Scientific Papers. Series A. Agronomy, Vol. LXIII, No. 1, 2020
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

INVESTIGATION OF RELATIONSHIPS BETWEEN SEED YIELD AND AGRONOMIC TRAITS IN SUNFLOWER

Claudia Ioana BORLEANU[1], Dorina BONEA[2]

[1]Agricultural Research and Development Station Simnic, Craiova, 54 Balcesti Road, Dolj County, Romania
[2]University of Craiova, Faculty of Agronomy, 19 Libertatii Street, Craiova, Romania

Corresponding author email: dbonea88@gmail.com

Abstract

Better understanding of the relationships between seed yield and agronomic traits could facilitate sunflower breeding programs. In this study, twenty sunflower hybrids were investigated to explore the relationships between yield and agronomic traits during two years (2017 and 2018), under Agricultural Research and Development Station (ARDS) - Simnic environmental conditions. The analyses of Pearson correlation coefficients showed that the seed yield was significantly and positively correlated only with the head diameter, suggesting a reliable selection criterion for improving of seed yield in sunflower. The plant height was significantly and positively correlated with thousand seed weight, while significantly and negatively correlated with hectolitre mass and days to physiological maturity. Also, hectolitre mass was significantly and negatively correlated with thousand seed weight. Days to flowering initiation were significantly and positively correlated with days to flowering completion.

Key words*: correlation, head diameter, plant height, thousand seed weight, sunflower (Helianthus annuus L.).*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) belongs to the genus *Helianthus* of the family *Asteraceae*, is one of the most important oil crops worldwide with an annual production of about 51 Million tonnes. In 2018, Romania achieved 3.062 Million tons sunflower seeds (FAO, 2018).

Due to the increasing population, selection and cultivation of high yielding sunflower varieties is very important.

Seed yield in sunflower is a complex character which is products of interaction between a numbers of other traits (Arshad et al., 2010). According to Abad et al. (2013), the seed yield is a function of genetic potential of the genotype, external conditions in which the crop is grown, applied technology and the interaction of all these factors.

Understanding the nature of relationships between seed yield and associated traits is a prerequisite for screening programs in plant breeding. Direct selection for this trait has a lower efficiency due to low heritability, so indirect selection using yield traits may improve seed yield of sunflower (Ghaffari et al., 2019).

In breeding program for increasing yield, morphological and physiological characteristics that are easily measured and that demonstrate a causal relationship with seed yield, can be used as selection criteria (Hladni et al., 2007).

Correlation coefficients reveals the strength of relationship among the group of traits, thus is one of the important biometrical tools for formulating a selection index (Jayakumar et al., 2007). According to Yagdi and Sozen (2009), analysis of correlation coefficient is the most widely used statistical tool one among numerous methods.

Many researchers used correlation coefficient for displaying the relationship of sunflower traits. Darvishzadeh et al. (2011) reported that head diameter had the highest significant positive correlation with seed yield, in both well-watered and water-stress conditions. Zeinalzadeh-Tabrizi et al. (2019) reported positive correlations of plant height, head diameter and seed numbers with seed yield in drought stress condition.

Therefore, due to environmental effects, relationships among sunflower traits could be variable.

The objective of this study was to investigate the correlation coefficients of seed yield with agronomic traits in sunflower hybrids.

MATERIALS AND METHODS

Twenty sunflower hybrids coming from the NARDI Fundulea (noted conventionally HF1-HF20) were used in this study.
Experiments were conducted under rain fed conditions in the years 2017 and 2018.
The field experiments were located within the Agricultural Research and Development Station (ARDS) Simnic, Craiova ($44^0$19' N, $23^0$48' E, and 182 m altitude).
Soil was a reddish preluvosol with a humus content of 2.68-2.23% and pH = 5.08-5.33 (Radu et al., 2019).

Figure 1. View from the experimental field (ARDS Simnic)

The experiment organized in a randomised block design with three replications (Figure 1). The row-to-row distance was 70 cm, and the plant-to-plant distance was 30 cm. Each 19.6 m^2 plot consisted of four 7.0 m long rows.
Sowing was performed on 12 April 2017 and 20 April 2018, respectively.
Fertilization was done with an application of 250 kg of complex fertiliser ($N_{20}P_{20}K_0$) prior to sowing.
Weeds were controlled by the help of herbicides, respectively Dual Gold 960 EC applied at a dose of 1.5 l/ha immediately after sowing. Also, one manual hoeing was performed.

The monthly precipitation, average temperatures and multiannual data for 2017 and 2018 are presented in Table 1.
Climatic conditions for the period 2017-2018, in general, were unfavourable for the growth and development of sunflower plants.
In 2017 growing season, the average annual temperature was 11.8°C, with lows of -5.1°C in January and highs of 25.4°C in August.
In 2018 the average annual temperature was 12.6°C, with minimal value of 0.8°C in February and maximum value of 24.1°C in August.
Compared to multiannual average, in both growing seasons, the average temperature was higher by 0.6ºC and 1.4ºC, respectively.
The total annual precipitation was 483.4 mm in 2017 and 905.4 mm in 2018, being with -81.7 mm lower and, respectively, with +340.3 mm higher than the multiannual average.
Although the June and the July precipitations in 2018 amounted to 182.3 mm and 177.3 mm, respectively, the higher average temperature during August caused the manifestation of diseases on the plants and so reduced production.
Data were recorded on the following parameters:
Days to flowering initiation were recorded from date of sowing till about ten percent of the buds opened flowers in each plot.
Days to flowering completion were recorded when about 75% of the buds opened flower in each plot.
Days to physiological maturity were recorded when back of the heads turned yellow and bracts started turning brownish in colour.
Plant height: a total of five plants randomly selected in each plot at the time of maturity and were measured from ground level to attachment of head with stem to record data on plant height.
Head diameter was measured from one edge of the disk to other at five plants.
Hectolitre mass was determined using the Perten AM 5200-A.
Thousand seed weight data was recorded by weighing thousand grains randomly taken, with the help of electronic balance, and then average weight was calculated for each hybrid.
Seed yield per hectare adjusted to 9% moisture.

The relationships between the yield and associated traits were established using Pearson correlation coefficients (r). The variability presence in the hybrids was estimated by coefficient of variations (CV) using the procedure suggested by Săulescu and Săulescu (1967).

RESULTS AND DISCUSSIONS

The analysis of some agronomical traits of 20 new sunflower hybrids in the experimental field during 2017 and 2018 are given in Table 2.

Table 1. Monthly and growing season precipitation and temperature at ARDS Simnic in 2017 and 2018

Months	Temperature (^{0}C)			Precipitation (mm)		
	2017	2018	Multiannual average	2017	2018	Multiannual average
October	10.3	12.7	11.8	63.3	100.2	44.5
November	5.2	6.4	5.5	75.2	70.3	44.9
December	-0.3	3.2	0.4	5.0	62.0	45.1
January	-5.1	1.4	-1.4	11.1	36.3	32.7
February	1.6	0.8	1.0	31.2	72.5	30.6
March	9.8	3.9	5.6	32.1	95.0	33.7
April	11.1	16.6	11.8	71.1	11.1	46.0
May	16.7	19.2	16.9	74.2	60.2	66.9
June	23.4	21.6	20.4	0	182.3	67.9
July	24.2	22.3	22.6	89.2	177.3	61.5
August	25.4	24.1	22.1	5.0	19.2	48.9
September	19.4	19.2	17.5	26.0	19.0	42.4
Average/Total	11.8	12.6	11.2	483.4	905.4	565.1

The average value for seed yield during the period of study (two years) was 1452.08 kg/ha. Hybrid HF1 has the highest average value for seed yield (1995.5 kg/ha) and the minimal yield observed at hybrid HF17 (1184.0 kg/ha). The results are in agreement with values reported by Bonea et al. (2010) and Bonea et al. (2012) for sunflower hybrids cultivated at ARDS Simnic in drought conditions.

Higher values for this trait at 20 new sunflower hybrids were presented by Clapco et al. (2019), who observed that the seed yield in 2017 ranged between 2139.1-3152.9 kg/ha, with an average value of 2743.5 kg/ha, and in 2018 seed yield varied between 1474-3202 kg/ha, with average value of 2442.5 kg/ha.

Regarding the plant height, the average value was 119.98 cm, and the hybrids HF19 was the tallest among tested hybrids with the height of 138.0 cm.

The average values for head diameter was 18.08 cm. The highest head diameter (20.5 cm) was observed in hybrid HF3 and the shortest head diameter (15.5 cm) was observed in hybrids HF17 and HF18. The diameter values are similar with the values reported by Clapco et al. (2019), but are higher comparative to those reported by other authors (Khan et al., 2018; Sincik and Goksoy, 2014).

The average value for hectolitre mass was 45.17 kg/hl. The highest value in both analysed years was showed by the hybrid HF6 (47.7 kg/hl), while the lowest value was showed by the hybrid HF14 (43.2 kg/hl).

Obtained data has shown that the average value of thousand seed weight of all hybrids was 52.22 g. High value of thousand seed weight was noticed in HF10 (69.3 g), while the lowest value of thousand seed weight (35.4 g) was noticed in HF5.

The average value for days to flowering initiation was 58.68 days. Hybrid HF15 took maximum days (60.5) to flowering initiation whereas hybrid HF17 took minimum days (56.5) for flowering initiation.

Regarding the days to flowering completion, the average value was 75.5 days. Hybrid HF8 took maximum days (78.0) for their flowering completion while hybrid HF13 took minimum days (72.5) to complete their flowers.

The average value for days to physiological maturity was 129.83 days. HF7 took maximum days (134.5) to be matured whereas HF14 and HF15 took minimum days (124.5) to be matured.

The moderate coefficient of variation was obtained for seed yield and thousand seed weight of 13.27 % and 16.62 %, respectively.

Similar results was also observed for 20 sunflower varieties tested in Ovche Pole locality, Republic of Macedonia by Gorgieva et al. (2015).

Table 2. Mean values for agronomic traits in sunflower hybrids during the period of study

Hybrids	SY	PH	HD	HM	TSW	DFI	DFC	DPM
HF1	1995.5	104.5	19.5	45.8	47.1	59.0	74.5	133.0
HF2	1528.0	110.5	19.5	44.9	48.1	60.0	76.5	133.0
HF3	1368.5	102.5	20.5	46.0	50.2	59.0	74.0	133.0
HF4	1196.0	111.5	16.5	46.1	37.9	60.0	76.0	134.0
HF5	1253.5	108.5	19.0	45.5	35.4	57.5	76.0	134.0
HF6	1420.0	112.0	18.5	47.7	42.1	57.5	75.0	131.0
HF7	1646.0	118.0	18.5	45.1	52.0	57.5	74.5	134.5
HF8	1567.5	112.0	18.0	45.1	50.7	59.5	78.0	132.0
HF9	1529.0	121.0	18.5	45.4	63.9	59.5	77.5	129.5
HF10	1589.5	122.0	18.5	45.9	69.3	58.5	76.0	129.5
HF11	1388.0	118.0	19.0	43.4	59.4	58.5	75.0	129.5
HF12	1510.5	137.5	18.0	44.2	59.3	59.5	75.5	130.5
HF13	1469.5	124.0	16.5	44.6	55.9	59.0	72.5	130.0
HF14	1655.5	131.0	19.0	43.2	55.8	57.5	73.0	124.5
HF15	1364.5	127.5	16.5	47.0	49.9	60.5	77.0	124.5
HF16	1435.5	124.5	19.5	44.7	51.3	57.5	75.5	125.0
HF17	1184.0	122.5	15.5	45.3	44.8	56.5	73.5	128.0
HF18	1203.5	121.5	15.5	45.7	49.1	57.5	75.5	128.0
HF19	1443.0	138.0	17.0	44.1	59.5	59.5	77.0	128.0
HF20	1294.0	132.5	18.0	43.6	62.7	59.5	77.5	125.0
Average	1452.08	119.98	18.08	45.17	52.22	58.68	75.50	129.83
Minim	1184.0	102.5	15.5	43.2	35.4	56.5	72.5	124.5
Maxim	1995.5	138.0	20.5	47.7	69.3	60.5	78.0	134.5
CV%	13.27	8.53	7.74	2.52	16.62	1.9	2.02	2.54

SY= Seed yield; PH = Plant height; HD = Head diameter; HM = Hectolitre mass; TSW = Thousand seed weight; DFI = Days to flowering initiation; DFC = Days to flowering completion; DPM = Days to physiological maturity

The correlation analyses of the combined two years of data revealed that seed yield was significant and positively correlated only with the head diameter ($r = 0.511^{*}$; $p = 0.05$), but non-significantly positive correlated with thousand seed weight, days to flowering initiation and days to physiological maturity (Table 3).

Previous studies have similarly reported that the association between seed yield and the head diameter is positive and significant (Bonea et al., 2008; Tahir et al., 2002; Sincik and Goksoy, 2014; Zeinalzadeh-Tabrizi et al., 2019)

Many researchers observed a positive but low correlation between seed yield and head diameter (Bonea et al., 2012; Bonea et al., 2013; Clapco et al., 2019).

In contrast to our results, Manivannan et al. (2007) reported that the correlation between seed yield and the head diameter was negative and non-significantly for most studied varieties and hybrids.

According to Sincik and Goksoy (2014), this discordance among results for correlations is most likely associated with differences in the genetic material and environmental conditions used in studies.

Plant height exhibited positive and significant association with thousand seed weight ($r = 0.587^{*}$; $p = 0.05$), and a negative significantly association with hectolitre mass ($r = -0.526^{0}$; $p = 0.05$) and with days to physiological maturity ($r = -0.721^{00}$; $p = 0.01$).

Tahir et al. (2002) found that plant height revealed significant and positive correlation with seed yield, head diameter and 1000-seed weight.

On the other hand, Khan et al. (2018) observed that the correlation of plant height with days to physiological maturity was non-significant.

Arshad et al. (2010), Sujatha and Nadaf (2013) concluded that plant height correlated positively and significantly with days to physiological maturity.

Table 3. Pearson correlation coefficients between seed yield and other agronomic yield traits

Traits	PH	HD	HM	TSW	DFI	DFC	DPM
SY	-0.117	0.511*	-0.101	0.297	0.125	-0.123	0.174
PH		-0.415	-0.526^{0}	0.587*	0.065	0.104	-0.721^{00}
HD			-0.109	0.091	0.016	-0.018	0.271
HM				-0.494^{0}	0.023	0.099	0.321
TSW					0.236	0.164	-0.433
DFI						0.555*	0.073
DFC							-0.052
DPM							

$^{*, 0}$: significant at p = 0.05 probability level; $^{**, 00}$: significant at p = 0.01 probability level;
SY = Seed yield; PH = Plant height; HD = Head diameter; HM = Hectolitre mass; TSW = Thousand seed weight; DFI = Days to flowering initiation; DFC = Days to flowering completion; DPM = Days to physiological maturity

Head diameter and thousand seed weight had insignificant correlative associations with all of the other observed traits.

In addition, hectolitre mass was negatively and significantly associated with thousand seed weight (r = -0.494^{0}; p = 0.05) and days to flowering initiation were positively and significantly associated with days to flowering completion (r = 0.555*; p = 0.05).

The our findings are in agreement with those of Khan et al., (2018) and Zeinalzadeh-Tabrizi et al. (2019), who reported that the association between days to flowering initiation and days to flowering completion is positive and significant.

CONCLUSIONS

The results from this study indicated that seed yield was positively and significantly correlated with head diameter.

It can be conclude that head diameter can be good selection criteria in breeding program to obtain the maximum seed yield in sunflower hybrids.

REFERENCES

Abad, A., Khajehpour, M.R., Mahloji, M., Soleymani, A. (2013). Evaluation of phenological, morphological and physiological traits in different lines of barley in Esfahan region. *International Journal of Farming and Applied Science*, *2*(18), 670–674.

Arshad, M., Khan, M.A., Jadoon, S.A., Mohmand, A.S. (2010).Factor analysis in sunflower (*Helianthus annuus* L.) to investigate desirable hybrids.*Pakistan Journal of Botany, 42*(6), 4393–402.

Bonea, D., Urechean, V., Constantinescu, E., Pandia, O. (2008). The interrelations between the capacity of production and the component elements at the sunflower. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca - Agriculture*, *65*(1), 355.

Bonea, D., Borleanu, C.I., Urechean, V., Constantinescu, E. (2010). Agronomic value of some sunflower hibryds cultivated in Oltenia area. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series*, *XL*(2), 46–51.

Bonea, D., Urechean, V., Constantinescu, E., Iancu, D. (2012). The behaviour of some sunflower (*Helianthus annuus*) hybrids from abroad under water and heat stress at ARDS Simnic. *Scientific Papers. Series A. Agronomy*, *LV*, 129–132.

Bonea, D., Urechean, V., Mîndrilă, G., Iancu, D. (2013). Results on the yield and correlations between characters in some sunflower (*Helianthus annuus* L.) hybrids grown in Oltenia. *Annalls of the University of Craiova - Agriculture, Montanology, Cadastre Series*, *XLIII*(1), 73–77.

Clapco, S., Gisca, I., Cucereavii, A., Duca, M. (2019). Analysis of yield and yield related traits in some sunflower (*Helianthus annuus* L.) hybrids under conditions of the Republic of Moldova. *Scientific Papers. Series A. Agronomy*, *LXII*(1), 248–257.

Darvishzadeh, R., Hatami-Maleki H., Sarrafi, A. (2011). Path analysis of the relationships between yield and some related traits in diallel population of sunflower (*Helianthus annuus* L.) under well-watered and water-stressed conditions. *Australian journal of Crop Science*, *5*(6), 674–680.

FAO. (2018). http://www.fao.org/faostat/en/#data/QC Accessed on February. 06, 2020.

Ghaffari, M., Davaji, A.M.N.R., Ghadimi, F.N. (2019).Oil yield determinant of sunflower in climatically different regions of Iran. *Bulgarian Journal of Agricultural Science*, *25*(1), 67–71.

Gorgieva, B., Ilija, K., Sasa, M., Ruzdik, M., Emilija, K., Biljana, K. (2015). Correlation and path analysis in sunflower (*Helianthus annuus* L.). *Helia*, *38*(63), 201–210.

Hladni, N., Škorić, D., Kraljević-Balalić, M., Sakač, Z., Miklič, V. (2007). Heterosis for eagronomically important traits in sunflower (*Helianthus annuus* L.). *Helia, 30*(47), 191–198.

Jayakumar, J., Sundaram, T., Prabu, D.A., Rajan, A.R.R. (2007). Correlation studies in maize (*Zea may*s L.) evaluated for grain yield and other yield attributes. *International Journal of Agriculture Sciences, 3*(2), 57–60.

Khan, H., Ali, S., Ahmad, I., Khan, I., Hussain, S., Khan B.A., Suhaib, M. (2018). Agronomic and qualitative evaluation of different local sunflower hybrids. *Pakistan Journal of Agricultural Research, 31*(1), 69–78.

Manivannan, N., Karthika, R., Punitha, B., Vindhiyavarman, P., Muralidharan, V. (2007). Association pattern among the yield attributes in varieties and hybrids of sunflower (*Helianthus annuus* L.). *Madras Agricultural Journal*, *94*(1-6), 84–88.

Radu, V., Popa, I., Dodocioiu, A.M., Buzatu, G.D. (2019). The quality status of the reddish preluvosol from ARDS Simnic. *Analele Universităţii din Craiova, seria Biologie, Horticultură, Tehnologia Prelucrării Produselor Agricole, Ingineria Mediului, 24*, 213–217.

Săulescu, N.A., Săulescu, N.N. (1967). *Câmpul de experienţă.* Editura Agro-Silvică, București.

Sincik, M., Goksoy, A.T. (2014). Investigation of correlation between traits and path analysis of confectionary sunflower genotypes. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 42*(1), 227–231.

Sujatha, K., Nadaf, H.L. (2013). Correlation for yield and yield related trait in mutant and segregating genotypes in sunflower (*Helianthus annuus* L.). *Molecular Plant Breeding*, *4*(32), 265–266.

Tahir, M.H.N., Imran, M., Hussain, M.K. (2002). Evaluation of sunflower (*Helianthus annuus* L.) inbred lines for drought tolerance. *International Journal of Agriculture and Biology*, *4*(3), 398–400.

Yagdi, K., Sozen, E. (2009). Heritability, variance components and correlations of yield and quality traits in durum wheat (*Triticum durum* Desf.). *Pakistan Journal of Botany*, *41*(2), 753–759.

Zeinalzadeh-Tabrizi, H., Ghaffari, M., Hosseinpour, A. (2019). Correlation and path analysis of yield and related traits in sunflower (*Helianthus annuus* L.) under normal and drought stress conditions. *Bioscience Research*, *16*(1), 658–666.