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# Correlation and Path Analysis in Sunflower (*Helianthus annuus* L.)

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**Abstract:** This study was carried out to determine the correlation between agronomic traits and seed yield of sunflower hybrids and also to determine the direct and indirect effects of analyzed traits on seed yield. The primary task in sunflower breeding programs is to increase the seed yield, as well as create new hybrids with high potential for seed and oil yield. The experiment was set up according to randomized block design during two growing seasons (2013 and 2014), on research area of the Faculty of Agriculture, "Goce Delchev" University – Shtip, in Ovche Pole locality, Republic of Macedonia. As an experimental material 20 sunflower hybrids were used. 1,000 seed weight, seed length and width, oil content, oleic acid content and seed yield were analyzed. 1,000 seed weight showed positive and significant correlation with seed width, seed length and seed yield. On the other hand, negative and significant correlation was obtained between 1,000 seed weight and oil content. 1,000 seed weight expressed the highest positive direct effect on seed yield. The results obtained from correlation and path analysis showed that the efficiency in the selection of seed yield in sunflower hybrids should increased through the selection of 1,000 seed weight.

**Keywords:** sunflower, correlation coefficient, path analysis, agronomic traits

## Introduction

Sunflower (*Helianthus annuus* L.) is an important crop, primarily grown for production of oil which is used for human consumption, but also as a row material in the industry (Mijić *et al.*, 2009). The main objective of any plant breeder is to develop new hybrids with a higher seed and oil yield (Vrânceanu

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*et al.*, 2005). The success of breeding programmes primarily depends on the variation present in seed yield and yield components as well as the nature of the initial material (Nehru and Manjunath, 2003).

Seed yield is a complex quantitative trait controlled by large number of genes and is highly influenced by environmental, morphological and physiological properties. On the other hand, the seed yield is a function of genetic potential of the hybrid, external conditions in which the crop is grown, applied technology and the interaction of all these factors (Abad *et al.*, 2013). Sunflower seed yield, like other crops, is also dependent of yield components which have interrelation among them and affect on seed yield directly or indirectly. More information is needed to clarify the relations between seed yield and yield components. Correlations between traits are an aspect that should be kept in mind for better planning of sunflower breeding programmes.

Many researchers used correlation coefficient and path analysis to determine the relationship among seed yield and yield components (Kaya and Atakisi, 2003; Nistor *et al.*, 2005; Sridhar *et al.*, 2005; Farhatullah and Khalil, 2006; Goksoy and Turan, 2007; Machikowa and Saetang, 2008; Kaya *et al.*, 2007). According to Joksimovic *et al.*, (2004) selection to seed yield in sunflower should be depended of 1,000 seed weight and head diameter. On the other hand, plant height has also an influence on seed yield (Kaya and Atakisi, 2003; Kaya *et al.*, 2003). Furthermore, seed size is the most important yield-related trait among the yield components (Hladni *et al.*, 2006).

The path coefficient analysis is used to determine the interrelationship among yield components and their direct and indirect effects on seed yield. Correlation coefficient and path coefficient analysis assist to identify the traits that are useful as selection criteria to improve seed yield.

The objectives of this research were to determine the relationships between seed yield and some agronomic traits and to determine the direct and indirect effects of certain traits on seed yield in sunflower hybrids.

## Materials and methods

The experimental material included 20 sunflower hybrids (NLK12M006, NLK12M008, NLK12M009, NLK12M058, NLK12M59, NLK12M063, NLK12M134, NLK12M139, NLK12M144, NLK12M148, NLK12S070, NLK12S074, NLK12S125, NLK12S126, NLN11001, NLN12N005, NLN12N007, NLN12N010 DMR, NLN12N011 DMR and NSK12001). All sunflower hybrids were developed from NUSEED, global company for breeding sunflower hybrids. The field trial was set up during

the 2013 and 2014 on the research area of the Faculty of Agriculture, "Goce Delchev" University – Shtip, in Ovche Pole locality, Republic of Macedonia. According to Filipovski *et al.*, (1996), Ovche Pole has continental and sub-Mediterranean climate. The summers are warm and dry and there are often no precipitations. The sunflower hybrids were planted in randomized complete block design (RCBD) with three replications. Each experimental plot was 6 m long, consisted of 4 rows, with 24 plants in one row. The seeds were sown by the sowing machine at a space of 0.30 m within the rows and 0.60 m between the rows. In the first year of setting the experiment (2013), the previous crop was wheat and in the second experimental year (2014) barley. In the first experimental year the sowing occurred on 19 April and in the second year on 15 April. The trial was treated with herbicide *Goal* in the second half of April. Diseases and insects were controlled by regular applications of fungicides and insecticides. Further irrigation was not used during the vegetation. The harvest was done by hand. The following traits were analyzed: 1,000 seed weight (g), seed length and width (mm), oil content (%), oleic acid content (%) and seed yield (kg $ha^{-1}$). For obtaining thousand seed weight, 100 seeds taken in random from each sample, were weighted in an electronic balance with an accuracy of 0.001 g and then multiplied by 10 to give weight of 1,000 seed. For determining the seed length and width about 20 randomly selected seeds of each sample were used and the measurements were done by micrometer gauge. Oil and oleic acid content were determined utilizing nuclear magnetic resonance (NMR). When the head samples became mature, they were harvest from each plot and dried. Seed yield was measured separately from each plot and expressed per kg $ha^{-1}$.

The results were statistically analyzed using statistical software (Stat Soft, 8.0). The correlation between the seed yield and agronomic traits was determined by linear correlation (Singh and Chaudhary, 1985), with SSPS statistics 19 (2010). Direct and indirect effects of the agronomic characteristics on seed yield were calculated using the path analysis (Dewey and Lu, 1959).

# Results and discussion

## Main values and variability

The main values for agronomic traits and seed yield of 20 sunflower hybrids, during the period of study are presented in Table 1.

Thousand seed weight is one of the most important traits when it comes to seed quality and yield. Generally, the seed used for growing should have as

**Table 1:** Mean values for agronomic traits and seed yield in sunflower hybrids during the period of study.

| Hybrid/Trait | 1,000 seed weight (g) | Seed length (mm) | Seed width (mm) | Oil content (%) | Oleic acid content (%) | Seed yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| NLK12M006 | 75.45 | 10.98 | 6.06 | 42.9 | 68.1 | 2,908 |
| NLK12M008 | 73.36 | 10.22 | 6.21 | 45.3 | 67.6 | 2,870 |
| NLK12M009 | 70.42 | 10.25 | 6.31 | 44.8 | 66.3 | 2,762 |
| NLK12M058 | 78.34 | 12.15 | 5.87 | 46.1 | 64.6 | 2,575 |
| NLK12M059 | 75.38 | 11.76 | 5.77 | 47.2 | 66.4 | 2,577 |
| NLK12M063 | 78.61 | 11.13 | 5.46 | 45.0 | 69.8 | 2,485 |
| NLK12M134 | 72.28 | 11.64 | 6.32 | 44.7 | 64.9 | 3,024 |
| NLK12M139 | 62.79 | 10.80 | 5.88 | 47.5 | 64.5 | 2,991 |
| NLK12M144 | 57.78 | 10.19 | 5.70 | 49.1 | 63.1 | 3,344 |
| NLK12M148 | 69.20 | 11.09 | 6.01 | 44.4 | 75.8 | 2,376 |
| NLK12S070 | 85.29 | 11.68 | 6.90 | 44.3 | 68.0 | 2,644 |
| NLK12S074 | 76.69 | 10.82 | 6.13 | 46.8 | 87.1 | 2,264 |
| NLK12S125 | 83.95 | 11.68 | 6.93 | 41.3 | 68.4 | 2,748 |
| NLK12S126 | 87.83 | 11.97 | 7.01 | 41.8 | 74.8 | 2,244 |
| NLN11001 | 81.49 | 10.26 | 6.39 | 48.5 | 48.4 | 3,720 |
| NLN12N005 | 87.63 | 11.34 | 6.69 | 46.2 | 39.4 | 3,047 |
| NLN12N007 | 80.21 | 11.32 | 6.51 | 43.5 | 57.4 | 2,914 |
| NLN12N010 DMR | 78.64 | 11.54 | 6.02 | 48.5 | 51.5 | 2,924 |
| NLN12N011 DMR | 87.36 | 11.67 | 6.32 | 45.0 | 51.0 | 3,549 |
| NSK12001 | 56.67 | 10.36 | 5.92 | 49.1 | 87.2 | 2,707 |
| Average | 75.97 | 11.14 | 6.22 | 45.6 | 65.2 | 2,834 |
| Min. | 56.67 | 9.06 | 4.07 | 38.1 | 36.4 | 1,000 |
| Max. | 87.83 | 13.45 | 8.51 | 50.3 | 89.0 | 5,681 |
| CV (%) | 12.08 | 5.10 | 7.28 | 3.73 | 6.40 | 12.18 |

high 1,000 weight as possible, because such seed has more developed embryos and larger amount of storage substance. The knowledge about 1,000 seed weight is important because this trait has direct effect on seedling rate and also influences indirectly to seed quality and yield (Škorić, 1988). This trait is one of the three most important yield components among the seed number in the head and plant number in the field in determining sunflower yield (Kaya *et al*., 2003).

In our study, 1,000 seed weight of sunflower hybrids ranged between 56.67–87.83 g with the 75.97 g average during the both experimental years. The lowest value for this trait was observed in hybrid NSK12001, while for the hybrid NLK12S126 the highest average value for 1,000 seed weight was recorded.

Similar results have been reported by Ghaffari and Farrokhi (2008). In their research the minimum and maximum values for this trait were 59.25 g and 84.25 g, respectively. According to Mijić *et al.* (2009) the values for 1,000 seed weight ranged from 54.8 g to 66.7 g and they are lower compared with average values from our experiment.

Sunflower seeds are excellent source of dietary fiber, protein, vitamin and minerals. On the other hand, there are several ways to increase the seed yield. One of the most commonly used ways is to increase the seed size and number of seed per head, maintain or raising the number of plants per unit area.

Several investigators (Singh and Goswami, 1996; Sahebeh *et al.*, 2011; Duca et and Glijin, 2013) have measured seed length and width to determine the seed size.

The seed length is a trait which has great variability but usually it ranges from 6 mm to 25 mm, while the seed width ranges between 3 and 13 mm (Fick, 1978). According to Duca and Glijin (2013) the highest value of seed length was 12.1 mm, while the highest seed width was 5.9 mm.

In our research the average values for seed length and width were 11.14 mm and 6.22 mm, respectively. The highest values for those traits were 13.45 mm for seed length and 8.51 mm for seed width. They are higher compared with the result obtained in Duca and Glijin (2013) research. The average value for seed length in Tan and Tan (2011) study was 11.57 mm.

Seifi and Alimardani (2010) reported values for seed length from 12.14 mm to 12.57 mm, while for seed width between 5.79 and 6.38 mm.

Oil content in sunflower hybrids depends on genetic potential and environmental conditions (Hladni *et al.*, 2006). According to Škorić *et al.* (1996) oil content in sunflower hybrids ranges between 38.1 and 49.2%, while Pacureanu – Joita *et al.* (2005) reported higher values for this trait (49.0–54.7%).

In this research the average value for oil content during the period of study was 45.6% and was within the values reported by Škorić *et al.* (1996). Higher values for oil content compared with ours were presented by Ghaffari and Farrokhi (2008), and Mijić *et al.* (2009).

According to oleic acid content, sunflower hybrids were grouped into three main classes namely high oleic, intermediate oleic and low oleic (Demurin *et al.*, 2004). In high oleic hybrids, oleic acid ranges from a minimum of 80% to a maximum of 90%. The effect of temperature on oil unsaturated fatty acid is smaller than in intermediate and low oleic classes.

In our study the average value for oleic acid content for both years was 65.2%. The sunflower hybrids used in this study belong to intermediate oleic class. According to Demurin *et al.* (2004), the oleic acid content in intermediate class usually ranges from 60 to 80%.

Higher average values for oleic acid content, compared with ours were presented by Pacureanu – Joita *et al.* (2005).

The yield and the agronomic efficiency of sunflower cultivation primary depend on the influence of hybrid, the level of applied technology and the presence of an important number of diseases (Duca and Glijin, 2013).

In our experiment, seed yield of sunflower hybrids ranged between 1,000 and 5,681 kg $ha^{-1}$ with average value 2,834 kg $ha^{-1}$ during the period of study.

According to Kaya *et al.* (2009) the average value for seed yield was 2,160 kg $ha^{-1}$. In Pacureanu – Joita *et al.* (2005) research the minimum and maximum values for seed yield were 3,220 and 4,145 kg $ha^{-1}$, respectively. Higher values for this trait, compared to results from our experiment were presented by Mijić *et al.* (2009).

The maximum coefficient of variation was obtained for seed yield (12.18%), followed by 1,000 seed weight (12.08%). According to Kholghi *et al.* (2011) the coefficient of variation for seed yield was higher (42.07%), while Nooryazdan *et al.* (2010) reported the highest coefficient of variation for 1,000 seed weight. Oil content showed the lowest coefficient of variation (3.73%). The lowest coefficient of variation for this trait (4.53%) was also presented by Karaaslan *et al.* (2010).

## Correlation and path analysis

The correlation coefficient between seed yield and other agronomic traits are presented in Table 2. In this study highly significant positive and negative correlations were obtained. The highest correlation coefficient was found between 1,000 seed weight and seed width (positive) and between oil content and seed width (negative).

**Table 2:** Correlation coefficient of seed yield and some agronomic traits.

| Trait | 1,000 seed weight | Seed length | Seed width | Oil content | Oleic acid content | Seed yield |
|---|---|---|---|---|---|---|
| 1,000 seed weight | **1** | | | | | |
| Seed length | **0.626**** | **1** | | | | |
| Seed width | **0.638**** | 0.320 | **1** | | | |
| Oil content | **−0.539*** | **−0.461*** | **−0.591**** | **1** | | |
| Oleic acid content | −0.437 | −0.140 | −0.188 | −0.120 | **1** | |
| Seed yield | **0.420*** | −0.317 | 0.003 | 0.358 | −0.709 | **1** |

*, ** Statistical significance at $P < 0.05$ and $P < 0.01$.

1,000 seed weight has direct influence on seed yield (Morozov, 1970). In our research 1,000 seed weight showed positive and significant correlation with seed width ($r = 0.638$), seed length ($r = 0.626$) and seed yield ($r = 0.420$). Similar positive and significant correlation coefficient between 1,000 seed weight and seed yield was also observed by Joksimović *et al.* (2004), Kaya *et al.* (2009), Mijić *et al.* (2009), and Anandhan *et al.* (2010).

Sunflower oil is highly qualitative one, with high percentage of unsaturated fatty acids which can achieve 90% from the total (Kinman and Earle, 1964). Negative and significant correlation was obtained between 1,000 seed weight and oil content ($r = -0.539$) as shown in our experiment. The similar results were reported by Joksimović *et al.* (2004) and Mijić *et al.* (2009).

In this paper among seed length and oil content negative and significant correlation ($r = -0.461$) at level of significance of 0.05 was determined. Negative and significant correlation was observed between seed width and oil content ($r = -0.591$) at level of significance of 0.01.

The correlation coefficients among other analyzed traits were not significant.

The proposal of using the path coefficient analysis in this study was to obtain further information about the interrelationships between the seed yield and other agronomic traits and about the influence of them on seed yield. Direct and indirect effects of analyzed traits on seed yield are presented in Table 3. In our study, path coefficient analysis showed that 1,000 seed weight has the highest direct positive effect on seed yield. Similar results were reported by Merrien *et al.* (1982), Marinković (1992), Gonzales *et al.* (2000), and Hladni *et al.* (2010). These results indicate that an increase of 1,000 seed weight causes some increase in sunflower seed yield.

Indirect positive effect on seed yield was obtained for oleic acid content.

**Table 3:** Direct and indirect effects of agronomic traits on seed yield.

| Indicators | Direct effect | Indirect effect | | | | | Total indirect effect |
|---|---|---|---|---|---|---|---|
| | | 1,000 seed weight | Seed length | Seed width | Oil content | Oleic acid content | |
| **1,000 seed weight** | 0.296 | | 0.185 | 0.189 | −0.159 | −0.129 | 0.085 |
| **Seed length** | −0.282 | −0.177 | | −0.090 | 0.130 | 0.040 | −0.097 |
| **Seed width** | 0.147 | 0.094 | 0.047 | | −0.087 | −0.028 | 0.026 |
| **Oil content** | 0.077 | −0.041 | −0.035 | −0.045 | | −0.009 | −0.131 |
| **Oleic acid content** | −0.824 | 0.360 | 0.115 | 0.155 | 0.099 | | 0.729 |

## Conclusion

Based on the conducted analyses, the following can be conducted: 1,000 seed weight showed positive and significant correlation with seed width, seed length and seed yield. On the other hand, negative and significant correlation was obtained between 1,000 seed weight and oil content. Oil content showed negative significant correlation with seed length and width. From path analysis, 1,000 seed weight has shown the highest direct positive effect on seed yield. The positive direct effect of this trait was associated with the positive and significant correlation with seed yield. It can be concluded that the efficiency in the selection for seed yield in sunflower hybrids should increased through the selection of 1,000 seed weight.

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