# **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).

Since polygenes influence quantitative features, direct selection for yield is not very effective. Therefore, it is essential to understand the relationships between characters that either directly or indirectly affect yield. The degree of link between the characteristics is explained by the correlation coefficient. When there is a greater degree of indirect relationship between the characters, it becomes more challenging to explain a correlation system. 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". [35] 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

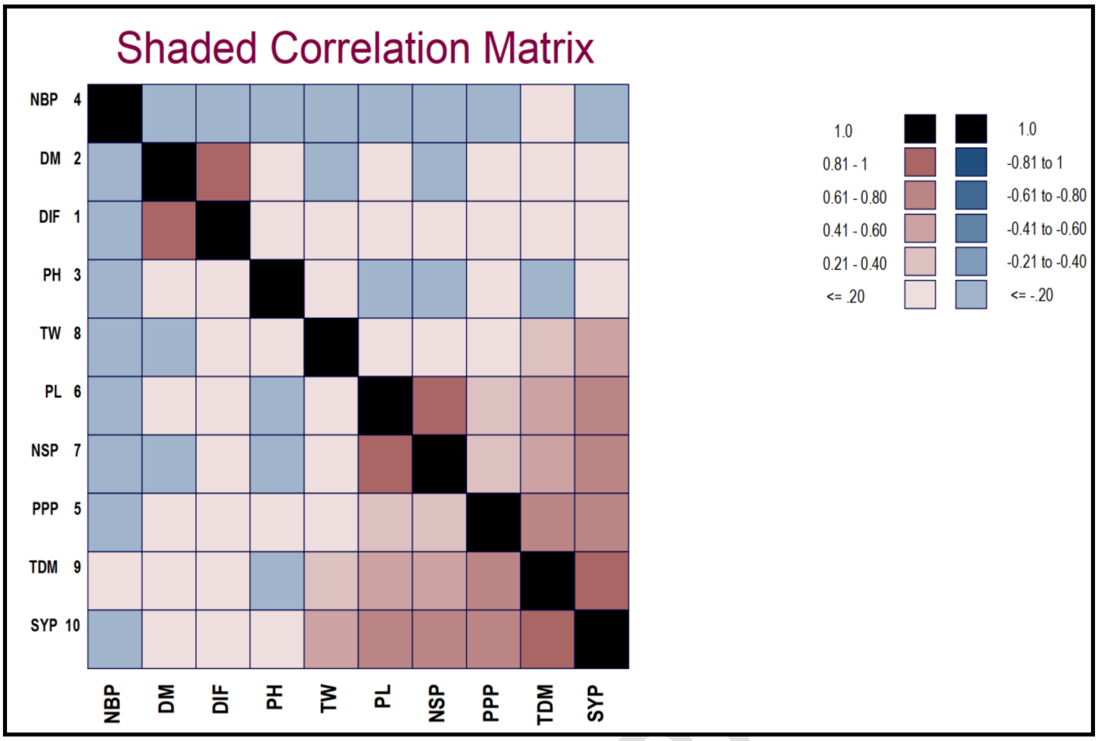


**Fig. 1: Shaded correlation matrix of quantitative traits in $F_3$ segregating generation of VBN-1 × RC-19**

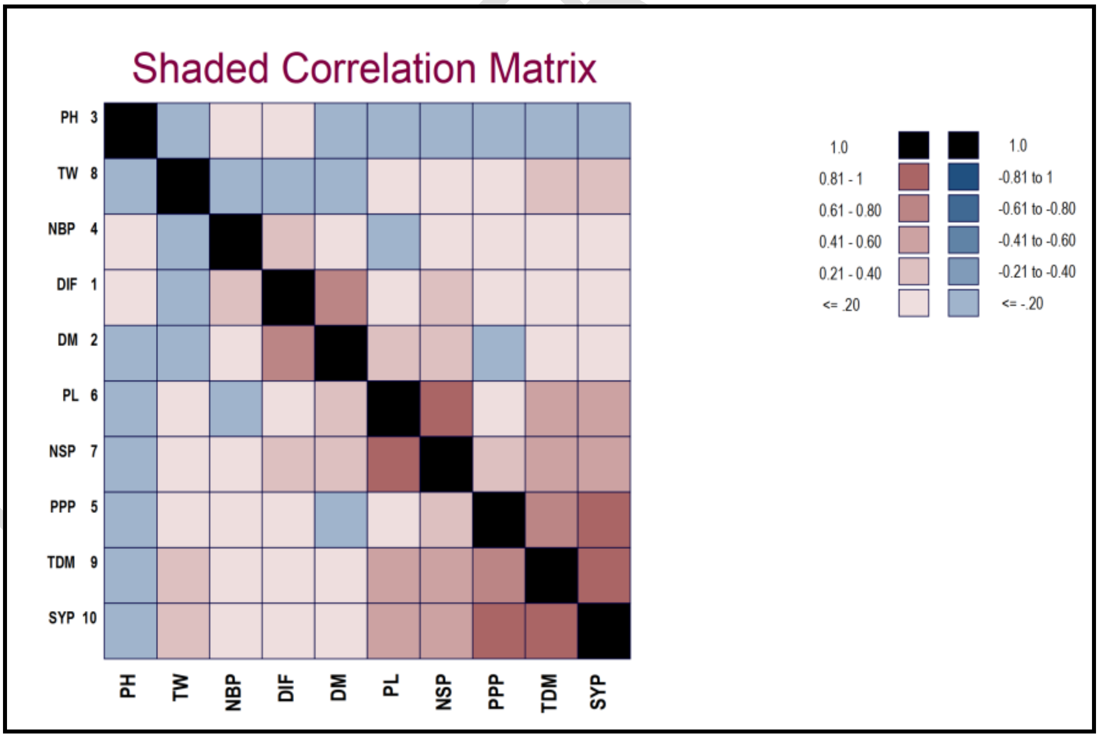


**Fig. 2: Shaded correlation matrix of quantitative traits in $F_3$ segregating generation of KBC-9 × PGCP-6**

**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

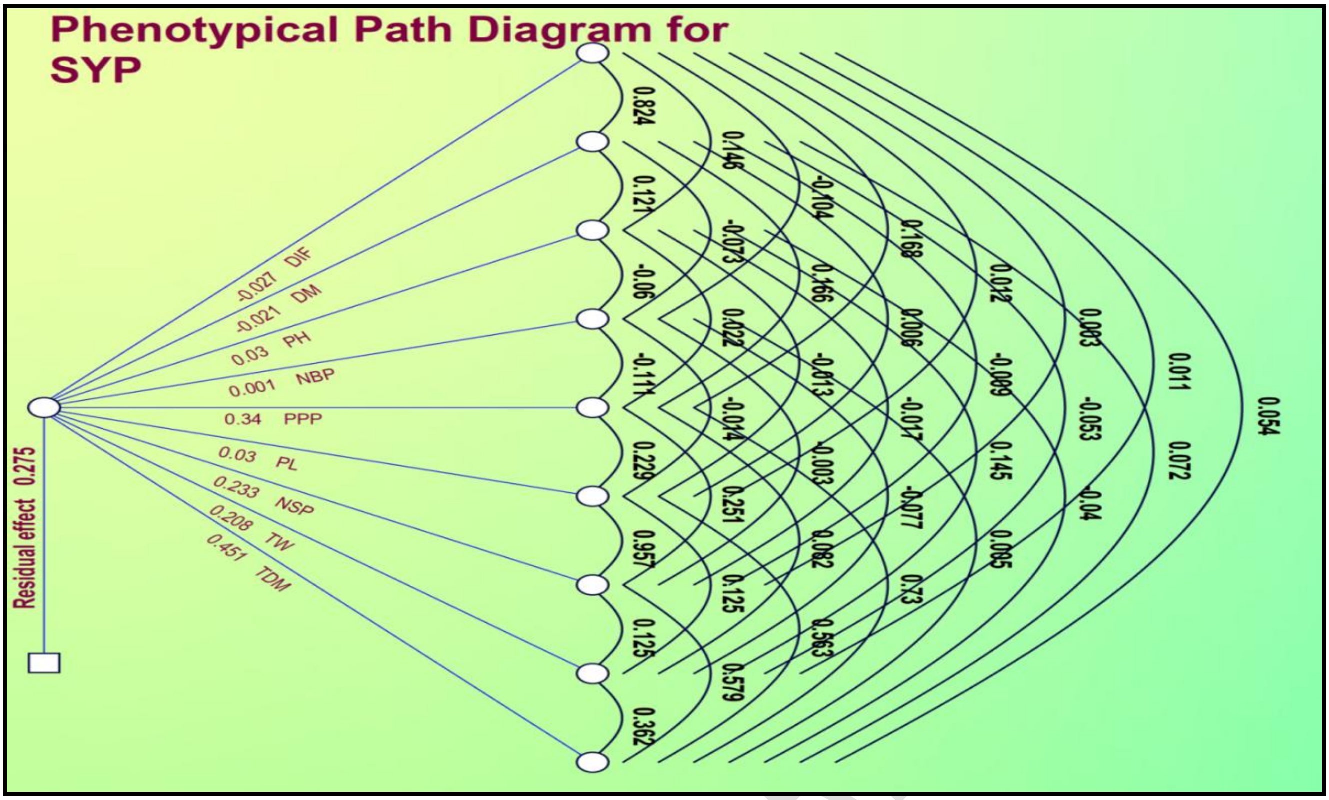


**Fig. 3: Phenotypic path diagram showing the influence of yield components on seed yield/plant n $F_3$ segregating generation of VBN-1 × RC-19**

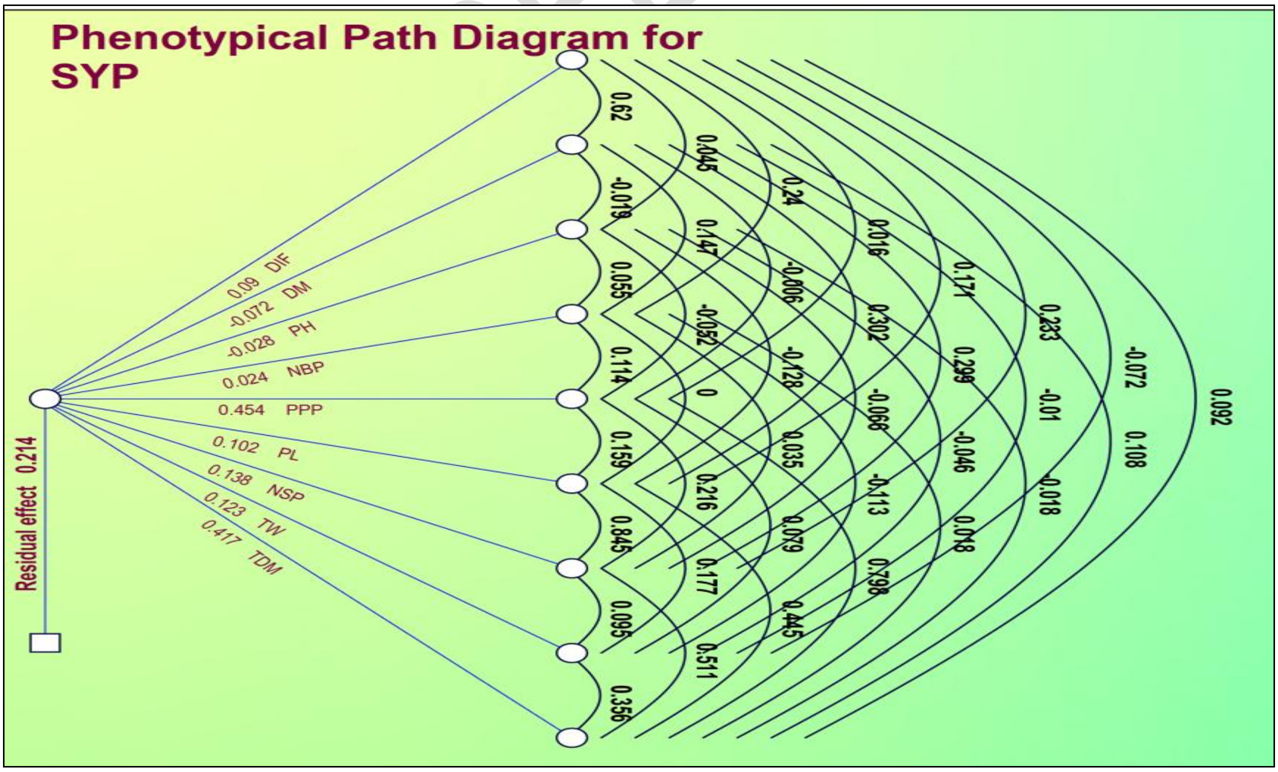


**Fig. 4: Phenotypic path diagram showing the influence of yield components on seed yield/plant in $F_3$ segregating generation of KBC-9 × PGCP-6**

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.

Studies using correlation analysis showed that, for both segregating populations, the number of pods per plant, number of seeds per pod, pod length, test weight, and dry matter per plant all significantly positively correlated with seed yield per plant. This suggests that each of these characteristics had a substantial impact on direct selection. Therefore, a high seed output in cowpea could be achieved by improving these features.

"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". [35] These traits were major determinants of seed yield. Thus, these traits should be given more emphasis during selection for yield improvement in cowpea.

**Conclusion**

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.

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