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BEE-ATTRACTIVENESS AND SELF-COMPATIBILITY OF SOME INBRED LINES AND THEIR HYBRIDS

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SUMMARY

Length of the styles, stigma shape and melliferous factors affecting bee-attractiveness were investigated in several cms-lines and their hybrids. Record of the visits of pollinators and production of hybrids seed for each cms-line were studied in relations to the factors of attractiveness. This results show that the floral morphology can play an important role in the attractiveness to the bees and on the final hybrid seed production.

INTRODUCTION

Sunflower, like other insect-pollinated species, exibits a number of morphophysiological factors associated with its attractiveness to insects, primarily honey bees.

The number of bees visiting the flowers has a major influence on both commercial sunflower production (McGregor, 1976) and hybrid seed production (Drane et al., 1982). In hybrid seed production, the provision of beehives is a compulsory technique for achieving a good transport of pollen from the restorerline to the male-sterile parent line and thus obtaining high seed yields.

The volume of nectar secreted, its sugar concentration and its saccharide composition have been factors most often studied in relation to the foraging behaviour of the pollinators (Pham- Delégue et al., 1985) . However, other traits such as the length and diameter of the corolla (Cirnu et.al., 1974; Shein et al., 1980) have also been related to the accessibility for bee visitation.

On the other hand, the development of insect-attractive patterns of flowering for enhancing cross-pollination, could result in a parallel loss of self-compatibility, according to Vranceanu et al.,(1985).

In the present work we considered length of styles and stigma shape as bee-attractiveness factors to take into account, together with other previously reported factors (corolla length, nectar volume and sugar concentration). We used several cytoplasmic male-sterile lines for assessing the relationship between bee-attractiveness factors, the visit of bees and the production of hybrid seed. The bee-attractiveness factors were also studied in some hybrids made on the cms-lines.

The same material was used for measuring self-compatibility in the parental lines and its correspondance with their hybrids, trying to determine if factors leading to improved cross-pollination are negatively correlated with self-compatibility.

MATERIAL AND METHODS

The experiments were conducted in the CONDOR Research Station of Torre de la Reina, Sevilla, Spain (37º 42' N).

The experiments consisted of crossing blocks of three cms-lines and one restorer-line under cage isolation and their hybrids in adjacent uncaged rows in three and two planting dates respectively (Table 1).

TABLE 1.- CMS-Line and hybrids planted in each cage and uncaged adyacent rows.

1st Planting date April 12, 1987	2nd planting date May 24, 1987	3rd planting date September 2, 1987
cage 1	cage 3	cage 5
CMS L-9	CMS L-9	CMS L-9
CMS L-7	CMS L-7	CMS L-7
CMS L-5	CMS L-5	CMS L-5
cage 2	cage 4	uncaged rows
CMS L-9	CMS L-9	CMS L-9 X R1
CMS L-7	CMS L-7	CMS L-9 X R2
CMS L-5	CMS L-5	CMS L-7 X R1
		CMS L-5 X R2
	uncaged rows	
	CMS L-9 X R1	
	CMS L-9 X R2	
	CMS L-7 X R1	
	CMS L-5 X R2	

Each crossing block had two rows of each cms or restorer line, with the r-line placed in the middle rows of the cage. The final population after thinning was 74,428 plants/hectare. One hive, with a similar number of bees, was placed in each crossing block, all hives coming from the same source.

Nectar was harvested with a 10 microliter micropipet, from 9 to 11 a.m., on alternate days of sampling during the period of flowering. It was collected on 10 pistillate receptive florets per head per sample on 10 previously bagged heads per entry.

Sugar percentage of the nectar was measured with a temperature compensated pocket refractometer. The product of the volume of nectar by its percent sugar was the melliferous index described by Vranceanu et al..(1985).

The length of the corolla and style, and the shape of the stigma were recorded on 20 pistillate receptive florets per head in different rings of the head from outside to inside on 20 heads per entry at mid-blooming.

The number of visiting bees was counted daily at 10 a.m. during flowering on 20 consecutive plants per cms-line and per crossing-block. The same 20 plants were used for measuring seed set, counting the number of filled seeds per plant and their weight.

The ratio between the number of filled seeds from the bagged plants and the number of filled seeds from an equal number of unbagged plants was computed as a measure of self-compatibility.

RESULTS

I .-Genotypic variability for attractiveness factors.

I.1 Nectar

CMS-lines showed significantly different values for both volume and sugar richness of the nectar (Table 2).

TABLE 2.- Volume, sugar richness of the nectar and melliferous index of CMS-lines in three plantig dates.

CMS-line	Planting date	Microliters of nectar per floret	sugar %	Melliferous index
CMS L-9	I	0.127	25.0	0.032
	II	0.264	26.0	0.068
	III	0.118	47.3	0.056
	X	0.170	32.8	0.052
CMS L-7	I	0.576	28.1	0.162
	II	0.782	37.9	0.296
	III	0.233	53.0	0.123
	X	0.530	39.7	0.194
CMS L-5	I	0.258	47.0	0.121
	II	0.576	37.5	0.216
	III	0.125	49.7	0.062
	X	0.320	44.7	0.133
F VALUE	Genotype	40.5**	67.3**	
	date	24.7**	169.8**	
	interaction	4.3**	35.5**	

CMS L-9 had the lowest level of both factors in all the planting dates. CMS L-7 produced the highest volume of nectar while CMS L-5 had the highest percentage of sugar in its nectar. CMS L-7 had the highest melliferous index while CMS L-9 had the lowest index.

Among hybrids, differences were also significant for nectar secretion but not for percentage of sugar.

All the cms-lines showed the highest nectar secretion and melliferous index in the second planting date and the lowest values for both factors in the third planting date. Meteorological records during the sampling periods (Table 3), appear to show that these differences are associated with the different minimum temperatures. However, the genotype ranking within the first two (normal) planting dates was the same, only showing a genotype x environment interaction if the third (out of season) planting date is taken into account.

TABLE 3.- Temperatures during the period of flowering for the three planting dates.

	First planting date	Second planting date	Third planting date
Mean temperature	24.8	26.7	13.5
Maximum temperature mean	34.2	34.9	19.8
Minimum temperature mean	13.4	18.5	7.2

In cms-lines, the highest percentages of sugar were found in the third planting, associated with the lowest volumes of nectar. It appears as if a general compensation effect does exist for these two traits, allowing to maintain a minimum level of melliferous index.

The relationship between nectar factors of inbred lines and their hybrids was not apparent. For example, two hybrids with CMS L-9 had high levels of nectar volume while their cms-line had the lowest level of nectar volume among the cms-lines. Inversely, CMS L-7 had higher nectar volume than its hybrid.

All the hybrids had higher percentages of sugar than the cms-lines and did not correspond with the relative differences among cms-lines (Figure 1).

I.2 Floret morphology

CMS L-9 and CMS L-7 had very long styles and corollas while CMS L-5 had short styles and corollas. Even though all the cms-lines appeared to have receptive stigmas when the styles were only 10-20 mm. long, elongation to their respective final lengths occured very rapidly (Figure 2). Therefore, the time of exposure to visiting bees before full elongation was irrelevant as compared to the time of exposure with styles fully elongated.

Differences in shape of stigmas are shown in Figure 2. CMS L-7 showed a high percentage of distorted pigmented multi-lobed stigmas.

Both CMS L-9 and CMS L-7 had slower rates of withering after pollination.

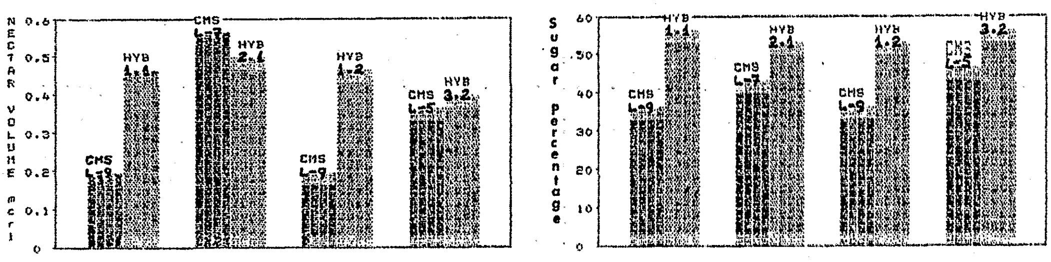

Figure 1.- Nectar factors for cms-lines and Hybrids.

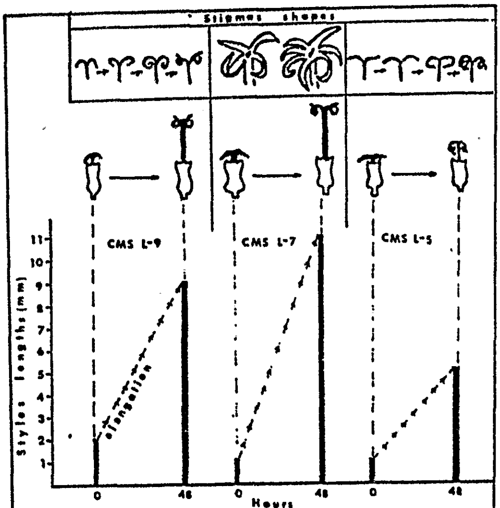

Figure 2 Styles lengths and stigmas shapes for the cms-lines. Elongation of styles in two days for each cms-line.

All hybrids had relatively short styles and corollas, as compared with the cms-lines (Figure 3), showing non-significant differences for these morphological traits and suggesting that the trait "long florets " was recessive as reported by Kovacik et al., (1980).

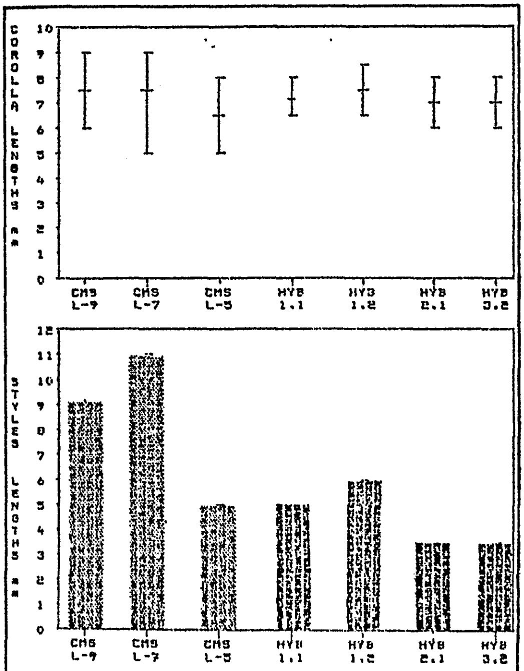

Figure 3.- Corolla and Stiles lengths (mm) of CMS-lines and Hybrids.

II.- Attractiveness factors, bee visitation and seed set of CMS-Lines.

Both number of bees per head and number of fertile seeds per head (Table 4) were significantly different among cms-lines; CMS L-5 had the highest values for both variables. However, production of seed in weight per unit surface for CMS L-9 was close to the CMS L-5 production . because of the high weight of the CMS L-9 seeds.

TABLE 4.- Number of bees per head, seed-set and yield of F1 seed per each cms-line (mean of first and second plantig date).

	CMS L-9	CMS L-7	CMS L-5
Nr. of bees per head	1.32	0.86	1.70
Nr. of filled seed per head	401	165	693
Weight of filled seed per head (gr)	17.3	11.2	19.4
Nr. of filled seed per square meter	2,170	1,137	3,714
Seed yield (kg/Hectare)	1,240	810	1,375
1,000 seed weight (gr)	57.8	71.6	40.0

The correlation between number of bees per head and seed production was significant ($r=0.65^*$) and was in agreement with Drane et al.,(1982).

There was not, however, a significant correlation between nectar factors and number of bees ($r=0.25$ for percentage of sugar and $r=-0.37$ for volume of nectar) in agreement with the results of Fonta et al., (1985). In fact, the correlations between seed set vs. nectar volume and seed set vs. melliferous index, were also negative, ($r=-0.46$ and $r=-0.37$ respectively). This was mainly due to the lack of association between nectar factors of CMS L-7 and its seed production. This line had the highest production of nectar with an intermediate sugar concentration but was the poorest seed yielder.

The correlation between sugar concentration and seed set was not significant either ($r=0.29$) although CMS L-5 had the highest seed set and the highset percentage of sugars.

Highly significant negative correlations between length of styles and number of bees per head and length of styles and seed set were obtained (r=-0.9** and r=-0.9** respectively). These results indicate that the floral morphology can play a very important role in the atractiveness to the bees, the long styles dramatically reducing the production of seed on the cms-lines studied. Both CMS L-9 and CMS L-7 had longer styles than CMS L-5 and were visited less than did CMS L-5 by bees and produced fewer seeds per square meter (table 4).

III.- Self-Compatibility

All the genotypes studied had fairly high rates of self-compatibility under the conditions examined (table 5).

TABLE 5.-Self-compatibility percentage of cms-lines and Hybrids.

GENOTYPE	% SELF-COMPATIBILITY
CMS L-9	84
CMS L-7	67
CMS L-5	96
HYB. 1.1 (CMS L-9 X R1)	88
HYB. 1.2 (CMS L-9 X R2)	100
HYB. 2.1 (CMS L-7 X R1)	100
HYB. 3.2 (CMS L-5 X R1)	72

The line with the highest sugar concentration and the most adequate floral morphology for cross-pollination (CMS L-5) had also the highest self-compatibility rate, showing that the adaptative traits for both cross and self-pollination can be found in the same genotype.

DISCUSSION

Honey bees show a selective foraging behaviour when different sources of food are available (Fonta et al., 1984, Louveaux, 1984). The quantity and richness of the food should be the most important factors for choosing one source, but the ease of access to the food could also play an important role in their choice (Sammataro et al., 1985). These data show that for the genotypes studied, the quantity and richness of the nectar did not result in selective visiting of different hives in several experiments at different dates. These results agree with those of Fonta et al., (1980), who found that only the di-saccharide (sucrose) composition of the nectar sugars had an influence on the choice of the bees. Our data also show a lack of association between nectar factors and the seed yield of the cms-lines studied.

We studied the possible influence of morphological traits of the florets, finding that the genotype with shortest corolla and styles (CMS L-5) had the highest rate of visitation by pollinators and the highest production of F1 seed. Bees are faced with a longer and more difficult access to the nectar of genotypes with long styles and can move less easily from one floret to another within the same head in genotypes with long styles. In addition, the physical contact of the pollen-carrying bee and the receptive stigmatic surface is less assured in genotypes with long styles because the bee remains under the stigma when foraging from one floret to the next.

These findings underline the importance of taking into account floral morphology when selecting lines for eventual use as female parent lines in hybrid combinations. These results also suggest that breeding for improved bee-attractiveness factors does not necessarily lead to a decrease in self-compatibility.

These experiments may be of particular interest to Spanish researchers since their location was in Southern Spain in the area where hybrid seed production normally occurs. The lack of correspondance between the negative factors of some cms-lines and their hybrids show that the results reported here apply more to the economy of F1 hybrid seed production than to commercial grain production.

RESUMEN

Se estudió la longitud de los estilos, la forma de los estigmas y las características del nectar de varias lineas cms y sus híbridos.- Se asociaroń los valores observado de estos factores de atracción para las abejas, con el número de abejas por planta y el rendimiento de cada línea cms. Los resultados muestran que la morfología floral puede jugar un papel muy importante en la atracción de polinizadores y, como consecuencia, en el rendimiento de la producción de semilla híbrida F1.

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