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*Full Length Research*

# Correlation and path coefficient analysis for seed yield in sunflower (*Helianthus annuus* L.)

Sunil D. Tyagi[1] and Mudasir H. Khan[2*]

[1]Department of Plant Breeding and Genetics Kisan (PG) College, Simbhaoli, Ghaziabad (UP) -245207, India.
[*2]Central Institute of Temperate Horticulture, ICAR, Srinagar, (J&K) – 190007, India.

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**An attempt was made to analyze the association between seed yield and related components in sunflower by the method of correlation and path coefficients using 22 diverse genotypes. A slight increase of genotypic correlation coefficients over phenotypic correlation coefficient was noticed for all the character combinations. Most of the characters examined except days to 50 % flowering, percent filled seeds, 100-seed weight and oil content, were significantly and positively associated with seed yield. Since plant height, head diameter, head weight and number of seeds per head were inter-correlated among themselves, selection for these traits can result in increased seed yield. Path coefficient analysis revealed that among all the traits studied, stem diameter at mid night and head weight contributed the most directly to seed yield. All other yield contributing traits had sizeable influence on seed yield indirectly only through stem diameter at mid height and total head weight.**

**Key words:** *Helianthus annuuss*, genetic improvement, characters association, seed production.

## INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important oil seed crops in India, after groundnut and rape seed mustard. Its adaptability to a wide range of soil and climatic conditions are the oft-cited phenomenon which makes its cultivation possible during any period of the year in the tropical and sub tropical regions of the country (Reddy and Kumar, 1996). It is the second major oilseed crop having a potential source of vegetable oil and protein. Its seed contains high oil content ranging from 35-48 %, and protein (20-27 %) (Nazir et al., 1994), besides high percentage of poly-unsaturated fatty acids (60 %) including oleic acid (16 %) and linoleic acid (72.5%), which control cholesterol in blood (Satyabrata et al., 1988). Sunflower oil is considered as premium oil due to its light color, mild flavor and ability to withstand at high cooking temperatures.

Most of the agronomic characters in crop plants are quantitative in nature. Yield is one such character that results of actions and interactions of various characters component (Grafius, 1960). It is also widely recognized that genetic architecture of yield can be improved more efficiently by studying its component characters. This can enables the plant breeder associate the development of high yielding genotypes with desired combinations of traits. Linear correlation between yield and several of its components can present a confusing picture due to inter-relationship between component characters themselves. Therefore, in order to gather a clear cut knowledge about the direct effects and

*Correspondence Email: drmhkhan8@gmail.com

indirect effects via alternate characters or pathways, correlations of the independent component characters with dependent variable (grain yield) can be analyzed further by path coefficient or standard regression coefficient technique. Path coefficient is helpful in partitioning the correlation into direct and indirect effects so that relative contribution of each component character to the yield could be assessed (Singh and Narayanam, 2007). In other words, path analysis measures the direct and indirect contribution of various independent characters on a dependent character. Therefore, the present investigation was undertaken to determine the mutual association among eight selected traits in sunflower and their direct and indirect effects on yield by using path coefficient analysis.

## MATERIALS AND METHODS

Twenty two genotypes of sunflower representing the germplasm of various states of India were collected from the Division of Genetics, Indian Agriculture Research Institute (IARI), New Delhi. They were evaluated in a randomized block design with three replications at Research Farm of Kisan (P.G.) College, Simbhaoli, Ghaziabad during rainy season 2010. Each genotype was assigned to two row plots of 3 m length with inter and intra row spacing of 75 cm and 30 cm, respectively. Recommended agronomic practices were followed to raise a good crop. Observations were recorded on 16 quantitative and qualitative traits: days to 50 % flowering (days), number of leaves per plant (unit), plant height (cm), stem diameter top height (cm), stem diameter at mid height (cm), leaf area ($cm^2$), head diameter of sterile area (cm), head diameter, total weight of head (g), number of seeds per head (unit), percent filled seed (%), 100-seed weight (g), seed yield per plant (g), seed oil content (%), leaf length (cm) and leaf breadth (cm) from ten competitive plants selected randomly from each experimental plot. Oil content was estimated by the Pulsed Nuclear Magnetic Resonance Spectrometer (NMR) technique (Tiwari et al., 1974). Phenotypic and genotypic correlation coefficients for all characters combinations were computed following Al-Jibouri et al. (1958). Path coefficient analysis was carried out according to Dewey and Lu, (1959) by partitioning the genotypic correlation coefficients into direct and indirect effects.

## RESULTS AND DISCUSSION

Correlation coefficients obtained both at phenotypic and genotypic levels for different characters combinations are presented in Table 1 and 2, respectively. A slight increase of genotypic correlation coefficients over phenotypic correlation coefficients was noticed for all the characters combinations indicating that though there is a strong inherent association between many traits studied, the phenotypic expression of the association is reduced under the influence of environment. Yasin and Singh (2010) reported such higher genotypic correlation coefficients over phenotypic correlation coefficients in sunflower. The relative magnitude of genotypic and phenotypic correlations suggests that phenotypic selection can be reliable since the underlying cause of association has a genetic basis.

Seed yield per plant was significantly and positively correlated with number of leaves per plant, plant height, stem diameter at top height, stem diameter at mid height, head diameter, head diameter of sterile area, weight of head, number of seeds per head, leaf length, leaf breadth and leaf area. In the literature similar positive significant correlations are observed between seed yield per plant and these traits (Patil, 2011; Sowmya et al., 2010; Machikowa and Saetang, 2008; Kaya et al., 2007; Hladni et al., 2006; Srimuenwai, 2006; Khokhar et al., 2006). On the other hand, Patil et al., (1996) reported that there was a negative correlation between seed yield and head diameter. Furthermore, some researchers could not find correlations between the seed yield with head diameter of sterile area, head diameter, total weight of head, and with the number of seeds per head (Varshney et al., 1977).

As a rule, the plants with a large size of heads tended to present a large number of seeds per head, as illustrated by the moderately significant positive correlation between the head diameter and the number of seeds per head ($r_G$=+0.441*).

The poor association of seed yield with days to 50 % flowering suggests that duration of photosynthetic activity is not a limitation in sunflower. Therefore, reducing the length of growing period without affecting final seed yield is at the realm of sun flowering breeding. Other authors also reported poor association between seed yield and days to flowering (Machikowa and Saetang, 2008; Satjawattana, 2005; Chikkadevaiah et al., 2002).

The positive significant correlation observed between plant height and seed yield is justifiable and is in agreement with results reported by Sowmya et al., (2010). Tall plant supporting many

**Table 1.** Phenotypic correlation coefficients among 16 characters in 22 genotypes of sunflower.

| Character Code | DF 50 % | NL/P | PH | SDTH | SDMH | HD | HDSA | TWH | NS/H | PFS | 100-SW | SY/P | OC % | LL | LB | LA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF 50 % | 1.000 | -0.18 | -0.120 | 0.294 | 0.225 | 0.139 | 0.190 | 0.351 | 0.440* | 0.023 | 0.028 | 0.182 | 0.166 | 0.118 | 0.085 | 0.086 |
| NL/P | | 1.000 | 0.793** | 0.427* | 0.575** | 0.538** | 0.445* | 0.486* | 0.413 | 0.199 | 0.161 | 0.628** | -0.116 | 0.702** | 0.710** | 0.716** |
| PH | | | 1.000 | 0.532* | 0.710** | 0.612** | 0.484* | 0.499* | 0.475* | -0.284 | 0.132 | 0.631** | -0.078 | 0.757** | 0.831** | 0.792** |
| SDTH | | | | 1.000 | 0.907** | 0.594** | 0.554** | 0.531* | 0.584** | -0.205 | 0.020 | 0.521* | 0.163 | 0.663** | 0.684** | 0.618** |
| SDMH | | | | | 1.000 | 0.613** | 0.612** | 0.612** | 0.646** | -0.238 | 0.201 | 0.669** | 0.169 | 0.747** | 0.790** | 0.726** |
| HD | | | | | | 1.000 | 0.554** | 0.612** | 0.505* | 0.169 | 0.118 | 0.587** | 0.002 | 0.578** | 0.648** | 0.556** |
| HDSA | | | | | | | 1.000 | 0.567** | 0.485* | -0.286 | 0.179 | 0.503* | 0.013 | 0.541** | 0.555** | 0.539** |
| TWH | | | | | | | | 1.000 | 0.601** | 0.218 | 0.290 | 0.727** | 0.150 | 0.610** | 0.596** | 0.582** |
| NS/H | | | | | | | | | 1.000 | 0.057 | 0.341 | 0.600** | 0.001 | 0.573** | 0.590** | 0.568** |
| PFS | | | | | | | | | | 1.000 | 0.032 | 0.246 | 0.118 | -0.303 | -0.291 | -0.335 |
| 100-SW | | | | | | | | | | | 1.000 | 0.088 | 0.0170 | 0.177 | 0.191 | 0.163 |
| SY/P | | | | | | | | | | | | 1.000 | -0.016 | 0.591** | 0.623** | 0.599** |
| OC % | | | | | | | | | | | | | 1.000 | 0.016 | 0.046 | 0.036 |
| LL | | | | | | | | | | | | | | 1.000 | 0.943** | 0.970** |
| LB | | | | | | | | | | | | | | | 1.000 | 0.968** |
| LA | | | | | | | | | | | | | | | | 1.000 |

*, **= Significant at p=0.05 and p=0.01 levels, respectively.

**Table 1** contd**. Character Code:**

| | | |
|---|---|---|
| DF 50 % = Days to 50 % flowering | HD = Head diameter (cm) | 100-SW = 100-Seed weight (g) |
| NL/P = Number of leaves per plant | HDSA = Head diameter of sterile area (cm) | SY/P = Seed yield per plant (g) |
| PH = Plant height (cm) | TWH = Total weight of head (g) | OC = Oil content (%) |
| SDTH = Stem diameter top height (cm) | NS/H = Number of seeds per head | LL = Leaf length (cm) |
| SDMH = Stem diameter at mid height (cm) | PFS = Percent filled seed (%) | LB = Leaf breadth (cm) |
| LA = Leaf area ($cm^2$) | | |

leaves as illustrated by highly significant positive association between plant height and number of leaves per plant could increase total biomass production through increased carbon fixation which can ultimately be partitioned to reproductive organs.

**Table 2.** Genotypic correlation coefficients among 16 characters in 22 genotypes of sunflower.

| Character Code | DF 50 % | NL/P | PH | SDTH | SDMH | HD | HDSA | TWH | NS/H | PFS | 100-SW | SY/P | OC % | LL | LB | LA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF 50 % | 1.000 | 0.432* | -0.276 | 0.382 | 0.241 | 0.159 | 0.131 | 0.388 | 0.608** | -0.024 | 0.107 | 0.209 | 0.229 | 0.074 | 0.029 | 0.039 |
| NL/P | | 1.000 | 0.900** | 0.510** | 0.699** | 0.562** | 0.599** | 0.656** | 0.390 | -0.727** | 0.455** | 0.776** | -0.024 | 0.740** | 0.798** | 0.766** |
| PH | | | 1.000 | 0.560** | 0.786** | 0.666** | 0.672** | 0.585** | 0.490* | -692** | 0.209 | 0.756** | 0.028 | 0.845** | 0.926** | 0.895** |
| SDTH | | | | 1.000 | 0.965** | 0.655** | 0.713** | 0.760** | 0.899** | -0.777** | 0.287 | 0.762** | 0.134 | 0.908** | 0.826** | 0.820** |
| SDMH | | | | | 1.000 | 0.749** | 0.842** | 0.832** | 0.809** | -0.864** | 0.310 | 0.838** | 0.229 | 1.043 | 0.995** | 1.006 |
| HD | | | | | | 1.000 | 0.338 | 0.801** | 0.441* | -0.310 | 0.237 | 0.785** | 0.008 | 0.726** | 0.786** | 0.719** |
| HDSA | | | | | | | 1.000 | 0.726** | 0.642** | -0.838** | 0.245 | 0.679** | 0.006 | 0.812** | 0.772** | 0.829** |
| TWH | | | | | | | | 1.000 | 0.600** | -0.642** | 0.356 | 0.779** | 0.186 | 0.908** | 0.905** | 0.898** |
| NS/H | | | | | | | | | 1.000 | -0.440* | 0.646** | 0.482* | 0.020 | 0.796** | 0.762** | 0.778** |
| PFS | | | | | | | | | | 1.000 | 0.263 | 0.917** | 0.356 | -0.745** | -0.660** | -0.754** |
| 100-SW | | | | | | | | | | | 1.000 | 0.166 | 0.095 | 0.260 | 0.274 | 0.262 |
| SY/P | | | | | | | | | | | | 1.000 | 0.020 | 0.789** | 0.805** | 0.790** |
| OC % | | | | | | | | | | | | | 1.000 | 0.171 | 0.145 | 0.149 |
| LL | | | | | | | | | | | | | | 1.000 | 1.006 | 1.000 |
| LB | | | | | | | | | | | | | | | 1.000 | 0.995** |
| LA | | | | | | | | | | | | | | | | 1.000 |

*, **= Significant at p=0.05 and p=0.01 levels, respectively.

**Table 2.** contd. **Character Code:**

| | | |
|---|---|---|
| DF 50 % = Days to 50 % flowering | HD = Head diameter (cm) | 100-SW = 100 Seed weight (g) |
| NL/P = Number of leaves per plant | HDSA = Head diameter of sterile area (cm) | SY/P = Seed yield per plant (g) |
| PH = Plant height (cm) | TWH = Total weight of head (g) | OC = Oil content (%) |
| SDTH = Stem diameter top height (cm) | NS/H = Number of seeds per head | LL = Leaf length (cm) |
| SDMH = Stem diameter at mid height (cm) | PFS = Percent filled seed (%) | LB = Leaf breadth (cm) |
| LA = Leaf area ($cm^2$) | | |

Thus, the number of internodes, which are sites of leaf initiation, should remain constant during breeding for shorter plant types. From the foregoing, it may be concluded that an intensive selection for plant height, head diameter, total weight of head and number of

**Table 3.** Direct effects (diagonal values) and indirect contribution of different characters towards seed yield in 22 genotypes of sunflower at genotypic level.

| Character Code | DF 50 % | NL/P | PH | SDTH | SDMH | HD | HDSA | TWH | NS/H | PFS | 100-SW | OC % | LL | LB | LA | Correlation with seed yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DF 50 % | **0.015** | 0.050 | 0.001 | -0.069 | 0.115 | 0.008 | -0.013 | 0.165 | 0.083 | -0.001 | -0.004 | 0.110 | -0.043 | -0.004 | 0.190 | 0.182 |
| NL/P | 0.003 | **0.269** | -0.008 | -0.100 | 0.295 | 0.030 | -0.030 | 0.229 | 0.078 | 0.013 | -0.003 | 0.008 | -0.256 | -0.034 | 0.156 | 0.628** |
| PH | 0.002 | 0.213 | **-0.011** | -0.125 | 0.364 | 0.035 | 0.320 | 0.235 | 0.090 | 0.019 | 0.020 | 0.005 | -0.276 | -0.400 | 0.173 | 0.631** |
| SDTH | 0.004 | 0.115 | -0.006 | **-0.235** | 0.465 | 0.034 | 0.037 | 0.250 | 0.110 | 0.014 | -0.034 | 0.011 | -0.242 | -0.330 | 0.125 | 0.521** |
| SDMH | -0.003 | 0.154 | -0.008 | -0.213 | **0.515** | 0.035 | -0.041 | 0.289 | 0.112 | 0.016 | -0.031 | 0.011 | -0.272 | -0.038 | 0.158 | 0.669** |
| HD | -0.002 | 0.144 | -0.007 | -0.140 | 0.314 | **0.057** | -0.037 | 0.289 | 0.096 | 0.011 | -0.018 | 0.000 | -0.211 | -0.031 | 0.121 | 0.587** |
| HDSA | -0.003 | 0.119 | 0.005 | -0.130 | 0.314 | 0.031 | **-0.066** | 0.268 | 0.092 | 0.019 | -0.027 | 0.000 | -0.197 | -0.027 | 0.118 | 0.503** |
| TWH | -0.005 | 0.131 | -0.005 | -0.125 | 0.314 | 0.350 | -0.038 | **0.471** | 0.114 | 0.014 | -0.044 | -0.100 | -0.220 | -0.029 | 0.127 | 0.727** |
| NS/H | -0.006 | 0.110 | -0.005 | -0.137 | 0.331 | 0.029 | -0.032 | 0.283 | **0.189** | 0.004 | -0.052 | 0.000 | -0.209 | -0.028 | 0.124 | 0.600** |
| PFS | 0.000 | -0.054 | 0.003 | 0.048 | -0.122 | 0.010 | 0.019 | -0.103 | -0.011 | **-0.066** | 0.005 | -0.008 | 0.110 | -0.014 | -0.073 | -0.246 |
| 100-SW | 0.000 | 0.043 | -0.001 | 0.052 | 0.103 | 0.007 | -0.012 | 0.137 | 0.064 | 0.002 | **-0.153** | -0.012 | -0.065 | -0.009 | 0.036 | 0.088 |
| OC % | -0.002 | 0.031 | 0.001 | 0.038 | 0.087 | 0.000 | -0.001 | 0.071 | 0.000 | 0.008 | -0.026 | **0.068** | 0.006 | -0.002 | 0.008 | -0.016 |
| LL | -0.002 | -0.188 | -0.008 | -0.156 | 0.383 | 0.033 | -0.036 | 0.287 | 0.108 | 0.020 | -0.027 | -0.001 | **0.365** | -0.046 | 0.211 | 0.591** |
| LB | -0.001 | 0.191 | -0.009 | -0.161 | 0.405 | 0.037 | -0.037 | 0.281 | 0.112 | 0.019 | 0.029 | 0.003 | -0.344 | **-0.048** | 0.211 | 0.623** |
| LA | -0.001 | 0.192 | -0.008 | 0.145 | 0.372 | 0.031 | -0.036 | 0.274 | 0.107 | 0.002 | -0.025 | 0.002 | 0.354 | -0.047 | **0.218** | 0.599** |

*, **= Significant at p=0.05 and p=0.01 levels, respectively.

**Table 2.** contd. **Character Code:**

| | | |
|---|---|---|
| DF 50 % = Days to 50 % flowering | HD = Head diameter (cm) | 100-SW = 100 Seed weight (g) |
| NL/P = Number of leaves per plant | HDSA = Head diameter of sterile area (cm) | SY/P = Seed yield per plant (g) |
| PH = Plant height (cm) | TWH = Total weight of head (g) | OC = Oil content (%) |
| SDTH = Stem diameter top height (cm) | NS/H = Number of seeds per head | LL = Leaf length (cm) |
| SDMH = Stem diameter at mid height (cm) | PFS = Percent filled seed (%) | LB = Leaf breadth (cm) |
| LA = Leaf area ($cm^2$) | | |

seeds per head could be accompanied by improvement of seed yield in sunflower. Again, since all these four traits are inter-correlated, the selection in any one of the traits can result in improvement of other traits, thereby finally increasing the seed yield.

With regard to one important quality character, oil content, the breeder facing real challenge, since oil content is not significantly

related to any of the yield components mentioned above, the selection of these traits cannot influence the oil content. Therefore, a compromise has to be arrived at to have an optimum oil content without sacrificing the seed yield. Since it is not possible to establish the cause and effect relationships between the examined yield components and seed yield per plant on the basis of simple correlation coefficients, the data were further processed by the path-coefficient analysis, which enabled the partitioning of the direct and indirect effects of individual yield components and identification of yield components applicable as selection criteria in sunflower breeding. Partitioning of genotypic correlations of other characters which yield into direct and indirect effect revealed that stem diameter at mid height and head weight had maximum direct effect on seed yield, equal to 0.515 and 0.471, respectively (Table 3). Other authors also observed high positive direct effect of stem diameter at mid height and head weight on seed yield (Machikowa and Saetang, 2008; Kaya et al., 2007; Hladni et al., 2006). The direct effect of stem diameter at top height, plant height, head diameter of sterile area and leaf breadth was negative on seed yield per plant, but their significant positive correlations with seed yield was due to their respectively high and moderate indirect effects through stem diameter at mid height. Oil content, the only trait which showed negative association with seed yield, had low positive direct effect. But its positive influence on seed yield was mainly due to high positive indirect effect through stem diameter at med height. Similar findings were reported by Miji et al., (2009). Even the traits which had no significant association with seed yield *viz.* days to 50 % flowering and 100 seed weight had moderate indirect influence on seed yield through diameter at mid height.

The above findings revealed that whatever may be the character chosen for increasing the seed yield, the improvement could be achieved only through stem diameter at mid height. All the characters exhibited their indirect effect mostly through stem diameter at mid height. Hence, it may be concluded that for increasing the seed and oil yield in sunflower, genotypes/cultivars with thick stem should be selected since more nutrients are supplied through a thicker stem measured in terms of the stems diameter at mid height.

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