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# Variability and association analyses in $F_2$ populations of groundnut (*Arachis hypogaea* L.)

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**Abstract**
Groundnut is the third-largest oilseed crop produced in the world and second largest in India. The $F_2$ populations of TMV 7 x Girnar 4 and R2001-2 x Girnar 4 were evaluated to determine the variability and association between yield and its attributing traits. High PCV and GCV along with high heritability and genetic advance as percent of mean were observed for the trait *viz.*, primary branches, secondary branches, number of pods, immature pods, mature pods and pod yield . Improvement of these traits would be possible through simple selection program as they are controlled by additive gene action. The traits number of pods, mature pods, 100 kernel weight and shelling percentage showed significant positive correlation with pod yield in both the crosses. The path analysis results revealed that the number of pods per plant had the highest positive direct effect on pod yield per plant and the selection for these traits could positively increase pod yield/ plant.

**Keywords:** Groundnut, Heritability, GAM, Correlation and path analysis.

## INTRODUCTION

The groundnut or peanut (*Arachis hypogea* L.) is a native of South America and is also found in tropical and subtropical areas (Stalker *et al*., 2016). The groundnut kernel contains 45 to 50 percent oil / 100 g dry weight, 25 to 28 percent easily digestible protein, 10 to 20 percent carbohydrates and 565 kcal of energy. Globally the area under groundnut cultivation is 31.5 million hectares and production of 53.6 million tones with productivity of 1701 kg /ha (https://www.fao.org/3/cb4477en/online/cb4477en.html). China, India, Nigeria, the United States, Sudan and Senegal are the major groundnut producing countries in the world.

The fundamental prerequisite for any crop improvement is based on the presence of genetic variability in the genetic population. The efficiency of selection depends on the kind, level, and amount of genetic variability in the breeding material for the targeted traits. Heritability is a crucial factor since it affects the response to selection. Heritability and genetic advancement are useful biometrical tools to determine the strength and direction of selection. The selection of traits with high heritability and high genetic advance is crucial for crop improvement since these traits are governed by additive gene action. Correlation analysis explains the degree and direction of association among the traits, which helps the selection index for an effective crop breeding program, while path analysis splits the correlation coefficient into direct and indirect effects so as to measure the relative contribution of each variable towards yield. Hence, the present study was conducted to assess the variability and association of quantitative traits in the $F_2$ segregating populations of groundnut.

## MATERIALS AND METHODS

The experimental material comprising of two $F_2$ populations

of the crosses TMV 7 x Girnar 4, and R2001/2 x Girnar 4 along with parents were raised at Oilseeds Research Station, Tindivanam during *Rabi,* summer 2022-23. Seeds were sown in 3 m rows with 30 cm x 10 cm spacing. Recommended agronomic practices and need-based crop protection measures were followed throughout the cropping period. Observations were recorded on 201 plants in the cross TMV x Girnar 4 and 157 plants in R2001-2 x Girnar 4 for 11 agro-morphological traits *viz*., plant height (PH), primary branches per plant (PB), secondary branches per plant (SB), days to first flowering (DFTF), days to 50 percent flowering (DFF), number of pods per plant (NP), immature pods per plant (IP), mature pods per plant (MP), hundred kernel weight (HKW), shelling percentage (SH%) and pod yield per plant (PY).
The data were subjected to statistical analysis. The phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability ($h^2$) and genetic advance as percent of mean (GAM) were calculated by following the statistical procedure proposed by Johnson (1955) and Robinson and Comstock (1955). The correlation coefficients were calculated using the formula proposed by Al-Jibouri *et al.* (1958). Using the Dewey and Lu (1959) method, path analysis for these traits were evaluated based on their direct and indirect effects on pod yield.

## RESULTS AND DISCUSSION

The *per se* performance of parents (**Table 1**) and $F_2$ populations (**Table 2**) were calculated. The significance of the parents for various traits was noted based on the grand mean and the standard error. The male parent Girnar 4 had a high mean performance for the traits *viz.,* Primary branches per plant (7.7), Secondary branches per plant (4.9) and hundred kernel weight (39.1g). The trait immature pods per plant (2.7) had a comparatively low mean value. The female parent TMV 7 recorded a superior mean performance of 36.2 cm for plant height and 72.6 % for the trait shelling percentage. The minimum value of 25 days for the trait days to first flowering and 33 days for the trait days to 50% flowering was observed in the parent TMV 7 suggesting its early flowering nature. The maximum mean for the traits number of pods per plant (20.4), mature pods per plant (14.5) and pod yield per plant (23.6 g) was exhibited by the parent R2001-2.

The $F_2$ populations TMV 7 x Girnar 4 and R2001-2 x Girnar 4 had differences in the mean performances for various traits. The $F_2$ population TMV 7 x Girnar 4 had a high mean for the traits plant height (32.9 cm), immature pods per plant (3.7), hundred kernel weight (37.3) and shelling percentage (69.8%). For the traits days to first flowering (27 days) and days to fifty percent flowering (32 days) it recorded the least value suggesting its early flowering nature. The $F_2$ population R2001-2 x Girnar 4 recorded the maximum value for the traits primary branches per plant (9.7), secondary branches per plant (10.7), number of pods per plant (22.6), mature pods per plant (19.4), pod yield per plant (23.6g).

The genetic variability parameters PCV, GCV, heritability and GAM were estimated for the $F_2$ populations which are indicated in **Table 2**. The values of PCV were higher than GCV for all the traits studied, indicating that environmental factors also play a role in influencing these traits but the narrow difference between the PCV and GCV infers the strong genetic influence on the traits.

High PCV and GCV were recorded in the $F_2$ population TMV 7 X Grinar 4 for the traits primary branches per plant (31.2%, 24.8%), secondary branches per plant (47.8%, 42.3%), number of pods per plant (30.5%, 29.1%), mature pods per plant (35.7%, 33.3%), immature pods per plant (41.8%, 36.0%) and pod yield per plant

**Table 1. Mean performance of parents in $F_2$ population of groundnut**

| TRAITS / PARENT | Girnar 4 | TMV 7 | R2001-2 | Grand Mean | SE |
|---|---|---|---|---|---|
| PH (cm) | 30.9** | 36.2** | 29.4 | 29.4 | 2.06 |
| PB | 7.7** | 4.4 | 6.4* | 4.4 | 0.96 |
| SB | 4.9* | 1.1 | 4.0* | 1.1 | 1.15 |
| DFTF | 29.4** | 25.3 | 32.8** | 25.3 | 2.17 |
| DFF | 37.9** | 32.9 | 41.3** | 32.9 | 2.44 |
| NP | 17 | 15 | 20.4** | 16 | 1.58 |
| IP | 2.7 | 4.2 | 6.0* | 3.5 | 0.95 |
| MP | 14.3** | 10.8 | 14.5** | 10.8 | 1.2 |
| HKW | 39.1** | 34.5 | 32.6 | 33.6 | 1.93 |
| SH% | 68.7 | 72.6** | 67.2 | 68 | 1.61 |
| PY (g) | 17.1 | 11.4 | 23.6* | 14.3 | 3.52 |

PH : Plant height, PB : Number of primary branches, SB : Number of secondary branches, DFTF : Days to first flowering, DFF : Days to 50% flowering, NP : Number of pods, IP : Number of immature pod, MP : Number of mature pod, HKW : SH (%) : shelling percentage PY : single plant yield

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**Table 2. Genetic variability in $F_2$ generation of groundnut**

| Characters | Crosses | Mean | PCV (%) | GCV (%) | $H^2$ (%) | GAM (%) |
|---|---|---|---|---|---|---|
| PH | C1 | 32.9 | 9.3 | 8.9 | 91.6 | 17.6 |
| | C2 | 20.3 | 20 | 19.3 | 93.1 | 38.3 |
| PB | C1 | 6.2 | 31.2 | 24.8 | 63 | 40.5 |
| | C2 | 9.7 | 41 | 38 | 86.1 | 72.7 |
| SB | C1 | 3.6 | 47.8 | 42.3 | 78.1 | 76.9 |
| | C2 | 10.7 | 43 | 41.5 | 93.2 | 82.5 |
| DFTF | C1 | 26.7 | 6.6 | 5.5 | 68.5 | 9.3 |
| | C2 | 32.1 | 6.5 | 5.4 | 67.7 | 9.1 |
| DFF | C1 | 31.9 | 6.2 | 5.2 | 70.5 | 9 |
| | C2 | 40.3 | 5.8 | 5.1 | 75.7 | 9.1 |
| NP | C1 | 16.5 | 30.5 | 29.1 | 91.4 | 57.3 |
| | C2 | 22.6 | 34.7 | 34.2 | 96.7 | 69.2 |
| IP | C1 | 3.7 | 41.8 | 36 | 74.1 | 63.8 |
| | C2 | 3.1 | 40.3 | 34.6 | 73.4 | 61 |
| MP | C1 | 12.8 | 35.7 | 33.3 | 87 | 64 |
| | C2 | 19.4 | 39.1 | 38.4 | 96.3 | 77.7 |
| HKW | C1 | 37.3 | 12 | 11.2 | 87.5 | 21.6 |
| | C2 | 31.7 | 16.5 | 15.7 | 90.7 | 30.9 |
| SH% | C1 | 69.8 | 5.4 | 5 | 86.8 | 9.7 |
| | C2 | 68.8 | 8.2 | 7.9 | 92.9 | 15.7 |
| PY | C1 | 14 | 33 | 30.9 | 87.5 | 59.5 |
| | C2 | 23.6 | 33.1 | 36.7 | 95.9 | 74.1 |

C1 - TMV 7 X Girnar 4, C2 - R2001-2 X Girnar 4

PH : Plant height, PB : Number of primary branches, SB : Number of secondary branches, DFTF : Days to first flowering, DFF : Days to 50% flowering, NP : Number of pods, IP : Number of immature pod, MP : Number of mature pod, HKW : SH (%) : shelling percentage PY : single plant yield

(33.0%, 30.9%). The findings were similar to Hiremath *et al*. (2011), Parameshwarappa *et al*. (2010), Savaliya *et al*. (2009) and Shoba *et al*. (2009). Moderate PCV and GCV were observed for the trait hundred kernel weight (12.0, 11.2) which is similar to the findings of Savaliya *et al*. (2009), Meta and Monpara, (2010) and Rao *et al*. (2014). The traits days to first flowering (6.6%, 5.5%), days to 50% flowering (6.2%, 5.2%), plant height (9.3%, 8.9%) and shelling percentage (5.4%, 5.0%) had a low PCV and GCV in parallel to the findings of Meta and Monpara, (2010) and Rao *et al*. (2014). The $F_2$ population R2001-2 x Girnar 4 recorded a high GCV and PCV for the traits primary branches per plant (41.0%, 38.0%), secondary branches per plant (43.0%, 41.5%), number of pods per plant (34.7%, 34.2%), mature pods per plant (39.1%, 38.4%), immature pods per plant (40.3%, 34.6%), and pod yield per plant (33.1%, 36.7%). These findings were identical to Hiremath *et al*. (2011), Parameshwarappa *et al*. (2010), Savaliya *et al*. (2009), Meta and Monpara, (2010), Rao *et al*. (2014) and Khote *et al*. (2009). Moderate PCV and GCV were observed for the traits plant height (20.0%, 19.3%) and hundred kernel weight (16.5%, 15.7%). Similar findings were reported by Shoba *et al*. (2009) and Savaliya *et al*. (2009). Low PCV and GCV were observed in days to first flowering (6.5%, 5.4%), days to 50% flowering (5.8%, 5.1%), and shelling percentage (8.2%, 7.9%). This is similar to the findings of Meta and Monpara, (2010), Rao *et al*. (2014) and Savaliya *et al*. (2009).

The coefficient of variances can only help to identify the range of variations, whereas the heritability and genetic advance give us a concise view of the behavior of gene action, by which the trait may be used for selection. The $F_2$ population TMV 7 x Girnar 4 recorded high heritability and genetic advance for the traits primary branches per plant (63%, 40.5%), secondary branches per plant (78.1%, 76.9%), number of pods per plant (91.4%, 57.3%), immature pods per plant (74.1%, 63.8%), mature pods per plant (87%, 64%) and pod yield per plant (87.5%, 59.5%). Similar findings were reported by Parameshwarappa *et al*. (2010), Thakur *et al*. (2011), Zaman *et al*. (2011), Hiremath *et al*. (2011), Narasimhulu *et al*. (2012), Babariya and Dobariya (2012) and Rao *et al*. (2014). This indicates the predominant role of additive gene action in determining the above traits hence selection method of breeding can be adopted for the improvement of the above traits. In the combination R2001-2 x Girnar 4 , high heritability and genetic advance was observed for the traits plant height (93.1%, 38.3%), primary branches per plant (86.1%, 72.7%), secondary branches per plant (93.2%, 82.5%), number of pods per plant (96.7%, 69.2%), immature pods per plant (73.4%, 61%), mature pods per plant (96.3%, 77.7%), hundred kernel weight (90.7%, 30.9%) and pod yield per plant (95.9%, 74.1%). The results are parallel to the findings of Parameshwarappa *et al*. (2010), Thakur *et al*. (2011), Zaman *et al*. (2011), Hiremath *et al*. (2011), Narasimhulu *et al*. (2012) and Babariya and Dobariya (2012). This indicates the predominant role of additive gene action.

Though yield is an important trait of consideration, improvement in yield could be brought about by improvement of the component traits which exert influence on the expression of the dependent trait.The simple correlation coefficients for the yield and yield contributing traits for both crosses of TMV 7 x Girnar 4 and R2001-2 x Girnar 4 are presented in **Table 3**. Pod yield per plant had a high significant positive correlation with the traits mature pods per plant (0.957, 0.995), number of pods per plant (0.912, 0.990), hundred kernel weight (0.266, 0.347) and shelling percentage (0.159, 0.487) in both the crosses. John *et al*. (2007) reported a high and significant positive correlation between the mature pods per plant and pod yield per plant and John *et al*. (2009) and Byadagi *et al*. (2018) reported a positive significant correlation with mature pods per plant, number of pods per plant and hundred kernel weight for pod yield per plant. This could be due to the linkage between the genes responsible for the above traits with the dependent trait, yield. Single plants with better performance for the traits mature pods per plant (0.957, 0.995), number of pods per plant (0.912, 0.990), hundred kernel weight (0.266, 0.347) and shelling percentage can be selected to improve the pod yield per plant. The remaining traits exhibited negligible association with pod yield per plant.

The correlation analysis depicts only the strength and direction of the relationship between the traits, where their direct and indirect effect are not depicted. In order to evaluate and study the direct and indirect effects that contributed to pod yield per plant through all other traits, path analysis was performed and the results are furnished in **Table 4**. It is important to consider a trait with high positive direct and indirect effect on pod yield during selection to develop a high-yielding groundnut progeny.

**Table 3. Simple correlation coefficient of pod yield and its attributing character in $F_2$ population of groundnut**

| Characters | Crosses | PH | PB | SB | DFTF | DFF | NP | IP | MP | HKW | Shelling % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PB | C1 | 0.037$^{NS}$ | | | | | | | | | |
| | C2 | 0.483$^{**}$ | | | | | | | | | |
| SB | C1 | 0.072$^{NS}$ | 0.047$^{NS}$ | | | | | | | | |
| | C2 | 0.439$^{**}$ | 0.690$^{**}$ | | | | | | | | |
| DFTF | C1 | -0.114$^{NS}$ | -0.013$^{NS}$ | -0.092$^{NS}$ | | | | | | | |
| | C2 | -0.173$^{*}$ | -0.116$^{NS}$ | -0.061$^{NS}$ | | | | | | | |
| DFF | C1 | -0.092$^{NS}$ | 0.009$^{NS}$ | 0.040$^{NS}$ | 0.893$^{**}$ | | | | | | |
| | C2 | -0.164$^{*}$ | -0.016$^{NS}$ | -0.083$^{NS}$ | 0.951$^{**}$ | | | | | | |
| NP | C1 | -0.043$^{NS}$ | -0.048$^{NS}$ | -0.054$^{NS}$ | 0.142$^{*}$ | 0.045$^{NS}$ | | | | | |
| | C2 | -0.015$^{NS}$ | 0.036$^{NS}$ | 0.048$^{NS}$ | -0.025$^{NS}$ | -0.073$^{NS}$ | | | | | |
| IP | C1 | 0.020$^{NS}$ | -0.001$^{NS}$ | -0.125$^{NS}$ | 0.197$^{**}$ | 0.082$^{NS}$ | 0.436$^{**}$ | | | | |
| | C2 | 0.126$^{NS}$ | 0.127$^{NS}$ | 0.179$^{*}$ | -0.040$^{NS}$ | -0.083$^{NS}$ | 0.259$^{**}$ | | | | |
| MP | C1 | -0.054$^{NS}$ | -0.053$^{NS}$ | -0.017$^{NS}$ | 0.090$^{NS}$ | 0.022$^{NS}$ | 0.952$^{**}$ | 0.140$^{*}$ | | | |
| | C2 | -0.036$^{NS}$ | 0.016$^{NS}$ | 0.020$^{NS}$ | -0.019$^{NS}$ | -0.062$^{NS}$ | 0.987$^{**}$ | 0.102$^{NS}$ | | | |
| HKW | C1 | -0.084$^{NS}$ | -0.119$^{NS}$ | 0.035$^{NS}$ | 0.047$^{NS}$ | 0.085$^{NS}$ | 0.067$^{NS}$ | -0.495$^{**}$ | 0.241$^{**}$ | | |
| | C2 | -0.013$^{NS}$ | -0.163$^{*}$ | 0.109$^{NS}$ | 0.115$^{NS}$ | 0.013$^{NS}$ | 0.310$^{**}$ | -0.087$^{NS}$ | 0.333$^{**}$ | | |
| SH % | C1 | -0.054$^{NS}$ | -0.202$^{**}$ | 0.012$^{NS}$ | 0.028$^{NS}$ | -0.022$^{NS}$ | 0.164$^{*}$ | 0.019$^{NS}$ | 0.174$^{*}$ | 0.197$^{**}$ | |
| | C2 | -0.005$^{NS}$ | -0.066$^{NS}$ | 0.006$^{NS}$ | 0.113$^{NS}$ | 0.078$^{NS}$ | 0.465$^{**}$ | 0.017$^{NS}$ | 0.476$^{**}$ | 0.511$^{**}$ | |
| PY | C1 | -0.066$^{NS}$ | -0.032$^{NS}$ | -0.028$^{NS}$ | 0.120$^{NS}$ | 0.056$^{NS}$ | 0.912$^{**}$ | 0.138$^{NS}$ | 0.957$^{**}$ | 0.266$^{**}$ | 0.159$^{*}$ |
| | C2 | -0.028$^{NS}$ | -0.004$^{NS}$ | 0.025$^{NS}$ | -0.023$^{NS}$ | -0.077$^{NS}$ | 0.990$^{**}$ | 0.150$^{NS}$ | 0.995$^{**}$ | 0.347$^{**}$ | 0.487$^{**}$ |

C1 - TMV 7 X Girnar 4, C2 - R2001-2 X Girnar 4

*, ** Significant at 1% and 5% level of probability, respectively
PH : Plant height, PB : Number of primary branches, SB : Number of secondary branches, DFTF : Days to first flowering, DFF : Days to 50% flowering, NP : Number of pods, IP : Number of immature pod, MP : Number of mature pod, HKW : SH (%) : shelling percentage PY : single plant yield

**Table 4. Path analysis of pod yield and its attributing character in $F_2$ population of groundnut**

| Characters | Crosses | PH | PB | SB | DFTF | DFF | NP | IP | MP | HKW | SH % | PY | (r) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH | C1 | **-0.009** | 0.001 | -0.001 | -0.001 | -0.002 | -0.022 | 0.002 | -0.023 | -0.005 | 0.001 | -0.058 | -0.066$^{NS}$ |
| | C2 | **0.01** | -0.014 | 0.004 | -0.01 | 0.011 | -0.018 | -0.04 | 0.011 | 0 | 0 | -0.046 | -0.028$^{NS}$ |
| PB | C1 | 0 | **0.022** | -0.001 | 0 | 0 | -0.025 | 0 | -0.022 | -0.007 | 0.002 | -0.03 | -0.032$^{NS}$ |
| | C2 | 0.005 | **-0.029** | 0.007 | -0.007 | 0.001 | 0.045 | -0.04 | -0.005 | -0.001 | -0.001 | -0.025 | -0.004$^{NS}$ |
| SB | C1 | -0.001 | 0.001 | **-0.011** | -0.001 | 0.001 | -0.028 | -0.011 | -0.007 | 0.002 | 0 | -0.054 | -0.028$^{NS}$ |
| | C2 | 0.004 | -0.02 | **0.01** | -0.004 | 0.006 | 0.06 | -0.056 | -0.006 | 0.001 | 0 | -0.006 | 0.025$^{NS}$ |
| DFTF | C1 | 0.001 | 0 | 0.001 | **0.009** | 0.018 | 0.073 | 0.017 | 0.037 | 0.003 | 0 | 0.157 | 0.120$^{NS}$ |
| | C2 | -0.002 | 0.003 | -0.001 | **0.057** | -0.063 | -0.031 | 0.013 | 0.006 | 0.001 | 0.002 | -0.015 | -0.023$^{NS}$ |
| DFF | C1 | 0.001 | 0 | 0 | 0.008 | **0.02** | 0.023 | 0.007 | 0.009 | 0.005 | 0 | 0.072 | 0.056$^{NS}$ |
| | C2 | -0.002 | 0.001 | -0.001 | 0.054 | **-0.066** | -0.092 | 0.026 | 0.019 | 0 | 0.001 | -0.059 | -0.077$^{NS}$ |
| NP | C1 | 0 | -0.001 | 0.001 | 0.001 | 0.001 | **0.511** | 0.037 | 0.397 | 0.004 | -0.002 | 0.949 | 0.912$^{**}$ |
| | C2 | 0 | -0.001 | 0.001 | -0.001 | 0.005 | **1.254** | -0.082 | -0.31 | 0.002 | 0.006 | 0.874 | 0.990$^{**}$ |
| IP | C1 | 0 | 0 | 0.001 | 0.002 | 0.002 | 0.223 | **0.084** | 0.058 | -0.028 | 0 | 0.342 | 0.138$^{NS}$ |
| | C2 | 0.001 | -0.004 | 0.002 | -0.002 | 0.006 | 0.325 | **-0.315** | -0.032 | -0.001 | 0 | -0.019 | 0.150$^{NS}$ |
| MP | C1 | 0.001 | -0.001 | 0 | 0.001 | 0 | 0.486 | 0.012 | **0.417** | 0.014 | -0.002 | 0.928 | 0.957$^{**}$ |
| | C2 | 0 | -0.001 | 0 | -0.001 | 0.004 | 1.238 | -0.032 | **-0.314** | 0.002 | 0.006 | 0.903 | 0.995$^{**}$ |
| HKW | C1 | 0.001 | -0.003 | 0 | 0 | 0.002 | 0.034 | -0.042 | 0.101 | **0.057** | -0.002 | 0.147 | 0.266$^{**}$ |
| | C2 | 0 | 0.005 | 0.001 | 0.007 | -0.001 | 0.388 | 0.028 | -0.105 | **0.007** | 0.007 | 0.336 | 0.347$^{**}$ |
| SH% | C1 | 0.001 | -0.005 | 0 | 0 | 0 | 0.084 | 0.002 | 0.073 | 0.011 | **-0.012** | 0.153 | 0.159$^{*}$ |
| | C2 | 0 | 0.002 | 0 | 0.007 | -0.005 | 0.584 | -0.005 | -0.149 | 0.003 | **0.013** | 0.449 | 0.487$^{**}$ |

C1 = TMV 7 X Girnar 4, C2 = R2001-2 X Girnar 4, "C1" Residue = 0.3285, "C2" Residue = 0.3248

Note: Bold numbers denote direct effect on pod yield per plant

PH : Plant height, PB : Number of primary branches, SB : Number of secondary branches, DFTF : Days to first flowering, DFF : Days to 50% flowering, NP : Number of pods, IP : Number of immature pod, MP : Number of mature pod, HKW : SH (%) : shelling percentage PY : single plant yield

In the $F_2$ population of the cross TMV 7 x Girnar 4, highest direct effect was observed for the trait number of pods per plant (0.511) followed by mature pods per plant (0.417) and immature pods per plant (0.084). Identical findings were reported by Byadagi *et al.* (2018) and John *et al.* (2015). The number of pods per plant (0.397) recorded the highest positive indirect effect on yield *via* mature pods per plant. The trait mature pods per plant (0.486) contributed to pod yield through the number of pods per plant. The trait hundred kernel weight (0.107) also contributed indirectly to the pod yield *via* mature pods per plant. This result is in line with the findings of Shrotri *et al*. (2021). The $F_2$ population R2001-2 x Girnar 4 had the highest direct effects for the traits number of pods per plant (1.254) and days to first flowering (0.057). The parallel findings were found by Byadagi *et al*. (2018) and John *et al*. (2015). The traits shelling percentage (0.584), hundred kernel weight (0.388), immature pods per plant (0.325), and mature pods per plant (1.238) contributed indirectly to pod yield through number of pods per plant. Similar results were observed by Babariya and Dobariya (2012). Hence selection of the number of pods, mature pods, shelling percentage and hundred kernel weight with positive indirect effect on pod yield will help to develop a high-yielding groundnut varieties through further generation advancements for both the populations. The residual value was 0.33 for TMV 7 x Girnar 4 and 0.32 for R2001-2 x Girnar 4, which indicates that the other traits contribute more than 60 % to pod yield in both the $F_2$ populations.

The genetic variability analysis indicated that the trait primary branches, secondary branches, number of pods, mature pods and pod yield could be enhanced through selection for crop improvement. Based on the association studies, the trait number of pods and mature pods could be suggested for the improvement of pod yield in groundnut crops.

## REFERENCES

Al-Jibouri, H. A., Miller, P. A. and Robinson, H. F. 1958. Genotypic and environmental variances and covariances in an upland Cotton cross of interspecific origin 1. *Agronomy Journal*, **50**(10): 633-636. [Cross Ref]

Babariya, C. A. and Dobariya, K. L. 2012. Correlation coefficient and path coefficient analysis for yield components in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding,* **3**(3): 932-938.

Byadagi, U. R., Venkataravana, P. and Priyadarshini, S. K. 2018. Character association studies between pod yield and its attributes in $F_2$ populations derived from three connected crosses of groundnut (*Arachis hypogaea* L). *Journal of Pharmacognosy and Phytochemistry,* **7**(5): 3135-3138.

Dewey, D. R. and Lu, K. 1959. A correlation and path-coefficient analysis of components of crested wheatgrass seed production. *Agronomy journal*, **51**(9): 515-518. [Cross Ref]

Hiremath, C. P., Nadaf, H. L. and Keerthi, C. M. 2011. Induced genetic variability and correlation studies for yield and its component traits in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding,* **2**(1): 135-142.

John, K., Reddy, P. R., Reddy, P. H., Sudhakar, P. and Reddy, N. P. 2015. Character association and path coefficient analysis for yield, yield attributes and water use efficieny traits in grounndut (*Arachis hypogaea* L.) A review. *Agricultural Reviews,* **36**(4): 277-286. [Cross Ref]

John, K., Vasanthi, R. P. and Venkateswarlu, O. 2007. Variability and correlation studies for pod yield and its attributes in $F_2$ generation of six Virginia× Spanish crosses of groundnut (*Arachis hypogaea* L.). *Legume Research-An International Journal,* **30**(4): 292-296.

John, K., Vasanthi, R. P. and Venkateswarlu, O. 2009. Studies on variability and character association in Spanish bunch grounnndut (*Arachis hypogaea* L.). *Legume Research-An International Journal,* **32**(1): 65-69.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*, **47**(7): 314-318. [Cross Ref]

Khote, A. C., Bendale, V. W., Bhave, S. G. and Patil, P. P. 2009. Genetic variability, heritability and genetic advance in some exotic genotypes of groundnut (*Arachis hypogaea* L.). *Crop Research (Hisar),* **37**(1/3): 186-191.

Ladole, M. Y., Wakode, M. M. and Deshmuk, S. N. 2009. Genetic variability and character association studies for yield and yield contributing traits in groundnut (*Arachis hypogaea* L.). *Journal of Oilseeds Research,* **26**: 123-125.

Meta, H. R. and Monpara, B. A. 2010. Genetic variation and trait relationships in summer groundnut,(*Arachis hypogaea* L.). *J. Oilseeds Res,* **27**(1): 8-11.

Narasimhulu, R., Kenchanagoudar, P. V. and Gowda, M. V. C. 2012. Study of genetic variability and correlations in selected groundnut genotypes. *International Journal of Applied Biology and Pharmaceutical Technology,* **3**(1): 355-358.

Parameshwarappa, K. G., Krupa Rani, K. S. and Bentur, M. G. 2010. Genetic variability and character association in large seeded groundnut genotypes. *Karnataka Journal of Agricultural Sciences,* **18**(2).

Prabhu, R., Manivannan, N., Mothilal, A. and Ibrahim, S. M. 2014. Magnitude and direction of association for yield and yield attributes in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding,* **5**(4): 824-827.

Rao, V. T., Venkanna, V., Bhadru, D. and Bharathi, D. 2014. Studies on variability, character association and path analysis on groundnut (*Arachis hypogaea* L.). *Int. J. Pure App. Biosci,* **2**(2): 194-197.

Robinson. H. F. and Comstock, R. E. 1950. Genotypic and phenotypic correlations in corn and their implications in selection. North Carolina State University. Dept. of Statistics.

Savaliya, J. J., Pansuriya, A. G., Sodavadiya, P. R. and Leva, R. L. 2009. Evaluation of inter and intraspecific hybrid derivatives of groundnut (*Arachis hypogaea* L.) for yield and its components. *Legume Research-An International Journal,* **32**(2): 129-132.

Shoba, D., Manivannan, N. and Vindhiyavarman, P. 2009. Studies on variability, heritability and genetic advance in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding,* **1**(1): 74-77.

Shrotri, S. M., Dhuppe, M. V., Gavade, S. S. and Sargar, P. R. 2021. Character association and path analysis for yield and yield contributing traits and in Groundnut (*Arachis hypogaea* L.). *The Pharma Innovation Journal,* **10**(11): 979-981.

Stalker, H. T., Tallury, S. P., Seijo, G. R. and Leal-Bertioli, S. C. 2016. Biology, speciation, and utilization of peanut species. In *Peanuts* (pp. 27-66): Elsevier. [Cross Ref]

Thakur, S. B., Ghimire, S. K., Chaudhary, N. K., Shrestha, S. M. and Mishra, B. 2011. Genic variability, heritability and genic advance of pod-yield component traits of groundnut (*Arachis hypogaea* L.). *Journal of the Institute of Agriculture and Animal Science,* **32**, 133-141.

Zaman, M. A., Tuhina-Khatun, M., Ullah, M. Z., Moniruzzamn, M. and Alam, K. H. 2011. Genetic variability and path analysis of groundnut (*Arachis hypogaea* L.). *The Agriculturists,* **9**(1-2), 29-36. [Cross Ref]