UDC 575.21
Original scientific paper

PHENOTYPIC AND GENOTYPIC VARIABILITY OF DISC FLOWER COROLLA LENGTH AND NECTAR CONTENT IN SUNFLOWER

Jovan JOKSIMOVIĆ, Jovanka ATLAGIĆ, Zvonimir SAKAČ, Vladimir MIKLIČ, and Nenad DUŠANIĆ

Institute of Field and Vegetable Crops, 21000 Novi Sad, Serbia and Montenegro

Joksimović J., J. Atlagić, Z. Sakač, V. Miklič, and N. Dušanić (2003): *Phenotypic and genotypic variability of disc flower corolla length and nectar content in sunflower*. – Genetika, Vol. 35, No. 2, 131-138.

The nectar content and disc flower corolla length are the two most important parameters of attractiveness to pollinators in sunflower. The phenotypic and genotypic variability of these two traits was studied in four commercially important hybrids and their parental components in a trial with three fertilizer doses over two years. The results showed that, looking at individual genotypes, the variability of disc flower corolla length was affected the most by year (85.38-97.46%). As the study years were extremely different, the phenotypic variance of the hybrids and parental components was calculated for each year separately. In such conditions, looking at all of the crossing combinations, the largest contribution to phenotypic variance of the corolla length was that of genotype: 57.27-61.11% (NS-H-45); 64.51-84.84% (Velja); 96.74-97.20% (NS-H-702) and 13.92-73.17% (NS-H-111). A similar situation was observed for the phenotypic variability of nectar content, where genotype also had the largest influence, namely 39.77-48.25% in NS-H-45; 39.06-42.51% in Velja; 31.97-72.36% in NS-H-702; and 62.13-94.96% in NS-H-111.

Key words: sunflower, disc flower corolla length, nectar content, phenotypic and genotypic variability

Corresponding author: Jovan Joksimović, Institute of field and vegetable crops, Maksima Gorkog 30, 21000 Novi Sad, Serbia and Montenegro
Tel: 381 021 4898 401
e-mail: atlagic@ifvcns.ns.ac.yu

INTRODUCTION

Sunflower seed yields depend to a large extent on the presence of pollinators. Since the sunflower is a melliferous plant, the ability of sunflower lines and hybrids to attract insects is a highly important character. This attractiveness is connected with the following characteristics of the inflorescence: color, size and number of ray flowers; disc flower length, disc flower corolla length, and color of the stigma.

MONTILLA *et al*. (1988) has shown that flower morphology is a very important factor in attracting bees and, hence, in hybrid seed production itself. BAILEZ and BEDASCARRASBURE (1988) have found different levels of attractiveness in CMS lines (different genotypes). The authors reported a negative correlation between bee visits and disc flower corolla length. In a study of attractiveness of different sunflower genotypes (hybrids and their parental components), MIKLIČ (1994) found significant differences among the genotypes as well as large influence of climatic factors on bee visits.

In recent years, attractiveness characters have been studied from the point of view of genotype, fertilizer application and microclimate effects in Novi Sad lines and hybrids of sunflower (MIKLIČ *et al*., 2002; MIKLIČ *et al*., 2003). The objective of the present paper was to investigate phenotypic and genotypic variability for the major attractiveness traits, disc flower corolla length and nectar content, in four commercially important sunflower hybrids and their parental components.

MATERIALS AND METHODS

The study materials consisted of four widely used commercial sunflower hybrids (NS-H-45, NS-H-111, NS-H-702 and VELJA) and their parental components (four male-fertile inbreds and three restorers) and were grown in a stationary trial established at Rimski Šančevi in 1966, which studies the effects of different fertilization treatments on maize, wheat, sunflower and sugar beet. Over a two-year period during 2000, 2001 and 2002, the sunflower hybrids and their parental lines were analyzed under three different fertilization treatments for disc flower corolla length (30 flowers per plant, three plants per treatment) and nectar content (20 flowers per plant, 3-5 plants per treatment). The former trait was measured using millimeter paper and the latter by the microcapillary technique. The measurements were carried out at flowering, the results were statistically processed using the MSTAT program, and analysis of variance, LSD and Duncan's test were performed. The values of components of variance were calculated according to SVAB (1973).

RESULTS AND DISCUSSIONS

Looking at all treatments and both study years, the mean values of disc flower corolla length in the genotypes ranged between 7.4 mm (Ha-26B) and 10.12 mm (CMS-3-8B). Significant differences were observed among the genotypes with

respect to the means of this trait; based on Duncan's test, they were divided into 10 different groups, with one to three genotypes per group at 0.05 significance level.

The nectar content means for all the genotypes and treatments and both years ranged from 2.37 mg/20 flowers (RHA-R-PL-2/1) to 14.4 mg/20 flowers (Ha-98B). Most of the genotypes differed significantly with regard to this trait and were classified into seven groups, with one to three genotypes per group at 0.05 significance level.

Table 1. Components of phenotypic and genotypic variance for disc flower corolla length in NS-H-45 and its parental components

Source of variation	Degrees of freedom	Mean square		F-test		Components of variance			
						Year 1		Year 2	
		Year 1	Year 2	Year 1	Year 2	σ^2	%	σ^2	%
Replicate	2	0.009	0.022	0.615	0.417				
Genotype (G)	2	1.105	1.369	75.556**	25.361**	0.1194	61.11	0.1315	57.27
Fertilizer rate (FR)	2	0.536	0.099	36.684**	1.843	0.0563	28.79	0	0.00
G/FR interaction	4	0.030	0.186	2.051	3.449*	0.0051	2.62	0.0441	19.20
Error (E)	16	0.015	0.054			0.0146	7.48	0.0540	23.52
Total (T)	26					0.1955	100.00	0.2296	100.00

Looking at the genotypes individually, the variability of disc flower corolla length was affected the most by year (85.38 and 97.46%). Because the two study years were drastically different, phenotypic and genotypic variances of the hybrids and lines were calculated for each year separately.

Components of variance for disc flower corolla length - In the hybrid NS-H-45, the greatest effect on this trait in both years was that of genotype (57.27 and 61.11%). Fertilizer rate effects in the first year and genotype x fertilizer rate interaction in the second were also highly significant (Table 1).

Table 2. Components of phenotypic and genotypic variance for disc flower corolla length in NS-H-111 and its parental components

Source of variation	Degrees of freedom	Mean square		F-test		Components of variance			
						Year 1		Year 2	
		Year 1	Year 2	Year 1	Year 2	σ^2	%	σ^2	%
Replicate	2	0.020	0.080	0.445	1.5631				
Genotype (G)	2	0.476	1.537	10.345**	29.854**	0.0216	13.92	0.1637	73.17
Fertilizer rate (FR)	2	0.102	0.102	2.225	1.981	0	0.00	0.0042	1.86
G/FR interaction	4	0.291	0.064	6.312**	1.252	0.0816	55.01	0.0043	1.94
Error (E)	16	0.041	0.051			0.0461	31.07	0.0515	23.03
Total (T)	26					0.1483	100.00	0.2237	100.00

In NS-H-111, genotype made the largest contribution to phenotypic variability of disc flower corolla length in the second year of study (73.17%), while in the first the largest contribution was that of genotype x fertilizer rate interaction (55.01%) (Table 2).

In NS-H-702 and VELJA, the components of variance indicated highly significant genotype effects on this trait in both study years (96.74 and 97.20%; 64.51 and 84.84%) (Table 3 and 4). In the latter hybrid, fertilizer rate in the first year and genotype x fertilizer rate interaction in the second had significant influence as well.

Table 3. Components of phenotypic and genotypic variance for disc flower corolla length in NS-H-702 and its parental components

Source of variation	Degrees of freedom	Mean square		F-test		Components of variance			
						Year 1		Year 2	
		Year 1	Year 2	Year 1	Year 2	σ^2	%	σ^2	%
Replicate	2	0.047	0.062	2.403	0.825				
Genotype (G)	2	8.192	23.524	18.790**	312.860**	0.9054	96.74	2.6099	97.20
Fertilizer rate (FR)	2	0.070	0.007	3.578	0.093	0.0029	0.31	0	0
G/FR interaction	4	0.044	0.035	2.236	0.462	0.0081	0.86	0	0
Error (E)	16	0.020	0.075			0.0196	2.09	0.0752	2.80
Total (T)	26					0.9360	100.00	2.6850	100.00

Table 4. Components of phenotypic and genotypic variance for disc flower corolla length in VELJA and its parental components

Source of variation	Degrees of freedom	Mean square		F-test		Components of variance			
						Year 1		Year 2	
		Year 1	Year 2	Year 1	Year 2	σ^2	%	σ^2	%
Replicate	2	0.007	0.038	0.412	0.815				
Genotype (G)	2	1.476	1.500	81.182**	32.182**	0.1614	84.84	0.1496	64.51
Fertilizer rate (FR)	2	0.103	0.058	5.691*	1.244	0.0089	4.67	0	0
G/FR interaction	4	0.023	0.154	1.292	3.298*	0.0018	0.93	0.0357	15.39
Error (E)	16	0.018	0.047			0.0182	9.56	0.0466	20.10
Total (T)	26					0.1903	100.00	0.2320	100.00

Components of variance for nectar content - In all four hybrids, genotype effects had in most cases the strongest influence on the expression of nectar content in both years.

In NS-H-45, genotype contribution to total variance of nectar content was 39.77 and 48.25%. Genotype x fertilizer rate interaction also had a highly significant effect on this trait in the second year of study (47.84%) (Table 5).

The largest genotype contribution to total phenotypic variance of nectar content was recorded in NS-H-111 in both study years (62.13 and 94.96%)(Table 6).

Table 5. Components of phenotypic and genotypic variance for nectar content in NS-H-45 and its parental components

Source of variation	Degrees of freedom		Mean square		F-test		Components of variance			
							Year 1		Year 2	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	σ^2	%	Σ^2	%
Replicate	2	4	45.994	0.362	4.662	0.544				
Genotype (G)	2	2	64.988	164.900	6.588**	5.152*	6.6928	39.77	8.2270	48.25
Fertilizer rate (FR)	2	2	7.191	34.150	0.729	51.27**	0.2710	1.61	0	0
G/FR interaction	4	4	4.752	41.460	0.482	62.24**	0	0.00	8.1590	47.84
Error (E)	16	32	9.865	0.666			9.8646	58.62	0.6660	3.91
Total (T)	26	44					16.8280	100.00	17.0500	100.00

Table 6. Components of phenotypic and genotypic variance for nectar content in NS-H-111 and its parental components

Source of variation	Degrees of freedom		Mean square		F-test		Components of variance			
							Year 1		Year 2	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	σ^2	%	σ^2	%
Replicate	2	4	1.524	2.564	0.414	1.588				
Genotype (G)	2	2	69.668	560.300	18.905**	347.000**	7.3039	62.13	37.2410	94.96
Fertilizer rate (FR)	2	2	10.094	6.845	2.739	4.239*	0.6845	5.82	0.3426	0.87
G/FR interaction	4	4	3.933	1.706	1.067	1.057	0.0825	0.70	0.0183	0.05
Error (E)	16	32	3.685	1.615			3.6853	31.35	1.6148	4.12
Total (T)	26	44					11.7560	100.00	39.2170	100.00

The calculated values of nectar content variance components indicated the largest genotype contribution in NS-H-702 (31.97 and 72.36%) (Table 7) as well as VELJA (39.06 and 42.51%) (Table 8). In the former hybrid, genotype x fertilizer rate interaction was also highly significant (46.61%) (Table 7). The same was true of VELJA (21.26%), but only in the second year (Table 8).

According to the results on phenotypic and genotypic variability of disc flower corolla length and nectar content, the expression of the two attractiveness parameters was affected the most by genotype in both years and in all of the geno-

types. These two traits, therefore, can be said to be genetically stable, which will come useful in future breeding programs.

Table 7. Components of phenotypic and genotypic variance for nectar content in NS-H-702 and its parental components

Source of variation	Degrees of freedom		Mean square		F-test		Components of variance			
							Year 1		Year 2	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	σ^2	%	σ^2	%
Replicate	2	4	0.684	2.501	0.401	3.018				
Genotype (G)	2	2	48.388	28.400	28.319**	0.887	5.1059	72.36	1.2370	31.97
Fertilizer rate (FR)	2	2	1.312	2.018	0.768	2.435	0	0.00	0	0.00
G/FR interaction	4	4	2.435	9.844	1.425	11.880**	0.2420	3.43	1.8030	46.61
Error (E)	16	32	1.709	0.829			1.7087	24.21	0.8290	21.42
Total (T)	26	44					7.0566	100.00	3.8690	100.00

Similar results on genotype effects on disc flower corolla length have been obtained by BAILEZ and BEDASCARRASBURE (1988), MIKLIČ (1994), and JOKSIMOVIĆ *et al*. (1996), but all these authors also report significant effects of environmental factors on attractiveness parameters in sunflower.

Table 8. Components of phenotypic and genotypic variance for nectar content in VELJA and its parental components

Source of variation	Degrees of freedom		Mean square		F-test		Components of variance			
							Year 1		Year 2	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	σ^2	%	σ^2	%
Replicate	2	4	4.736	1.560	3.487	0.957				
Genotype (G)	2	2	10.338	35.000	7.613**	1.097	1.0289	39.06	1.9120	42.51
Fertilizer rate (FR)	2	2	3.305	3.548	2.434	2.177	0.2474	9.39	0	0
G/FR interaction	4	4	1.078	6.412	0.794	3.934*	0	0.00	0.9560	21.26
Error (E)	16	32	1.358	1.630			1.3580	51.55	1.6300	36.23
Total (T)	26	44					2.6343	100.00	4.4980	100.00

ATLAGIĆ *et al*. (1996) studied a group of sunflower inbreds (sterile, fertile analogues and restorer lines) and found them to be different in terms of variability of disc flower length and disc flower corolla length. Studying the same materials, JOKSIMOVIĆ *et al*. (1996) demonstrated the largest effect of genotype on disc flower length and disc flower corolla length.

In the present paper, besides the greatest influence of genotype on the attractiveness parameters studied, a significant effect of genotype x fertilizer rate

interaction and a slight effect of fertilizer rate alone were also recorded, although only in individual study years. In their study of nectar production of different sunflower hybrids at different locations in Hungary from the point of view of bee visits, BUJÁKI and HORVÁTH (2000) found significant differences among the hybrids but also reported stability of the character concerned and considerable influence of environmental conditions and mineral fertilizers on the traits studied.

CONCLUSION

Our results on phenotypic and genotypic variability of disc flower corolla length andnectar content showed that genotype had the largest effect on the expression of these traits in both study years. Based on these findings, we can conclude that these traits are genetically stable, which will facilitate our work in further sunflower breeding programs.

Received October 1st, 2003
Accepted December 29th, 2003

REFERENCES

ATLAGIĆ J., J. JOKSIMOVIĆ i V. MIKLIČ (1996): Osobine cvasti inbred linija suncokreta. Zbornik radova instituta za ratarstvo i povrtarstvo, *25*, 5-12.

BAILEZ O. and E. BEDASCARRASBURE (1988): Evaluacion de la preferencia de les abejes por lincas androesteriles de girasol. Proc. of the 12th Int. Sunfl. Conf., 25-29 juli 1988, 429-436.

BUJÁKI G. and Z. HORVÁTH (2000): The nectar production of sunflower hybrids and the frequency of bee visits at two locations in Hungary. Proc. of the 15th Inter. Sunflower Conf. 12-15. july 2000, Touluse, France, H7-H11.

JOKSIMOVIĆ J., J. ATLAGIĆ i V. MIKLIČ (1996): Fenotipska i genotipska varijabilnost inbred linija suncokreta za dužinu cevastog cveta i dužinu krunice cevastog cveta. Zbornik radova, 37. Savetovanje Proizvodnja i prerada uljarica, 27-31.05.1996., Budva, 458-467.

MIKLIČ V. (1994): Attractiveness of sunflower as melliferous plant. Jugoslovenski naučni skup za pčelarstvo sa medjunarodnim učešćem. 1-3 juli 1994, Sremski Karlovci.

MIKLIČ V., N. DUŠANIĆ, J. ATLAGIĆ, Z. SAKAČ, J. JOKSIMOVIĆ, J. CRNOBARAC, D. MIHAILOVIĆ i D. VASIĆ (2002): Uticaj genotipa, djubrenja i mikroklimata na posetu polinatora i prinos suncokreta. Zbornik radova Instituta za ratarstvo i povrtarstvo, Novi Sad, *36*,179-188.

MIKLIČ V., J. ATLAGIĆ, Z. SAKAČ, N. DUŠANIĆ, J. JOKSIMOVIĆ i D. MIHAILOVIĆ, (2003): Uticaj genotipa i uslova gajenja na neke parametre atraktivnosti suncokreta prema pčelama. Zbornik radova Instituta za ratarstvo i povrtarstvo, Novi Sad, *38*, 181-193.

MONTILLA F., J. GOMEZ-ARNAU, and P. DUHING (1988): Bee-attractiveness and self-compatibility of some inbred lines and their hybrids. Proc. of the 12th Inter. Sunflower Conf. Vol I, July 1988, Novi Sad, Yugoslavia, 423-428.

SVAB J. (1973): Biometrial Modszereh a nu atasban Mezogazdasagi Kiado, Budapest.

FENOTIPSKA I GENOTIPSKA VARIJABILNOST DUŽINE KRUNICE CEVASTOG CVETA I SADRŽAJA NEKTARA KOD SUNCOKRETA

Jovan JOKSIMOVIĆ, Jovanka ATLAGIĆ, Zvonimir SAKAČ, Vladimir MIKLIČ i Nenad DUŠANIĆ

Naučni institut za ratarstvo i povrtarstvo, 21000 Novi Sad, Srbija i Crna Gora

I z v o d

Najznačajniji parametri atraktivnosti za oprašivače kod suncokreta su sadržaj nektara i dužina krunice cevastog cveta. Fenotipska i genotipska varijabilnost ovih svojstava je izučavana kod 4 komercijalno važna hibrida i njihove roditeljske komponente u ogledu sa 3 doze djubrenja, u dve godine. Rezultati istraživanja pokazuju da je na varijabilnost dužine krunice cevastog cveta bio najznačajniji uticaj godine (85.38-97.46%), ako se ona posmatra za pojedinačne genotipove. Pošto su godine istraživanja bile ekstremno različite fenotipska varijansa je izračunata za hibride i roditeljske komponente za svaku godinu posebno. U takvim okolnostima za sve kombinacije ukrštanja najveći udeo u fenotipskoj varijansi za dužinu krunice cevastog cveta je imao genotip: 57.27-61.11% (NS-H-45); 64.51-84.84% (Velja); 96.74-97.20% (NS-H-702) i 13.92-73.17% (NS-H-111). Slično je bilo i sa fenotipskom varijabilnošću za sadržaj nektara, jer je takodje bio najznačajniji uticaj genotipa i to: 39.77-48.25% kod NS-H-45; 39.06-42.51% kod Velja; 31.97-72.36% kod NS-H-702 i 62.13-94.96% kod NS-H-111.

Primljeno 1. X 2003.
Odobreno 29. XII 2003.