A-5846
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RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume Issue : ()

Genetic Variability, Correlation and Path Analysis in Cowpea [*Vigna unguiculata* (L.) Walp]

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10.18805/IJARe.A-5846

ABSTRACT

Background: Cowpea [*Vigna unguiculata* (L.) Walp] is a self pollinated crop, belonging to family fabaceae and sub family papilionaceae. It is an important multipurpose grain legume extensively cultivated in arid and semi arid regions of Sub-Saharan Africa, Asia, Central and South America. The assessment of variability present in any crop species is an essential pre requisite for formulating an effective breeding programme, as the existing variability can be used to enhance the yield level of cultivars after following appropriate breeding strategies.

Methods: The present investigation was carried out during the *Kharif* season of the year 2019. The field experiment was carried out at Pulses Research Station, NAU, Navsari in randomized block design. The study was undertaken on fifty three genotypes of cowpea to know the variability present among genotypes for thirteen traits and correlation and path analysis of yield components.

Result: Analysis of variance indicated significant genotypic differences for all the characters under study. The highest GCV was recorded for plant height, pods per plant, pods per cluster, seed yield per plant, straw yield per plant, 100 seed weight and harvest index. High heritability coupled with high genetic advance was exhibited by days to 50 per cent flowering, days to maturity, plant weight, seed yield per plant, 100 seed weight, pod length, pods per cluster and seeds per pod indicating the presence of additive gene action. Seed yield per plant was found to be positively and significantly correlated with pods per plant, pods per cluster, pod length, days to 50 per cent flowering and straw yield per plant or seed yield per plant. The present study has indicated the need for giving due weightage to pods per plant, pods per cluster, seeds per pod, 100 seed weight, pod length with straw yield per plant for improving seed yield in cowpea.

Key words: Correlation, Cowpea, Genetic variability, Path analysis, Pulse.

INTRODUCTION

Pulses are the chief components of the agricultural system, effectively boosting food and nutrition, revenue and environment across the globe and hence assumed ideal for acquiring food security in the developing world including India. Even though India is the leading producer of pulses with 26% of the total world production, obtained from about 35% of the total world area, yet a prominent yield gap of 18% exists. Cowpea is also called as vegetable meat as it is rich in protein and can fulfill protein requirements especially in low income families and helps in fight against malnutrition.

Cowpea [*Vigna unguiculata* (L.) Walp] is self pollinated crop, belongs to family Fabaceae and sub family Papillonaceae with chromosome number 2n = 2X = 22. It is an important multipurpose grain legume extensively cultivated in arid and semi arid regions of Sub-Saharan Africa, Asia, Central and South America. It is used as dry seed or green pod as vegetable or as forage crop. It is a source of protein, vital nutrient for healthy growth in humans and livestock. Its leaves, green pods and grain or consumed as a dietary source of protein (Ghaly *et al.,* 2010). Estimation of genetic variability parameters in the foremost step to be adopted in the source population, if the breeding programme is aimed at improving economically important traits. The assessment of variability present in any crop species is an essential pre requisite for formulating an effective breeding programme, as the existing variability can be use to enhance the yield level of cultivars following appropriate breeding strategies. The information on heritability alone may not help to identify characters for selection whereas heritability estimates in conjunction with predicted genetic advance are more reliable (Johnson *et al.*, 1955). Heritability provides the information on the magnitude of inheritance of characters from parents to off springs, while genetic advance will be helpful in finding the actual gain expected under selection. Estimation of correlation coefficient among the yield contributing variable is necessary to understand the direction of selection and to maximize yield in the shortest period of time. Genetic correlation indicates the relative importance of character(s) on which greater emphasis should be made in selection for yield. However, as the number of variables

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How to cite this article: Gupta, S., Intwala, C.G. and Ganesh, S.S. (2022). Genetic Variability, Correlation and Path Analysis in Cowpea [*Vigna uinguiculata* (L.) Walp]. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-5846.

Submitted: 10-06-2021 **Accepted:** 17-02-2022 **Online:** 11-04-2022

in the correlation study increases the direct and indirect association between yield and particular character becomes complex. It only reveals the direction and magnitude of association between any two characters but the path coefficient analysis helps in partitioning the correlation into direct and indirect effect of various yield components on yield. The success of a systemic breeding programme depends mainly on judicious selection of promising parent from the gene pool, a clear understanding of genetic mechanism involved in combining ability, heritability, genetic advance and association of different yield attributing characters with yield, which helps the breeder in deciding the appropriate breeding procedure towards the genetic potentials. Hence, the present investigation was taken up to study the association of yield and its components traits in cowpea.

MATERIALS AND METHODS

The present study comprises a set of selected 53 genotypes of cowpea. This work shown during *Kharif*-2019 at pulses research station, NAU, Navsari, Gujarat in randomized block design, with a spacing of about 45×15 cm in three replications and standard agronomic practices were followed. Five random plants were selected and tagged from each genotype and recorded the observations on thirteen characters (days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, pods per plant, pods per cluster, pod length (cm), seeds per pod, seed yield per pod (g), straw yield per plant (g), 100 seed weight (g), harvest index (%) and protein content (%).

Genetic variability parameters *viz*., mean, variance, phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), heritability (h^2bs) and Genetic Advance (GA) among characters were calculated by following the standard procedures with help of INDOSTAT software. The path coefficient analysis was performed according to Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the genotypes for all the characters studied which indicated the presence of sufficient variability for the character which could be utilized in further breeding programmes (Table 1).

The mean performance of all genotypes is presented in Table 2. The variation among different genotypes for mean value for all characters in the study can be observed. The range of values indicated the good scope for selection of suitable basic material for breeders for further improvement. The mean values for each character play an important role in selection.

The estimates of mean genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability (h^2bs) and genetic advance over mean (GAM) for different characters are presented in Table 3. The phenotypic coefficient of variation was found to be higher than the genotypic coefficient of variation for all the traits under study. High values of phenotypic and genotypic variations were recorded for important traits like plant height, pods per plant, pods per cluster, seed yield per plant, straw yield per plant, 100 seed weight and harvest index indicating the existence of sufficient variability among the genotypes studied. These results are in agreement with the results of Singh *et al.,* (2017), Dinakar *et al.,* (2018), Gupta *et al.,* (2019) and Thouseem *et al*., (2018). The genotypic coefficient of variation ranged from 60.04% for plant height to 3.24% for protein content. Moderate GCV and PCV for days to 50 per cent flowering, number of branches per plant, pod length, seeds per pod and days to maturity whereas low for protein content. These results are in agreement with Thouseem *et al*., (2018) and Chaudhary *et al.,* (2020). But the difference between PCV and GCV was narrow for days to days to 50 per cent flowering, plant height and days to maturity indicated that influence of environment on the expression of traits was little or negligible, hence selection would be effective for all these traits. For different characters range of heritability broad sense varied from 3.24 to 97.6 per cent (Table 3). The highest heritability was shown for plant height (97.6%) followed by days to maturity (94.4%), days to 50 per cent flowering, 100 seed weight (89.3) and seed yield per plant (88.9%). Genetic advance as per cent of mean ranged from 122.18 for plant height to 3.74 for protein content. For seed yield per plant also recorded a high genetic advance (64.23%). High genetic advance indicated that editor genes govern these characters and selection will be rewarding for improvement of these traits (Sarath and Reshma, 2017). High heritability coupled with high genetic advance was recorded for the traits, days to 50 per cent flowering, days to maturity, plant height, seeds per plant, 100 seed weight, pod length, seed yield per plant, pods per plant, pods per cluster and seeds per pod which indicates that selection will be effective for improving these traits. Moderate heritability coupled with high genetic advance was observed in the number of branches per plant and harvest index. Similar results were reported by Dinakar *et al.,* (2018), Thouseem *et al*., (2018) and Chaudhary *et al.,* (2020). Similarly moderate heritability coupled with low genetic advance was observed in protein content. This might be attributed to the fact that the parental genotypes might have possessed both additive and /or non additive genes for these traits in different magnitudes and as a result of more pronounced expression of non additive genes moderate heritability with low genetic advance was noticed. The findings were also collaborated with findings of Chaudhary *et al.,* (2020).

The phenotypic and genotypic correlation coefficient between different characters is presented in Table 4. Genotypic coefficient of correlation in general, were greater in magnitude than the corresponding phenotypic ones, indicating that there was an inherent association among various characters and phenotypic expression of correlation was lessened under the influence of environment. Similar

Table 1: Analysis of variance for thirteen characters of cowpea.

Characters	Mean sum of square		
	Replication (df =2)	Genotypes (df=52)	Error (df=104)
Days to 50 per cent flowering	2.77	213.51**	4.14
Plant height (cm)	135.24	4497.92**	36.70
Number of branches per plant	3.25	1.37**	0.27
Pods per plant	10.79	37.52**	5.78
Pods per cluster	0.046	1.11**	0.078
Pod length (cm)	1.31	18.41**	2.77
Seed per pod	2.75	10.13**	1.18
Days to maturity	3.64	213.28**	4.14
Seed yield per plant (g)	0.34	48.66**	1.95
Straw yield per plant (g)	31.97	267.94**	38.40
100 seed weight (g)	0.26	29.30**	1.13
Harvest index (%)	5.57	87.12**	19.63
Protein content (%)	3.09	2.65**	1.12

*, ** significant at 5% and 1% level of significance, respectively.

Table 2: Mean performance of cowpea genotypes for various quantitative traits.

Genotypes	DF	PH	NB	PPP	PPC	PL	SPP	DM	TW	SYP	StYP	HI	PC
NC-19-309	57.33	29.93	3.67	9.27	2.67	15.36	11.93	82.33	9.63	14.31	17.34	16.94	22.33
NC-19-11	56.00	53.33	4.63	7.60	2.80	14.47	12.80	79.67	10.03	9.71	27.24	26.51	20.62
NC-19-41	57.33	62.32	4.93	6.82	2.00	14.69	9.53	83.67	17.67	11.50	20.11	29.68	22.33
NC-19-65	58.67	83.73	4.80	10.54	2.80	15.17	11.13	83.00	9.33	10.92	31.35	20.70	21.12
NC-19-317	58.67	35.80	3.00	7.47	2.00	10.33	9.20	81.00	10.43	7.18	26.99	13.76	20.89
NC-19-305	51.00	54.65	4.53	5.82	2.67	14.52	9.13	74.33	17.57	9.30	30.28	20.27	22.02
NC-19-232	56.67	41.88	3.99	7.27	3.87	17.31	14.00	81.67	13.53	14.11	51.30	22.39	22.81
NC-19-263	60.67	64.92	3.50	6.12	2.33	15.69	13.27	84.00	12.10	9.81	21.28	24.32	21.87
NC-19-128	58.67	44.10	3.75	5.93	2.93	14.07	10.93	79.00	11.13	7.26	16.34	22.45	21.00
NC-19-29	60.67	32.28	5.32	13.80	4.00	18.03	13.47	86.67	10.47	19.42	32.36	34.18	23.56
NC-19-279	56.67	138.10	2.46	8.20	3.80	14.82	14.47	83.67	17.17	20.32	30.11	31.02	23.65
NC-19-327	47.33	34.45	3.25	8.68	3.60	12.30	9.73	66.00	17.03	14.38	38.85	24.83	21.39
NC-19-249	38.33	34.70	3.78	7.19	2.00	12.21	10.47	61.33	9.53	7.15	12.45	14.83	21.18
NC-19-13	70.33	51.37	4.15	14.54	4.00	14.13	14.93	92.33	8.60	18.67	44.20	24.16	22.97
NC-19-70	36.33	157.53	3.20	10.21	3.00	22.05	13.87	57.67	9.27	13.20	30.05	25.71	21.07
NC-19-3	73.33	60.37	3.62	7.92	2.00	13.99	14.40	91.00	6.40	7.26	14.70	22.86	22.38
NC-19-261	45.67	41.53	3.78	8.95	2.00	12.07	8.93	69.33	9.10	7.34	16.05	15.15	20.26
NC-19-300	60.67	78.05	4.97	7.33	2.87	15.40	13.53	82.33	10.77	10.69	17.65	25.39	20.87
NC-19-30	42.00	46.43	3.45	6.00	2.00	17.45	12.87	70.67	16.20	12.47	32.17	26.03	20.58
NC-19-325	58.67	37.96	4.19	8.67	2.87	17.05	13.87	79.33	10.47	12.59	24.18	30.89	22.07
NC-19-306	43.67	41.03	5.47	7.16	2.87	17.24	12.47	68.67	13.43	12.09	21.34	27.69	22.50
NC-19-24	60.00	27.02	3.40	9.55	2.00	12.73	12.33	84.67	6.17	7.25	19.20	22.41	21.36
NC-19-93	57.33	54.99	4.28	8.73	3.00	15.47	12.33	84.67	10.50	11.40	26.12	28.76	22.35
NC-19-310	71.33	68.93	4.28	6.01	2.00	11.85	11.00	87.00	11.50	7.60	10.82	24.80	20.93
NC-19-6	63.67	40.42	4.04	10.00	3.00	14.59	13.80	87.33	8.53	11.74	18.15	29.14	22.28
AVCP-1	60.67	64.10	3.48	16.87	2.67	13.51	11.13	82.67	8.57	16.18	27.60	20.20	22.63
NC-19-293	54.00	110.89	3.88	4.13	2.93	13.87	14.07	81.33	16.50	9.65	36.91	18.04	21.16
NC-19-92	71.33	27.32	3.75	5.20	2.00	15.63	12.47	92.67	11.93	7.71	26.53	22.39	22.51
NC-19-316	46.33	48.37	2.92	4.60	2.93	15.66	12.67	62.33	13.07	7.60	26.18	17.85	21.57
NC-19-238	53.67	42.01	4.83	10.40	3.00	16.74	13.33	83.00	10.73	14.86	23.73	28.90	22.03
NC-19-307	52.33	29.02	4.32	4.60	2.67	17.28	11.80	78.67	17.87	9.69	22.03	18.30	23.82
NC-19-217	56.00	26.62	3.90	10.27	2.67	14.97	9.80	79.00	7.40	7.44	11.21	11.85	21.59

Table 2: Continue...

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NC-19-292	62.00	79.90	3.17	7.47	2.87	16.89	15.87	85.33	10.50	12.35	13.28	34.78	23.23
NC-19-32	64.33	109.44	4.67	9.53	3.33	18.35	15.00	87.00	12.20	17.42	36.30	34.61	21.11
NC-19-314	59.67	43.17	5.17	10.07	3.00	12.64	11.27	81.00	8.63	9.85	29.77	26.96	21.72
NC-19-315	67.33	177.53	3.98	7.60	3.00	17.98	13.00	85.67	15.40	15.21	32.96	26.08	21.43
NC-19-14	62.67	26.76	3.90	6.47	2.33	9.72	13.87	84.67	8.53	7.63	26.67	26.37	22.92
GDVC-2	53.67	37.00	4.82	12.00	3.00	14.52	13.20	75.67	10.90	17.24	16.53	22.86	23.00
NC-19-27	65.67	113.34	4.17	8.67	3.00	17.25	15.00	87.67	10.87	13.96	27.72	29.10	22.21
NC-19-120	62.67	51.75	5.06	9.67	4.00	15.33	14.53	84.33	14.93	20.95	38.56	29.20	23.20
NC-19-230	46.67	37.30	4.43	5.67	2.33	17.83	10.93	67.67	8.47	9.07	36.51	22.80	22.01
NC-19-26	49.67	133.82	3.82	20.67	3.87	14.02	13.47	71.67	14.67	18.97	16.41	33.09	22.13
NC-19-58	48.67	136.56	4.93	7.43	2.33	17.82	8.87	73.67	13.23	7.95	50.32	24.74	22.69
NC-19-304	58.67	25.22	3.52	8.47	3.00	12.43	14.87	84.00	12.07	14.67	17.64	20.30	21.65
NC-19-319	43.33	83.34	4.80	6.80	2.93	11.21	12.20	63.00	6.37	8.19	11.34	27.07	21.43
NC-19-206	63.67	54.58	3.70	7.80	3.00	17.77	14.13	88.00	11.73	11.94	29.00	26.65	22.15
NC-19-129	61.67	70.93	4.06	11.53	3.47	14.35	10.53	85.33	9.97	15.40	28.11	22.89	21.92
NC-19-324	55.33	148.20	3.30	7.67	2.47	10.82	9.73	83.00	10.87	7.36	17.71	18.84	21.71
GC-4	47.00	37.50	4.55	4.47	2.27	13.82	11.87	79.00	12.80	8.15	17.65	18.79	24.66
NC-19-195	60.67	52.11	3.80	20.57	3.87	14.25	11.40	83.67	9.83	16.02	20.86	27.01	22.88
NC-19-329	51.67	33.64	3.23	14.00	3.67	9.48	14.80	76.67	15.37	18.27	25.18	17.74	21.30
GC-5 (LC)	43.33	59.55	4.78	11.70	3.87	12.55	12.80	63.00	6.83	12.49	22.20	28.83	22.22
GC-3 (NC)	54.33	128.48	4.12	11.67	2.87	14.72	11.40	88.00	9.20	8.47	27.00	27.91	23.84
Mean	56.19	64.23	4.07	8.98	2.88	14.80	12.42	79.60	11.43	11.93	25.41	24.32	22.06
C. D. 5%	3.53	9.81	0.85	3.89	0.45	2.70	1.76	3.29	1.72	2.26	10.00	7.17	1.71
Lowest value	36.33	25.22	2.46	4.13	2.00	9.48	8.87	57.67	6.17	7.15	10.82	11.85	20.26
Highest value	73.33	177.53	5.47	20.67	4.00	22.05	15.87	92.67	17.87	20.95	51.30	34.78	24.66
CV%	3.88	9.43	12.87	26.79	9.69	11.25	8.74	2.55	9.28	11.70	24.31	18.22	4.80

DF: Days to 50 per cent flowering. PPC: Pods per cluster. PPP: Pods per plant.
DM: Days to maturity. SPP: Seed per pod. TW: 100 Seed weight (g).
PH: Plant height (cm). PL: Pod length (cm). SYP: Seed yield per plant (g).
NB: Branches per plant. HI: Harvest Index (%). StYP: Straw yield per plant (g).
PC: Protein content (%).

Table 3: Estimates of genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic advance as per cent of the mean for thirteen different characters of cowpea.

Characters	PCV (%)	GCV (%)	Heritability (h^2bs)	GAM (%)
Days to 50 per cent flowering	15.35	14.85	93.6	29.59
Plant height (cm)	60.77	60.04	97.6	122.18
Branches per plant	19.65	14.84	57.1	23.105
Pods per plant	45.07	36.24	64.7	60.02
Pods per cluster	22.61	20.43	81.7	38.04
Pod length (cm)	19.09	15.43	65.3	25.68
Seeds per pod	16.43	13.90	71.7	24.26
Days to maturity	10.80	10.49	94.4	20.99
Seed yield per plant (g)	35.08	33.07	88.9	64.23
Straw yield per plant (g)	42.32	34.53	66.6	58.05
100 seed weight (g)	28.36	26.80	89.3	52.17
Harvest index (%)	26.69	19.50	53.4	29.36
Protein content (%)	5.79	3.24	31.4	3.74

Table 4: Genotypic and phenotypic correlations of seed yield per plant (g) with other characters in 53 genotypes of cowpea.

Characters		DF	PH	NB	PPP	PPC	PL	SPP	DM	StYP	TW	HI	PC
DF	r_g	1	-0.02	-0.006	0.1	0.04	-0.05	0.33**	0.92**	0.04	-0.14	0.25**	0.22**
	r_p	1	-0.02	-0.02	0.08	0.4	-0.03	0.27**	0.90**	0.03	-0.13	0.15	0.09
PH	r_g		1	-0.13	0.1	0.15	0.31**	0.1	-0.003	0.21**	0.18*	0.35**	-0.05
	r_p		1	-0.09	0.09	0.14	0.24**	0.06	-0.0001	0.18*	0.15	0.25**	-0.03
NB	r_g			1	0.03	0.13	0.23**	-0.11	0.02	0.12	-0.08	0.41**	0.17*
	r_p			1	0.002	0.09	0.15	-0.06	0.02	0.1	-0.06	0.21**	0.15
PPP	r_g				1	0.63**	-0.11	0.11	0.11	0.01	-0.27**	0.26**	0.23**
	r_p				1	0.47**	-0.07	0.1	0.06	-0.03	-0.21*	0.24**	0.08
PPC	r_g					1	0.17*	0.49**	0.03	0.40**	0.14	0.52**	0.39**
	r_p					1	0.09	0.36**	0.03	0.32**	0.15	0.31**	0.18*
PL	r_g						1	0.28**	-0.01	0.46**	0.19*	0.46**	0.21**
	r_p						1	0.27**	-0.01	0.25**	0.16*	0.30**	0.14
SPP	r_g							1	0.32**	0.13	-0.01	0.58**	0.25**
	r_p							1	0.26**	0.05	0.01	0.38**	0.18*
DM	r_g								1	0.08	-0.05	0.25**	0.43**
	r_p								1	0.05	-0.05	0.15	0.20**
StYP	r_g									1	0.37**	0.24**	0.21**
	r_p									1	0.27**	0.07	0.04
TW	r_g										1	0.06	0.12
	r_p										1	0.05	0.1
HI	r_g											1	0.39**
	r_p											1	0.19*
PC	r_g												1
	r_p												1
SYP	r_g	0.15	0.15	0.05	0.67**	0.83**	0.25**	0.50**	0.17*	0.37**	0.29**	0.53**	0.36**
	r_p	0.13	0.13	0.06	0.53**	0.70**	0.23**	0.52**	0.15	0.26**	0.28**	0.41**	c

*, ** Significant at 5.0 and 1.0 per cent level, respectively.

Residual effect = 0.312 (genotype).

results were reported by Walle *et al.,* (2018). Seed yield per plant was highly significant and positively correlated with pods per plant (0.67**), pod length (0.25**), pods per cluster (0.83**), seeds per pod (0.50**), straw yield per plant (0.36**), 100 seed weight (0.29**) and harvest index (0.59**) at both genotypic and phenotypic levels indicating mutual association of these traits. It could be suggested from correlations estimates that yield could be improved through selection based on either of these characters. It is also significantly and positively correlated with days to maturity (0.17*). These findings are in agreement with those of Meena *et al.,* (2015), Lal *et al.*, (2018), Walle *et al.,* (2018), Waghmare *et al.,* (2019) and Chaudhary *et al.,* (2020).

In path coefficient analysis, where the total genetic association between seed yield per plant and other characters revealed that maximum direct contribution was made by pods per plant (0.67) followed by 100 seed weight (0.44), seed per pod (0.30), pods per cluster (0.17), pod length (0.13), days to 50 per cent flowering (0.10) and straw yield (0.06). These results are in according with Patel *et al.,* (2016), Kwon-Ndung and Kwala (2017), Gupta *et al.,* (2019) and Waghmare *et al.*, (2019) (Table 5). Days to maturity (-0.06), harvest index (-0.01) and protein content (-0.05) showed a highly significant and positive correlation with seed yield per plant but have a negative direct effect, this indicated that direct selection would be rewarding for improvement in seed yield *via* these traits.

The residual effect determines how best the causal factor amounts for the variability of the dependent factor that is yield per plant in this study. In the present investigation the residual effect of path coefficient was 0.312 which indicated that about 70% of the variability in seed yield per plant was contributed by different characters studied. These residual effects towards seed yield per plant in present study might be due to other characters or environmental factors or sampling error (Sengupta and Kataria, 1971). Based on the above results the traits such as pods per plant, pods per cluster, seeds per pod, 100 seed weight, pod length, straw yield per plant were important yield contributing traits which were positive and significantly correlated with seed yield contributing traits which were positive and significantly correlated with seed yield per plant and also showed direct effect on seed yield per plant. Therefore, these traits shall be used as selection criteria for the improvement of yield directly in cowpea.

Conflict of interest: None.

Table 5: Genotypic path coefficient analysis depicting direct effect and indirect effects of twelve different traits on seed yield per plant of cowpea.

Characters	DF	PH	NB	PPP	PPC	PL	SPP	DM	TW	StYP	HI	PC
DF	0.10	-0.002	-0.0006	0.01	0.004	-0.01	0.03	0.09	-0.01	0.004	0.03	0.02
PH	0.002	-0.10	0.01	-0.01	-0.02	-0.03	-0.01	0.0003	-0.02	-0.02	-0.03	0.005
NB	-0.0002	-0.005	0.04	0.001	0.005	0.01	-0.004	0.001	-0.003	0.005	0.02	0.01
PPP	0.07	0.07	0.02	0.67	0.42	-0.07	0.07	0.08	-0.18	0.01	0.17	0.15
PPC	0.01	0.03	0.02	0.11	0.17	0.03	0.08	0.005	0.02	0.07	0.09	0.07
PL	-0.01	0.04	0.03	-0.01	0.02	0.13	0.04	-0.008	0.02	0.06	0.06	0.03
SPP	0.10	0.03	-0.03	0.03	0.15	0.09	0.31	0.10	-0.002	0.04	0.18	0.08
DM	-0.06	0.0002	-0.001	-0.01	-0.001	0.0004	-0.02	-0.06	0.003	-0.005	-0.02	-0.03
TW	-0.06	0.08	-0.04	-0.12	0.06	0.08	-0.003	-0.02	0.44	0.16	0.03	0.05
StYP	0.002	0.01	0.01	0.001	0.02	0.03	0.01	0.005	0.02	0.06	0.01	0.01
HI	0.003	0.003	0.004	0.003	0.01	0.005	0.01	0.002	0.001	0.002	-0.01	0.004
PC	-0.01	0.002	-0.01	-0.01	-0.02	-0.01	-0.01	-0.02	-0.01	-0.01	-0.02	-0.05
Correlation with SYP	0.15	0.15	0.05	0.67**	0.83**	0.25**	0.50**	0.17*	0.29**	0.37**	0.53**	0.36**

*, ** Significant at 5.0 and 1.0 per cent level, respectively. Residual effect = 0.312 (Bold figures show direct effect).

DF: Days to 50 per cent flowering.
PPC: Pods per cluster.
PPP: Pods per plant.
DM: Days to maturity.
SPP: Seed per pod.
TW: 100 Seed weight (g).
PH: Plant height (cm).
PL: Pod length (cm).
SYP: Seed yield per plant (g).
NB: Branches per plant.
HI: Harvest Index (%).
StYP: Straw yield per plant (g).
PC: Protein content (%).

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