UDC 575.630
DOI: 10.2298/GENSR1603983B
Original scientific paper

VARIABILITY OF HEAD DIAMETER IN SUNFLOWER HYBRIDS DEPENDING ON PLANTING DATE

Igor BALALIĆ[1], Jovan CRNOBARAC[2], Siniša JOCIĆ[1], Vladimir MIKLIČ[1], Velimir RADIĆ[1], Nenad DUŠANIĆ[1]

[1]Institute of Field and Vegetable Crops, Novi Sad, Serbia
[2] University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia

Balalić I., J. Crnobarac, S. Jocić, V. Miklič, V. Radić, N. Dušanić (2016): *Variability of head diameter in sunflower hybrids depending on planting date*. - Genetika, Vol 48, No.3, 983 - 990.

Head size contributes substantially to seed yield of sunflower because it influences both number of seeds per head, and seed size. The aim of this field study was to determine the variability of head diameter in sunflower hybrids depending on planting date across three cropping seasons. Three hybrids (Miro, Rimi, Pobednik) were sown at four planting dates (PD1 - 20th of March, PD2 - 10th of April, PD3 - 30th of April, PD4 - 20th of May). Head diameter was analysed in the stage of flowering and physiological maturity. The trial was arranged as Randomized Complete Block Design (RCBD) with four replications. Analysis of variance (ANOVA) showed that the effect of year, hybrid, planting date and most interactions were highly significant for head diameter in the flowering stage. In the stage of physiological maturity head diameter varied significantly depending only on the planting date. Also, all interactions, except year × hybrid (Y × H), were highly significant. Planting date had significant influence on head diameter in the stage of flowering and physiological maturity in sunflower. With later sowing head diameter increased, so that significantly highest head diameter across planting dates was found in PD4 (11.8 cm in flowering stage, and 22.6 cm at the stage of physiological maturity). Study results may be helpful in the recommendation for optimal planting date in sunflower.

Keywords: head diameter, hybrid, planting date, sunflower, variability

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oil crops, widely grown in many parts of the world (HU *et al*., 2010). It is one of the four most important oilseed crops in

Corresponding author: Igor Balalić, Institute of Field and Vegetable Crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia, Phone: +381214898318; Fax: +381216413833; E-mail: igor.balalic@ifvcns.ns.ac.rs

the world which include rape oilseed, soybean and cotton (YADAVA *et al*., 2012; BALALIĆ *et al*., 2012). In Serbia, sunflower is the main oil crop. The sunflower acreage varies from 160 to 210 thousand ha, with the seed yield ranging from 1.7 to 2.3 t ha^{-1} (MIKLIČ *et al*., 2015).

Head diameter is very important trait in the sunflower seed yield structure. The size of the head diameter influences the number of flowers and seeds per head which directly influence the seed yield per plant. Head size should be intermediate, with a diameter of 20-25 cm and with firm epidermis underside. Increase in head size above the optimum value results in reduced seed yield (g/head), increased husk percentage, increased number of empty seeds and reduced oil content in seed (ŠKORIĆ, 2012). Sunflower head has a variable diameter; it is
dependent on the genotype, environmental factors and interaction between these two parameters (BONCIU *et al*., 2010; HLADNI *et al*., 2014).

Numerous researchers have found significant positive correlations between morphological characters such as head diameter and seed yield (HLADNI *et al*., 2003; KAYA *et al*., 2009; HLADNI *et al*., 2010; DARVISHYADEH *et al*., 2011; ŠKORIĆ, 2012; HAMZA and SAFINA, 2015).

Planting date (LAWAL *et al*., 2011, DUTTA, 2011, AHMED *et al*., 2015), and stand density (DUŠANIĆ *et al*., 2004, ALI *et al*., 2011, BAGDADI *et al*., 2014) showed significant influence on head diameter in sunflower.

The objective of this field study was to determine the influence of planting dates on the variability of head diameter in sunflower hybrids, grown during three vegetation periods.

MATERIALS AND METHODS

In order to investigate the influence of planting date on head diameter three medium early maturity sunflower hybrids were used: Miro, Rimi and Pobednik. These hybrids have been developed at the Institute of Field and Vegetable Crops, Novi Sad, Serbia. They were cultivated during three growing seasons (2005, 2006, 2007) and sown at four different planting dates (PD1 - 20th of March, PD2 - 10th of April, PD3 - 30th of April, PD4 - 20th of May), in randomized complete bloch design (RBCD) with four replications at the Institute of Field na Vegatable Crops, Novi Sad, Serbia. Each plot consisted of six rows, 0,7 m apart and 10 m long. Plants were sown at 25 cm intervals within rows. Head diameter (cm) was measured, from one edge of the head to the other, at the stage of flowering and physiological maturity. The sample consisted of 12 plants (3 plants x 4 replications) in both of the stages. Three plants were sampled per plot (12 plants per hybrid × planting date combination).

The analysis of collected data was done statistically by analysis of variance (ANOVA) technique using GenStat12.1 software. Treatment means were compared by LSD test at 5% and 1% level of probability.

RESULTS AND DISCUSSION

Head size, expressed as head diameter (cm), is one of the sunflower yield components that directly influence hybrid model changes (ŠKORIĆ, 2012). Head diameter in the structure of sunflower seed yield is a significant trait, because it influences the number of flowers, and thus the number of grains per head, which are important preconditions for yield of sunflower hybrids.

Head diameter in the stage of flowering

Head diameter at the stage of flowering was largely influenced by the year of investigation (46.6%), although other sources of variation showed also significance, except

interaction H × PD. Of all the interactions Y × PD had the greatest influence on the formation of head diameter in this stage (Table 1).

Table 1. ANOVA of head diameter in the stage of flowering

Source of variation	df	SS (%)	MS	*P*
Rep.	3	1,6	0,5	0,018
Year (Y)	2	46,6	19,5	0,000**
Hybrid (H)	2	9,9	4,1	0,000**
Planting date (PD)	3	12,4	3,5	0,000**
Y × H	4	2,9	0,6	0,002**
Y × PD	6	21,0	2,9	0,000**
H × PD	6	0,5	0,1	0,753
Y × H × PD	12	5,0	0,3	0,004**
Error	105		0,1	

*$P < 0,05$; **$P < 0,01$

Table 2. Mean values for head diameter (cm) in the stage of flowering

Year (Y)	Hybrid (H)	Planting date (PD) PD1	PD2	PD3	PD4	Average (Y × H)	Average (Y)
2005	Miro	10,6	9,7	9,7	11,5	10,4	10,7
	Rimi	10,8	10,4	10,5	11,7	10,9	
	Pobednik	10,7	10,4	10,4	11,7	10,8	
	Average	10,7	10,2	10,2	11,6		
2006	Miro	11,3	12,3	12,3	11,5	12,0	12,1
	Rimi	11,6	11,7	11,7	11,9	11,8	
	Pobednik	11,6	12,4	12,4	12,5	12,4	
	Average	11,5	12,2	12,2	11,9		
2007	Miro	10,9	11,4	12,0	11,6	11,5	11,9
	Rimi	11,3	11,6	12,5	11,5	11,7	
	Pobednik	12,2	12,7	12,5	12,1	12,4	
	Average	11,5	11,9	12,3	11,7	11,9	
Average (3 year)	Miro	10,9	11,2	11,3	11,5	Average (H)	11,3
	Rimi	11,2	11,2	11,6	11,7		11,5
	Pobednik	11,5	11,8	11,8	12,1		11,9
	Average	11,2	11,4	11,6	11,8		

V (%) 6,9

LSD	Y	H	PD	Y × H	Y × PD	H × PD	Y×H×PD
0,05	0,10	0,10	0,17	0,18	0,29	0,29	0,51
0,01	0,14	0,14	0,23	0,24	0,39	0,39	0,68

	2005			2006			2007		
LSD	H	PD	H×PD	H	PD	H×PD	H	PD	H×PD
0,05	0,19	0,32	0,10	0,18	0,29	0,09	0,18	0,29	0,09
0,01	0,26	0,42	0,13	0,24	0,38	0,12	0,24	0,38	0,13

The highest value of head diameter in the flowering stage was in the year 2006, while in 2005 was the lowest value for this parameter. Decreased head diameter in 2005 in relation to 2006 and 2007 was related to weather conditions which were not favorable for sunflower (Table 2).

The largest head diameter is manifested in the hybrid Pobednik (11.9 cm). Hybrid Miro had the lowest average value for head diameter, which amounted to 11.3 cm, on the basis of the three-year experiments (Table 2).

Planting date showed significance in the mean values for head diameter. In PD4 head diameter had the highest value (11.8 cm). Looking at the mean head diameter in particular by different years, it can be noted that there were significant differences in the mean values for both individual hybrids, and for the planting dates (Table 2).

Coefficient of variation was low and amounted to 6.9% for head diameter in the stage of flowering (Table 2).

Head diameter in the stage of physiological maturity

Head diameter in physiological maturity varied significantly depending on the planting date (18.6%). Years, as well as hybrids had no significant influence on this trait. All interactions, except year × hybrid (Y × H), were also highly significant. The highest value showed the second-order interaction Y × H × PD (30.0%), Table 3.

Table 3. ANOVA of head diameter in the stage of physiological maturity

Source of variation	df	SS (%)	MS	*P*
Rep.	3	4,0	2,1	0,003
Year (Y)	2	0,3	0,3	0,548
Hybrid (H)	2	0,9	0,7	0,200
Planting date (PD)	3	18,6	10,0	0,000**
Y × H	4	29,2	11,2	0,093
Y × PD	6	6,3	1,7	0,002**
H × PD	6	10,0	2,7	0,000**
Y × H × PD	12	30,6	1,7	0,000**
Error	105		4,1	

*$P < 0,05$; **$P < 0,01$

As stated by JOKSIMOVIC *et al*. (2003) head diameter showed highly significant values for hybrid, year and their interaction. Head diameter varied depending on the year of production (temperature, amount and distribution of rainfall) and hybrid, but it was mostly influenced by the hybrid. The values ranged from 18.1 cm (2001) to 22.9 cm (1997), averaging 19.6 cm in the period of 11 years, depending on the year of investigation, as reported by SIMIC *et al*. (2008). MARINKOVIC *et al*. (2011) found that head diameter in sunflower hybrids ranged between 20.5 cm (UK-PA 45 x Snrf 583) and 24.5 cm (UK-PA 243 x RHA-B-1). In the study of MASVODZA *et al*. (2015) sixteen cytoplasmic male sterile (CMS) lines and ten male restorer (R) lines were used. They concluded that head diameter ranged between 5.9 cm in CMS 124 x Issanka to 11.1 cm in CMS HA 290. Head diameter for hybrids ranges from 12.0 cm to 29.2 cm, as mentiond by IMRAN *et al*. (2015). The values of head diameter in hybrids varied from 12.7 cm (SMH-2002-8)

to 17.0 cm (SMH-2002-14), but head diameter showed non-significant correlation with yield (KHAN *et al*., 2003). MACHIKOWA and SAETANG (2008) reported significant positive correlations between head diameter and 100-seed weight. From their results, can be also seen that the head diameter and plant height have shown considerable direct positive effects on seed yield.

Values of head diameter are doubled in the stage of physiological maturity in relation to the flowering stage (Table 2 and 4). Between the mean values for hybrids and years, there were no significant differences in the head diameter at the stage of physiological maturity (Tab. 4).

Table 4. Mean values of head diameter (cm) in the stage of physiological maturity

Year (Y)	Hybrid (H)	Planting date (SD) SD1	SD3	SD5	SD7	Average (Y x H)	Average (Y)
2005	Miro	22,5	21,2	21,1	22,8	21,9	21,8
	Rimi	21,8	21,5	21,2	21,1	21,4	
	Pobednik	21,7	20,4	21,5	24,6	22,1	
	Average	22,0	21,0	21,3	22,8		
2006	Miro	22,5	21,2	22,3	24,4	22,6	21,9
	Rimi	23,2	22,6	21,2	22,3	22,3	
	Pobednik	20,2	20,8	21,4	20,9	20,8	
	Average	22,0	21,5	21,7	22,6		
2007	Miro	20,5	22,3	20,3	22,7	21,5	21,9
	Rimi	21,0	21,0	21,9	22,2	21,5	
	Pobednik	22,7	22,8	22,7	22,6	22,7	
	Average	21,4	22,0	21,6	22,5		
Average (3 year)	Miro	21,8	21,6	21,2	23,3	Average (H)	22,0
	Rimi	22,0	21,7	21,4	21,9		21,8
	Pobednik	21,5	21,3	21,9	22,7		21,9
	Average	21,8	21,5	21,5	22,6		

V (%) 4,7

LSD	Y	H	SD	Y × H	Y × SD	H × SD	Y×H×SD
0,05	0,19	0,19	0,31	0,33	0,54	0,54	0,93
0,01	0,25	0,28	0,41	0,44	0,72	0,72	1,25

	2005			2006			2007		
LSD	H	PD	H×PD	H	PD	H×PD	H	PD	H×PD
0,05	0,44	0,72	0,23	0,27	0,45	0,14	0,18	0,29	0,09
0,01	0,59	0,97	0,31	0,37	0,60	0,19	0,24	0,38	0,12

Regarding planting date significantly higher mean value for head diameter can be noted in PD4 compared with earlier planting dates in the three-year average (Table 4). The same conclusion can be made, observing values obtained separately by years, so in each of the year head diameter had highest mean value at later planting date i.e. in PD4 (Table 4). That planting dates have significant influence on head diameter showed also the results of ESECHIE (2008). In

his experiment two sunflower hybrids, Islero and Upsol-veraflor, were sown at three different dates during two vegetation periods. Head diameter, number of seeds per head and percentage of large seeds increased with delay in planting date. DUTTA (2011) reported the results of planting date (November 15, November 30, December 15, December 30 and January 15) on head diameter for the region of India. The statistical analysis revealed that head diameter showed a decreasing trend with delayed date of planting. Planting on November 30 exhibited maximum head diameter (16.8 cm). Plant spacing has also significant influence on head diameter. So ALI *et al*. (2011) concluded that there was a linear increase in head diameter with increase in plant spacing. These results are supported with the findings of AL-THABET (2006) who stated that head diameter was significantly increased as the space between plants increased. Coefficient of variation for head diameter in the stage of physiological maturity was rather low (4.7%), table 4. Higher values for this trait (7.4%; 7.1%) were mentioned by SUEZER (2010) and AHMED *et al*. (2015).

CONCLUSIONS

Based on the research of variability of head diameter in sunflower hybrids, depending on planting date, the following conclusions can be drawn: Analysis of variance (ANOVA) showed that the effect of year, hybird, planting date and most interactions were highly significant for head diameter in the flowering stage. In the stage of physiological maturity head diameter varied significantly depending only on the planting date, while values for hybrid and year were non-significant. Also, all interactions, except year × hybrid (Y × H), were highly significant. Planting date had significant influence on head diameter in the stage of flowering and physiological maturity in sunflower, taking into account the results of the three-year experiments. With later sowing head diameter increased, so that the highest value was achieved in the PD4 (11.8 cm in the flowering stage and 22.6 cm at the stage of physiological maturity). Coefficient of variation for head diameter in the three-year experiments was V=6.9%, in the flowering stage, and V=4.7% in the stage of physiological maturity. Study results may be helpful in recommending optimal sunflower planting date.

ACKNOWLEDGMENTS

The study was supported by the Ministry of Education, Science and Technological Development, Republic of Serbia (Grant No. TR 31025).

Received April 03th, 2016
Accepted September 22th, 2016

REFERENCES

AHMED, B., M. SULTANA, J. ZAMAN, S.K. PAUL, M.M. RAHMAN, M.R. ISLAM, F. MAJUMDAR (2015): Effect of sowing date on the yield of sunflower. Bangladesh Agron. J., *18*(1): 1-5

ALI, A., M. AFZAL, I. RASOOL, S. HUSSAIN, M. AHMAD (2011): Sunflower (*Helianthus annuus* L.) hybrids performance at different plant spacing under agro-ecological conditions of Sargodha, Pakistan. International Conference on Food Engineering and Biotechnology IPCBEE, IACSIT Press, Singapore *9*: 317- 322

AL-THABET, S.S. (2006): Effect of plant spacing and nitrogen levels on growth and yield of sunflower *(Helianthus annuus* L.) J. Agric. Sci., *19*: 1-11

BAGDADI, A., R.A. HALIM, A. NASIRI, I. AHMAD, F. ASLANI (2014): Influence of plant spacing and sowing time on yield of sunflower (*Helianthus annuus* L.). J. Food Agric. Environ., *12*(2): 688-691

BALALIĆ, I., M. ZORIĆ, G. BRANKOVIĆ, S. TERZIĆ, J. CRNOBARAC (2012): Interpretation of hybrid × sowing date interaction for oil content and oil yield in sunflower. Field Crops Res., *127*: 70-77

BONCIU, E., P. IANCU, M. SOARE (2010): Studies regarding the breeding value to some Romanian sunflower hybrids. J. Hortic. Forest. Biotechnol., *14*(3): 85-88

DARVISHZADEH, R., H. HATAMI MALEKI, A. SARRAFI (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. AJCS, *5*(6): 674-680

DUŠANIĆ, N., V. MIKLIČ, J. JOKSIMOVIĆ, J. ATLAGIĆ (2004): Path coefficient analysis of some yield components of sunflower. Proc. 16th International Sunflower Conference, Fargo, North Dakota, USA, II: 531-537

DUTTA, A. (2011): Effects of sowing dates on yield and yield components of hybrid sunflower *(Helianthus annuus* L.) in non-traditional areas of West Bengal. J. Crop& Weed, *7*(2): 226-228

HAMZA, M., S.A. SAFINA (2015): Performance of sunflower cultivated in sandy soils at the wide range of planting dates in Egypt. J. Plant Prod. Mansoura University *6*(6): 821-835

HLADNI, N., D. ŠKORIĆ, M. KRALJEVIĆ-BALALIĆ (2003): Components of phenotypic variability for head diameter in sunflower (*Helianthus annuus* L.). Genetika *35*(2): 67-75

HLADNI, N., S. JOCIC, V. MIKLIC, A. MIJIC, D. SAFTIC-PANKOVIC, D. SKORIC (2010): Effect of morphological and physiological traits on seed yield and oil content in sunflower. Helia, *33*(53): 101-116

HLADNI, N., V. MIKLIČ, S. JOCIĆ, M. KRALJEVIĆ-BALALIĆ, D. ŠKORIĆ (2014): Mode of inheritance and combining ability for plant height and head diameter in sunflower (*Helianthus annuus* L.). Genetika, *46*(1): 159-168

HU, J., G. SEILER, C. KOLE (2010): Genetics, genomics and breeding of sunflower. Routledge, USA, 342 pages.

IMRAN, M , A. SAIF-UL-MALOOK, A. QASRANI, M.A. NAWAZ, M.K. SHABAZ, M. ASIF, Q. ALI (2015): Combining ability analysis for yield related traits in sunflower (*Helianthus annuus* L.). American-Eurasian J. Agric. Environ. Sci., *15*(3): 424-436

JOKSIMOVIC, J., J. ATLAGIC, V. MIKLIC (2003): Phenotypic variability of several biological traits in sunflower inbred lines. Book of papers, Scientific Institute of Field and Vegetable Crops, Novi Sad *38*: 193-201 (in Serbian)

KAYA, Y., G. EVCI, S. DURAK, V. PEKCAN, T. GUCER (2009): Yield components affecting seed yield and their relationships in sunflower (*Helianthus annuus* L.). Pak. J. Bot., *41*(5): 2261-2269

KHAN, A., I. ULLAH, S.B. MURTAZA, M.Y. KHAN (2003): Variability and correlations study in different newly developed sunflower hybrids. Asian J. Plant Sci., *2*(12): 887-890

LAWAL, B.A., G.O. OBIGBESAN, W.B. AKANBI, G.O. KOLAWOLE (2011): Effect of planting time on sunflower (*Helianthus annuus* L.) productivity in Ibadan, Nigeria. Afr. J. Agric. Res., *6*(13): 3049-3054

MACHIKOWA, T., C.H. SAETANG (2008): Correlation and path coefficient analysis on seed yield in sunflower. Suranaree J. Sci. Technol., *15*(3): 243-248

MARINKOVIĆ, R., M. JOCKOVIĆ, S. JOCIĆ, M. ĆIRIĆ (2011): Variability of plant height and head diameter in new hybrid combinations of sunflower. Field Veg. Crop Res., *48*(2): 239-244

MASVODZA, D.R., E. GASURA, N. ZIFODYA, P. SIBANDA, B. CHISIKAURAYI (2015): Genetic diversity analysis of local and foreign sunflower germplasm (*Helianthus annuus*) for the national breeding program: Zimbabwe. J. Cereals&Oilseeds, *6*(1): 1-7

MIKLIČ, V., I. BALALIĆ, S. JOCIĆ, R. MARINKOVIĆ, S. CVEJIĆ, N. HLADNI, D. MILADINOVIĆ (2015): Results of small-plot trials of NS sunflower hybrids in 2014, and recommendations for 2015 sowing season. Proc. 49th Institute of Field and Vegetable Crops Agronomy Seminar, Zlatibor 25.01.-31.01.2015, 86-99 (in Serbian)

SIMIC, B., J. COSIC, I. LIOVIC, M. KRIZMANIC, J. POSTIC (2008): The influence of weather conditions on economic characteristics of sunflower hybrids in macro experiments from 1997 to 2007. Proc. 17th International Sunflower Conference, Córdoba, Spain 261-263

SUEZER, S. (2010): Effects of nitrogen and plant density on dwarf sunflower hybrids. Helia, *33*(53): 207-214

ŠKORIĆ, D. (2012): Sunflower breeding. In: Sunflower Genetics and Breeding. International Monography (eds: Škorić D & Sakač Z), Serbian Acad. Sci. Arts, Branch in Novi Sad 165-354

YADAVA, D.K., S. VASUDEV, N. SINGH, T. MOHAPATRA, K.V. PRABHU (2012): Breeding major oil crops: Present status and future research needs. Book chapter in Gupta SK (ed.), Technological Innovations in Major World Oil Crops, *1*: Breeding 17-51.

VARIJABILNOST PREČNIKA GLAVE HIBRIDA SUNCOKRETA U ZAVISNOSTI OD ROKA SETVE

Igor BALALIĆ[1], Jovan CRNOBARAC[2], Siniša JOCIĆ[1], Vladimir MIKLIČ[1], Velimir RADIĆ[1], Nenad DUŠANIĆ[1]

[1]Institut za ratartsvo i povrtarstvo. Novi Sad, Srbija
[2]Univerzitet u Novom Sadu, Poljoprivredni fakultet, Novi Sad, Srbija

Izvod

Cilj ovog poljskog ogleda bio je da se analizira varijabilnost prečnika glave hibrida suncokreta u zavisnosti od roka setve. Tri hibrida (Miro, Rimi, Pobednik) posejana su u četiri roka setve (PD1 - 20 mart, PD2 - 10 april, PD3 - 30 april, PD4 - 20 maj). Prečnik glave praćen je u fazi cvetanja i fiziološke zrelosti, tokom tri vegetaciona perioda. Ogled je postavljen po slučajnom blok sistemu (RCBD) u četiri ponavljanja. Analiza varijanse (ANOVA) za prečnik glave u fazi cvetanja pokazala je visoku značajnost za godinu, hibrid, rok setve i većinu interakcija. U fazi fiziološke zrelosti visoka značajnost za prečnik glave dobijena je samo za rok setve i sve interakcije, osim za interakciju godina × hibrid (Y × H). Prečnik glave u fazi cvetanja varirao je između 11,3 cm (Miro) i 11,9 cm (Pobednik). Vrednosti prečnika glave su se udvostručile u fazi fiziološke zrelosti u odnosu na fazu cvetanja. Rok setve imao je značajan uticaj na prečnik glave suncokreta u fazi cvetanja i fiziološke zrelosti. Značajno najveća vrednost prečnika glave bila je u PD4 (11,8 cm u fazi cvetanja i 22,6 cm u fazi fiziološke zrelosti). Rezultati ispitivanja mogu biti od značaja pri preporuci za optimalni rok setve hibrida suncokreta.

Primljeno 03. IV. 2016.
Odobreno 22. IX. 2016.