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Character association and path coefficient analysis for yield, yield attributes and water use efficieny traits in grounndut (*Arachis hypogaea* L.) - A review

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ABSTRACT

Correlation analysis provides useful information for basis of selection for trait like pod and seed yield. Seed yield is the most economic as well as very complex character in nature because it is governed by polygene and greatly influenced by environmental factors. The estimate of genotypic correlation coefficients in general higher than their corresponding phenotypic correlations indicating strong inherent association among the traits. Pod yield in groundnut is a complex and depends upon the interplay of number of components attributes. Primary yield components of groundnut *viz.,* pod size, sound mature kernels, shelling percentage, 100 kernel weight, kernel yield and number of mature pods per plant showed positive correlation with each other and with pod yield. A clear picture of contribution of each component is the final expression of character would emerge through the study of correlation and causation of path concept revealing different ways in which component attributes influence the complex traits. Path coefficient analysis helps in formulating the selection criteria based on these direct and indirect effects. In order to achieve the goal of increased production by increasing the yield potential of crop, knowledge of direction and magnitude of association between various traits is essential for plant breeders.

Key words: Character association, Groundnut, Path analysis, Yield attributes.

Character association: Yield is a polygenically controlled character and highly influenced by the environment. Selection merely based on yield is not effective. Selection based on its component increases yield as they are not only less complex but also relatively simply inherited and is much less influenced by environmental deviations. Character association analysis measures the actual relationship between various plant characters and helps the plant breeder in formulating selection criteria for pod yield in parental lines and segregating populations. Phenotypic correlation is the association between two characters, which can be directly observed and is subjected to changes in the environment. It measures the environmental deviations together with non-additive gene action. Genotypic correlation is the correlation of breeding values i.e. (Additive + Additive x Additive gene action). Correlation coefficient reveals the type, nature and magnitude of correlation between any pair of characters.

Yield component characters show association among themselves and with yield. Unfavourable associations between the desired attributes under selection may limit genetic advance. Hence, a sound knowledge of association between the yield components is essential for planning an effective selection programme. Syakudo and Kawabata (1965) studied the F_2 progeny of s cross between Virginia, Spanish and Valencia botanical groups. They found a significant positive correlation between pod and kernel weights. Similarly Dholaria *et al.* (1973) reported positive and significant association of pod yield with number of mature pods per plant. Coffelt and Hammons (1974) studied correlation coefficients for 9 characters in five F_2 population between Argentine (Spanish type) and Early Runner (Virginia type) observed highly significant positive correlation between number of pods and pod weight and number of seeds and seed weight. Shettar (1974) reported that pod yield had positive correlation with height of main axis, number of primary branches and number of mature pods and negative correlation with number of days to flowering, shelling percentage and number of pods.

Sandhu and Khehra (1977) studied correlations in a cross between semi-spreading x bunch varieties of groundnut and reported positive and significant correlation of pod yield with number of mature pods. Balakisan (1979) also reported positive and significant correlation of pod yield with number of mature pods in the parents and F_2 progenies. Sangha *et al*. (1979) in F_2 progenies of crosses M145 x Tiffton 1108 reported that pod yield was positively and highly associated with number of pods. Correlation studies of Reddy and Reddy (1979) indicated that pod yield per plant was

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positively correlated with number of mature pods per plant regardless of the habit group in the segregating populations from the cross M145 x U-2-47-3. High positive association of pod yield with number of mature pods was observed by Labana *et al.* (1980) in the segregating F_2 population from the cross M145 x U2-47-3. Layrisse *et al.* (1980) obtained significant and positive correlation for pod yield and kernel yield with oil per cent in the F_2 generation of 10 parent diallel studies. Similarly in 105 semi-spreading F_2 segregants yield was positively and significantly correlated with number of mature pods per plant (Balaiah *et al.*, 1980).

Mahesh Kumar (1981) studied correlations in 28 F_1s and their parents. Correlations studies among parents revealed a positive and significant association of pod yield per plant with number of mature pods per plant (0.8831). Among F_1s also the association of pod yield per plant with number of mature pods per plant (0.7962) was positive and significant. Raju *et al.* (1981) studied correlations in both parents and 10 F_1s of 5 parent diallel. They found that number of mature pods positively correlated with pod yield in both ai parents and F_1s at genotypic level.

Yadava *et al.* (1981) in their study for 6 yield components in 26 groundnut strains observed that pod yield was significantly and positively associated with number of mature pods per plant. Pod yield in groundnut was positively and significantly correlated with number of mature pods and shelling out turn (Nagabhushanam *et al.,* 1982). Alam *et al.* (1985) observed that pod yield per plant had positive association with number of pods per plant, days to maturity and plant height. Shelling percentage had negative association with 100-kernel weight. Further oil content was negatively associated with all the characters except days to maturity and 100- kernel weight. Deshmukh *et al.* (1986) reported significant positive association of pod yield with number of mature pods per plant, 100-kernel weight and percentage of sound mature kernels, while negative association with dry matter at harvest. Reddi *et al.* (1986) reported that primary yield components of groundnut *viz.*, shelling percentage, kernel yield and number of mature pods per plant showed positive correlation with each other and with pod yield. Makne and Bhale (1987) in a 10 x 10 diallel combining ability analysis in groundnut showed that both in ten parents and 45 crosses pod yield per plant was negatively correlated with oil per cent both at phenotypic (-0.199) and genotypic levels(-0.258), suggesting that pod yield per plant would not be assisted by oil per cent.

Reddy *et al.* (1987) reported that primary yield components of groundnut *viz.,* shelling percentage, kernel yield and number of mature pods per plant showed positive correlation with each other and with pod yield. Madhavi (1988) reported that LAI in the initial stages had positive correlation with pod yield, kernel yield and number of pods. She also observed correlation of LAI from 60 days with pod yield, kernel yield and total drymatter. She concluded that initial LAI together with initial drymatter could be employed profitably as selection criteria to select productive genotypes in groundnut breeding. Tekale *et al.* (1988) observed positive and significant correlation of pod weight per plant and dry pod yield per plant with plant height, branches per plant, developed pods per plant and total pods per plant.

Correlation studies of Nadaf and Habib (1989) and Dahiphale *et al.* (1990) showed that pod yield per plant was positively correlated with number of developed pods per plant and Pod yield showed highly significant association with kernel yield and pods per plant (Prasanthi *et al.,* 1989 and Mishra and Yadav, 1992). Abraham (1990) reported that kernel yield had significant positive correlation with pods per plant, kernels per plant, 100-kernel weight and shelling percentage. Manoharan *et al.* (1990a) recorded positive correlation of pod yield per plant with drymatter production, harvest index, number of mature pods per plant in F_2 population of J11x Chico. Further pod number positively correlated with drymatter production and harvest index. Manoharan *et al.* (1990b) in study of 21 F_1 hybrids observed significant positive association of pod yield per plant with pod number. They also observed non-significant positive association of pod yield per plant with shelling per cent.

Sharma and Varsheny (1990) observed that the yield of mature pods per plant had positive association with number of mature pods, number of immature pods, 100-kernel weight, yield of immature pods and biological yield. Sudarsanam *et al. (*1989); Prasanthi *et al.* (1990) and Venkateswarlu *et al.* (1991) showed that pod yield was closely associated with kernel yield, number of pods per plant and harvest index. Patra *et al.* (1992) while studying correlations in advanced generations of groundnut reported significant positive association of pod yield with number of mature pods per plant and harvest index. Further negative association between shelling per cent and harvest index indicates that high shelling per cent was linked with low harvest index and low pod yield. Pushkaran and Nair (1993) reported that pod yield was significantly and positively correlated with haulms yield, number of mature pods and number of immature pods. They also observed the significant and positive association of number of mature pods with shelling percentage.

Wright *et al.* (1993) reported significant negative association of specific leaf area with harvest index. They concluded that selection for low specific leaf area in peanuts may be appropriate in water limited systems, where both pod yield for human consumption and vegetative yield for animal fodder need to be maximized. Sharma and Varshney (1995) reported positive correlation of pod yield, pods per plant and shelling per cent with harvest index and concluded that improvement in harvest index with an ultimate objective of improvement in yield could be achieved by increasing pods per plant, kernels per pod and shelling per cent. They also reported positive correlation between pods per plant and shelling per cent.

Sumathi and Ramanthan (1995b) revealed strong positive association of pod yield per plant with number of mature pods per plant (0.907) and with kernel yield per plant (0.908) and in 32 F_2 progenies of crosses. Further number of mature pods per plant registered positive and highly significant association (0.657) with kernel yield per plant. Mishra (1995) recorded that pod yield was positively and significantly correlated with harvest index and number of pods per plant, whereas number of pods per plant was significantly and positively correlated with harvest index. Uddin *et al.* (1995) reported significant positive correlation of seed yield per plant with days to maturity, seeds per plant, plant height and primary branches per plant but was negatively associated with shelling percentage and 100-seed weight. Francies and Ramalingam (1996) from their studies in F_2 generation indicated that kernel yield was strongly associated with pod yield. Similarly Ofori (1996) observed positive correlation between number of pods per plant and seed yield.

Ofori (1996) observed negative correlation between number of pods per plant and 100-seed weight but both were positively correlated with seed yields. Varman and Raveendran (1996) reported negative non-significant association with length of main axis with pod yield. Varman and Raveendran (1996) in 63 F_1 populations observed significant positive correlation of pod yield per plant with shelling percentage (0.520) and number of mature pods per plant (0.497), shelling out-turn had non-significant positive association with oil content. Similarly pods per plant also exhibited non-significant positive association with kernel yield per plant and pod yield per plant. Arjunan *et al*. (1997) reported positive non-significant association of pod weight with specific leaf area and non-significant negative association of specific leaf area with harvest index. Moinuddin (1997) observed strong positive association of pod yield with number of mature pods per plant, 100-kernel weight and biomass per plant. It was also revealed that haulm yield per plant and shelling percentage had negative correlation with pod yield. Islam and Rasul (1998) observed significant positive correlations between days to 50% flowering and days to maturity and between shelling percentage and seed yield. Highest negative correlation was noticed between number of developed pods per plant and seed weight.

Jayaramaiah and Thimmegowda (1998) observed positive significant correlation of pod yield with number of filled pods per plant and oil yield. Vasanthi *et al.* (1998) from their study on advanced breeding lines found that pod weight per plant showed significant positive correlation with sound mature kernel percentage and significant negative association with days to 50 per cent flowering. Shelling percentage showed significant positive association with sound mature kernel percentage but significant negative association with days to maturity and haulm weight per plant. Singh and Singh (1999) indicated that yield improvement could be achieved by selection for number and weight of pods per plant and kernel weight. Total dry matter at harvest had significant negative relationship with harvest index. Pod yield had significant positive association with harvest index. Antony *et al.* (2000) observed that plant height had a negative relationship with number of branches per plant. Plant height had positive relationship with leaf area index and harvest index.

Jayalakshmi *et al.* (2000) in parents and 21 F_1s revealed that mature pods per plant, specific leaf area and harvest index had positive significant correlation with kernel yield per plant in both parents and crosses. Significant association of specific leaf area with harvest index in parents and F_1s and non-significant association in F_3 s generations suggesting that concurrent improvement in both low specific leaf area and high harvest index may be possible in the advanced generations of the material studied, while oil content had negative association with kernel yield per plant in parental genotypes. Naazar Ali *et al.* (2000) also reported that pod yield was positively and significantly correlated with seed yield and oil content. Rostini *et al.* (2000) reported positive genetic correlation between yield and chlorophyll content at 16 days after flowering. Singh *et al.* (2000) observed highly significant positive association of pod yield with number of mature kernels. Similarly, Venkataravana *et al.* (2000) revealed that pod yield had significant positive association with number of mature pods, shelling per cent, 100-kernel weight and kernel oil yield. Similarly, it was also observed that number of mature pods, shelling per cent and kernel yield were significantly and positively associated *inter-se* as well as with pod yield.

Johar Singh and Mohinder Singh (2001) studied correlations in 5 advanced lines and 8 segregating populations of two crosses. They observed that number of pods had the significant positive association with pod yield per plant which is an indication of favorable partition of source to sink. Positive association of harvest index with pod yields per plant and sound mature kernel per cent was also observed. Nageswara Rao *et al.* (2001) reported significant correlations between SLA with SPAD chlorophyll meter reading (SCMR) and suggested that SPAD chlorophyll meter reading could be used as a rapid, low cost, non-destructive technique to screen large breeding populations.

Vijayasekhar (2002) reported that pod yield per plant had highly significant positive association with kernel yield per plant, harvest index and pods per plant. Bindu Madhava *et al.* (2003) reported positive relationship between specific leaf nitrogen and chlorophyll content (r =0.76) and also between SPAD chlorophyll meter reading and leaf chlorophyll content (r=0.86). Leaf nitrogen status is often reflected through leaf chlorophyll content and such association has been shown in several crops (Takebe *et al.*, 1990 and Chapman and Baretto, 1997). Significant relationship between SPAD chlorophyll meter reading and chlorophyll content and Nitrogen content in leaves have been found in crops such as rice, Balasubramanian *et al.* (2000); Corn, Dwyer *et al.* (1995) and in wheat, Reeves *et al.* (1993). Makhan lal *et al.* (2003) reported significant positive association between pod yield per plant and number of mature pods per plant; root length and number of nodules per plant; root length and root weight and root weight and pod yield in groundnut.

Daboria *et al.* (2004) encouraged the direct selection for high protein content that may eventually result in high sugar but low oil content based on correlations they observed in their studies. They have also observed positive correlation of protein content with sugar and negative correlation with oil content. Hemanth Kumar (2004) reported significant positive association of kernel yield per plant with mature pods per plant, 100-kernel weight and harvest index and positive non-significant association with shelling percentage. Lakshmidevamma *et al.* (2004) reported that pod yield had significant but negative association with shelling percentage. Days to 50% flowering, number of branches per plant, plant height, number of mature pods and kernel yield had significant positive association.

Reddy *et al.* (2003) observed a positive correlation between SCMR and seed yield and negative correlation between SCMR and SLA and substantiated the conclusion that SCMR was a potential physiological trait to employ as a surrogate for transpiration efficiency. Seethala Devi (2004) reported significant positive association of kernel yield per plant, harvest index and sound mature kernel per cent with pod yield per plant in parents and F_2 populations, whereas Suneetha *et al.* (2004) in parents and F_1s reported significant positive association of pod yield per plant with number of well mature pods per plant and harvest index. Mahalaksmi *et al.* (2005) reported significant positive association of kernel yield per plant with shelling per cent, 100-kernel weight and pod yield. They also reported positive association of pod yield with kernel yield per plant.

Correlation studies of Sirisha (2005) revealed positive association of pod yield with number of primary branches, immature pods and harvest index. Number of primary branches exhibited positive association with number of mature pods per plant. Suneetha *et al.* (2005) reported that pod yield had high and significant positive association with number of mature pods and harvest index. Days to 50 per cent flowering and height of main axis were negatively correlated with pod yield per plant. Studies of Venkateswarlu (2005) showed that pod yield was positively correlated with number of mature pods per plant and kernel yield per plant. Kalmeshwer Gouda Patil *et al.* (2006) reported that pod yield per plant had significant positive association with number of pods per plant and shelling percentage. Number of branches per plant showed non- significant positive association with pod yield per plant.

Venkateswarlu *et al.* (2007) revealed the highly significant positive association of harvest index, number of well filled and mature pods per plant and kernel yield per plant with pod yield. John *et al.* (2008) reported significant positive association of pod yield with number mature pods per plant, SPAD chlorophyll meter reading, kernel yield per plant, pod width and harvest index in F_2 population of six single crosses. John *et al.* (2009) reported significant positive association of pod and kernel yields with number of secondary branches per plant, number of mature pods per plant, sound mature kernel weight, sound mature kernel number and 100- kernel weight. Sumathi and Muralidharan (2009) reported sound mature kernel weight had significant positive correlation with pod yield per plant.

Path coefficient analysis: Path coefficient analysis, an effective tool for partitioning the correlation coefficient into direct and indirect effects of yield attributes, which would be helpful for selection. Path coefficient analysis is a statistical device developed by Wright (1921) helps in partitioning of the correlation coefficients into direct and indirect effects of independent variable on dependent variable. The correlation coefficients do not give a complete picture of the causal basis of association. Path coefficient analysis of different components of yield brings out relative importance of their direct and indirect effects and gives a clear understanding of their association with yield. Thus, path coefficient analysis helps in formulating the selection criteria based on these direct and indirect effects. Hence, path analysis of much importance in any plant breeding programmes.The available literature on path coefficient analysis is furnished here under.

Sandhu and Khehra (1977) found that in Virginia x Spanish and Virginia x Virginia crosses of groundnut, large direct contribution to the pod yield per plant affected by the number of mature pods per plant, whereas the contribution of the other characters was largely indirect through pod number. Balkisan (1979) in a study with 5 parents and F_2 progenies of 8 crosses involving them reported that pod yield was mainly contributed by number of mature pods per plant. Raju *et al.* (1981) in their studies on 5 parents and 10 F_1s indicated that number of mature pods had pronounced indirect effect on pod yield. Similarly Yadava *et al.* (1981) also reported that pod number had maximum direct effect on pod yield. Nagabhushanam *et al.* (1982) studied 18 genotypes of groundnut and reported that number of mature pods had direct contribution to pod yield. Prakash Kumar and Yadava (1982) studied 22 bunch genotypes of groundnut and reported that pod yield has positive association with number of mature pods per plant owing to direct effects.

Mohindersingh *et al.* (1984) observed high indirect effect of pod length and 100-kernel weight on pod yield via different characters. Deshmukh *et al.* (1986) observed high positive direct effect of mature pods, 100-kernel weight and percentage of sound matured kernels on pod yield. Studies of Nigam *et al.* (1984) revealed that selection for increased mature seed yield per plant would be possible by selecting the component characters such as mature pods per plant, mature pod weight and mature seeds per plant individually or in combination. Sudarshanam (1985) observed that number of mature pods per plant and 100-seed weight had maximum positive direct effect on pod yield in spanish group where as 100- kernel weight had maximum direct effect in Virginia group. Reddi *et al.* (1986b) reported that kernel yield had maximum positive direct effect on pod yield followed by number of mature pods per plant similarly Kuriakose and Joseph (1986) and Bhagat *et al.* (1986) revealed the high and positive direct effect of mature pod number on pod yield.

Durga Rani *et al.* (1987) revealed that number of pods, shelling percentage and 100- kernel weight exhibited positive direct effect on yield. Selection for the above characters may be highly effective for increasing yield in groundnut. Sathyanarayana *et al.* (1988) in their path analysis studies using all the three types of groundnut reported strong contribution of total bio-mass per plant to pod yield. Manoharan *et al.* (1990a) observed that drymatter production, pod weight, number of mature pods per plant had maximum positive direct effect (0.225, 0.442 and 0.650 respectively) on pod yield in F_2 population of J11x Chico. Further both drymatter production and harvest index has positive indirect effects via pod number, on pod yield. Manoharan *et al.* (1990b) in study of 21 F_1 hybrids observed pod number had the highest positive direct effect (0.953) on pod yield. Shelling per cent exhibited a higher positive indirect effect on pod yield per plant via pod number and low residual effect. Abraham (1990) reported that kernels per plant had high positive direct effect on kernel yield. It was also found that indirect effects of pods per plant and shelling percentage via kernels per plant, and sound mature kernels and shelling percentage via 100-kernel weight were positive indicating that kernels per plant and 100-kernel weight are the major yield contributors.

Prasanthi *et al.* (1990) reported that weight of kernels had high positive direct effect on pod yield. Pods per plant expressed moderate negative direct effect even though the association was significant. Raj Kumar (1991) reported that dry weight of the plant, number of mature pods per plant and harvest index had high positive direct effect on yield. Patra *et al.* (1992) while studying path coefficient analysis in advanced generations of groundnut reported that number of mature pods per plant had high positive direct effect (0.629) on pod yield per plant followed by harvest index (0.089). Vaddoria and Patel (1992) reported that harvest index exerted the highest positive effect on pod yield followed by number of primary branches. Manoharan *et al.* (1993) from their studies in F_2 population of a cross between Robut 33-1 and Chico noted low positive direct effect of total drymatter production on pod yield.

Pathirana (1993) studied 125 diverse bunch groundnut genotypes and indicated that number of pods per plant and seed size had positive direct effects on pod yield. Similarly Patel and Shelke (1991) indicated that filled pods per plant and total dry matter had positive and direct effect on pod yield. Nisar Ahamed (1995) revealed that pod yield per plant had high positive direct effect on kernel yield per plant in both parents and crosses. Number of mature pods per plant and harvest index in crosses exerted their indirect effect via source contributions through several other characters. Kernel yield per plant had highest positive direct effect on pod yield per plant in both hybrids and parents. Sumathi and Ramanthan (1995b) reported that number of mature pods per plant, kernel yield per plant had the highest positive direct effect on pod yield per plant, while negative direct effect was recorded for shelling per cent. The path analysis showed that pod yield per plant was highly influenced by number of mature pods per plant and kernel yield per plant in 32 F_2 progenies of crosses.

Uddin *et al.* (1995) revealed that nuts per plant had large direct effects on seed yield per plant. Contrary to this, Ofori (1996) observed that the number of pods per plant had high positive direct effects on seed yield. Patra *et al.* (1995) reported that LAI at 50 and 70 DAS had positive and significant influence on number of pods per plant, shelling percentage, 100-kernel weight, pod yield and oil content. Varman and Raveendran (1996) in 63 F_1 populations observed that kernel yield had high positive direct effect on oil content and significant positive correlation. The highest direct effect of pod yield was nullified by indirect effect of oil content. Jayalakshmi (1997) reported that harvest index was positively associated with SLA in parents and F_1 (but exhibited non-significant association in F_3 generation).

Moinuddin (1997) observed strong positive association of pod yield with number of mature pods per plant, 100-kernel weight and biomass per plant and also their direct effects were positive and high in almost all environments. Haulms yield per plant and shelling per cent exhibited negative association and negative direct effect on pod yield. Islam and Rasul (1998) noticed highest positive direct effect of shelling percentage on yield. Vasnathi (1998) reported high positive direct effect of 100-pod weight on pod yield followed by 100-kernel weight. Studies of Arjunan *et al.* (1999) for drought resistance and pod yield per plant in 24 crosses of groundnut genotypes revealed that drymatter production had the highest positive direct effect on pod yield per plant, while leaf area had the highest negative direct effect. Azad and Hamid (2000) path analysis revealed that highest and positive direct effects of pod number on pod yield per plant followed by kernel yield per plant contributed significantly both directly and indirectly to pod yield per plant. Similarly Venkataravana *et al.* (2000) revealed high and positive direct effects of kernel yield and number of mature pods on pod yield.

Studies of Bera and Das (2000) in 44 genotypes of groundnut for path coefficient analysis showed positive direct contribution of pods per plant and harvest index to the seed yield. Their correlation with seed yield is also significant and positive .So pod yield per plant and harvest index can be used directly as selection criteria for improvement of seed yield in groundnut. Mathews *et al.* (2000) revealed maximum direct effect of kernel yield per plant followed by plant height on dry pod yield per plant; hence emphasis should be given on these characters while breeding for high yield in groundnut. Sah *et al*. (2000) reported that seed yield per plant had high direct effect on pod as well as oil yield per plant. Number of mature pods per plant, 100-seed weight and oil yield per plant had high and positive association with pod yield but their direct effects were very low and they contribute mainly through seed yield per plant.

Johar Singh and Mohinder Singh (2001) studied correlations in 5 advanced lines and 8 segregating populations of two crosses. They found that the sound mature kernel percentage, harvest index and number of pods per plant had maximum positive direct effect on pod yield. Studies of Vijayasekhar (2002) indicated maximum direct effect of kernel yield per plant on pod yield followed by pods per plant and harvest index. High and positive indirect effect of kernel yield per plant was exerted through harvest index while pods per plant and harvest index contributed kernel yield per plant. Makhan lal *et al.* (2003) reported that the direct effect of number of mature pods per plant and root length on pod yield per plant is positive and high. Yield which has so far been improved through the use of selection of yield contributing traits showed now include root length as selection criteria for improving yield.

Trivikram Reddy (2003) reported high positive direct effect of pod yield, mature pods per plant, 100-kernel weight and harvest index on kernel yield in groundnut. Reports of Chaitanya Varma (2004) showed that 100-kernel weight and shelling percentage had positive direct effects on kernel yield. The positive indirect effects of most of the characters were exerted through pods per plant and sound mature kernels per plant. Hemanth Kumar (2004) reported positive moderate indirect effect of SLA on kernel weight through SCMR. The direct effect of pod weight per plant on kernel weight per plant was high. High and positive indirect effects were observed through LAI at 90 days and harvest index. Lakshmidevamma (2004) noticed that kernel yield per plant had exerted the highest positive direct effect on pod yield where as shelling percentage exerted high but negative direct effect on pod yield. Indirect effects of the component characters *i.e.* days to 50 per cent flowering, plant height, number of branches per plant, number of mature pods per plant and test weight were found to be high through kernel yield on pod yield.

Nagda and Joshi (2004) were reported that harvest index had the highest positive direct effect (1.3269) on pod yield per plant followed by haulms yield. Among indirect effects the influence of 100-kernel weight through harvest index was positive and strong (0.2233) followed by indirect effect of shelling per cent through haulms yield. Seethala Devi (2004) reported that in parents SPAD chlorophyll meter reading and in crosses sound mature kernel per cent exhibited high positive direct effect on pod yield per plant.

Studies of Suneetha *et al*. (2005) indicated that harvest index exerted the highest positive direct effect on pod yield per plant followed by 100-kernel weight. Days to maturity, number of primary branches, number of mature pods, shelling percentage and 100- pod weight also exhibited positive direct effect but of lower magnitude while days to 50 per cent flowering, height of main axis had negative direct effects.

Kalmeshwer *et al*. (2006) observed that number of pods per plant, shelling percentage and sound mature kernel per cent had the maximum direct effect on pod yield per plant. Venkateswarlu *et al*. (2007) revealed high positive direct effects of kernel yield per plant, followed by specific leaf nitrogen, root length, shelling per cent, number of well filled and mature pods per plant on pod yield per plant.

From the above information it may be concluded that in groundnut improvement programme number of primary branches, number mature pods/plant, number of sound kernels, shelling per cent, 100 kernel weight and harvest index can be pyramid in the breeding material for overall pod yield improvement in groundnut.

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