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# PHENOTYPIC, GENOTYPIC CORRELATION AND PATH COEFFICIENT IN SUNFLOWER (*HELIANTHUS ANNUUS*)

**Wajeeha Abed Hassan**

Department of Field Crop, Agricultural Engineering Sciences, University of Baghdad, Iraq.

## Abstract

The experiments were conducted during spring and fall season of 2013, by using factorial experiment within RCBD with four replications. The plant populations were 40000, 50000 and 60000 plant, $ha^{-1}$(the spaces between the furrows 90 cm and within furrows 27.8, 22.2 and 18,5 cm, which variable due to plant population). The field was fertilized by adding compound fertilizer 18% N: 18%$P_2O_5$ and urea 46%N at 350 kg $ha^{-1}$ for two varieties of sunflower (oil and non-oil). The result revealed that there are positive and high significant genetic and phenotypic correlation between all studied traits and yield in spring, the highest value for leaves area (0.98) for genetic and phenotypic correlation, followed by 97% and 96% for crop growth rate and head area, respectively. In fall seasonthe highest genetic and phenotypic correlation 99% for leaves area, followed by 97% for crop growth rate and total dry matter. All environmental correlation for spring and fall was very small, for this all traits were genetic controlled. The highest direct effect was 6.50 and total effect 0.94 for seed weight in spring. And 11.73 for dry matter and its total effect was 0.98, followed by 1,63 and 0.94 for direct and total effect of seed weight.

It can be conclude that seeds weight and total dry matter revealed the highest direct effect, for this can rely these traits as selection criteria in breeding and improvement programs of yield of sunflower.

***Key words :*** Genetic correlation, path coefficient, total effect and sunflower.

## Introduction

The relationships among some morphological and phonological traits have been determined in many crops. The improvement in any crop plants depends mainly on the magnitude of genetic variability. The breeder needs to identify the sources of variability in yield in any specific environment before yield improvements can be achieved (Tyagi and Khan, 2010). As the fluctuation in environment affects yield primarily through its components many researchers have analyzed yield through its components (Esan and Omolaja, 2002). Most traits are complex and results from the interaction of a many components. So it is necessary to recognize the relationship among yield and its components to use in the selection program (Savawgi *et al*., 1997). Phenotypic variability expressed by a genotype can be partitioned in to genotypic and phenotypic components. The genotypic components being the heritable part of the total variability. Yield components don't only direct effect the yield, but also indirectly by affecting other yield components in negative or positive ways (Bidgoli *et al*., 2006).

Correlation coefficients illustrate relationships among independent variables and the degree of linear relation between the traits, but it does not adequately predict the success of selection. However, path coefficient analysis that is developed by Wright (1929) is the most worthy tool to estimate the exact correlation in terms of "cause and effect", it allows one to identify the direct, indirect and total causal effect, as well as to remove any un realistic effect that may be present. Path coefficient can be defined as the ratio of standard deviation of the effect due to a given cause to the total standard deviation of the effect (Singh and Chuadhary, 1985). Hassan (2016) found that there are genotypic and phenotypic homogeneity in both varieties according to the lowest $S\bar{y}$, CV., GCV and PCV for most of studied traits. As well as the broad sense heritability values rang from 83% -98% at the 60000 plant population in fall season for most of traits that cause to increase genetic gain 16%-42%. The number of seeds per plant contributed in yield variance by 79% for its positive and highly significant correlation 0.89 with yield, the trait number of seeds per plant was significant correlated and affected the yield (Wuhaib, 2012). There were highly significant and positive correlation between number of heads with weight of 100 seeds and with seed yield (Omidi, 2002). The correlation between seed yield and number of seed in head and head area were positive highly significant, the trait percentage of fertile was less correlation with seed yield, while the plant height was highly significant correlation with seed yield (Alrawi *et al*., 2004). Heritability of seed weight ranged between 5% to 24% (Elsahookie and Eltaweel, 2001). Seed yield showed highly significant and positive correlation with seed head$^{-1}$ and seed weight (Khan *et al*., 2007). Genotypic and phenotypic coefficients of variation were high for 1000 kernel weight and head diameter. Correlation analysis showed head diameter was significantly correlated with 1000 kernel weight (Safavi *et al*., 2015). Hassan *et al*. (2012) found that the trait seed weight showed high heritability. No. of seeds per head, 1000 seed weight and head length in diameter had the highest and positive direct effect with yield, hence the importance of these traits as selection criteria for improvement of yield in sunflower (Abrar *et al*., 2010).

## Materials and Methods

In order to estimate genotypic ,phenotypic and environmental correlation, and path coefficient of two varieties of sunflower (Shimoos and Aqmar) with three plant densities (40,000, 50,000 and 60,000 plants per hectare), a field experiment was conducted in Field Crops Department, College of Agriculture, University of Baghdad for spring and fall seasons 2013. In a factorial experiment (three plant densities of 40, 50 and 60 thousand plants per hectare with two varieties) were used in a Randomized Complete Block Designwith four replicates. Seeding was carried out with 90 cm distance between rows, and the distances between plantswere 27.8, 22.2 and 18.5 cm for the three plant densities 40,000, 50,000 and 60,000 plants per hectare respectively. At soil preparation, 350 kg.ha$^{-1}$ of compound fertilizer (18% N, 18% $P_2O_5$) was added. 350 kg.ha$^{-1}$of urea fertilizer (46% N) was applied in two times. The first was after two weeks of germination and the second at the beginning of the flowering stage. A random sample of five plants was taken to study the following traits:Days to flowering, Plant height, Leaves number, Leaf area, Disc area, Number seeds per disc,Seed weigh, Total dry matter, Days to maturity, Percentage of fertile, Crop growth rate,*Seed yield* per *unit area*.

The phenotypic, genetic, environmental variations and path coefficient were estimated as mentioned by Singh and Chuadhary (1985) using SPAR2.0 software.

## Results and Discussion

### Correlation

Tables 1, 2 and 3 illustrate the genotypic, phenotypic and environment correlation of sunflower in spring. Most of traits were correlated positive and highly significant correlation with seed yield of sunflower at genetic and phenotypic levels. Only number of leaves was non-significant at genetic and phenotypic levels. The highest values for genetic and phenotypic correlation were 0.984, 0.983 for leaf area followed by crop growth rate (0.969, 0.894, 0.958, 0.956) for disc area, 0.941, 0.939 for seed

**Table 1 :** Genotypic correlation coefficients among twelve traits in genotypes of sunflower in the spring 2013.

| Y | CGR | F% | DTM | TDM | SW | SN | DA | LA | LN | PH | DTF | Traits * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.736 | 0.580 | -0.792 | 0.972 | 0.787 | 0.906 | -0.930 | 0.676 | 0.721 | -0.006 | 0.821 | 1.000 | DTF |
| 0.890 | 0.740 | -0.976 | 0.679 | 0.737 | 0.918 | -0.797 | 0.899 | 0.824 | -0.227 | 1.000 | | PH |
| 0.094 | 0.313 | 0.385 | 0.137 | 0.342 | 0.113 | -0.015 | -0.051 | 0.270 | 1.000 | | | LN |
| 0.984 | 0.993 | -0.681 | 0.684 | 0.963 | 0.935 | -0.619 | 0.919 | 1.000 | | | | LA |
| 0.958 | 0.938 | -0.823 | 0.580 | 0.848 | 0.904 | -0.636 | 1.000 | | | | | DA |
| 0.626 | -0.479 | 0.817 | -0.873 | -0.648 | 0.850 | 1.000 | | | | | | SN |
| 0.941 | 0.866 | -0.837 | 0.851 | 0.927 | 1.000 | | | | | | | SW |
| 0.931 | 0.949 | -0.590 | 0.804 | 1.000 | | | | | | | | TDM |
| 0.667 | 0.554 | 0.625 | 1.000 | | | | | | | | | DTM |
| 0.768 | -0.574 | 1.000 | | | | | | | | | | F% |
| 0.969 | 1.000 | | | | | | | | | | | CGR |
| 1.000 | | | | | | | | | | | | Y |

*Traits; DTF :Days to flowering ,PH: Plant height, LN: Number of leaves, LA; leaf area, DA: Disc Area, SN: No. seeds.disc$^{-1}$ , SW: seeds weight ,TDM: Total dry matter, DTM: Days to maturity, F%:Percentage of fertile, CGR: Crop growth rate, Y:Yield

**Table 2 :** Phenotypic correlation coefficients among twelve traits in genotypes of sunflower in the spring 2013.

| Y | CGR | F% | DTM | TDM | SW | SN | DA | LA | LN | PH | DTF | Traits * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.729 | 0.515 | -0.774 | 0.965 | 0.778 | 0.897 | -0.903 | 0.670 | 0.712 | 0.005 | 0.808 | 1.000 | **DTF** |
| 0.883 | 0.660 | -0.964 | 0.670 | 0.733 | 0.915 | -0.777 | 0.893 | 0.820 | -0.228 | 1.000 | | **PH** |
| 0.095 | 0.284 | 0.383 | 0.174 | 0.341 | 0.113 | -0.016 | -0.050 | 0.269 | 1.000 | | | **LN** |
| 0.983 | 0.908 | -0.676 | 0.682 | 0.961 | 0.934 | -0.612 | 0.917 | 1.000 | | | | **LA** |
| 0.956 | 0.853 | -0.817 | 0.576 | 0.847 | 0.902 | -0.625 | 1.000 | | | | | **DA** |
| -0.615 | -0.436 | 0.802 | -0.861 | 0.638 | -0.837 | 1.000 | | | | | | **SN** |
| 0.939 | 0.791 | -0.832 | 0.847 | 0.926 | 1.000 | | | | | | | **SW** |
| 0.929 | 0.870 | -0.587 | 0.7994 | 1.000 | | | | | | | | **TDM** |
| 0.663 | 0.507 | -0.614 | 1.000 | | | | | | | | | **DTM** |
| -0.764 | -0.538 | 1.000 | | | | | | | | | | **F%** |
| 0.894 | 1.000 | | | | | | | | | | | **CGR** |
| 1.000 | | | | | | | | | | | | **Y** |

*Traits; DTF :Days to flowering ,PH: Plant height, LN: Number of leaves, LA; leaf area, DA: Disc Area, SN: No. seeds.disc$^{-1}$ , SW: seeds weight ,TDM: Total dry matter, DTM: Days to maturity, F%:Percentage of fertile, CGR: Crop growth rate, Y:Yield.

**Table 3 :** Environmental correlation coefficients among twelve traits in genotypes of sunflower in the spring 2013.

| Y | CGR | F% | DTM | TDM | SW | SN | DA | LA | LN | PH | DTF | Traits * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.257 | -0.159 | 0.343 | 0.559 | -0.258 | 0.138 | 0.119 | 0.265 | -0.168 | 0.682 | 0.043 | 1.000 | **DTF** |
| -0.167 | -0.336 | 0.223 | 0.000 | -0.089 | 0.518 | 0.276 | -0.150 | 0.080 | -0.388 | 1.000 | | **PH** |
| 0.355 | -0.086 | 0.160 | 0.275 | 0.007 | -0.021 | -0.097 | 0.066 | 0.090 | 1.000 | | | **LN** |
| 0.368 | 0.071 | 0.077 | 0.349 | 0.202 | 0.282 | -0.442 | -0.196 | 1.000 | | | | **LA** |
| -0.033 | -0.231 | 0.152 | -0.082 | 0.059 | -0.323 | 0.131 | 1.000 | | | | | **DA** |
| -0.007 | -0.072 | 0.080 | -0.358 | 0.144 | 0.056 | 1.000 | | | | | | **SN** |
| -0.154 | -0.040 | 0.193 | 0.320 | -0.109 | 1.000 | | | | | | | **SW** |
| -0.395 | 0.199 | 0.185- | -0.248 | 1.000 | | | | | | | | **TDM** |
| 0.039 | 0.069 | 0.520 | 1.000 | | | | | | | | | **DTM** |
| -0.338 | -0.382 | 1.000 | | | | | | | | | | **F%** |
| 0.408 | 1.000 | | | | | | | | | | | **CGR** |
| 1.000 | | | | | | | | | | | | **Y** |

*Traits; DTF :Days to flowering ,PH: Plant height, LN: Number of leaves, LA; leaf area, DA: Disc Area, SN: No. seeds.disc$^{-1}$ , SW: seeds weight ,TDM: Total dry matter, DTM: Days to maturity, F%:Percentage of fertile, CGR: Crop growth rate, Y:Yield.

weight and 0.931, 0.929 for total dry matter. The traits number of seeds per head and percentage of fertile exhibited negative and high significant correlation with seed yield at phenotypic levels only. Thus, the environment correlation with yield for these traits were negative and non significant, means less effect for these traits. Trait days to flowering correlated with plant height, leaf area, head area, seed weight, total dry matter, days to maturity and crop growth rate positive and highly significant. It correlated negative highly significant genetically and phenotypically with number of seeds and percentage of fertile, and non significant with number of leaves. Plant height correlated positive and highly significant at genotypic and phenotypic level with all other traits except number of leaves, number of seeds head$^{-1}$ and percentage of fertile were negative correlation. All genetic and phenotypic correlation for number of leaves with other trait were non-significant. Leaf area exhibit positive highly significant genetic and phenotypic correlation with other traits, but it negative highly significant with number of seed head$^{-1}$ and percentage of fertile. As well as, the trait head area showed positive highly significant genetic and phenotypic correlation with other traits except number of seed head$^{-1}$ and percentage of fertile negative highly significant. The trait number of seeds head$^{-1}$ exhibit positive genotypic and phenotypic highly significant correlation with seed weight and percentage of fertile and negative with total dry matter, day to maturity and crop growth rate. Seed weight and total dry matter showed negative highly significant at genetic and phenotypic level with percentage of fertile, and positive with other traits. Days to maturity correlated positive

**Table 4 :** Genotypic correlation coefficients among twelve traits in genotypes of sunflower in the fall season 2013.

| Y | CGR | F% | DTM | TDM | SW | SN | DA | LA | LN | PH | DTF | Traits * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.213 | 0.070 | -0.397 | 0.343 | 0.1395 | 0.550 | -0.909 | 0.350 | 0.086 | 0.167 | 0.645 | 1.000 | **DTF** |
| 0.751 | 0.622 | -0.673 | 0.281 | 0.7030 | 0.903 | -0.432 | 0.746 | 0.665 | 0.668 | 1.000 | | **PH** |
| 0.845 | 0.813 | -0.514 | 0.112 | 0.8858 | 0.771 | 0.127 | 0.909 | 0.831 | 1.000 | | | **LN** |
| 0.989 | 0.991 | -0.368 | -0.377 | 0.9841 | 0.887 | 0.246 | 0.915 | 1.000 | | | | **LA** |
| 0.952 | 0.883 | -0.670 | -0.131 | 0.9156 | 0.951 | -0.055 | 1.000 | | | | | **DA** |
| 0.102 | 0.297 | 0.721 | -0.503 | 0.2272 | -0.267 | 1.000 | | | | | | **SN** |
| 0.948 | 0.850 | -0.725 | -0.145 | 0.8744 | 1.000 | | | | | | | **SW** |
| 0.972 | 0.988 | -0.407 | -0.278 | 1.000 | | | | | | | | **TDM** |
| -0.289 | -0.422 | -0.224 | 1.000 | | | | | | | | | **DTM** |
| -0.479 | -0.339 | 1.000 | | | | | | | | | | **F%** |
| 0.966 | 1.000 | | | | | | | | | | | **CGR** |
| 1.000 | | | | | | | | | | | | **Y** |

*Traits; DTF :Days to flowering ,PH: Plant height, LN: Number of leaves, LA; leaf area, DA: Disc Area, SN: No. seeds.disc$^{-1}$ , SW: seeds weight ,TDM: Total dry matter, DTM: Days to maturity, F%:Percentage of fertile, CGR: Crop growth rate, Y:Yield.

**Table 5 :** Phenotypic correlation coefficients among twelve traits in genotypes of sunflower in the fall season 2013.

| Y | CGR | F% | DTM | TDM | SW | SN | DA | LA | LN | PH | DTF | Traits * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.201 | 0.071 | -0.857 | 0.276 | 0.131 | 0.479 | 0.870 | 0.337 | 0.083 | 0.159 | 0.616 | 1.000 | **DTF** |
| 0.736 | 0.615 | -0.645 | 0.258 | 0.693 | 0.811 | -0.429 | 0.735 | 0.656 | 0.641 | 1.000 | | **PH** |
| 0.799 | 0.788 | -0.482 | 0.100 | 0.856 | 0.658 | 0.123 | 0.882 | 0.804 | 1.000 | | | **LN** |
| 0.986 | 0.989 | -0.365 | -0.349 | 0.984 | 0.826 | 0.245 | 0.915 | 1.000 | | | | **LA** |
| 0.948 | 0.881 | -0.664 | -0.122 | 0.915 | 0.882 | -0.055 | 1.000 | | | | | **DA** |
| 0.101 | 0.296 | 0.710 | -0.467 | 0.227 | -0.250 | 1.000 | | | | | | **SN** |
| 0.891 | 0.779 | 0.690 | -0.075 | 0.813 | 1.000 | | | | | | | **SW** |
| 0.969 | 0.986 | -0.403 | -0.256 | 1.000 | | | | | | | | **TDM** |
| -0.276 | -0.411 | -0.201 | 1.000 | | | | | | | | | **DTM** |
| -0.478 | -0.334 | 1.000 | | | | | | | | | | **F%** |
| 0.962 | 1.000 | | | | | | | | | | | **CGR** |
| 1.000 | | | | | | | | | | | | **Y** |

*Traits; DTF :Days to flowering ,PH: Plant height, LN: Number of leaves, LA; leaf area, DA: DiscArea,SN: No. seeds.disc$^{-1}$ , SW: seeds weight ,TDM: Total dry matter,DTM:Days to maturity, F%:Percentage of fertile,CGR:Crop growth rate,Y:Yield.

highly significant genetically with percentage of fertile and crop growth rate, and phenotypically was positive highly significant only with crop growth rate and negatively with percentage of fertile. Negative highly significant genetically and phenotypically correlation for trait percentage of fertile with crop growth rate. It is noted that all genetic correlation higher than phenotypic correlation, and environment correlation is very little. These mean that all traits (except number of leaves) were genetically controlled thus,it gives better response for seed yield improvement than would be expected on the basis of phenotypic association alone (Robinson *et al*., 1951).

The phenotypic, genotypic and environment correlation presented in tables 4, 5 and 6 in fall season.

In this season the relationships among traits were different from the relation in spring. All environment correlation were non-significant and all little. Most of traits were positive and highly significant genetically and phenotypically. Only days to flowering, number of seeds and days to maturity were negative and non-significant at genetic and phenotypic level. The higher value of genetic and phenotypic correlation was (0.989, 0.986) for leaf area and (0.973, 0.969) for total dry mater, (0.967, 0.962) for crop growth rate, (0.952, 0.948) for disc area (table 4, 5). The days to flowering trait showed positive and highly significant with plant height and number of seeds per head only (0.616 and 0.870) and negative highly significant with percentage of fertile,(-0.857) (phenotypically). Genetically was correlated positive highly significant with plant height and seed weight (0.645 and 0.550), negative highly significant with number of

**Table 6 :** Environmental correlation coefficients among twelve traits in genotypes of sunflower in the fall season 2013 .

| Y | CGR | F% | DTM | TDM | SW | SN | DA | LA | LN | PH | DTF | Traits * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.132- | 0.185 | 0.053- | 0.276- | 0.313- | 0.143- | 0.195 | 0.057 | 0.004- | 0.048 | 0.092 | 1.000 | **DTF** |
| 0.102- | 0.247 | 0.587 | 0.028 | 0.034- | 0.293- | 0.388- | 0.072 | 0.549 | 0.091 | 1.000 | | **PH** |
| 0.718- | 0.169 | 0.338 | 0.002 | 0.169- | 0.408- | 0.031- | 0.323 | 0.049- | 1.000 | | | **LN** |
| 0.222 | 0.338 | 0.012 | 0.191- | 0.381 | 0.061 | 0.038- | 0.004 | 1.000 | | | | **LA** |
| 0.044- | 0.167 | 0.128 | 0.013- | 0.559 | 0.512- | 0.070 | 1.000 | | | | | **DA** |
| 0.129- | 0.111 | 0.448- | 0.121- | 0.170 | 0.111- | 1.000 | | | | | | **SN** |
| 0.387 | 0.490- | 0.418- | 0.358 | 0.055- | 1.000 | | | | | | | **SW** |
| 0.296 | 0.060 | 0.093- | 0.094 | 1.000 | | | | | | | | **TDM** |
| 0.280- | 0.903- | 0.080 | 1.000 | | | | | | | | | **DTM** |
| 0.410- | 0.214 | 1.000 | | | | | | | | | | **F%** |
| 0.116 | 1.000 | | | | | | | | | | | **CGR** |
| 1.000 | | | | | | | | | | | | **Y** |

*Traits; DTF :Days to flowering ,PH: Plant height, LN: Number of leaves, LA; leaf area, DA:DiscArea,SN: No. seeds.disc$^{-1}$ , SW: seeds weight ,TDM: Total dry matter,DTM:Days to maturity, F%:Percentage of fertile,CGR:Crop growth rate,Y:Yield

**Table 7 :** Path coefficient of some traits of sunflower yield in spring season of 2013.

| Traits | Days to flowering | Plant height | Leaves number | Leaves area | Disc area | Total effects |
|---|---|---|---|---|---|---|
| **Days to flowering** | -0.0230 | -0.0097 | 0.0001 | 0.7983 | -0.0292 | 0.7359 |
| **Plant height** | -0.0144 | -0.0118 | 0.0475 | 0.9125 | -0.0388 | 0.8900 |
| **Leaves number** | 0.0000 | 0.0027 | -0.2090 | 0.2986 | 0.0022 | 0.0943 |
| **Leaves area** | -0.0171 | -0.0097 | 1.1070 | -0.0564 | 1.1072 | 0.9843 |
| **Disc area** | -0.016 | -0.0106 | 0.0106 | 1.0174 | -0.0436 | 0.9582 |

seeds per head 0.909. Plant height was positive and highly correlated with most traits, and negative highly significant with number of seeds and percentage of fertile (genetically and phenotypically). All genetic correlation of number of leaves with other trait were higher than phenotypic correlation. It was positive and highly correlated with five traits, non significant correlated with number of seeds per head and days to mature, negative significant with percentage of fertile. Leaves area exhibited positive highly significant with head area (0.915, 0.916), seed weight (0.887, 0.826), total dry mater (0.984, 0.984) and crop growth rate (0.991, 0.989), and negative with days to maturity and percentage of fertile at genotypic and phenotypic levels. The head area was positive highly genetic and phenotypic correlation with seed weight, total dry matter and crop growth rate (0.951, 0.882), (0.916, 0.915) , 0.883, 0.881), negative with percentage of fertile, non-significant with number of seeds per head and days to maturity. Number of seeds per head was positive highly correlation with percentage of fertile only (0.721, 0.710), significant negative with days to maturity and non correlated with others. Seed weight was positive highly significant (genetic and phenotypic) correlate with total dry matter and crop growth rate(0.874, 0.813), (0.850, 779), negative highly significant with percentage of fertile.Total dry matter showed positive high significant genetic and phenotypic correlation with crop growth only (0.988, 0.986), negative with percentage of fertile, non significant with days to maturity. Days to maturity and percentage of fertile exhibited negative non significant with each other and with seed yield.

All environment correlation for all traits with yield were negative indicated that all these trait are controlled by genetic effect (table 6).

In fall season the relationships among traits were different. The number of trait which significant correlations were lower than the number of traits in spring. The higher magnitude of genotypic correlation helps in selection for genetically controlled traits and gives a better response for seed yield improvement than that would be expected on the basis of phenotypic association alone (Robinson *et al*., 1951).

### Path coefficient

Path coefficient and its two components direct and indirect effect provide significant information on contribution of traits in yield, thus its consider the basis of selection to improve the yield. In spring season as the data illustrate in table 7 all direct effect for all trait were negative and worthless, in spite of the most genetic and

**Table 8 :** Path coefficient of some traits of sunflower yield in spring season of 2013.

| Traits | No.seeds $dis^{-1}$ | Seeds weight | TDM | DTM | Percentage of fertile | CGR | Total effect |
|---|---|---|---|---|---|---|---|
| **No.seeds.$dis^{-1}$** | 2.0029 | -5.5320 | 2.2088 | -0.3625 | 1.0845 | -0.0271 | -0.6255 |
| **Seed weight** | -1.7020 | 6.5086 | -3.1570 | 0.3535 | -1.1110 | 0.0491 | 0.9408 |
| **TDM** | -1.2980 | 6.0320 | -3.4060 | 0.3340 | -0.7830 | 0.0538 | 0.9312 |
| **DTM** | -1.7470 | 5.5380 | -2.7400 | 0.4154 | -0.8299 | 0.0314 | 0.6671 |
| **Percentage of fertile** | 1.6370 | -5.4500 | 2.0107 | -0.2599 | 1.3260 | -0.0325 | -0.7670 |
| **CGR** | -0.9590 | 5.6370 | -3.2340 | 0.2300 | -0.7610 | 0.0567 | 0.9691 |

**Table 9 :** Path coefficient of some traits of sunflower yield in fall season of 2013.

| Traits | Days to flowering | Plant height | Leaves number | Leaves area | Disc area | Total effects |
|---|---|---|---|---|---|---|
| **Days to flowering** | -0.0700 | 0.1129 | -0.0276 | 0.0554 | 0.1427 | 0.2131 |
| **Plant height** | -0.0454 | 0.1751 | -0.1103 | 0.4271 | 0.3044 | 0.7510 |
| **Leaves number** | -0.0118 | 0.1170 | -0.1652 | 0.5336 | 0.3712 | 0.8448 |
| **Leaves area** | -0.0061 | 0.1164 | -0.1372 | 0.6425 | 0.3736 | 0.9893 |
| **Disc area** | -0.0246 | 0.1306 | -0.1502 | 0.5881 | 0.4082 | 0.9521 |

**Table 10 :** Path coefficient of some traits of sunflower yield in fall season of 2013.

| Traits | No.grains.$dis^{-1}$ | Seed weight | TDM | DTM | Percentage of fertile | CGR | Total effect |
|---|---|---|---|---|---|---|---|
| **No. seeds.$dis^{-1}$** | 0.3178 | -0.4092 | 3.3604 | 1.0156 | 0.3922 | -4.5671 | 0.1097 |
| **Seed weight** | 0.0796 | 1.6341 | 10.1030 | 0.1899 | -0.3414 | -10.570 | 0.9356 |
| **TDM** | 0.0911 | 1.4079 | 11.7263 | 0.4994 | -0.1841 | -12.556 | 0.9845 |
| **DTM** | -0.1811 | -0.1741 | -3.2855 | -0.093 | -1.7825 | 5.2189 | -0.298 |
| **Percentage of fertile** | 0.2771 | -1.2403 | -4.8005 | 0.3702 | 0.4498 | 4.4612 | -0.483 |
| **CGR** | 0.1144 | 1.3620 | 11.6090 | 0.7336 | -0.1582 | -12.682 | 0.9799 |

phenotypic correlation with yield were positive and highly significant, more over the total effect was positive, this due to positive and highly indirect effect via leaves area for days to flowering; leaf area for plant height; number of leaves, head area for leaves area and leaves area for head area. Table 8 showed that seed weight have the highest value of direct effect in the yield (6.509), followed by number of seeds (2.003) and percentage of fertile (1.326). The direct effect of trait crop growth rate was very little. Dry matter exhibited negative direct effect, in spite of high genetic and phenotypic correlation with yield. The result revealed that, the total effects of number of seeds per head was negative in spite of the positive of direct effect, thus, due to the negative and high values of indirect effect via seed weight (-5.532), beside low values via days to maturity and crop growth rate, in contrast the trait total dry matter. The total effect for negative total dry matter was positive (0.931), but it direct effect was negative and have high value (-3.406), this case resulted from the positive and high values of indirect effect via seed weight6.508 and of little value via days to maturity 0.334 and crop growth rate 0.056. In contrast of this, the total effect of percentage of fertile was negative -0.767 in spite of positive and high value of direct effect 1.326, because the negative high value via seed weight -5.45 and little value of days to maturity and crop growth rate. The total effect of seed weight was positive and direct effect also positive and high value, in spite of negative high values of indirect effect via dry matter, number of seed $head^{-1}$ and percentage of fertile. Both of days to maturity and crop growth rate have positive total effect and direct effect also positive high value indirect effect via seed weight and positive via days to maturity, and negative indirect effect via number of seeds, total dry matter and percentage of fertile. It can be conclude that seed weight, number of seeds $head^{-1}$ and percentage of fertile gave the highest value of direct path coefficient in spring. Thus, these traits could be explored as selection criteria for yield improvement in the breeding programs.

The result of fall season presented in tables 9 and 10. In this season the path coefficient for these traits and its contributions in seed yield were different. All total effects for traits in table 9 were positive, all of them was higher, only days to flowering was less. Direct effect for days to flowering was negative, but indirect effect via plant height, leaves area and head area were positive, only indirect effect via number of leaves was negative. Plant height exhibited positive direct effect 0.175 and positive indirect effect via leaves area and head area, and negative indirect effect via days to flowering and number of leaves. In spite of positive value of total effect for trait number of leaves, the direct effect was negative, but it has positive indirect effect via plant height, leaves area and head area. Leaves area showed positive higher value of direct effect and positive indirect effect via plant height and head area, negative indirect via days to flowering and number of leaves. The direct effect and total effect for head area and indirect effect via plant height and leaves area were positive, negative indirect effect via days to flowering and number of leaves. Three traits, seeds head$^{-1}$, seed weight and total dry matter showed positive total effects and direct effect (table 10). The higher value was for total dry matter (11.726), followed by seed weight (1.634), and seeds head$^{-1}$ (0.318). Days to maturity exhibited negative direct effect and total effect due to negative indirect effect via four traits number of seed, seed weight, total dry matter and percentage of fertile. The total effects of percentage of fertile was negative in spite of positive direct effect due to high negative indirect effect via total dry matter and seed weight. In contrast of this, the total effects for crop growth rate was positive, but direct effect was negative due to high positive value via total dry matter (11.609), followed by seed weight (1.362) and via number of seed (0.114) and days to maturity (0.734). Singh and Chuodhry (1985) reported if the correlation coefficient between a causal factor and the effect is almost equal to its direct effect, then correlation explains the true relationship and direct selection through this traits will be effective.

## References


Alrawi, W. M., M. M. Elsahookie and A. E. Almarsomi (2004). Study of correlation between some traits of sunflower. *The Iraqi J. of Agric. Sci*., **1(3)** : 31-39.

Bidgoli, A. M., G. A. Akbari, M. J. Mirhadi, E. Zand and S. Soufizadeh (2006). Path analysis of the relationships between seed yield and some morphological and phenological traits in safflower (*Carthamus tinctorious* L.). *Euphytica*, **148**: 261-268.

Elsahookie, M. M. and S. K. Eltaweel (2001). Selection, heritability and genetic gain of sunflower seed weight by parent-offspring regression. *The Iraqi J. of Agric. Sci*., **32 (1)** : 99-108.

Esan, E. B. and S. S. Omolaja (2002). Genotypic association, path analysis and pluck quality value in tea [*Camellia sinensis* ( L.) o. kuntze). *Trop. Agric*., **79** : 100-104.

Hassan, W. A. (2016). Estimation of some genetic parameters of growth and yield characters of sunflower under three plant densities. *The Iraqi J. of Agric. Sci*., **47(4)**: 921-932.

Hassan, S. M. F., M. S. Iqbal, G. Rabbani, Naeem-ud-Din and G. Shabbir (2012). Genetic variability, heritability and genetic advance for yield and yield components in sunflower (*Helianthus annuus* L.). *Electronic J. of Plant Breeding*, **3 (1)** : 707-710.

Khan, H., S. Muhammad, R. Shah and N. Iqbal (2007). Genetic analysis of yield and some yield components in sunflower. *Sarhad J. of Agric*., **23(4)** : 985-990.

Omidi, A. H. and O. Tabrizi (2002). Correlation between traits and path analysis for grain and oil yield in spring safflower. *Sesame and Safflower*, **15**: 87-82.

Robinson, H. F., R. E. Comstick and P. H. Harrery (1951). Genotypic and phenotypic correlations in corn and their implication in selection. *Agron. J*., **43**: 282-287.

Safavi, S. M., A. S. Safavi and S. A. Safavi (2015). Assessment of genetic diversity in sunflower (*Helianthus annuus* L.) genotypes using agro-morphological traits. *J. Bio. &Env. Sci*., **6(1)** : 152-159.

Sarawagi, A. K., N. K. Rastogi and D. K. Soni (1997). Correlation and path analysis in rice accessions from Madhya Pradesh. *Field Crops Res*., **52** : 161-167.

Singh, R. K. and B. D. Chaudhary (1985). Biometrical Methods in Quantitative Genetic Analysis. Kalyanipublishers . New Delhi-Ludhiana, Pp 69-78.

Tyagi, S. D. and M. H. Khan (2010). Studies on genetic variability and interrelationship among the different traits in microsperma lentil (*Lens culinaris* Medik). *J. Agric. Biotechnol. Sustain Dev*., **2**: 15-20.

Wright, S. (1929). Path coefficient and path regression : Alternative complementary concepts. *Biometric*, **16**: 189-202.

Wuhaib, K. M. (2012). Correlation in safflower to determine selection criteria. *The Iraqi J. of Agric. Sci*., **43(3)** : 24-32.

Yasin, A. B. and S. Singh (2010). Correlation and path coefficient analysis in sunflower. *J. of Plant Breeding and Crop Sci*., **2(5)** : 129-133.