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Genetic divergence studies in cowpea *Vigna unguiculata* (L.) Walp

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Abstract
The higher genotypic variance and phenotypic variance was observed in Fruit yield plant -1 (gm) followed by Total soluble solids (Brix0), higher genotypic coefficient of variance (GCV) was observed ni Seed Weight/ Plant (g) (44.61) followed by Seed Yield (kg/ha) (35.47), Higher phenotypic coefficient of variance (PCV) was observed for Seed Weight/ Plant (g) (44.71) followed by Seed Yield (kg/ha) (35.63), High heritability coupled with high genetic advance (% of mean) was observed for characters like seed weight per plant (100 & 91.70) followed by seed yield (99 & 72.71), Nodes on main stem (0.5610), days to first pod formation (0.2192), days to first flowering (0.2870), days to 50% flowering (0.3033), days to 50% maturity (0.0849), peduncles per plant (0.2560), pods per peduncle (0.1202), pods per plant (0.6711), dry pod weight (0.6292), seeds per pod (0.4325), seeds per plant (0.7879), seed weight per plant (0.6573), TSS (0.2406), protein content % (0.1948), pod yield (0.8015), showed significant positive correlation with seed yield (kg/ha) at genotypic level., while at phenotypic level Nodes on main stem (0.5309), days to first pod formation (0.2200), days to first flowering (0.2837), days to 50% flowering (0.3005), days to 50% maturity (0.0838), peduncles per plant (0.2481), pods per peduncle (0.1064), pods per plant (0.6654), dry pod weight (0.6153), seeds per pod (0.4279), seeds per plant (0.7841), seed weight per plant (0.6534), TSS (0.2222), protein content % (0.1712), pod yield (0.8009), showed significant positive correlation with seed yield (kg/ha) at phenotypic level.

Keywords: Cowpea, correlation, genetic variability, genetic advance, GCV, PCV, heritability

Introduction
Cowpea, *Vigna unguiculata* (L.) Walp, Leguminosae (2n= 2x = 22), is an essential food crop in less-developed countries of the tropics and subtropics, especially in sub- Saharan Africa, Asia, and Central and South America (Singh *et al*., 1997) [16]. The wild forms are endemic to Africa (Pasquet, 1999; Coulibaly *et al*., 2002) [12, 3]. It is the second most important grain legume crop after groundnut as well as second only to cereals (Blade *et al*., 1997) [2]. Because the cowpea is native to West Africa where wild and weedy forms exist in many parts of the region (Ng and Marechal, 1985) [9], it is one of the most variable species and genetic variability is the basis of genetic enhancement (Singh, 2003) [15].
The chemical composition (%) of cowpea seeds is summarized as follows Carbohydrates (56-66), Protein (22-24), Water (11), Crude fibre (5.9-7.3), Ash (3.4-3.9), Fat (1.3-1.5), Phosphorus (0.146), Calcium (0.104-0.076), Iron (0.005). (Kay, 1979; Tindall, 1983; Quass, 1995) [6, 17, 13]
Genotypes can be identified by its phenotypic expression, while genetic advance aids in exercising the necessary selection pressure. The knowledge of heritability and genetic advance guides the breeder to select superior parents to initiate an effective and fruitful crossing programme (Johnson *et al*., 1955) [5]. The assessment of variation provides us a correct picture of the extent of variation, further helping us to improve the genotypes.
Correlation coefficient is a statistical measure which is used to find out the degree (strength) and direction of relationship between two or more variable. In plant breeding, correlation coefficient analysis measures the mutual relationship between various plant characters and determines the components characters on which selection can be based for genetic improvement in yield. A positive correlation between desirable characters is favorable to the plant breeder because it helps in simultaneous improvement of both the characters. A negative correlation, on the other hand, will hinder the simultaneous expression of both the characters with high values. In such situations some economic compromise has to be made. The genetic improvement in dependent traits can be achieved by applying strong selection to a character which is genetically correlated with the dependent character.

This is called correlated response (Jibouri *et al*., 1958) [4]. Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects (Wright, 1921) [18]. In other words, it measures the direct and indirect contribution of various independent characters on a dependent character. The information obtained by this technique helps in indirect selection for genetic improvement of yield. Selection for a component trait with a view to improve yield is called indirect selection, while selection for yield per se is termed as direct selection. A greater yield response is obtained when the character for which indirect selection is practiced has a high heritability and a high correlation with yield. Searle (1965) [14] has given the minimum combinations of heritability and correlation coefficient values necessary for indirect selection to be more efficient than direct selection for yield.

The efficiency of selection and proper handling of segregating generations depends upon the knowledge on nature and magnitude of genetic variability. The extent of genetic and non-genetic components of variation formulates the proper breeding program me to reach the goal. Higher genetic variation affords a scope for selection. Selection based on multiple traits is always better than selection based on yield alone. As we know that yield is a quantitative character controlled by many genes, an adequate knowledge about the magnitude and degree of association of yield with its attributing characters is of great significance to the breeders, through which they can clearly understand the strength of correlated traits, when they have to exercise selection for simultaneous improvement of more than one character. However, correlation alone does not provide information on the contribution of related characters, which necessitates the study of cause and effect relationship of different characters among themselves. Therefore, the path analysis depicts the exact relationship of characters thereby providing more information than correlation.

Basically these techniques aim to improve a dependent character like yield when the independent characters have a significant relation in desirable direction and positive direct effect or indirect effect through other traits on the dependent characters.

Genetic diversity is one of the criteria of parent selection in the hybridization programme. The availability of transgressive segregant in any breeding program depends upon the diversity between the parents involves. The quantification of genetic diversity through biometrical procedures such as Mahalanobis's D^2-statistic has made possible to choose genetically diverged parents. Recent works indicated that the Mahalanobis generalized distance (D^2-statistic) may be an efficient tool in the quantitative estimation of genetic diversity (Mahalanobis, 1936) [7]. The divergence analysis has a definite role to play in an efficient choice of divergent parents for hybridization to exploit maximum heterosis. The present study was undertaken to select the divergent parent for future hybridization programme.

Material and Methods

The present investigation was conducted during kharif season at Vegetable Research Farm, Department of Horticulture, Allahabad School of Agriculture, SHUATS, Prayagraj (Uttar Pradesh) during July 2019 to October 2019. The planting materials for the present study comprised of the 20 genotypes (released varieties, breeding lines and local collection) which were collected from IIVR, Varanasi (Table-1). The data were recorded on both quantitative and qualitative traits like plant height at first flowering, Plant height at maturity, No. of nodes on main stem, Days to First flower formation, **,** days to first pod formation, days to 50% flowering, days to 50% maturity , no. of pods per peduncle, no. of pods per plant, no. of peduncles per plant, Dry pod weight(g.), pod length in cm., pod yield kg. per hectare, Test weight (g), seed yield kg. per hectare, no. of seeds per pod, no. of seeds per plant, seed weight per plant, Protein content(%) and Total soluble solids (Brix0) were taken into parameters studied. The analysis of variance was done as suggested by Panse and Sukhatme (1957) [11]. Variability for different characters were estimated as suggested by Burton (1952). Expected genetic advance was calculated according to Mahalanobis (1936) [7]. Correlation coefficient analysis Jibouri *et al*., 1958 [4].

Table 1: List of genotype

S. No.	Name of Varieties	Source of Genotypes	S. No.	Name of Varieties	Source of Genotypes
01.	Kashi Shyamal	IIVR, Varanasi	11.	EC 399251	IIVR, Varanasi
02.	EC58905	IIVR, Varanasi	12.	IC202804	IIVR, Varanasi
03.	EC 572715	IIVR, Varanasi	13.	Kashi Gauri	IIVR, Varanasi
04.	IC209711	IIVR, Varanasi	14.	Kashi Kanchan	IIVR, Varanasi
05.	IC249588	IIVR, Varanasi	15.	IC97797	IIVR, Varanasi
06.	EC 1738	IIVR, Varanasi	16.	IC201098	IIVR, Varanasi
07.	IC202280	IIVR, Varanasi	17.	IC202526	IIVR, Varanasi
08.	EC 390213	IIVR, Varanasi	18.	Kashi Unnati	IIVR, Varanasi
09.	IC202526	IIVR, Varanasi	19.	Kashi Nidhi	IIVR, Varanasi
10.	EC97738	IIVR, Varanasi	20.	IC34009	IIVR, Varanasi

Result and Discussion

Genetic components of variability

In the present study the genetic estimates of variability indicated the existence of considerable amount of genetic variability for all the characters. Both genetic and non-genetic components are responsible for total variance which could be split into genetic and phenotypic variance.

With a view to understand the extent to which the observed variation are due to genetic factors, the phenotype variance (PV) and genotype variance (GV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense variability (h^2), genetic advance (GA) and genetic advance over mean (GAM) were worked out and presented in table 3. The data revealed the existence of large amount of variability for the most of the characters studied.

Higher genotypic variance and phenotypic variance were observed for pod yield per hectare and seed yield per hectare indicating more contribution of genetic components of these

characters. The present findings are in accordance with the findings of Nath *et al.* (2009) for higher genotypic and phenotypic variance for pod yield**.** Therefore, these characters would be considered and exploited in breeding programs for these purpose. Medium to low genotypic and phenotypic coefficient of variation were noticed for characters like days to first pod formation, TSS, days to first flowering, protein content, nodes on main stem, days to 50% flowering, days to 50% maturity, pods per peduncle, pod length, seeds per pod, test weight. PCV is higher than the GCV for all the traits.

Highest GCV and PCV were recorded for seed weight per plant (44.61, 44.71 respectively), which are in accordance with similar studies of Manggoel *et al.* (2012) [8] for high GCV and PCV for seed weight per plant; followed by seed yield (35.47, 35.63). Lowest GCV and PCV were recorded for Protein Content % (3.71, 4.02) followed by TSS (5.78, 6.18).

In the present study it is observed that the difference between GCV and PCV for most of the characters is narrow. Thus reflecting that the existing variability can be utilized in cowpea breeding programme.

The phenotypic coefficient of variability (PCV) was much larger than genotypic coefficient of variances (GCV) for all characters, indicating that all the characters under study are influenced to various degrees by the environmental factors.

Heritability and Genetic Advance

The estimates of genotype and phenotype coefficient of variation indicates the extent of genetic variability present in a given germplasm but, significance lies in the amount of heritable portion of the variation that play significant role in improvement of a trait by selection.

Heritability in its broad sense discloses the portion of variability that is attributable to genetic differences. High heritability (bs) coupled with high genetic advance is a reliable measure of the genetic gain through selection of best individual from the variable population.

Genetic advance reflects on the improvement in the performance of the selected lines over the base or original population. High genetic advance gives substantial scope for selection to improve the yield and its attributing characters. A high heritability is not always accompanied by high genetic advance as reported by (Panse, 1957) [11]. That is why high heritability coupled with high genetic advance is a reliable measure of the genetic gain.

In the present study high heritability (bs) coupled with high genetic advance at (% of mean) were observed for the characters like seed weight per plant (100 & 91.70), seed yield (99 & 72.71), plant height at flowering (100 & 71.04).

High genetic advance at 5% was observed for the characters like pod yield per hectare (3278.60), seed yield (kg/ha) (913.71), seeds per plant (426.28)**,** whereas low genetic advance at 5% was observed for characters like dry pod weight (0.94), pods per peduncle (1.05) & TSS^0 (1.47). Similar high values of genetic advance % was also reported by Nwosu *et al.* (2013) [10].

High heritability, GCV and genetic advance were reported for seed weight per plant. and seed yield (kg/ha) which could be improved by simple selection. Similar studies of high heritability, GCV and genetic advance for seed weight were reported by Ajayi *et al.* (2014) [1].

For the other characters, though the heritability was high, the genetic advance was medium to low. These characters include nodes on main stem, days to first flowering, days to 50% maturity, dry pod weight, pods per peduncle, peduncles per plant, and days to first pod formation.

Correlation Coefficient Analysis

Correlation studies with Seed Yield

Genotypical Correlation

Among the twenty (20) characters studied, Nodes on main stem (0.5610), days to first pod formation (0.2192), days to first flowering (0.2870), days to 50% flowering (0.3033), days to 50% maturity (0.0849), peduncles per plant (0.2560), pods per peduncle (0.1202), pods per plant (0.6711), dry pod weight (0.6292), seeds per pod (0.4325), seeds per plant (0.7879), seed weight per plant (0.6573), TSS (0.2406), protein content % (0.1948), pod yield (0.8015), showed significant positive correlation with seed yield (kg/ha) at genotypic level. Similar findings were reported by Manggoel *et al.* (2012) [8] for peduncles per plant, pods per plant and seed weight per plant.

Plant height at flowering (-0.0835), plant height at maturity (0.0583), pod length (-0.0485), test weight (-0.0092) showed significant negative correlation with seed yield (kg/ha) at genotypic level. The association among different characters are presented below in table 4 a and 4 b.

Phenotypical Correlation

Among the twenty (20) characters studied, Nodes on main stem (0.5309), days to first pod formation (0.2200), days to first flowering (0.2837), days to 50% flowering (0.3005), days to 50% maturity (0.0838), peduncles per plant (0.2481), pods per peduncle (0.1064), pods per plant (0.6654), dry pod weight (0.6153), seeds per pod (0.4279), seeds per plant (0.7841), seed weight per plant (0.6534), TSS (0.2222), protein content % (0.1712), pod yield (0.8009), showed significant positive correlation with seed yield (kg/ha) at phenotypic level. The present findings are in conformity with Manggoel *et al.* (2012) [8] for plant height, leaf length, number of leaves and weight of plant.

Plant height at flowering (-0.0840), plant height at maturity (0.0583), pod length (-0.0469), test weight (-0.0092) showed significant negative correlation with seed yield (kg/ha) at phenotypic level. The association among different characters are presented below in table 5 a and 5 b.

Conclusion

The results from the present investigation revealed that cowpea variety Kashi Nidhi identified as desirable with maximum pod yield. Maximum seed yield was recorded in variety EC 390213 (1963.99 kg). Maximum protein content was recorded in variety IC249588 (25.79%). Analysis of variance showed significant difference for all the characters under study, indicates that there was ample scope for selection of promising genotypes for yield improvement. Seed weight and seed yield recorded high estimates of GCV and PCV. Nodes on main stem, days to first pod formation, days to first flowering, days to 50% flowering, days to 50% maturity, peduncles per plant, pods per peduncle, pods per plant, dry pod weight, seeds per pod, seeds per plant, seed weight per plant, TSS, Protein content %, pod yield had direct positive correlation with seed yield at phenotypic and genotypic level. At genotypic and phenotypic level Nodes on main stem, days to first pod formation, days to first flowering, days to 50% flowering, days to 50% maturity, peduncles per plant , pods per peduncle, pods per plant, dry pod weight, seeds per plant, seed weight per plant, TSS, protein content %, seed yield had direct positive effect on pod yield per plant.

Table 2a Mean Performance of Cowpea for different Genotypes.

Genotype	Plant Height At Flowering	Plant Height At Maturity	Nodes On Main Stem	Days to First Pod Formation	Days to First Flowering	Days to 50% Flowering	Days to 50% Maturity	Peduncles/ Plant	Pods/ Peduncle	Pods / Plant
1 IC 209711	115.9933	135.1333	9.8667	33.6667	29.5000	39.8333	57.0000	13.0000	3.4000	27.4333
2 Kashi Unnati	97.0633	110.1200	10.4667	32.7333	28.5000	37.9000	55.6333	16.6000	2.6667	37.1000
3 Kashi Kanchan	67.1333	85.5667	12.6000	33.6000	30.4667	40.2000	54.2333	24.6667	2.6667	47.0000
4 EC 572715	56.6667	74.6000	14.4667	36.0667	32.0333	44.9000	63.7000	18.5333	2.7333	40.6333
5 EC 58905	109.0667	130.5667	17.0000	39.1333	35.4667	49.5333	66.5000	29.7333	2.8000	65.1667
6 EC 399251	77.2667	94.4000	17.3333	42.4667	37.9000	51.1667	69.3667	20.6667	2.6667	50.4333
7 Kashi Shyamal	98.9033	113.7333	13.5333	43.0000	38.4000	51.5333	68.1667	25.2000	3.7333	33.3000
8 IC 97797	67.6000	87.2667	14.5333	40.2000	36.7000	50.9000	67.9000	18.0000	3.4667	53.8000
9 IC 249588	70.5333	89.5000	17.0667	38.9333	34.7000	49.1333	62.3000	23.0667	2.6667	51.0000
10 IC 34009	86.4667	107.4333	16.0667	37.6667	33.6333	46.5000	60.8000	21.4667	2.8000	49.8333
11 Kashi Nidhi	69.2000	90.4667	12.4667	41.1333	36.6000	48.2667	61.6333	23.9333	3.3333	67.4333
12 IC 202526	88.4000	108.1333	13.2667	35.7333	32.3333	46.4333	60.1333	28.0667	2.6000	63.2333
13 EC 390213	58.5333	78.4000	14.0667	32.8667	30.2000	39.5000	43.7667	27.4667	2.7333	63.0333
14 IC 202280	80.2000	98.8333	12.2000	40.4000	36.4333	50.4000	61.8000	21.6000	3.4000	60.8000
15 EC 9738	81.8667	101.8567	15.4667	41.0000	37.0333	51.3667	66.2333	18.6667	3.5333	64.2333
16 IC 202526	104.1333	125.7200	14.0000	39.7333	36.2667	49.3667	61.4333	23.7333	2.6667	62.4100
17 Kashi Gauri	62.1333	79.9333	13.1333	33.3333	30.3667	39.8000	53.8000	29.9333	3.3333	58.5667
18 IC 202804	40.0667	57.2333	16.7333	39.4667	35.9000	50.8333	66.2000	19.0000	4.6667	73.5667
19 IC 201098	162.8000	184.4333	19.6667	38.8000	35.0333	51.8000	68.2333	12.2667	4.0000	46.2333
20 EC 1738	145.9133	165.1000	14.4000	38.1333	34.5000	45.5667	60.2667	17.5333	3.6000	33.6333
Mean	86.9970	105.9215	14.4167	37.9033	34.0983	46.7467	61.4550	21.6567	3.1733	52.4422
C.V.	1.7591	1.4498	4.7865	1.6993	1.0029	1.8298	0.7973	5.9423	7.0637	2.6168
F ratio	1156.9460	1195.7360	36.9195	78.0799	234.4483	93.6366	495.1271	46.4792	19.0335	269.1861
F Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S.E.	0.8836	0.8866	0.3984	0.3719	0.1974	0.4939	0.2829	0.7430	0.1294	0.7923
C.D. 5	2.5296	2.5383	1.1406	1.0646	0.5653	1.4139	0.8099	2.1271	0.3705	2.2683
C.D. 1	3.3882	3.3999	1.5278	1.4260	0.7571	1.8938	1.0848	2.8491	0.4963	3.0383
Range Lowest	40.0667	57.2333	9.8667	32.7333	28.5000	37.9000	43.7667	12.2667	2.6000	27.4333
Range Highest	162.8000	184.4333	19.6667	43.0000	38.4000	51.8000	69.3667	29.9333	4.6667	73.5667

Table 2b: Mean Performance of Cowpea for different Genotypes

Genotype	Dry Pod Weight (g)	Pod Length cm	Seeds/ Pod	Seeds/ Plant	Seed Weight/ Plant (g)	Test Weight	TSS %	Protein Content (%)	Pod Yield kg/ ha	Seed Yield kg/ ha
1 IC 209711	1.7167	21.2633	16.2133	337.8133	44.9167	157.8533	12.3167	22.5367	3102.2670	674.5240
2 Kashi Unnati	1.5300	15.8000	15.0333	461.4833	72.8367	172.4600	12.4400	23.9367	4019.1890	1041.9060
3 Kashi Kanchan	1.4700	14.1967	12.9233	501.0633	61.9767	147.7267	13.5067	25.4400	4403.5780	745.9366
4 EC 572715	1.4000	16.2167	13.4667	443.8667	50.7833	134.6467	12.5067	25.5267	3986.4220	576.2797
5 EC 58905	2.5433	17.7933	15.9733	924.9833	89.8767	136.3167	14.0933	25.5967	8016.6670	1879.2400
6 EC 399251	2.8300	19.4500	16.6467	751.3666	92.8633	144.3600	12.7000	23.0767	6513.8670	1802.0970
7 Kashi Shyamal	2.4667	21.3600	12.2000	312.0867	26.0167	168.0333	12.4900	24.7933	4439.2670	834.7867
8 IC 97797	2.6833	19.8333	13.6333	623.4900	38.4133	133.5333	13.8567	25.3500	6624.0000	1333.0990
9 IC 249588	2.4300	14.6033	12.1333	510.6333	67.7267	146.1567	12.7067	25.7900	6494.3330	1199.5080
10 IC 34009	2.5200	17.0233	10.6333	421.1200	51.4867	143.5533	14.3400	24.3800	6433.1000	935.3437
11 Kashi Nidhi	2.9000	15.2567	11.8000	666.9434	53.1200	125.7033	12.4300	24.5633	9136.6670	1459.6340
12 IC 202526	1.9867	18.4000	13.6667	759.8700	111.3033	148.0700	13.3467	23.3467	5239.0000	1092.5450
13 EC 390213	2.6600	14.8267	14.9000	819.8734	136.2967	165.0400	12.5067	24.3400	7478.0000	1963.9980
14 IC 202280	1.8767	19.4300	13.3667	712.1967	95.4667	126.1133	14.0933	24.0500	5606.4000	882.8350
15 EC 9738	2.0967	15.4700	12.0333	670.4700	67.5800	165.4833	12.7000	25.4533	6313.3330	1349.1300
16 IC 202526	2.6000	15.3300	14.4667	843.1900	68.0000	141.5300	14.3333	25.5267	7069.6670	1628.6580
17 Kashi Gauri	2.7933	20.1700	16.3667	827.6633	96.0733	125.1033	13.8567	25.1533	6484.0000	1442.5790
18 IC 202804	1.9767	19.1033	15.2733	1000.3130	150.3600	122.5100	12.7067	24.6767	8386.3330	1778.8260
19 IC 201098	2.6167	18.5533	14.4867	549.5567	96.8200	176.0633	14.3500	24.7400	6064.0000	1774.3110
20 EC 1738	2.4667	16.4433	13.2867	316.7633	29.1467	136.6933	12.3733	23.5033	4628.0000	736.0593
Mean	2.2782	17.5262	13.9252	622.7374	75.0532	145.8475	13.1827	24.5890	6021.9050	1256.5650
C.V.	5.5772	2.3146	1.4979	0.2147	2.9306	0.1229	2.1817	1.5517	1.4368	3.4621
F ratio	42.8088	95.8679	198.1642	71893.1300	696.1341	25882.7400	22.0676	18.1134	1019.1370	315.8175
F Prob.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S.E.	0.0734	0.2342	0.1204	0.7718	1.2699	0.1035	0.1661	0.2203	49.9525	25.1171
C.D. 5	0.2100	0.6705	0.3448	2.2096	3.6355	0.2963	0.4754	0.6307	143.0103	71.9084
C.D. 1	0.2813	0.8981	0.4618	2.9596	4.8695	0.3969	0.6368	0.8447	191.5524	96.3163
Range Lowest	1.4000	14.1967	10.6333	312.0867	26.0167	122.5100	12.3167	22.5367	3102.2670	576.2797
Range Highest Processed by	2.9000 9.3 from	21.3600 Hyderabad	16.6467 Central	1000.3130 rmplasm	150.3600 e HOSUR Date	176.0633 18 Time	14.3500	25.7900	9136.6670	1963.9980

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Table 3: Mean Performance of Cowpea Genotypes for different characters

Character	Range		Mean	GV	PV	CV		h^2	GA 5%	GA as % of
	MIN	MAX		(σ^2g)	(σ^2p)	GCV	PCV	(bs)		mean at 5%
Plant Height At Flowering (cm)	40.06	162.80	86.99	902.41	904.75	34.53	34.57	1.00	61.80	71.04
Plant Height At Maturity (cm)	57.23	184.43	105.92	939.19	941.54	28.93	28.97	1.00	63.05	59.53
Nodes On Main Stem	9.86	19.66	14.41	5.70	6.18	16.56	17.24	0.92	4.73	32.78
Days to First Pod Formation	32.73	43.00	37.90	10.66	11.07	8.61	8.78	0.96	6.60	17.41
Days to First Flowering	28.50	38.40	34.09	9.10	9.22	8.85	8.90	0.99	6.18	18.11
Days to 50% Flowering	37.90	51.80	46.74	22.59	23.33	10.17	10.33	0.97	9.64	20.62
Days to 50% Maturity	43.76	69.36	61.45	39.54	39.78	10.23	10.26	0.99	12.91	21.01
Peduncles/ Plant	12.26	29.93	21.65	25.11	26.76	23.14	23.89	0.94	10.00	46.16
Pods/ Peduncle	2.60	4.66	3.17	0.30	0.35	17.32	18.70	0.86	1.05	33.03
Pods / Plant	27.43	73.56	52.44	168.35	170.24	24.74	24.88	0.99	26.58	50.69
Dry Pod Weight (g)	1.40	2.90	2.27	0.22	0.24	20.82	21.55	0.93	0.94	41.43
Pod Length (cm)	14.19	21.36	17.52	5.20	5.37	13.02	13.22	0.97	4.63	26.40
Seeds/ Pod	10.63	16.64	13.92	2.86	2.90	12.14	12.24	0.99	3.46	24.83
Seeds/ Plant	312.08	1000.31	622.73	42822.56	42824.34	33.23	33.23	1.00	426.28	68.45
Seed Weight/ Plant (g)	26.01	150.36	75.05	1120.94	1125.78	44.61	44.71	1.00	68.82	91.70
Test Weight (g)	122.51	176.06	145.84	277.26	277.29	11.42	11.42	1.00	34.30	23.52
TSS (^{0}brix)	12.31	14.35	13.18	0.58	0.66	5.78	6.18	0.88	1.47	11.14
Protein Content (%)	22.53	25.79	24.58	0.83	0.98	3.71	4.02	0.85	1.73	7.04
Pod Yield (kg/ha)	3102.26	9136.66	6021.90	2540506.75	2547992.50	26.47	26.51	1.00	3278.60	54.44
Seed Yield (kg/ha)	576.27	1963.99	1256.56	198608.28	200500.89	35.47	35.63	0.99	913.71	72.71

Table 4a: Genotypic Correlation Matrix for seed yield

No.	Character	Plant Height At Flowering (cm)	Plant Height At Maturity (cm)	Nodes On Main Stem	Days to First Pod Formation	Days to First Flowering	Days to 50% Flowering	Days to 50 % Maturity	Peduncles/ Plant	Pods/ Peduncle	Pods / Plant
1	Plant Height at Flowering (cm)	1.0000	0.9977**	0.1471	0.0810	0.0597	0.1182	0.2075	-0.4098**	0.1334	-0.4813**
2	Plant Height at Maturity (cm)		1.0000	0.1706	0.0913	0.0745	0.1377	0.2077	-0.3949**	0.1281	-0.4407**
3	Nodes On Main Stem			1.0000	0.4823**	0.5163**	0.6582**	0.5510**	-0.0625	0.1978	0.2953*
4	Days to First Pod Formation				1.0000	0.9951**	0.9445**	0.8320**	-0.0651	0.3539*	0.2292
5	Days to First Flowering					1.0000	0.9551**	0.7976**	-0.0051	0.3767**	0.3114*
6	Days to 50% Flowering						1.0000	0.8703**	-0.1043	0.4039**	0.3341*
7	Days to 50% Maturity							1.0000	-0.3119*	0.3910**	0.0230
8	Peduncles/ Plant								1.0000	-0.4074**	0.5065**
9	Pods/ Peduncle									1.0000	0.0731
10	Pods / Plant										1.0000
11	Dry Pod Weight (g)										
12	Pod Length (cm)										
13	Seeds/ Pod										
14	Seeds/ Plant										
15	Seed Weight/ Plant (g)										
16	Test Weight (g)										
17	TSS (^{0}brix)										
18	Protein Content (%)										
19	Pod Yield (kg/ha)										
20	Seed Yield (kg/ha)	-0.0835	-0.0583	0.5610	0.2192	0.2870	0.3033	0.0849	0.2560	0.1202	0.6711

Table 4b: Genotypic Correlation Matrix for seed yield (cont.)

No.	Character	Dry Pod Weight (g)	Pod Length (cm)	Seeds/ Pod	Seeds/ Plant	Seed Weight/ Plant (g)	Test Weight (g)	TSS (^{0}brix)	Protein Content (%)	Pod Yield (kg/ha)
1	Plant Height At Flowering (cm)	0.1347	0.1428	0.0620	-0.4068**	-0.3202*	0.4586**	0.2019	-0.3007*	-0.3191*
2	Plant Height At Maturity (cm)	0.1624	0.1227	0.0478	-0.3792**	-0.3106*	0.4353**	0.2337	-0.2792*	-0.2780*
3	Nodes On Main Stem	0.4639**	-0.0476	-0.0309	0.2798*	0.2859*	0.0144	0.3173*	0.3446**	0.4749**
4	Days to First Pod Formation	0.4526**	0.2186	-0.3058*	0.1050	-0.1963	-0.1826	0.0906	0.1628	0.3965**
5	Days to First Flowering	0.4974**	0.2029	-0.2847*	0.1914	-0.1306	-0.2188	0.1563	0.2193	0.4579**
6	Days to 50% Flowering	0.3946**	0.2225	-0.2682*	0.2174	-0.0212	-0.1580	0.2706	0.2543	0.4250**
7	Days to 50% Maturity	0.1734	0.3742**	-0.1271	-0.0053	-0.2298	-0.1160	0.1618	0.1641	0.1356
8	Peduncles/ Plant	0.3128*	-0.1346	-0.0020	0.4893**	0.2724*	-0.3099*	0.1930	0.3002*	0.3957**
9	Pods/ Peduncle	0.1033	0.4922**	0.0254	0.0513	0.1150	-0.1050	-0.0720	-0.0488	0.1692
10	Pods / Plant	0.3209*	-0.2157	0.0165	0.8973**	0.6560**	-0.4452**	0.3353*	0.3639*	0.8476**
11	Dry Pod Weight (g)	1.0000	0.1189	0.0283	0.3011*	0.0325	-0.1401	0.2585	0.1044	0.6655**
12	Pod Length (cm)		1.0000	0.4004**	-0.0124	-0.0043	-0.0894	0.1216	-0.4082**	-0.1893
13	Seeds/ Pod			1.0000	0.4435**	0.4710**	-0.0333	-0.0045	-0.3167*	-0.0018

14	Seeds/ Plant				1.0000	0.7871**	-0.4054**	0.3289*	0.2296	0.7459**
15	Seed Weight/ Plant (g)					1.0000	-0.0815	0.1382	-0.0613	0.4643**
16	Test Weight (g)						1.0000	-0.1927	-0.1560	-0.4155**
17	TSS (^{0}brix)							1.0000	0.3276**	0.2519
18	Protein Content (%)								1.0000	0.3596*
19	Pod Yield (kg/ha)									1.0000
20	Seed Yield (kg/ha)	0.6292	-0.0485	0.4325	0.7879	0.6573	-0.0092	0.2406	0.1948	0.8015

Table 5a: Phenotypic Correlation Matrix for seed

No.	Character	Plant Height At Flowering (cm)	Plant Height At Maturity (cm)	Nodes On Main Stem	Days to First Pod Formation	Days to First Flowering	Days to 50% Flowering	Days to 50% Maturity	Peduncles/ Plant	Pods/ Peduncle	Pods / Plant
1	Plant Height at Flowering (cm)	1.0000	0.9972**	0.1401	0.0802	0.0584	0.1175	0.2075	-0.3950**	0.1214	-0.4778**
2	Plant Height at Maturity (cm)		1.0000	0.1654	0.0894	0.0737	0.1353	0.2074	-0.3787**	0.1137	-0.4379**
3	Nodes On Main Stem			1.0000	0.4486**	0.4971**	0.6100**	0.5222**	-0.0329	0.2027	0.2771*
4	Days to First Pod Formation				1.0000	0.9782**	0.9205**	0.8146**	-0.0650	0.3278*	0.2219
5	Days to First Flowering					1.0000	0.9357**	0.7911**	-0.0022	0.3407**	0.3057*
6	Days to 50% Flowering						1.0000	0.8625**	-0.0932	0.3648**	0.3288*
7	Days to 50% Maturity							1.0000	-0.2986*	0.3545**	0.0240
8	Peduncles/ Plant								1.0000	-0.3990**	0.4869**
9	Pods/ Peduncle									1.0000	0.0636
10	Pods / Plant										1.0000
11	Dry Pod Weight (g)										
12	Pod Length (cm)										
13	Seeds/ Pod										
14	Seeds/ Plant										
15	Seed Weight/ Plant (g)										
16	Test Weight (g)										
17	TSS (^{0}brix)										
18	Protein Content (%)										
19	Pod Yield (kg/ha)										
20	Seed Yield (kg/ha)	-0.0840	-0.0583	0.5309	0.2200	0.2837	0.3005	0.0838	0.2481	0.1064	0.6654

Table 5b: Phenotypic Correlation Matrix for seed (cont.)

No.	Character	Dry Pod Weight (g)	Pod Length (cm)	Seeds/ Pod	Seeds/ Plant	Seed Weight/ Plant (g)	Test Weight (g)	TSS (^{0}brix)	Protein Content (%)	Pod Yield (kg/ha)
1	Plant Height at Flowering (cm)	0.1255	0.1406	0.0614	-0.4064**	-0.3195*	0.4581**	0.1860	-0.2750*	-0.3182*
2	Plant Height at Maturity (cm)	0.1538	0.1208	0.0466	-0.3787**	-0.3102*	0.4348**	0.2206	-0.2549*	-0.2772*
3	Nodes On Main Stem	0.4171**	-0.0475	-0.0298	0.2686*	0.2686*	0.0137	0.3046*	0.3487**	0.4522**
4	Days to First Pod Formation	0.4404**	0.2057	-0.2964*	0.1028	-0.1939	-0.1787	0.0705	0.1595	0.3925**
5	Days to First Flowering	0.4813**	0.1951	-0.2771*	0.1900	-0.1302	-0.2177	0.1423	0.2053	0.4544**
6	Days to 50% Flowering	0.3791**	0.2188	-0.2600*	0.2140	-0.0180	-0.1557	0.2319	0.2317	0.4191**
7	Days to 50% Maturity	0.1604	0.3685**	-0.1253	-0.0053	-0.2280	-0.1157	0.1492	0.1498	0.1348
8	Peduncles/ Plant	0.2857*	-0.1312	0.0015	0.4741**	0.2637*	-0.2999*	0.2036	0.3109*	0.3828**
9	Pods/ Peduncle	0.0850	0.4455**	0.0316	0.0474	0.1034	-0.0967	-0.0758	-0.0155	0.1542
10	Pods / Plant	0.3130*	-0.1964	0.0178	0.8923**	0.6566**	-0.4425**	0.3035*	0.3224*	0.8424**
11	Dry Pod Weight (g)	1.0000	0.1199	0.0251	0.2908*	0.0354	-0.1353	0.2237	0.0625	0.6498**
12	Pod Length (cm)		1.0000	0.3939**	-0.0120	0.0039	-0.0879	0.0988	-0.3877**	-0.1853
13	Seeds/ Pod			1.0000	0.4400**	0.4698**	-0.0333	-0.0059	-0.2841*	-0.0015
14	Seeds/ Plant				1.0000	0.7854**	-0.4053**	0.3077*	0.2115	0.7447**
15	Seed Weight/ Plant (g)					1.0000	-0.0813	0.1251	-0.0613	0.4629**
16	Test Weight (g)						1.0000	-0.1804	-0.1437	-0.4149**
17	TSS (^{0}brix)							1.0000	0.3483**	0.2326
18	Protein Content (%)								1.0000	0.3260*
19	Pod Yield (kg/ha)									1.0000
20	Seed Yield (kg/ha)	0.6153	-0.0469	0.4279	0.7841	0.6534	-0.0092	0.2222	0.1712	0.8009

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