. (13), Sundaram *et al*. (18) and Choudhary *et al.* (3) in watermelon. High GCV and PCV were recorded for fruit weight, yield plant^{-1}, fruits plant^{-1}, rind thickness, vine length, fruit polar diameter, weight of 100 seeds and number of seeds fruit^{-1} clearly indicating that selection will be rewarding. High magnitude of GCV was reported for number of seeds fruit^{-1} and yield plant^{-1} by Sundaram *et al*. (18) and Choudhary *et al*. (3) in watermelon. Moderate PCV and GCV were recorded for fruit equatorial diameter, node to first female flower, days to first male flower and days to first harvest. The genotypic coefficient of variation was quite low for days to first female flower. Sundaram *et al*. (18) and Choudhary *et al*. (3) reported moderate GCV value for days to first female flower in watermelon.

The genotypic coefficient of variation does not offer full scope to estimate the variation that is heritable and, therefore, estimation of heritability becomes necessary. The knowledge of heritability along with genetic advance aid in drawing valuable conclusions for effective selection based on phenotypic performance (Johnson *et al*., 8). In the present investigation high heritability was observed

Table 1. Range, mean and analysis of variance for different quantitative characters in watermelon.

Character	Range		Mean	Standard error ±	MSS value	CD at 5%
	Min.	Max.				
Vine length (m)	1.20	6.29	4.02	0.34	2.237**	1.01
Days to 1st male flower (DAT)	27.50	42.50	35.55	0.94	37.995**	2.76
Node to 1st male flower	5.50	13.00	9.28	0.62	6.183**	1.82
Days to 1st female flower (DAT)	35.00	47.00	40.78	0.69	29.814**	2.06
Node to 1st female flower	14.50	23.50	19.28	0.75	12.183**	2.22
Fruit equatorial diameter (cm)	12.65	23.50	17.16	0.91	13.858**	2.69
Fruit polar diameter (cm)	15.00	31.00	21.92	1.45	44.738**	4.29
Rind thickness (cm)	0.75	2.20	1.41	0.10	0.311**	0.30
Fruit weight (kg)	1.55	6.38	3.24	0.31	3.164**	0.90
TSS	9.30	12.90	10.71	0.24	2.186**	0.72
Days to first harvest (DAT)	54.00	91.50	74.90	0.75	172.035**	2.22
Fruits per plant	1.25	4.47	2.50	0.22	1.454**	0.65
Yield per plant (kg)	3.01	14.17	7.67	0.40	17.513**	2.00
Seeds per fruit	0	366.5	235.53	14.65	25835.0**	3.35
Weight of 100 seeds (g)	0	11.85	3.62	0.37	10.899**	1.09

**Significant at 1% level

Table 2. Components of variance, coefficient of variation, heritability, genetic advance and genetic advance as % of mean for different quantitative traits.

Character	Variance		Coefficient of variation		Heritability	Genetic Advance	GA as % of mean
	Phenotypic	Genotypic	PCV	GCV			
Vine length	1.235	1.002	27.614	24.882	81.188	1.858	46.184
Days to 1st male flower	19.879	18.116	12.542	11.973	91.131	8.370	23.544
Node to 1st male flower	3.472	2.711	20.091	17.751	78.060	2.997	32.307
Days to 1st female flower	15.390	14. 420	9.622	9.313	93.68	7.572	18.570
Node to 1st female flower	6.657	5.526	13.385	12.196	83.020	4.412	22.892
Fruit equatorial diameter	7.755	6.104	16.226	14.395	78.706	4.515	26.308
Fruit polar diameter	24.476	20.261	22.570	20.535	82.779	8.437	38.488
Rind thickness	0.166	0.145	28.853	26.949	87.238	0.732	51.851
Fruit weight	1.678	1.491	39.993	37.704	88.882	2.372	73.226
TSS	1.255	1.136	10.459	9.950	90.515	2.089	19.500
Days to 1st harvest	86.579	85.453	12.423	12.342	98.699	18.919	25.258
Fruits per plant	0.773	0.678	35.175	32.932	87.66	1.588	63.516
Yield per plant	8.920	8.590	38.965	38.244	96.34	5.927	77.326
Seeds per fruit	13132.020	12703.005	48.655	47.854	96.733	228.354	96.956
Weight of 100 seeds	5.586	5.313	65.350	63.730	95.104	4.631	128.030

for all the characters studied. The magnitude of heritability ranged from 78.06 to 98.69%. Highest heritability was recorded for days to first harvest followed by seeds fruit^{-1}, yield plant^{-1}, weight of 100 seeds, days to first female flower, days to first male flower, fruit weight and fruits plant^{-1}. High value of heritability indicates that phenotype of the trait strongly reflects the genotype and suggests the major role of genotypic constitution in the expression of the character. Therefore, reliable selection could be made for these traits on the basis of phenotypic expression. This is in agreement with the findings of Sundaram *et al*. (18) and Choudhary *et al*. (3). For total soluble solids (TSS), high heritability was observed in this study. Similar results were also reported by Kumar and Wehner (10), Choudhary *et al*. (3) and Said and Fatiha (16) suggesting that genotypic components may play an important role in the improvement of this trait in watermelon. High heritability combined with high genetic advance as per cent of mean was observed for characters like yield plant^{-1}, fruit weight, fruits plant^{-1}, rind thickness, vine length, weight of 100 seeds and seeds fruit^{-1}. The result showed that these characters were controlled by additive gene effects and phenotypic selection for these characters is likely to be effective. Similar results were reported by Sundaram *et al*. (18). Despite high heritability, genetic advance as per cent of mean was moderate for days to first female flower and TSS. Choudhary *et al*. (3) reported high heritability combined with low GA for vine length, fruit weight, rind thickness and yield plant^{-1}. Gusmini and Wehner (7) recorded low to intermediate estimates of broad and narrow sense heritability for fruit weight in watermelon.

Yield of watermelon is a result of interactions of a number of interrelated characters. For rational approach towards the improvement of yield, selection will be more rewarding when it is based on the components of yield. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its components and among themselves. In the present study, for all the characters, genotypic correlation coefficient was higher than respective phenotypic correlation coefficient (Table 3), which may be ascribed to the low effect of environment on the character expression (Said and Fatiha, 16). Yield plant^{-1} was found to be significantly and positively associated with fruit equatorial diameter, fruit polar diameter, fruit weight, fruits plant^{-1} and seeds fruit^{-1} at genotypic and phenotypic levels. Positive correlation of fruit yield with fruits plant^{-1} and fruit weight has also been reported by Singh and Singh (17), Gopal *et al*. (6), Rolania *et al*. (15), Sundaram *et al*. (18), Kumar and Wehner (10) and Choudhary *et al*. (3) in watermelon. Vine length was positively and significantly correlated with days to first harvest and node to first female flower. Days to first female flower exhibited positive and significant correlation with days to first harvest

Table 3. Genotypic (G) and phenotypic (P) correlation coefficient for different quantitative characters in watermelon.

Character		Vine length (m)	Days to 1st female flower	Node to 1st female flower	Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Fruits per plant	Fruit weight (kg)	Days to first harvest	Seeds per fruit	Weight of 100 seeds (g)	Yield per plant (kg)
Vine length (m)	G		0.368	0.542**	0.166	-0.029	-0.357	0.165	0.632**	-0.363	0.173	-0.163
	P		0.331	0.493*	0.168	0.049	-0.288	0.106	0.557**	-0.315	0.160	-0.138
Days to 1st female flower	G			0.564**	-0.183	0.078	-0.435*	-0.014	0.712**	-0.349	0.161	-0.273
	P			0.496*	-0.182	0.043	-0.392	0.004	0.682**	-0.333	0.128	-0.230
Node to 1st female flower	G				0.092	0.222	-0.587**	0.223	0.544**	-0.099	0.324	-0.200
	P				0.018	0.165	-0.569**	0.236	0.497*	-0.073	0.294	-0.194
Fruit equatorial diameter (cm)	G					0.379	-0.324	0.932**	0.076	0.511**	0.115	0.469*
	P					0.421	-0.267	0.752**	0.059	0.437*	0.119	0.411
Fruit polar diameter (cm)	G						0.045	0.805**	-0.249	0.621**	0.123	0.755**
	P						0.011	0.680**	-0.221	0.536**	0.153	0.663**
Fruits per plant	G							-0.294	-0.619**	0.002	-0.150	0.546**
	P							-0.355	-0.575**	0.004	-0.157	0.528**
Fruit weight (kg)	G								-0.0244	0.659**	0.149	0.587**
	P								-0.030	0.605**	0.145	0.534**
Days to first harvest	G									-0.594**	-0.179	-0.405
	P									-0.578**	-0.178	-0.399
Seeds per fruit	G										0.325	0.503**
	P										0.298	0.479*
Weight of 100 seeds (g)	G											-0.033
	P											-0.045

*,** Significant at 5 and 1% levels respectively.

and node to first female flower. This is in agreement with the findings of Singh and Singh (17) and Sundaram *et al.* (18) in watermelon. Days to first harvest exhibited significant negative correlation with fruits plant^{-1}. This view was supported by Choudhary *et al.* (2) in muskmelon and Sundaram *et al*. (18) in watermelon. The inter correlation involving fruit weight with fruit equatorial and polar diameters were positive and significant (Kumar and Wehner, 10) while it was negative with days to first female flower and fruits plant^{-1}. Thus any improvement in the fruit weight would improve fruit equatorial and polar diameters but number of fruits would be reduced.

Correlation studies give an idea about the positive and negative associations of different characters with yield and also among themselves. However, the nature and extent of contribution of these characters towards yield is not obtained. Path coefficient analysis can provide a more realistic picture of relationships between different traits, as it takes into consideration direct as well as indirect effects of the different yield components. Determination of interrelationships between and among yield components and yield helps a plant breeder to easily identify traits that make the most significant contribution to yield. Among yield attributes, fruit weight (0.858) exhibited the highest positive direct effect on fruit yield followed by fruits plant^{-1} (0.832). Fruit weight and fruits plant^{-1} also showed positive and significant correlation with yield plant^{-1} (Table 4). This indicated that direct selection based on fruit weight and fruits plant^{-1} would result in appreciable improvement of yield plant^{-1}. These findings are in agreement with Choudhary *et al*. (2) in muskmelon and Choudhary *et al*. (3) in watermelon. Days to first female flower, node to first female flower and fruit polar diameter also exerted positive direct effect on yield (Kumar *et al*., 9). Vine length, fruit equatorial diameter, seeds fruit^{-1} and weight of 100 seeds had negative direct effect on yield.

Therefore, it can be inferred that fruit weight and number of fruits plant^{-1} were the main yield contributing characters in fruit yield of watermelon because of its high, positive direct effect and positive correlation with fruit yield plant^{-1}. Since these characters also have high level of heritability and genetic advance, they can be considered dependable for improvement of yield in watermelon.

Table 4. Estimates of direct and indirect effects at genotypic level on yield of watermelon.

Character	Vine length (m)	Days to 1st female flower	Node to 1st female flower	Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Fruits plant^{-1}	Fruit weight (kg)	Seeds fruit^{-1}	Weight of 100 seeds (g)	Genotypic correlation with yield
Vine length	**-0.1060**	0.0064	0.0771	-0.0051	-0.0017	-0.2967	0.1417	0.0290	-0.0077	-0.163
Days to 1st female flower	-0.0389	**0.0174**	0.0802	0.0056	0.0045	-0.3502	-0.0118	0.0278	-0.0072	-0.273
Node to 1st female flower	-0.0574	0.0098	**0.1423**	-0.0028	0.0128	-0.4885	0.1914	0.0079	-0.0144	-0.200
Fruit equatorial diameter	-0.0176	-0.0032	0.0130	**-0.0305**	0.0219	-0.2693	0.8002	-0.0407	-0.0051	0.469
Fruit polar diameter	0.0031	0.0013	0.0315	-0.0115	**0.0577**	0.0373	0.6906	-0.0496	-0.0055	0.755
Fruits plant^{-1}	0.0378	-0.0073	-0.0835	0.0099	0.0026	**0.8321**	-0.2522	-0.0002	0.0067	0.546
Fruit weight	-0.0176	-0.0002	0.0317	-0.0284	0.0464	-0.2446	**0.8583**	-0.0518	-0.0066	0.587
Seeds fruit^{-1}	0.0385	-0.0061	-0.0141	-0.0156	0.0359	0.0020	0.5566	**-0.0798**	-0.0145	0.503
Weight of 100 seeds	-0.0183	0.0028	0.0461	-0.0035	0.0071	-0.1249	0.1280	-0.0259	**-0.0445**	-0.033

Residual effect = 0.2585 Bold values indicate direct effects

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