Genetic relationship studies for seed yield and other important agronomic traits in $F_{2:3}$ populations of cowpea (*Vigna unguiculata* L.)

Abstract

The present investigation on genetic relationship studies for seed yield traits in $F_{2:3}$ populations of cowpea involving VBN-1 × RC-19 and KBC-9 × PGCP-6 was carried during *summer* 2021. The results revealed that seed yield/plant recorded significant and positive correlation with pods/plant, seeds/pod, pod length, test weight and total dry matter content/plant in $F_{2:3}$ population of VBN-1 × RC-19; pods/plant seeds/pod, pod length, test weight and total dry matter content/plant in $F_{2:3}$ population of KBC-9 × PGCP-6 indicating the importance of these traits in improvement of cow pea yield. Pods/plant registered significant and positive association with seeds/pod and total dry matter content/plant in $F_{2:3}$ population of VBN-1 × RC-19. Seeds/pod recorded significant and positive association with pods/plant, pod length and total dry matter content/plant and test weight registered significant and positive association with total dry matter content/plant in $F_{2:3}$ population of KBC-9 × PGCP-6. Seed yield/plant recorded negative association with primary branches/plant in $F_{2:3}$ population of VBN-1 × RC-19 and plant height in $F_{2:3}$ population of KBC-9 × PGCP-6 which suggested that selection for these traits is not rewarding for yield improvement.

Key words: cowpea, correlation coefficient, path analysis, direct effect, indirect effect

Introduction

Cowpea (*Vigna unguiculata* L.) belongs to the family Fabaceae, tribe Phaseoleae, genus *Vigna* and section Catiang (Verdcourt, 1970). It is an annual self-pollinated diploid ($2n = 2x = 22$) warm-season grain legume with 620 Mb genome size (Munoz *et al.* 2017).Cowpea has been named so because of its use as cattle feed. It is commonly known as Lobia. Its dry edible grains are rich in protein (20–32%) with high amounts of essential amino acids (lysine and tryptophan), minerals (zinc, iron, calcium), vitamins (thiamine, folic acid and riboflavin) and fibre (6%) with low fat (<1%) (Sebetha *et al.,* 2014; Boukar *et al.,* 2015). Cowpea is a multifunctional legume grown for food, fodder, vegetable and green manure (Timko and Singh, 2008; Gonçalves *et al*., 2016). It is photo insensitive in nature and can be cultivated throughout the year. Cowpea is grown in different cropping system as it has relatively drought tolerant nature (Vavilov, 1949). Cowpea can be grown in arid, semiarid and subtropical areas. It is resilient to high temperature and limited water stresses, and grows well on poor soil with a wide range of soil pH thus making it a good choice for resource-poor small-scale farmers for their sustenance (Carvalho *et al.,* 2017).

Approximately 8.9 mt of dry cowpea grains are produced annually across the world over an area of 14.5 mha with productivity of 616 kg/ha (FAOSTAT, 2019). It is cultivated in Africa, South and Central America, East/Southeast Asia, US and Southern Europe (Singh *et al.,* 2014). It plays an important role in the developing countries of the tropics and subtropics especially in sub Saharan Africa, Asia, Central and South America. In India, cowpea is grown in the states of Gujarat, West Bengal, Tamil Nadu, Andhra Pradesh, Kerala and Orissa (Aykroyd, 1963). In India, cowpea occupies about 4 lakh ha area with 300 kg/ha productivity (FAOSTAT, 2018).

Direct selection for the yield is not much effective as quantitative characters are controlled by polygenes. Hence, knowledge about association of characters which will directly or indirectly contribute to yield is crucial. Correlation coefficient explains the degree of association among the characters. However, it is difficult to explain a system of correlation when the indirect association between the characters increases. The method of path coefficient analysis developed by Wright (1921) is helpful in partitioning correlation coefficients into direct and indirect effects and in the assessment of relative contribution of each component to the yield.

Materials and methods

The experimental material consisted of 100 and 70 F_3 family rows derived from crosses VBN-1 × RC-19 (cross I) and KBC-9 × PGCP-6 (cross II), respectively. These F_3 family rows were evaluated during *summer* 2021 using Augmented Block Design with five checks (C-152, KBC-2, KBC-9, PGCP-6 and IT-803695-1) replicated five times and parents at Department of Genetics and Plant Breeding, College of Agriculture, Kalaburagi, University of Agricultural Sciences, Raichur. Each F_3 progeny family was sown in row length of 4 meter with a spacing of 45 cm × 10 cm. Five competitive plants selected randomly from each family row were used to record observation on ten traits *viz.*, days to initiation of flowering, days to physiological maturity, plant height, number of primary branches/plant, number of pods/plant, number of seeds/pod, pod length, test weight, dry matter/plant, seed yield/plant. The mean data of all traits were recorded and utilized for statistical analysis *viz.*, correlation coefficient and path analysis.

Results and discussion

Correlation analysis:

Seed yield/plant recorded significant and positive correlation with of pods/plant (0.744), seeds/pod (0.633), pod length (0.609), test weight (0.438) and total dry matter content/plant (0.922) in $F_{2:3}$ population of VBN-1 × RC-19 (Table 1 and Fig 1); pods/plant (0.849), seeds/pod (0.549), pod length (0.495), test weight (0.331) and total dry matter content/plant (0.941) in $F_{2:3}$ population of KBC-9 × PGCP-6 (Table 2 and Fig 2) indicating the importance of these traits, while selection is under consideration for yield. Similar findings were reported by Patil *et al.* (2021), Sabale *et al.* (2019), Patil *et al.* (1989) and Sawant (1994) for pods/plant, pod length and test weight; Onkar and Paroda (1986), Gowda (1996), Ananda (2012) and Khan *et al.* (2013) for seeds/pod; Bhardu and Navale (2011) for total dry matter content/plant.

Pods/plant registered significant and positive association with seeds/pod and total dry matter content/plant. Similar results were reported by Khan *et al.* (2013), Onkar and Paroda (1986) and Biradar *et al.* (1996) for seeds/pod. Pod length recorded significant and positive association with seeds/pod and total dry matter content/plant. Similar findings were reported by Walle *et al.* (2018) for dry matter/plant.

Seeds/pod recorded significant and positive association with pods/plant, pod length and total dry matter content/plant. Similar findings were reported by Onkar and Paroda (1986), Biradar *et al.* (1996) and Khan *et al.* (2013) for pods/plant. Test weight registered

Table 1: Phenotypic correlation coefficient between yield and yield attributing in $F_{2:3}$ population of VBN-1 × RC-19

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	1.000	0.824**	0.146	-0.104	0.168	0.012	0.003	0.011	0.054	0.045
X_2		1.000	0.121	-0.073	0.166	0.006	-0.009	-0.053	0.072	0.036
X_3			1.000	-0.060	0.022	-0.013	-0.017	0.145	-0.040	0.038
X_4				1.000	-0.112	-0.015	-0.003	-0.077	0.005	-0.049
X_5					1.000	0.229 **	0.251 **	0.082	0.730 **	0.744**
X_6						1.000	0.957 **	0.125	0.563 **	0.609**
X_7							1.000	0.125	0.580 **	0.633**
X_8								1.000	0.362 **	0.438**
X_9									1.000	0.922**

*= Significance at 0.05 % of probability ** Significance at 0.5 % of probability

Table 2: Phenotypic correlation coefficient between yield and yield attributing in $F_{2:3}$ population of KBC-9 × PGCP-6

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	1.000	0.620 **	0.045	0.240 *	0.016	0.171	0.233 *	-0.072	0.092	0.136
X_2		1.000	-0.019	0.147	-0.006	0.302 **	0.299 **	-0.010	0.108	0.101
X_3			1.000	0.055	-0.052	-0.128	-0.066	-0.046	-0.018	-0.080
X_4				1.000	0.114	0.000	0.035	-0.113	0.018	0.084
X_5					1.000	0.159	0.216 *	0.079	0.798 **	0.849 **
X_6						1.000	0.845 **	0.177	0.445 **	0.495 **
X_7							1.000	0.095	0.511 **	0.549 **
X_8								1.000	0.356 **	0.331 **
X_9									1.000	0.941 **

*= Significance at 0.05% of probability ** Significance at 0.5 % of probability

Where

X_1=Days to initiation of flowering X_2=Days to physiological maturity X_3=Plant height X_4=Number of branches/plant X_5= Number of pods/plant X_6 = Pod length X_7 = Number of seeds/pod X_8 =Test weight X_9 =Total dry matter content/plant X_{10} =Seed yield/plant

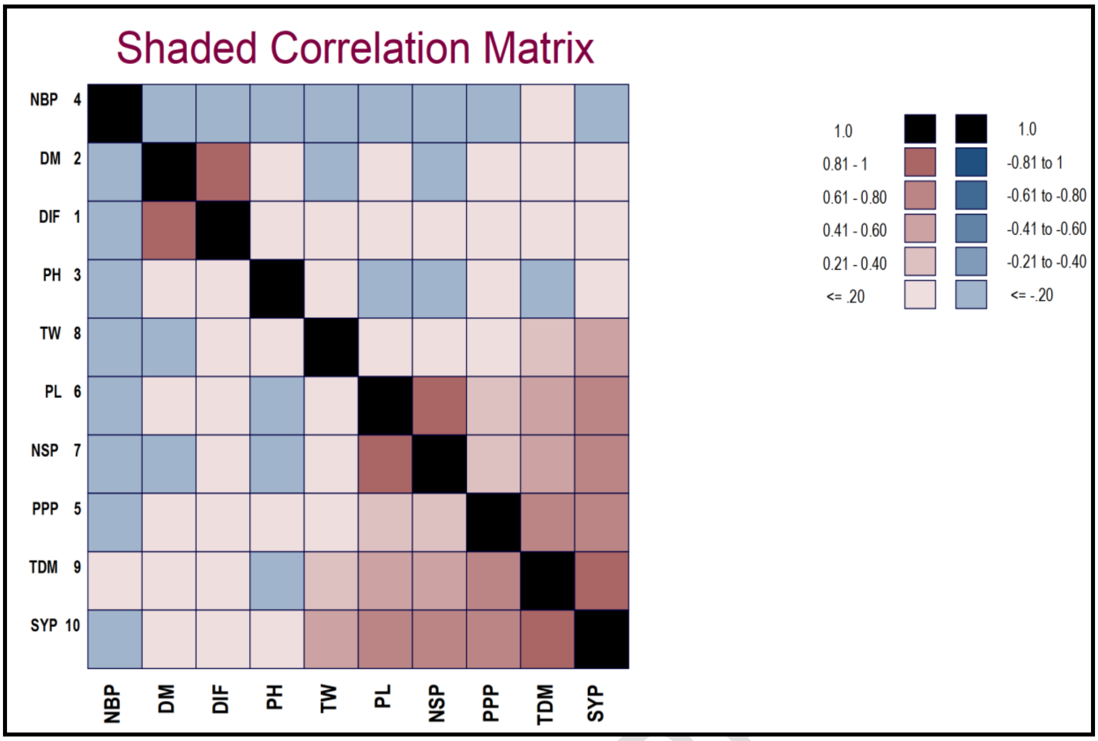

Fig. 1: Shaded correlation matrix of quantitative traits in F_3 segregating generation of VBN-1 × RC-19

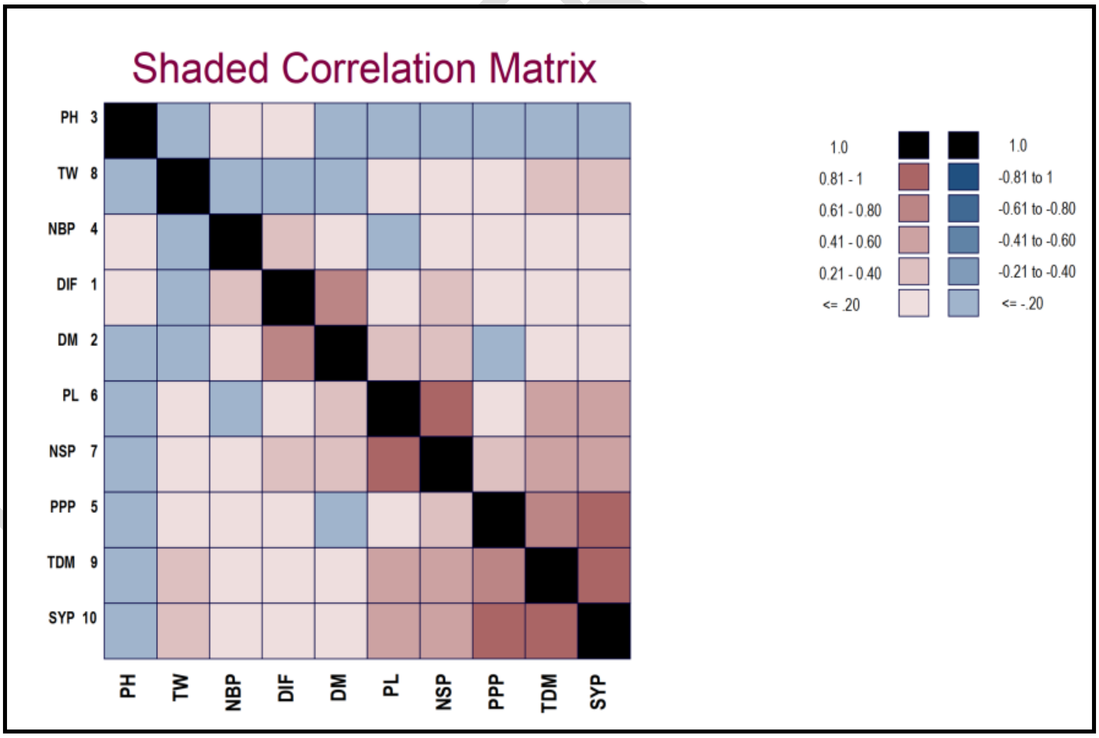

Fig. 2: Shaded correlation matrix of quantitative traits in F_3 segregating generation of KBC-9 × PGCP-6

Table 3: Phenotypic path co-efficient among seed yield and its attributing characters in $F_{2:3}$ population of VBN-1 × RC-19

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	**-0.0268**	-0.0221	-0.0039	0.0028	-0.0045	-0.0003	-0.0001	-0.0003	-0.0015	0.0446
X_2	-0.0174	**-0.0211**	-0.0026	0.0015	-0.0035	-0.0001	0.0002	0.0011	-0.0015	0.0363
X_3	0.0043	0.0036	**0.0295**	-0.0018	0.0007	-0.0004	-0.0005	0.0043	-0.0012	0.0383
X_4	-0.0001	-0.0001	-0.0001	**0.0010**	-0.0001	0.0000	0.0000	-0.0001	0.0000	-0.0489
X_5	0.0569	0.0562	0.0075	-0.0378	**0.3396**	0.0776	0.0852	0.0280	0.2480	0.7440**
X_6	0.0003	0.0002	-0.0004	-0.0004	0.0068	**0.0296**	0.0283	0.0037	0.0167	0.6090**
X_7	0.0006	-0.0020	-0.0039	-0.0006	0.0583	0.2225	**0.2325**	0.0291	0.1348	0.6330**
X_8	0.0022	-0.0110	0.0302	-0.0160	0.0172	0.0261	0.0260	**0.2083**	0.0755	0.4380**
X_9	0.0245	0.0327	-0.0182	0.0024	0.3296	0.2542	0.2616	0.1635	**0.4514**	0.9220**
Residual effect = 0.275										

** Significance at 0.5 % of probability

Table 4: Phenotypic path co-efficient among seed yield and its attributing characters in $F_{2:3}$ population of KBC-9 × PGCP-6

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	**0.0899**	0.0558	0.0040	0.0215	0.0014	0.0154	0.0209	-0.0065	0.0083	0.1360
X_2	-0.0449	**-0.0724**	0.0013	-0.0106	0.0004	-0.0218	-0.0216	0.0007	-0.0078	0.1007
X_3	-0.0012	0.0005	**-0.0277**	-0.0015	0.0014	0.0036	0.0018	0.0013	0.0005	-0.0801
X_4	0.0058	0.0036	0.0013	**0.0243**	0.0028	0.0000	0.0008	-0.0028	0.0004	0.0841
X_5	0.0072	-0.0026	-0.0238	0.0519	**0.4545**	0.0721	0.0980	0.0359	0.3626	0.8490**
X_6	0.0174	0.0306	-0.0130	0.0000	0.0161	**0.1016**	0.0858	0.0180	0.0451	0.4950**
X_7	0.0322	0.0414	-0.0091	0.0048	0.0298	0.1169	**0.1383**	0.0132	0.0707	0.5490**
X_8	-0.0089	-0.0013	-0.0057	-0.0140	0.0097	0.0218	0.0117	**0.1232**	0.0438	0.3310**
X_9	0.0385	0.0451	-0.0075	0.0076	0.3327	0.1854	0.2133	0.1483	**0.4171**	0.9410**
Residual effect = 0.214										

** Significance at 0.5 % of probability

Where

X_1=Days to initiation of flowering X_2=Days to physiological maturity X_3=Plant height X_4=Number of branches/plant X_5= Number of pods/plant
X_6 = Pod length X_7 = Number of seeds/pod X_8 =Test weight X_9 =Total dry matter content/plant X_{10} =Seed yield/plant

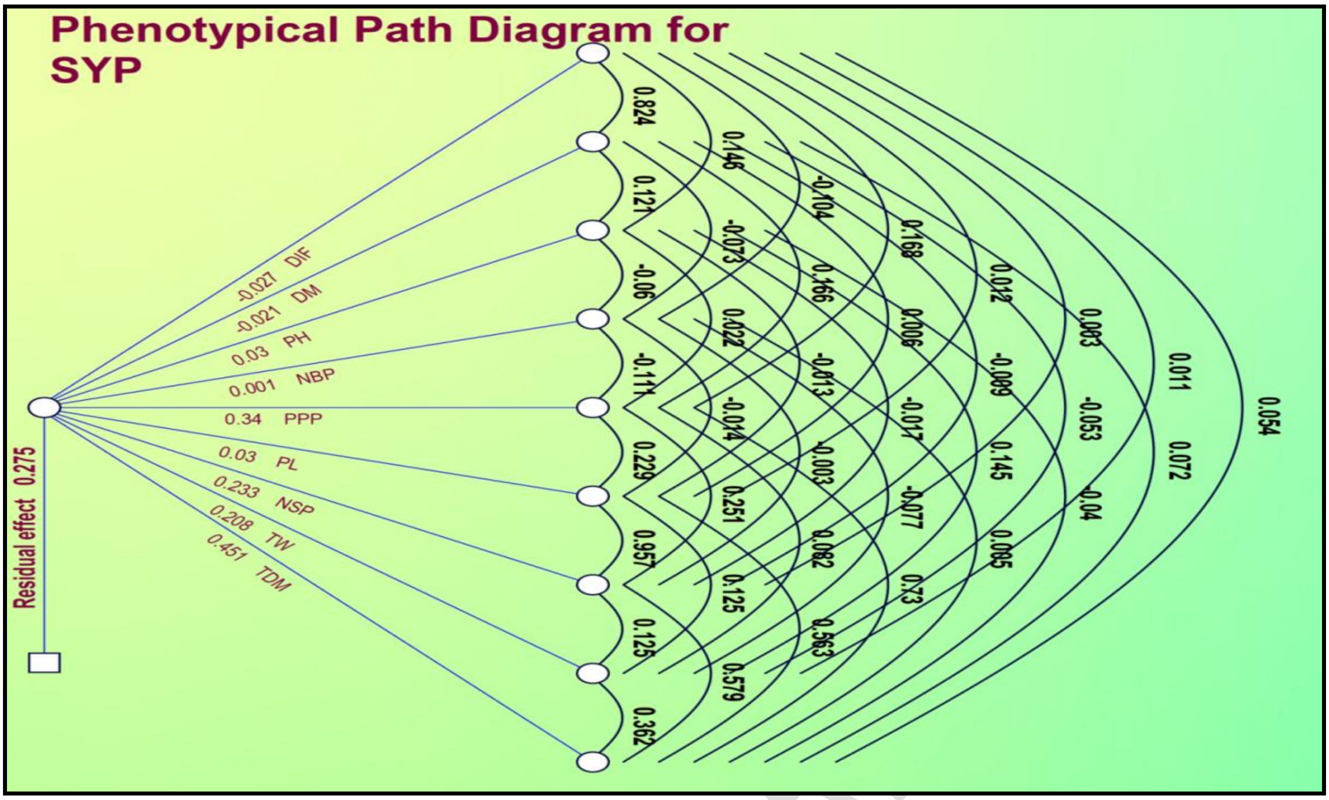

Fig. 3: Phenotypic path diagram showing the influence of yield components on seed yield/plant n F_3 segregating generation of VBN-1 × RC-19

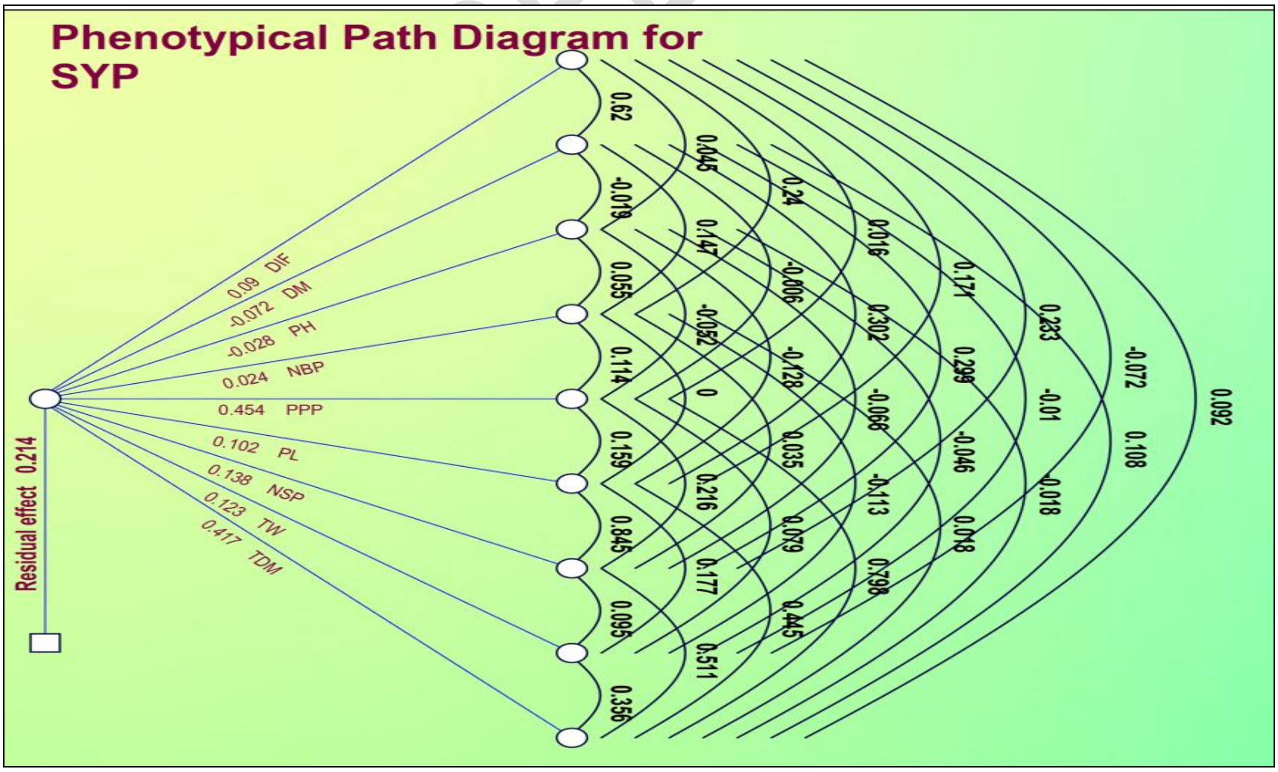

Fig. 4: Phenotypic path diagram showing the influence of yield components on seed yield/plant in F_3 segregating generation of KBC-9 × PGCP-6

significant and positive association with total dry matter content/plant. These results are in consonance with the findings of Walle *et al*. (2018).

Seed yield/plant recorded negative association with primary branches/plant (−0.049) in $F_{2:3}$ population of VBN-1 × RC-19 and plant height (−0.080) in $F_{2:3}$ population of KBC-9 × PGCP-6 which suggested that selection for these traits is not rewarding for yield improvement. These results are in consonance with the findings of Dinesh *et al*. (2017) for primary branches/plant and Rangaiah *et al.* (1999) for plant height. However, Sabale *et al.* (2019), Bhardu and Navale (2011), Kurer (2007), Sawant (1994) and Biradar *et al.* (2007) obtained contrasting results for branches/plant; Belhekar *et al.* (2003), Kurer (2007), Bhardu and Navale (2011) for plant height.

Path co-efficient analysis: Path co-efficient analysis indicated that high direct effect for seed yield/plant was recorded by total dry matter content/plant (0.4514) followed by pods/plant (0.3396) in F_3 population of VBN-1 × RC-19 (Table 3 and Fig 3); pods/plant (0.4545) followed by total dry matter content/plant (0.4171) in F_3 population of KBC-9 × PGCP-6 (Table 4 and Fig 4). Similar findings were also reported by Patil *et al*. (1989), Sawant (1994), Kalaiyarasi and Palanisamy (2002), Biradar *et al.* (2007), Dinesh *et al*. (2017), Sheela (2017), Srinivas *et al.* (2017), Nistha and Khan (2020) and Kurer (2007). Yadav *et al.* (2003) for pods/plant; Bhadru and Navale (2011) for total dry matter content/ plant.

Pods/plant had positive indirect effect *via* days to first flowering (0.0569), days to maturity (0.0562) and plant height (0.0075), seeds/pod (0.0852), pod length (0.0776), test weight (0.0280) and dry matter/plant (0.2480) in F_3 population of VBN-1 × RC-19; days to first flowering (0.0072), primary branches/plant (0.0519), seeds/pod (0.0980), pod length (0.0721), test weight (0.0359), dry matter/plant (0.3626) in F_3 population of KBC-9 × PGCP-6. Total dry matter content/plant had positive indirect effect *via* days to first flowering (0.0245), days to physiological maturity (0.0327), primary branches/plant (0.0024), pods/plant (0.3296), pod length (0.2542), seeds/pod (0.2616) and test weight (0.1635) in F_3 population of VBN-1 × RC-19; days to first flowering (0.0385), days to physiological maturity (0.0451), primary branches/plant (0.0076), pods/plant (0.3327), pod length (0.1854), seeds/pod (0.2133), test weight (0.1483) in F_3 population of KBC-9 × PGCP-6. Thus, selecting the above said traits while breeding will help to accelerate cowpea improvement programme.

Correlation studies revealed that seed yield per plant had a highly significant positive association with number of pods per plant, number of seeds per pod, pod length, test weight and dry matter per plant for both the segregating populations. This indicates that all these traits were significantly important for direct selection. Hence, improvement in these traits could result in high seed yield in cowpea.

Path analysis gave an idea that the traits *viz.,* plant height, number of branches/plant, number of pods/plant, pod length, number of seeds/pod, test weight and total dry matter content/plant in $F_{2:3}$ population of VBN-1 × RC-19; days to initiation of flowering, plant height, number of branches/plant, number of pods/plant, pod length, number of seeds/pod, test weight and total dry matter content/plant in $F_{2:3}$ population of KBC-9 × PGCP-6 possessed high direct effect and significant positive relationship with seed yield/plant. These traits were major determinants of seed yield. Thus, these traits should be given more emphasis during selection for yield improvement in cowpea.

REFFERENCE

Ananda M. 2012. Comparative assessment of genetic variability in F_2, F_3 and biparental mating progenies in cowpea (*Vigna unguiculata* L. Walp.). *M. Sc. (Agri) Thesis*, Univ. Agric. Sci., Bangalore.

Aykroyd W R. 1963. ICMR Special Report, Series No. 42.

Bhardu D and Navale P A. 2011. Correlation and path analysis studies in F_3 population of cowpea (*Vigna unguiculata* L. Walp.). *Legume Res*. 34(1): 41-44.

Belhekar P S, Bendale V W, Jamadagni B M and Birari S P. 2003. Correlation and path coefficient analysis of cowpea and asparagus bean crosses in F_2 generation. *J. Maharastra Agric. Univ*. 28(2): 145-147.

Biradar B D, Goud J V and Patil S S. 1996. Association of grain yield with other characters in three F_2 populations of cowpea (*Vigna unguiculata* L. Walp.). *Crop Res.* 11: 179-183.

Biradar S, Salimath P M and Sridevi O. 2007. Association studies in the three segregating populations of cowpea (*Vigna unguiculata* L. Walp.). *Karnataka J. Agric. Sci.* 20(2): 252-254.

Boukar O, Fatokun C A, Roberts P A, Abberton M, Huynh B L, Close T J and Ehlers J D. 2015. Cowpea, In: De Ron AM (ed) Grain legumes, Hand Book of Plant Breeding. *Springer, New York*, pp. 219–250.

Carvalho M, Lino Neto T, Rosa E and Carnide V. 2017. Cowpea: a legume crop for a challenging environment. *J. Sci. Food. Agric.* 97: 4273–4284.

Dinesh H B, Viswanatha K P, Lohithaswa H C, Pavan R and Singh P. 2017. Variability, correlation and path analysis studies in F_3 generation of cowpea [*Vigna unguiculata* (L.) Walp]. *Int. J. Curr. Microbiol. Appl. Sci.* 6(9): 1420-1428.

FAOSTAT. 2018. Agriculture organization of the United Nations statistics division, economic and social development department, Rome.

FAOSTAT. 2019. Agriculture organization of the United Nations statistics division, economic and social development department, Rome.

Gowda T H. 1996. Studies on the association of yield components in three F_2 populations of cowpea (*Vigna unguiculata* L. Walp.) and their implication in selection. *Legume Res.,* 14: 15-19.

Gonçalves A, Goufo P, Barros A, Domínguez-Perles R, Trindade H, Rosa E A and Rodrigues M. 2016. Cowpea (*Vigna unguiculata* L. Walp.), a renewed multipurpose crop for a more sustainable agri food system: nutritional advantages and constraints. *J. Sci. Food Agric*. 96: 2941-2951.

Kalaiyarasi R and Palanisamy G A. 2002. Path analysis of F_3 populations in cowpea (*Vigna unguiculata* L. Walp.). *Legume Res.*, 25(1): 47-49.

Khan H, Vishwanatha K P and Sowmya H C. 2013. Genetic variabilty and association studies in cowpea (*Vigna unguiculata* L. walp.). *J. Food Legumes* 26(3 & 4): 42-45.

Kurer S. 2007. Genetic variability studies in F_2 and F_3 generations of cowpea (*Vigna unguiculata* L. Walp.), *M. Sc. Thesis*, Univ. Agric. Sci., Dharwad (India).

Munoz A M, Mirebrahim H, Xu P, Wanamaker S I, Luo M, Alhakami H and Bozdag S. 2017. Genome resources for climate resilient cowpea, an essential crop for food security. *Pl. J.,* 89:1042–1054.

Nistha M and Khan H. 2020. Character association and path analysis in F_3 segregating generations for yield and its component traits in groundnut (*Arachis hypogaea* L.). *J. Pharmacogn. Phytochem*. 9(4): 794-799

Onkar S and Paroda R S. 1986. Association analysis of grain yield and its components in chickpea following hybridization and combination of hybridization and mutagenesis. *Indian J. Agric. Sci.* 56: 1329-1341.

Patil S, Pethe U B, Mahadik S G, Dalvi V V and Joshi M S. 2021. Correlation and path analysis study in F_3 generation of cowpea (*Vigna unguiculata* L. Walp.) genotypes. *J. Pharmacogn. Phytochem.* 10(1): 203-207.

Patil S J, Venugopal R, Gouda J V and Parameshwarappa R. 1989. Correlation and path coefficient analysis in cowpea. *Karnataka J. Agric. Sci.* 2: 170-175.

Rangaiah S, Nehru S D and Mahadeva P. 1999. Genetic studies in two cross derivatives of cowpea (*Vigna unguiculata* L. Walp.). *Mysore J. Agric. Sci.* 33: 125-129.

Sabale G R, Pandurang D W, Bhave S G and Desai S S. 2019. Correlation and path analysis studies in F_2 generation of cowpea (*Vigna unguiculata* subsp. *unguiculata*). *J. Pharmacogn. Phytochem.* 8(6): 1451-1454.

Sawant D S. 1994. Association and path analysis in cowpea. *Ann. Agri. Res.* 15: 134-139.

Sheela H. 2017. Variability studies in segregating populations of cowpea (*Vigna unguiculata* L. Walp). *Ph. D. Thesis*, Univ. Agric. Hortic. Sci., Shivamogga (India).

Srinivas J, Kale V S, Nagre P K and Meshram S. 2017. Correlation and path analysis study in cowpea (*Vigna unguiculata* L. Walp.) genotypes. *Int. J. Curr. Microbiol. App. Sci.* 6(6): 3305-3313.

Singh B B, Timko M P and Aragao F J. 2014. Advances in cowpea improvement and genomics. *In Legumes in the Omic Era, Springer,* New York pp. 131-153.

Sebetha E T, Modi A T and Owoeye L G. 2014. Cowpea crude protein as affected by cropping system, site and nitrogen fertilization. *J. Agric. Sci.* 7: 224.

Timko M P and Singh B B. 2008. Cowpea, a multifunctional legume. *Genomics of Tropical Crop Plants, Springer*, New York pp. 227-258.

Vavilov N J. 1949. The origin, variation, immunity and breeding cultivated plants. *Chron. Bot.* Vol. 10. The Ronald Press Co.; Newyork. pp. 364.

Verdcourt B. 1970. Studies in the Leguminosae-Papilionoideae for the flora of tropical East Africa. *IV Kew Bulletin*. 24: 507-569.

Walle T, Mekbib F, Amsalu B and Gedil M. 2018. Correlation and path co-efficient analyses in Ethiopia. *American J. Pl. Sci*. 9: 2794-2812.

Wright S. 1921. Correlation and causation. *J. Agric. Res*. 20: 557-585.

Yadav K S. Yadava H S and Naik M L. 2003. Correlations and path analysis in early generations of cowpea. *Indian J. Pulses Res.* 16: 101-103.