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MODE OF INHERITANCE AND HERITABILITY OF DISC FLOWER COROLLA LENGTH AND NECTAR CONTENT IN SUNFLOWER

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Since disc flower corolla length and nectar content are the two most important parameters of attractiveness to pollinators in sunflower and we monitored them in the parental lines F_1 hybrids, we thought it would be interesting to determine the mode of inheritance and heritability of these two traits. The mean values of disc flower corolla length ranged between 7.23-10.22 mm. Differences among most of the genotypes were significant. Year had significant influence on the expression of this trait. In the inheritance of the corolla length, partial dominance of the parent with the smaller corolla length (NS-H-702) was observed when determining mode of inheritance relative to the parents. Relative to the parental average, however, it was not possible to determine the mode of inheritance in any of the hybrid combinations. The nectar content means ranged from 2.08 to 15.54 mg/20 flowers and differences among most of the genotypes were significant. Partial dominance of the parent with the smaller nectar content mean was recorded in the inheritance of this trait (NS-H-702). Negative heterosis was found in the hybrid NS-H-45.

Key words: sunflower, disc flower corolla length, nectar content, inheritance

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INTRODUCTION

The two most important components of sunflower attractiveness to pollinators are disc flower corolla length and nectar content. The sunflower is an open pollinated plant species whose flowers require the presence of pollinators in order for fertilization to take place. The need for pollinator presence has become particularly prominent with the introduction of sunflower hybrids instead of cultivars into commercial production. The most important insect pollinator is the domestic bee. That is why the sunflower is a major melliferous plant. Attractiveness parameters were studied in this paper from the point of view of both fertilization success rate and high seed and honey yields.

PALMER and STEER (1985) have shown that flower development and characteristics depend primarily on genotype, but also that they depend on environmental factors as well. SAMMATARO *et al*. (1983) have pointed out that genotypes with disc flower size between 8 and 10 mm are much more attractive to bees than those whose disc flowers are over 10 mm in size. In 1984, those same authors found that the nectary volume and nectar sugar content of different sunflower inbreds and hybrids affected how often they were visited by bees. FURGALA *et al*. (1976) determined that F_1 hybrids produced by crosses between CMS lines and restorers had a higher level of nectar production than their parents. Because of the importance of sunflower attractiveness traits and study of their variability in the parental lines and F_1 hybrids, the objective of this paper was to determine the mode of inheritance and heritability of disc flower corolla length and nectar content in four commercially important NS 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 mode of inheritance was determined according to BOROJEVIĆ (1965), while differences between parental and progeny means were determined by the t-test. Broad sense heritability (h^2) of the traits was calculated according to BOROJEVIĆ (1992).

RESULTS AND DISCUSSIONS

The mean values of disc flower corolla length ranged between 7.23 mm (Ha-26B) and 10.22 mm (CMS-3-8B). Significant differences in means of this trait were found among most of the genotypes and very few of the fertilization treatments.

Table 1. Mean values and variability indicators for disc flower corolla length and nectar content in sunflower

Genotype	Fertilizer rate	Disc flower corolla length (mm)				Nectar content (mg/20 flowers)			
			sx	S	CV	X	sx	S	CV
Ha-74B	1	8.75	0.25	0.61	6.95	9.28	1.31	3.70	39.88
	8	8.73	0.52	1.27	14.51	14.58	1.21	3.42	23.44
	13	8.87	0.50	1.22	13.80	8.99	1.26	3.58	39.80
NS-H-45	1	8.47	0.28	0.70	8.21	4.34	0.65	1.83	42.13
	8	8.35	0.39	0.96	11.52	4.11	0.24	0.67	16.20
	13	8.20	0.36	0.88	10.72	6.49	0.47	1.32	20.42
RHA-583	1	8.22	0.38	0.94	11.40	6.43	0.68	1.92	29.81
	8	8.02	0.42	1.03	12.84	6.26	0.47	1.34	21.32
	13	8.00	0.45	1.10	13.76	7.58	0.65	1.85	24.45
Ha-98B	1	8.40	0.55	1.36	16.13	14.26	0.85	2.42	16.95
	8	8.70	0.46	1.14	13.09	14.16	0.79	2.24	15.81
	13	8.91	0.43	1.07	11.95	15.51	0.80	2.27	14.62
NS-H-111	1	8.38	0.49	1.20	14.27	5.26	0.77	2.18	41.38
	8	8.71	0.45	1.09	12.55	5.44	0.78	2.20	40.52
	13	8.65	0.56	1.38	15.98	7.08	1.22	3.46	48.90
RHA-583	1	8.22	0.38	0.94	11.40	6.43	0.68	1.92	29.81
	8	8.02	0.42	1.03	12.84	6.26	0.47	1.34	21.32
	13	8.00	0.45	1.10	13.76	7.58	0.65	1.85	24.45
CMS-3-8B	1	10.03	0.51	1.25	12.43	4.75	0.57	1.60	33.81
	8	10.12	0.60	1.47	14.52	5.55	0.56	1.58	28.54
	13	10.22	0.47	1.14	11.17	5.81	0.62	1.77	30.37
NS-H-702	1	8.79	0.38	0.94	10.72	6.55	0.45	1.26	19.26
	8	8.78	0.36	0.89	10.13	4.13	0.36	1.02	24.71
	13	8.87	0.38	0.92	10.43	5.00	0.76	2.15	42.96
RHA-R-PL-2/1	1	7.60	0.21	0.52	6.90	2.50	0.41	1.17	46.79
	8	7.51	0.22	0.55	7.33	3.36	0.69	1.95	57.91
	13	7.54	0.22	0.54	7.22	2.30	0.34	0.95	41.51
Ha-26B	1	7.23	0.19	0.46	6.42	6.03	0.76	2.15	35.63
	8	7.47	0.28	0.68	9.13	5.45	0.49	1.38	25.25
	13	7.50	0.25	0.61	8.07	4.24	0.54	1.53	36.03
VELJA	1	7.94	0.40	0.98	12.33	3.01	0.30	0.86	28.47
	8	7.85	0.29	0.70	8.90	2.70	0.67	1.89	70.05
	13	7.92	0.35	0.86	10.81	3.25	0.35	1.00	30.73
RHA-113N	1	7.95	0.23	0.57	7.14	2.08	0.26	0.73	35.11
	8	8.29	0.22	0.53	6.42	3.25	0.38	1.06	32.69
	13	8.18	0.21	0.51	6.23	3.26	0.41	1.17	35.86
LSD	0.05	0.231				1.944			
	0.01	0.306				2.568			

Rates: 1-$N_0P_0K_0$; 8-$N_{50}P_{50}K_{50}$; 13-$N_{100}P_{100}K_{100}$;

As variability indicators, the standard deviation (S) and coefficient of variation (CV) suggested that variability existed for all of the traits within the genotypes. The CV ranged between 6.23% (RHA-113N) and 16.13% (Ha-98B).

The lowest mean of nectar content was found in RHA-113N (2.08mg/20 flowers) and the highest in Ha-98B (15.51mg/20 flowers).

The CV of this trait was the smallest in Ha-98B (14.62%) and the largest in the hybrid VELJA (70.05%) (Table 1).

The LSD and Duncan's test showed that there were significant differences among the genotypes in disc flower corolla length (10 groups with one to three genotypes each at 0.05 significance level) as well as nectar content (seven groups with one to three genotypes each at 0.05 significance level) (Table 2).

Table 2. Significance of differences among the genotypes for disc flower corolla length and nectar content

Genotype	Disc flower corolla length (mm)			Nectar content (mg/20 flowers)		
	X	Significance		X	Significance	
		0.050	0.010		0.050	0.010
Ha-74B	8.79	BC	B	10.71	B	B
NS-H-45	8.34	E	D	5.13 h-	DE	D
RHA-583	8.08	F	EF	7.05	C	C
Ha-98B	8.67	CD	BC	14.41	A	A
NS-H-111	8.58	D	C	6.61 d	CD	C
RHA-583	8.08	F	EF	7.05	C	C
CMS-3-8B	10.12	A	A	5.19	DE	D
NS-H-702	8.81 pd	B	B	5.31 pd	DE	D
RHA-R-PL-2/1	7.55	H	G	2.37	F	E
Ha-26B	7.40	I	G	4.94	E	D
VELJA	7.90	G	F	2.97 d	F	E
RHA-113N	8.14	F	E	2.97	F	E
LSD 0.05	0.134			1.122		
LSD 0.01	0.176			1.483		

Analysis of variance suggested that sources of variation had highly significant effects on disc flower corolla length in the following order: year, genotype, genotype x year interaction. The effects of fertilizer rate, genotype x fertilizer rate x year interaction and genotype x fertilizer rate interaction were significant as well (Table 3).

Nectar content was highly significantly influenced by genotype, replicate, genotype x year interaction and genotype x fertilizer rate interaction and significantly influenced by genotype x fertilizer rate x year interaction (Table 3).

In the inheritance of disc flower corolla length, partial domination of the parent with shorter disc flowers (NS-H-702) was found in the case of inheritance in relation to the parents. With the other hybrid combinations, however, it was not possible to determine the mode of inheritance, because differences between the means of the F_1 hybrids and parents or parental averages were not significant for this trait (disc flower corolla length) (Table 2).

In the inheritance of nectar content, we found domination of the parent with the lower mean value of this trait (NS-H-111 and VELJA), partial domination of such parent (NS-H-702), and negative heterosis (NS-H-45) (Table 2).

Table 3. Analysis of variance for disc flower corolla length and nectar content

Source of variation	Degrees of freedom	Disc flower corolla length (mm)			Nectar content (mg/20 flowers)		
		S^2	F-test		S^2	F-test	
Replicate	2	0.006	0.150		21.858	7.547	**
Genotype (A)	10	9.948	245.548	**	231.390	79.897	**
Fertilizer rate (B)	2	0.171	4.231	*	8.190	2.828	
A x B	20	0.106	2.613	*	8.458	2.921	**
Year (C)	1	131.582	3247.772	**	7.015	2.422	
A x C	10	1.093	26.990	**	19.912	6.875	**
B x C	2	0.092	2.268		8.387	2.896	
A x B x C	20	0.130	3.198	*	4.796	1.656	*
Error (E)	130	0.041			2.896		
Total (T)	197						
		h^2 = 94.27%			h^2 = 94.44%		

High values of broad sense heritability for disc flower corolla length and nectar content were calculated (h^2=94.27% and h^2=94.44%, respectively), indicating significant differences among the genotypes for the traits in question.

Many authors have studied the variability of disc flower corolla length and nectar content and the effects of various factors on these two traits, but their inheritance has been seldom determined. The results we obtained in this paper are therefore very significant. The fact that we found mostly partial domination or domination suggests the direction future breeding efforts should take, namely the development of inbred lines with favorable mean values of the two traits.

FURGALA *et al*. (1976) studied 70 lines and cultivars and found significant variability between nectar quantity and quality. The authors established that non-oily genotypes of the cultivated sunflower, lines with nuclear and cytoplasmic male sterilility, and restorer lines generally had less nectar secretion than oily cultivars of Russian origin. They also determined that F_1 hybrids from crosses between CMS and restorer lines produced more nectar than their parents, indicating dominant and complementary gene effects, which may prove significant in controlling this trait. VEAR *et al*. (1990) have concluded that nectar volume per flower is a highly heritable trait, as confirmed by the heritability findings obtained in the present paper.

CONCLUSION

Our results have shown that many of the lines and hybrids involved in the study carry desirable genes for disc flower corolla length and nectar content. Thevariability of thesetwo traits was most significantly affected by genotype, followed by year, genotype x year interactions and genotype x year x fertilizer rate

interactions. Partial dominance of the parent with the smaller value of disc flower corolla length manifested itself in the inheritance of this trait, while in the inheritance of nectar content we recorded either dominance or partial dominance of the parent with the smaller mean value or, in the case of one hybrid combination, negative heterosis. The heritibility of both traits was extremely high.

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NAČIN NASLEDJIVANJA I HERITABILNOST DUŽINE KRUNICE CEVASTOG CVETA I SADRŽAJA NEKTARA KOD SUNCOKRETA

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Izvod

Pošto su dužina krunice cevastog cveta i sadržaj nektara najvažniji parametri atraktivnosti genotipova suncokreta za oprašivače i praćeni su kod roditeljskih linija i F_1 hibrida bilo je interesantno utvrditi način nasledjivanja i heritabilnost za ova dva svojstva. Srednje vrednosti za dužinu krunice cevastog cveta su se kretale od 7.23-10.22mm. Razlike su bile značajne izmedju većine ispitivanih genotipova. Na ekspresiju dužine krunice cevastog cveta su značajno uticale godine. U nasledjivanju ovoga svojstva ispoljila se parcijalna dominacija roditelja sa manjom dužinom krunice cevastog cveta (NS-H-702) i to u slučaju utvrdjivanja načina nasledjivanja u odnosu na roditelje, dok u odnosu na roditeljski prosek nije bilo moguće utvrditi način nasledjivanja ni u jednoj hibridnoj kombinaciji. Srednje vrednosti za sadržaj nektara su se kretale od 2.08-15.54mg/20 cvetova i razlike su bile značajne kod većine ispitivanih genotipova. U nasledjivanju sadržaja nektara se ispoljila parcijalna dominacija roditelja sa manjom srednjom vrednošću za ovo svojstvo (NS-H-702), dok se kod hibrida NS-H-45 ispoljio negativni heterozis.

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