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Vanlalruati Sailo
PG Student, Department of Horticulture, NAI, SHUATS, Allahabad, Uttar Pradesh, India

Anita Kerketta
Assistant Professor, Department of Horticulture, NAI, SHUATS, Allahabad, Uttar Pradesh, India

VM Prasad
Professor, Department of Horticulture, NAI, SHUATS, Allahabad, Uttar Pradesh, India

Corresponding Author:
Vanlalruati Sailo
PG Student, Department of Horticulture, NAI, SHUATS, Allahabad, Uttar Pradesh, India

Genetic analysis of different genotypes of cowpea [*Vigna unguiculata* (L.) Walp.] Under Allahabad agro-climatic conditions

Vanlalruati Sailo, Anita Kerketta and VM Prasad

Abstract
Evaluation of twenty genotypes of cowpea was done in a field experiment designed in Randomized Block Design with three replications during kharif season of the year 2020 at Vegetable Research Farm, SHUATS, Allahabad, Uttar Pradesh. The analysis of variance revealed significant differences between genotypes indicating presence of sufficient amount of variability in all the characters. The mean replicated data on twenty genotypes for fourteen quantitative traits revealed that the maximum Green Pod Yield/ha was observed in COPBVAR-4(12.328tonnes), the earliest genotype was found to be 2019/COPBVAR-6. Close relationship between GCV and PCV was found in all the traits. High heritability coupled with high genetic advance as percentage of the mean was recorded in number of days to germination, Plant height after 40 days, number of peduncles/plant, number of branches/plant, pod length, pod girth, pod weight and green pod yield/ha.

Keywords: Correlation, cowpea, genotype, yield, GCV, PCV, heritability, genetic advance

1. Introduction
Cultivated cowpea, also called yard long bean [*Vigna unguiculata* (L.) Walp.] is a commonly grown and consumed grain legume vegetable. It is most commonly cultivated for its tender green long pods and also for seeds. Being a legume, cowpea fixes atmospheric nitrogen, some of which it uses for its growth and development and leaves some in the soil for the benefit of companion and following crops (Boukar *et al.*, 2019) [2]. The rapid growth rate of cowpea in the field enables the canopy to cover the soil thereby helping to reduce soil erosion. The available genetic resources maintained in the different gene banks are being used for the improvement of cowpea (Boukar *et al.*, 2019) [2]. The World production of the cowpea is estimated at over 8.9 million MT per year on about 14.4 million hectares (FAOSTAT 2020). Over 95% of the global production is in Africa, especially in the SSA. (ICRISAT 2017; Nkongolo *et al.* 2009). The genetic yield potential of cowpea is 1500 to 2500 kg ha^{-1} (ICRISAT 2017; Nkongolo *et al.* 2009). The available genetic resources maintained in the different gene banks are being used for the improvement of cowpea.

2. Materials and Methods
The present investigation was carried out with 20 genotypes of cowpea collected from different sources. The experiment was conducted in randomized block design with three replications during kharif season of 2020, at Vegetable Research Farm, Department of Horticulture, SHUATS, Prayagraj (U.P.), India, which is situated at about 25.41’21.3”N, longitude of 81.84’72.5”E and an altitude of 101m above mean sea level. Observation was recorded on five randomly selected plants of each genotype from each replication for the fourteen quantitative characters i.e., Number of days to germination, Plant Height after 20 days, Plant Height after 40 days, Plant Height after 60 days, Days to 1st Flower Appearance, Number of Peduncles/Plant, Number of Branches/Plant, Days to 1st Harvest, Days to Last Harvest, Number of Pods/Plant, Pod Length (cm), Pod Girth (cm), Pod Weight (cm), Green Pod Yield/ha (tonnes).

3. Results and Discussion
The analysis of variance revealed significant differences among the genotypes for all the characters under study. It indicated the presence of ample variability among the twenty genotypes under study.

Availability of ample variability in the material studied is of enormous importance for the success of any breeding programme. Under the mean analysis of the observations recorded for the twenty genotypes (Table 2), the maximum Green Pod Yield/ha was observed in COPBVAR-4 (12.328tonnes), followed by COPBVAR-3 (11.745 tonnes) and IC-202803 (10.912 tonnes) whereas the minimum Green Pod Yield per hectare was recorded in EC-1738 (2.083 tonnes), followed by IC-259085 (3.193 tonnes) and EC-390213 (3.276 tonnes). Thus, 2019/COPBVAR-3 and 2019/COPBVAR-4 outperformed the rest eighteen genotypes in terms of yield.

Table 1: Name of Genotypes

S. No.	Genotypes	Source
1	2019/COPBVAR-1	IIVR, Varanasi, Uttar Pradesh, India
2	2019/COPBVAR-2	IIVR, Varanasi, Uttar Pradesh, India
3	2019/COPBVAR-3	IIVR, Varanasi, Uttar Pradesh, India
4	2019/COPBVAR-4	IIVR, Varanasi, Uttar Pradesh, India
5	2019/COPBVAR-5	IIVR, Varanasi, Uttar Pradesh, India
6	2019/COPBVAR-6	IIVR, Varanasi, Uttar Pradesh, India
7	IC 202782	IIVR, Varanasi, Uttar Pradesh, India
8	IC 214751	IIVR, Varanasi, Uttar Pradesh, India
9	IC 202803	IIVR, Varanasi, Uttar Pradesh, India
10	IC 219594	IIVR, Varanasi, Uttar Pradesh, India
11	IC 202707	IIVR, Varanasi, Uttar Pradesh, India
12	IC 202280	IIVR, Varanasi, Uttar Pradesh, India
13	IC 202791	IIVR, Varanasi, Uttar Pradesh, India
14	IC 202835	IIVR, Varanasi, Uttar Pradesh, India
15	IC 202718	IIVR, Varanasi, Uttar Pradesh, India
16	IC 202743	IIVR, Varanasi, Uttar Pradesh, India
17	IC 259085	IIVR, Varanasi, Uttar Pradesh, India
18	IC 249588	IIVR, Varanasi, Uttar Pradesh, India
19	EC 390213	IIVR, Varanasi, Uttar Pradesh, India
20	EC 1738	IIVR, Varanasi, Uttar Pradesh, India

3.1 Genetic Components of Variability

3.1.1 Genotypic and Phenotypic Coefficient of Variation (GCV and PCV)

The estimate of genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) was ranged between 8.408 to 46.57 and 10.59 to 46.75 respectively, the highest being pod weight and the lowest is days to last harvest for both GCV and PCV(Table 3). Close relationship between GCV and PCV was found in all the traits, indicating that environmental factor had little effect on the expression of these characters. Similar report was also given by Verma *et al.* (2014) [14] and Gupta *et al.* (2019) [10]. The results of GCV and PCV were classified as suggested by Burton and Devane (1953) [3]. Characters like Green pod yield/ha, pod weight, pod girth, pod length, number of branches/plant and plant height after 60 days showed high GCV and PCV, while it was recorded to be moderate for characters like number of peduncles/plant and number of pods/plant. GCV was recorded to be low in days to first flower appearance, days to first harvest and days to last harvest. These findings are in close harmony with the findings of Manggoel *et al.* (2012) [8] and Mofokeng *et al.* (2020) [7].

3.1.2 Heritability and Genetic Advance (h^2 and GAM)

The heritability estimates along with expected genetic advance are more useful in predicting yield under phenotypic selection than heritability estimates alone (Johnson *et al.* 1955) [5]. Broad sense heritability is classified as suggested by Singh (2001) [12] and heritability coupled with genetic advance as percent of the mean was classified as suggested by Johnson *et al.* (1955) [5]. Plant height after 40 days, number of peduncles/plant, number of branches/plant, pod length, pod girth, pod weight and green pod/ha exerted very high heritability in the broad sense, the findings are in close harmony with Belay *et al.* (2021) [1] for Pod Length, Krishnan *et al.* (2019) [11] for Number of branches/plant and pod length, Kouam *et al.* (2018) [4] for pod length and pod girth, Ugale *et al.* (2020) [9] for plant height, number of primary branches per plant, pod length and mean pod weight.

Plant height after 60 days, days to first harvest and days to last harvest were moderately high. Number of pods/plant and number of days to germination were medium and plant height after 20 days and days to first flower appearance were low in terms of heritability, similar report was also given by Kouam *et al.* (2018) [4] for number of pods/plant.

The improvement in the mean performance of progeny of the selected families over the base population is known as genetic advance, when expressed as per cent of mean is called genetic gain (Johnson *et al.* 1955) [5]. According to Johnson *et al.* (1955) [5] the expected genetic advance is categorized into less than 10% as low, 10-20% as moderate and more than 20% as high expected genetic advance. In the present study, GAM ranged between 12.25 - 95.57, the highest being pod weight (95.57) and the lowest being Days to first flower appearance (12.25). High genetic advance as percent of the mean were recorded in Number of days to germination, Plant Height after 40 days, Plant Height after 60 days, Number of Peduncles/Plant, Number of Branches/Plant, Pod Length, Pod Girth, Pod Weight, Green Pod Yield/ha, while Plant height after 20 days, days to first flower appearance, Number of Pods/Plant, days to first harvest and days to last harvest showed medium GAM. Similar report in high GAM was reported in Number of branches/plant by Mofokeng *et al.* (2020) [7] and Srinivas *et al.* (2017) [13] and in pod weight by Khanpara *et al.* (2016) [6].

Furthermore, high heritability coupled with high genetic advance as percentage of the mean was recorded in number of days to germination, Plant height after 40 days, number of peduncles/plant, number of branches/plant, pod length, pod girth, pod weight and green pod yield/ha. Similar report in most of the characters was also given by Gupta *et al.* (2019) [10]. Thus, these traits showing high heritability combined with high genetic advance is an indication of additive gene action and selection based on these parameters would be more rewarding.

Table 2: Mean Performance of twenty genotypes of cowpea for fourteen traits

S. No	Genotype	DG	PH 20	PH 40	PH 60	FA	PP	BP	FH	LH	NPP	PL	PG	PW	PY(t)
1	2019/COPBVAR - 1	2.33	13.20	27.00	47.67	43.13	15.33	7.67	57.13	86.13	41.00	32.57	1.65	14.47	6.05
2	2019/COPBVAR - 2	2.33	17.40	32.00	43.63	39.60	14.67	7.33	51.80	81.47	39.33	27.87	2.75	27.00	6.33
3	2019/COPBVAR - 3	2.67	20.00	33.73	46.23	42.93	20.33	10.67	54.53	85.87	60.67	21.93	2.90	16.93	11.75
4	2019/COPBVAR - 4	2.33	21.67	33.17	50.80	40.53	14.67	7.33	50.33	84.33	43.33	23.47	2.90	27.00	12.33
5	2019/COPBVAR - 5	2.67	14.33	28.73	44.80	50.87	16.67	8.33	66.93	95.27	44.67	30.67	2.81	15.13	6.83
6	2019/COPBVAR - 6	2.00	22.00	37.60	47.63	38.33	15.33	7.67	52.74	79.74	42.00	31.60	3.09	13.73	6.89

7	IC-202782	3.33	14.07	28.17	39.90	47.73	22.33	25.33	61.20	98.87	52.33	15.13	1.75	10.07	3.97
8	IC-214751	3.67	22.00	44.73	64.87	44.60	20.33	23.33	65.20	102.87	55.00	19.27	1.81	10.87	9.50
9	IC-202803	2.33	19.00	32.87	117.00	43.53	18.67	21.67	59.47	96.47	56.67	14.07	1.66	10.07	10.91
10	IC-219594	3.33	18.33	35.13	42.53	59.00	19.67	22.67	67.00	104.00	59.00	13.33	1.33	8.93	4.83
11	IC-202707	2.33	18.33	38.53	65.47	51.87	21.67	24.67	69.07	105.73	50.33	17.80	1.13	10.00	4.41
12	IC-202280	2.00	21.33	41.73	105.00	51.73	19.33	21.33	61.67	98.67	45.33	14.27	1.43	9.53	5.83
13	IC-202791	2.67	17.67	41.47	95.93	49.13	22.67	25.67	63.53	100.53	55.00	13.00	1.32	10.53	8.05
14	IC-202835	2.67	19.00	30.53	44.43	51.27	23.33	26.33	74.07	111.40	48.00	16.13	1.32	9.13	4.67
15	IC-202718	3.67	20.33	41.07	71.93	46.73	19.33	22.33	63.00	100.67	45.00	16.00	1.00	8.20	4.91
16	IC-202743	3.67	18.33	43.53	57.67	50.20	19.00	22.00	65.73	103.40	41.00	14.60	1.21	7.73	3.33
17	IC-259085	3.33	21.67	51.67	85.03	45.93	22.67	25.33	65.00	101.67	53.00	18.33	1.10	8.93	3.19
18	IC-249588	2.33	20.67	40.73	85.67	46.40	26.33	30.00	57.00	90.67	62.33	15.87	1.14	10.00	8.27
19	EC-390213	2.33	15.33	31.07	62.17	49.73	23.67	26.67	62.13	99.47	54.00	15.53	1.02	7.67	3.28
20	EC-1738	2.33	14.33	24.13	42.73	57.60	23.33	26.33	66.93	103.93	47.67	15.27	1.54	7.80	2.08
Mean		2.72	18.45	35.88	63.06	47.54	19.97	19.63	61.72	96.56	49.82	19.34	1.74	12.19	6.37
C.V		19.59	15.68	8.09	18.12	11.61	16.80	6.08	7.05	9.19	14.13	4.27	3.78	4.12	3.60
S.Em		0.31	1.67	1.68	6.59	3.19	0.72	0.69	2.51	3.59	9.57	0.48	0.04	0.29	0.13
CD 5%		0.88	4.78	4.80	18.88	9.13	2.06	1.97	7.19	10.28	27.40	1.36	0.11	0.83	0.38
Highest		3.67	22.00	51.67	117.00	59.00	26.33	30.00	74.07	111.40	62.33	32.57	3.09	27.00	12.33
Lowest		2.00	14.07	24.13	39.90	38.33	14.67	7.33	50.33	79.74	39.33	13.00	1.00	7.67	2.08

DG=Number of Days to Germination, PH 20=Plant Height after 20 DAS, PH 40=Plant Height after 40 DAS, PH 60=Plant Height after 60 DAS, FA=Days to 1st Flower Appearance, PP=Number of Peduncles/Plant, BP=Number of Branches/Plant, FH=Days to First Harvest, LH=Days to Last Harvest, NPP=Number of Pods/Plant, PL=Pod Length (cm), PG=Pod Girth (cm), PW=Pod Weight (cm), GPY=Green Pod Yield/ha (tonnes)

Table 3: Estimation of Genetic Variability Parameters for Fourteen Characters of Cowpea

S. No	Characters	Mean	Range Highest	Range Lowest	$\sigma^2 g$	$\sigma^2 p$	GCV	PCV	h2 (b) %	GA	GAM
1	Number of days to germination	2.72	3.67	2.00	0.22	0.51	17.44	26.23	44.22	0.65	23.90
2	Plant Height after 20 DAS	18.45	22.00	14.07	5.52	13.89	12.73	20.20	39.72	3.05	16.53
3	Plant Height after 40 DAS	35.88	51.67	24.13	46.03	54.46	18.91	20.57	84.52	12.85	35.81
4	Plant Height after 60 DAS	63.06	117.00	39.90	493.23	623.71	35.22	39.61	79.08	40.68	64.52
5	Days to 1st Flower Appearance	47.54	59.00	43.53	20.10	50.59	9.43	14.96	39.74	5.82	12.25
6	Number of Peduncles/Plant	19.97	26.33	18.67	10.73	12.28	16.41	17.55	87.37	6.31	31.60
7	Number of Branches/Plant	19.63	30.00	21.33	63.38	64.81	40.55	41.00	97.8	16.22	82.61
8	Days to 1st Harvest	61.72	74.07	57.00	32.73	51.67	9.27	11.65	63.33	9.38	15.19
9	Days to last Harvest	96.56	111.40	90.67	65.92	104.60	8.41	10.59	63.02	13.28	13.75
10	Number of Pods/Plant	49.82	62.33	41.00	38.80	70.79	12.51	16.90	54.81	9.50	19.08
11	Pod Length (cm)	15.61	19.27	13.00	41.24	41.93	33.22	33.49	98.37	13.12	67.87
12	Pod Girth (cm)	1.74	1.81	1.00	0.52	0.52	41.27	41.44	99.17	1.47	84.66
13	Pod Weight (cm)	12.19	10.87	7.67	32.21	32.46	46.57	46.75	99.22	11.65	95.57
14	Green Pod Yield/ha (Tonnes)	6.37	10.91	2.08	8.74	8.79	46.40	46.54	99.4	6.07	95.30

σ2g = Genotypic variance, σ2p = Phenotypic variance, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, h2 (%) = Heritability, GA = Genetic advance, GAM = Genetic advance as percentage of mean

4. Conclusion

The results from the present investigation concluded that the maximum Green Pod Yield/ha was observed in COPBVAR-4, the earliest genotype was found to be COPBVAR-6. The analysis of variance revealed significant differences between genotypes indicating presence of sufficient amount of variability in all the characters. Close relationship between GCV and PCV was found in all the traits, indicating that environmental factor had little effect on the expression of these characters. High heritability coupled with high genetic advance as percentage of the mean indicated that direct selection will be more effective.

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