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RESEARCH ARTICLE

# Path effects as influenced by recombination and induced mutation in $F_2$ and $F_2M_2$ populations of groundnut (*Arachis hypogaea* L.)

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## SUMMARY

Path coefficient analysis of pod yield with its component characters was carried out in $F_2$ and $F_2M_2$ populations generated by crossing GPBD-4 and CTMG-1 and by subjecting 50 per cent of $F_0$ seeds of the cross to 20 kR g-rays treatment in groundnut (*Arachis hypogaea* L.). Highly significant positive correlation of pod yield with harvest index (0.973), number of matured pods (0.671), total number of pods (0.537), oil content (0.316), hundred kernel weight (0.184), number of branches (0.162), plant height (0.137), shelling percentage (0.134) and late leaf spot (0.256) was observed in $F_2M_2$ population. Harvest index recorded highest positive direct effect (0.848) followed by number of matured pods (0.543) and total number of pods (0.465) on pod yield in $F_2M_2$ population. In $F_2$ population, sound mature kernels (0.015) showed positive direct effect that was indirectly and positively influenced by hundred kernel weight (0.031). The proportion of transgressive segregants was also highest in $F_2M_2$ population. The present findings reveals the possibility of disruption of undesirable linkage relationship by reshuffling of genes through hybridization followed by mutagenesis and selection in these populations could be practiced to identify genotypes with desirable characters.

***Key Words*** **:** Groundnut, Hybridization, Mutation, $F_2/F_2M_2$ populations, Path analysis

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Groundnut (*Arachis hypogaea* L.), a member of the legume family, is commercially popular because of its vegetable protein content (11.00 - 36.40 %), oil content (35.80 - 54.20%) and soluble sugars (8-14%) with sucrose as the major source of carbohydrate and is known as poor man's nut. The oil cake meal is also used as an animal feed and organic fertilizer (Aruna and Nigam, 2009). Globally, it is cultivated on 23.4 million ha with annual production of 34.9 million metric tons and an average yield of 1.5 tons $ha^{-1}$. India production is 6.25 m.t which is the second largest producer after China (14.3 m.t), USA (2.34 m.t), Nigeria (1.55 m.t), Indonesia (1.25 m.t.), Sudan (0.85 m.t.), Senegal (0.71 m.t), Argentina (0.58 m.t), and Vietnam (0.5 m.t) (Upadhyaya *et al*., 2011). India and China together are the world's leading groundnut producers accounting for nearly 60 per cent of the production and India's share is about 18 per cent in total world production. The major groundnut producing states of India are Gujarat which ranks first (3.3 m.t.), followed by Andhra Pradesh (2.6 m.t), Tamil Nadu (1.0 m.t), Karnataka (0.7 m.t) and Maharashtra (0.4 m.t). However, a wide gap exists between the currently realizable yield and the potential yield of cultivars.

The efficiency of any breeding programme is basically dependent upon the effective selection of plants *via* the inherent characters expressed externally as a result of environmental interaction that are assessed phenotypically. Such an effective selection is possible by using information

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of the phenotypic and genotypic inter-relationships of pod yield with its component characters and also among the component characters.

The correlations study indicates the extent of association, but not the causal relationship. Path analysis in many studies proved that the strong correlations observed among most of the traits were found to be contributed by other traits but not by themselves. The total correlation coefficient between yield and its component characters may sometimes be misleading, as it may be an over or underestimate of its association with other characters. Hence, the correlations as such may not be useful in selecting for high pod yields.

Since, the interdependence of these characters will influence pod yield either directly or indirectly the path co-efficient analysis permits the partitioning of these correlations into direct and indirect effects via other characters and thus helps in effective selection through development of appropriate breeding strategy. The present investigation on path analysis of pod yield and with its attributes in each generation was carried out so as to understand direct and indirect effects that have occurred either through hybridization and combination of mutation and hybridization and to identify desirable segregants in the population.

## MATERIALS AND METHODS

The present investigation was carried out from 2005 - 2008 in the field unit of All India Co-ordinate Research Project (AICRP) on Groundnut, Agricultural Research Station, Chintamani, representing the Eastern dry zone (Zone-5) of Karnataka. The experimental material was generated using two genotypes of groundnut *viz*., GPBD-4 and CTMG-1 belonging to Virginia and Spanish groups, respectively. These two genotypes were crossed to generate $F_0$ seeds, 50 per cent of $F_0$ was treated with 20 kR g-rays and carried forward upto $F_2M_2$ generations while the remaining 50 per cent untreated $F_0$ seeds were forwarded upto $F_2$ generation. All the $F_2$'s and $F_2M_2$'s population were raised along with their parents in un replicated blocks. About 242 plants of $F_2$'s and 235 plants of $F_2M_2$'s survived to maturity and were considered for recording observations on incidence of leaf spots, rust and peanut bud necrosis disease one week before harvest and on plant height (cm), number of branches, days to 50 per cent flowering, total pods per plant, matured pods per plant, pod yield (g/plant), hundred kernel weight (g), shelling per cent, sound mature kernel percentage, oil content (%) and harvest index at the time of harvest.

The correlation coefficients of pod yield and its components and also among the yield components were further partitioned into direct and indirect effects through path coefficient analysis as suggested by Wright (1921) and as illustrated by Dewey and Lu (1959) in both $F_2$ and $F_2M_2$ population.

## RESULTS AND DISCUSSION

Yield is a complex character influenced by different component traits, some of which affect it directly while the others indirectly which can be understood from path coefficient analysis. Path analysis unravels the intricacies of yield components. Thus, direct selection could be carried out for such characters to improve the dependent character.

Hence, a thorough knowledge of the association of different traits with pod yield and their possible association among themselves is very much essential for achieving improvement in pod yield. The path analysis furnishes a method for partitioning the correlation coefficient into direct and indirect effects and measures the relative importance of the causal factors involved. The results of the same have been discussed in hybridization or combination of hybridization and mutagen treated populations.

### Path analysis in $F_2$ and $F_2M_2$ populations of groundnut :

The direct and indirect effects of component characters on pod yield in $F_2$ and $F_2M_2$ population of groundnut are presented in Table 1 and Table 2.

Highest positive direct effect on pod yield was manifested by total number of pods (0.053) which was influenced by negative indirect effect of shelling percentage (-0.027), hundred kernel weight (-0.013), sound mature kernels (-0.011) in $F_2$ population (Table 1). While, harvest index recorded highest positive direct effect (0.848) followed by number of matured pods (0.543), total number of pods (0.465), while, oil content (0.235), shelling percentage (0.131), number of branches (0.106) and plant height (0.096) registered low positive direct effects on pod yield in $F_2M_2$ population (Table 2).

The highest direct positive effect was manifested by harvest index (0.848) resulting in a very high strong and significant association with pod yield (r = 0.973). Total number of pods (0.116) and number of matured pods (0.231) also contributed indirectly and positively to harvest index in $F_2M_2$ population.

In $F_2$ population sound mature kernels (0.015) showed positive direct effect that was indirectly and positively influenced by hundred kernel weight (0.031). Shelling percentage (0.013) also showed positive direct effect with positive indirect effect of plant height (0.033), number of matured pods (0.026), number of branches (0.011) and hundred kernel weight (0.010). Number of branches (0.009) showed low positive direct effect and was influenced by positive indirect effect of harvest index (0.023), total number of pods (0.013), hundred kernel weight (0.009), oil content (0.009) and sound mature kernels (0.006). The direct effect of oil content was negative (-0.211) which was indirectly but positively influenced by harvest index (0.165) followed by plant height (0.018), number of matured pods (0.018) and hundred kernel weight (0.011), but negatively influenced by total number of pods (-0.064), shelling percentage (-0.006) and sound mature kernels (-0.001). Though, hundred kernel weight exhibited a positive correlation with pod yield, the direct effect of hundred kernel weight (-0.018) was negative, which was negatively influenced by shelling percentage (-0.016), sound mature kernels (-0.019). This was further nullified by positive indirect effect of plant height (0.043), number of matured pods (0.030), number of branches (0.016), and total number of pods (0.012). Number of matured pods (-0.041) also manifested negative direct effect which was cumulatively influenced by negative indirect effect of sound mature kernels (-0.025), total number of pods (-0.032), plant height (-0.012).

Similarly, in $F_2M_2$ population number of matured pods (0.543) manifested high direct positive effect which was enhanced by positive indirect effect through hundred kernel weight (0.153) and harvest index (0.160) resulting in strong positive and significant correlation with pod yield (0.671). Total number of pods (0.465) registered high positive direct effect, which was enhanced by indirect positive effect through number of matured pods (0.329) resulting in strong positive significant association with pod yield (0.537).

The significant association of plant height with pod yield (0.137) was attributed to its direct positive effect (0.096) and indirect positive effect through harvest index (0.185). Number of branches exhibited low positive direct effect (0.106) resulting in significant association with pod yield (0.162) because of low indirect positive effect through total number of pods (0.046), number of matured pods (0.095) and hundred kernel weight (0.053).

Shelling percentage also showed positive direct effect (0.131) which was further enhanced by positive indirect effect through total number of pods (0.121) and harvest index (0.121)

**Table 1 : Estimates of direct (diagonal) and indirect effects of yield contributing characters on pod yield in $F_2$ population of groundnut (*Arachis hypogaea* L.)**

| Characters | Plant height (cm) | Number of branches | Total number of pods | Number of matured pods | Hundred kernel weight (g) | Shelling percentage | Sound mature kernels (%) | Oil content (%) | Harvest Index. | 'r' value with pod yield |
|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) | 0.002 | -0.007 | -0.009 | 0.011 | 0.018 | 0.006 | -0.016 | 0.008 | 0.009 | 0.022 |
| Number of branches | -0.011 | 0.009 | 0.013 | -0.021 | 0.009 | -0.011 | 0.006 | 0.009 | 0.023 | 0.026 |
| Total number of pods | 0.016 | 0.007 | 0.053 | 0.005 | -0.013 | -0.027 | -0.011 | 0.006 | 0.009 | 0.040 |
| Number of matured pods | -0.012 | 0.008 | -0.032 | -0.041 | 0.015 | 0.035 | -0.025 | 0.003 | 0.013 | -0.036 |
| Hundred kernel weight (g) | 0.043 | 0.016 | 0.012 | 0.030 | -0.018 | -0.061 | -0.019 | 0.009 | 0.012 | 0.024 |
| Shelling percentage | 0.033 | 0.011 | -0.044 | 0.026 | 0.010 | 0.013 | -0.018 | 0.000 | -0.012 | 0.019 |
| Sound mature kernels (%) | -0.005 | -0.013 | -0.011 | 0.009 | 0.031 | -0.011 | 0.015 | 0.005 | -0.001 | 0.029 |
| Oil content (%) | 0.018 | 0.003 | -0.064 | 0.018 | 0.011 | -0.006 | -0.001 | -0.211 | 0.165 | -0.067 |
| Harvest Index | -0.043 | 0.110 | -0.103 | -0.032 | 0.016 | 0.009 | -0.012 | 0.036 | -0.148 | -0.167* |

Residual effect = 0.0967 * and ** indicates significance of value at p=0.05 and 0.01, respectively Note :Bold face figures indicate direct effects

**Table 2 : Estimates of direct (diagonal) and indirect effects of yield contributing characters on pod yield in $F_2M_2$ populations of groundnut (*Arachis hypogaea* L.)**

| Characters | Plant height (cm) | Number of branches | Total number of pods | Number of matured pods | Hundred kernel weight (g) | Shelling percentage | Sound mature kernels | Oil content (%) | Harvest Index. | 'r' value with pod yield |
|---|---|---|---|---|---|---|---|---|---|---|
| A. population | | | | | | | | | | |
| Plant height (cm) | 0.096 | -0.049 | -0.057 | -0.004 | -0.006 | -0.013 | -0.005 | -0.01 | 0.185 | 0.137* |
| Number of branches | -0.033 | 0.106 | 0.046 | 0.095 | 0.053 | -0.002 | 0.002 | 0.006 | -0.111 | 0.162** |
| Total number of pods | -0.012 | -0.008 | 0.465 | 0.329 | -0.079 | -0.016 | -0.065 | -0.073 | -0.004 | 0.537** |
| Number of matured pods | -0.056 | -0.006 | 0.026 | 0.543 | 0.153 | -0.008 | -0.085 | -0.056 | 0.160 | 0.671** |
| Hundred kernel weight(g) | -0.034 | -0.075 | -0.031 | 0.431 | -0.085 | 0.023 | -0.123 | -0.095 | 0.173 | 0.184** |
| Shelling percentage | -0.043 | -0.096 | 0.160 | -0.065 | -0.056 | 0.131 | -0.006 | -0.012 | 0.121 | 0.134* |
| Sound mature kernels (%) | 0.068 | -0.056 | -0.123 | 0.038 | -0.015 | -0.003 | -0.092 | 0.108 | -0.034 | -0.109 |
| Oil content (%) | 0.042 | -0.032 | -0.005 | 0.06 | -0.056 | -0.009 | -0.031 | 0.235 | 0.112 | 0.316** |
| Harvest Index | -0.046 | -0.092 | 0.116 | 0.231 | 0.061 | -0.083 | -0.056 | -0.006 | 0.848 | 0.973** |

Residual effect = 0.0026 * and ** indicate significance of values at p=0.05 and 0.01, respectively. Note :Bold face figures indicate direct effects resulting in positive significant correlation with pod yield (0.134). Oil content showed high direct positive effect (0.235) which was further enhanced by positive direct effect of harvest index (0.112) resulting in strong positive significant correlation with pod yield (0.316). Though, hundred kernel weight exhibited negative direct effect (-0.085), it had significant positive correlation with pod yield (0.184) due to high positive indirect effect *via* matured pods (0.431), harvest index (0.173) and shelling percentage (0.023).

In a similar study, Veeramani *et al*. (2005) observed direct effect of number of clusters per plant, number of pods per plant and pod length on seed yield in $F_2$ populations of blackgram, while among the indirect effects, plant height influenced the number of pods per plant and clusters per plant. Sah *et al*. (2000) also reported high direct effect of seed yield per plant on oil yield per plant in a study of mutant cultures of groundnut.

The results obtained in the present study confirm the findings of Venkateswarlu *et al*. (2007) who observed high positive direct effects of kernel yield per plant followed by shelling per cent and number of well filled and mature pods per plant on pod yield. In groundnut genotypes studied by Lakshmidevamma *et al*. (2004), path analysis revealed high direct effects of kernel yield and oil content on oil yield. Path analysis studies by Baskaran and Muthiah (2007) also revealed that pods per plant, 100 seed weight and plant height to be the major contributors for seed yield and the selection based on these attributes would be most advantageous in pigeonpea.

In $F_2M_2$ population, harvest index, number of matured pods and total number of pods recorded highest positive direct effect on pod yield. On the other hand, oil content exhibited direct negative effect on pod yield in $F_2$ population but low indirect effect resulted in negative correlation of oil content with pod yield. The undesirable linkage blocks were disrupted and selection in these populations could be stabilized for release as a variety with desirable characters. These results indicated that mutagenic treatment of hybridized material was quite effective in changing undesirable linkages and thereby generating productive segregating population. This resulted in release of concealed variability, which was locked up in corresponding $F_2$ generation thus providing lot of scope for selection.

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