Natural Cross-Fertilization of Sesame Grown in Sonora, Mexico[1]

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ABSTRACT

The extent of natural cross-fertilization of seven white seeded genotypes of sesame (*Sesamum indicum* L.) was studied under growing conditions in Sonora, Mexico. A line with black seed (a simply inherited dominant character) was used as control. The genotypes investigated showed significant differences in the extent of natural cross-fertilization. The percentages of natural cross fertilization ranged from 6.1% to 20.1% and averaged 12.8 ± 2.2 percent. Honey bees were observed as the most active pollinators. The results obtained indicated that a high degree of natural cross-fertilization occurs in sesame. Possible applications for sesame breeding are discussed.

COMPENDIO

Se estudió el grado de fecundación cruzada natural de siete genótipos de grano blanco de ajonjolí (*Sesamum indicum* L.), en las condiciones de crecimiento imperantes en Sonora, Méx. Una línea de grano negro (carácter dominante de herencia simple) fue utilizada como marcador genético. Los resultados indicaron diferencias significativas en el grado de fecundación cruzada natural, en los genótipos de ajonjolí evaluados. Los porcentajes de cruzamiento natural tuvieron un rango de 6.1% a 20.1%, con una media general de 12.8 ± 2.2 por ciento. Se observó que las abejas fueron las más activas polinizadoras. Los datos indican la presencia de un alto grado de fecundación cruzada natural en ajonjolí. En el presente trabajo se discuten las posibles aplicaciones de estos resultados en el mejoramiento genético de ajonjolí.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is generally considered as a self-pollinated crop. However, 1% cross-fertilization was reported in experimental plots by Kinman and Martin (8). Collister (5) reported natural cross-fertilization values of 0.5% to 9.6 percent. Yermanos (22) found 68% natural cross-fertilization in Moreno, California, where sesame was the only blooming plant species in the midst of a semiarid area. Levels of 60% to 65% natural cross fertilization have also been reported in sesame (21).

Martinez and Quilantan (10) found natural cross fertilization to range from 3% to 15% for sesame grown in Iguala, Mex., during the summer and winter. The values were dependent on the season and the frequency of insect pollinators. In India, natural cross fertilization values of 1% to 17% have been reported (1, 2, 19). Langham (9) reported 4.6% natural cross fertilization for sesame grown in Venezuela.

Rheenen (15) found natural cross-fertilization to range from 3.5% to 9.6% in Nigeria, the values depending on variety and experimental design. Similarly, Khidir (6) estimated the extent of natural cross fertilization in sesame grown in Sudan to range from 3.1% to 6.7% depending on location and planting pattern. Chaudhari and Zope (3) reported maximum cross fertilization in sesame cultivar UT-43 sown at 28 distances from 0.3 m to 16.2 m to 16.2 m to be within 2.0%, the values being dependent on the direction. Using the dt45 (determinate) plants as marker gene, Brigham (2) found 10.2% natural cross fertilization in sesame plants grown at Lubbock, Texas. The range of natural cross fertilization in sesame is this very wide (1% - 65%), apparently being dependent on genotype and environmental conditions.

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In view of the sporadically high amounts of natural cross fertilization and high variation with various environmental factors, maintenance of purity of varietal characteristics is complicated. In order to avoid the occurrence of genetic shifts in a crop species, it is important that a breeder have an estimate of the degree of contamination of his advanced breeding lines due to natural cross fertilization. According to McVetty and Nugent-Rigby (11), knowledge of the estimate of natural cross fertilization in a crop species would ensure that significant genetic shifts occur in subsequent years of testing, or final years of seed increase of new varieties.

In Sonora, Mexico, no precise research exists on the extent of natural cross fertilization in sesame. Maintenance of genetic purity of the commercially grown varieties has been difficult. Since most of the sesame varieties are highly heterogeneous, it is imperative to obtain information on the extent of natural cross fertilization of sesame grown in Sonora, so as to formulate an effective breeding strategy for crop improvement. The sesame breeding program in Sonora employs the pedigree and bulk breeding methodologies.

The present study was thus conducted with the aim of determining the extent of natural cross fertilization for seven different genotypes of sesame under conditions in Sonora.

MATERIALS AND METHODS

Five commercial cultivars of sesame Ciang 16, Ciang 27, Yori 77, Teras 77, and Pachequeño and two advanced breeding lines, Liza 70 and Sinaloa 2, were studied for natural cross fertilization. All seven genotypes carry a recessive allele for white-colored seeds in a presumably homozygous condition.

The genotype M-T-B-3, from the sesame germplasm collection that carries a dominant allele for black seed, was used as a pollen donor in this study. The condition of black seeds is inherited in a monofactorial fashion, as previously reported by Sikka and Gupta (20).

In order to facilitate the occurrence of natural cross fertilization, the tested genotypes with seeds were each planted in alternate rows with "M-T-B-3" (black seeds) during the summer of 1986. Single row plots 6 m long and 75 cm between rows were used. Plant to plant distance was kept at 10 cm within the row. A randomized complete block experimental design with four replications was used. During the growing season, samples of the most prevalent insect populations were taken. Honey bees were observed as the most active and frequent insect pollinators.

In order to determine the extent of natural cross fertilization, seeds from individual plots of the white seeded genotype were harvested separately. These were grown out as FW1 plants during the summer of 1987. Due to lack of xenia in sesame, all of the harvested FW1 seed were white. The seed harvested from each plot of the white seeded genotype was used as a separate treatment. Two-row plots 6 m long and 75 cm between rows were planted in a randomized complete block experimental design with four replications.

In the F_2 generation, seed color segregates; this relation has been used in estimating the extent of natural cross fertilization in sesame (10, 18).

Seeds of the segregating F_2 generation were harvested from plants and bulked within each plot in 1987. This seed was used in determining the extent of natural cross fertilization in the seven genotypes under study. Data from each cultivar were combined using an analysis of variance approach as outlined by Cochran and Cox (4). Differences among means were determined using Duncan's multiple range test. The estimate of natural cross fertilization was made be calculating the percentage of black seeds (dominant) in the progeny of white seeded genotypes.

Since the amount of the harvested seed from the plot of the white seeded genotypes was large, a 10 cm^3 sample of seeds (containing approximately 3000 seeds) was taken. Two samples were taken from each harvested plot. The F_1 seed harvested from each plot in 1986 was divided in four parts and grown out in each replication in 1987. The segregating F_2 seed used for determining natural cross fertilization represented 16 samples per genotype with white seed. The number of white, black and total seeds were determined. The percentage of black seeds which segregated and was observed in each white seeded genotype indicated the extent of natural cross fertilization as previously outlined by Martinez and Quilantan (10).

RESULTS AND DISCUSSION

The data in Table 1 show the percentage of natural cross fertilization in the seven genotypes of sesame grown in Sonora. The extent of natural outcrossing ranged from 6.1% to 20.1% and averaged 12.8 $\pm$ 2.2% natural cross fertilization.

Two genotypes, Ciano 27 and Pachequeño, presented low natural cross fertilization values of 6.1 $\pm$ 0.8% and 7.2 $\pm$ 3.0%, respectively. These two genotypes are slightly later-flowering than the other materials tested. The low values obtained may have resulted from the short flowering period to which they

Table 1. Natural cross-fertilization in the progenies of seven white seeded genotypes of sesame grown in Sonora, Mex.

Genotype	Cross fertilization (%)	
	Mean[1]	Range
"Liza 70"	20.1a ± 3.7	16.7 - 24.8
"Ciano 16"	16.5 b ± 1.7	14.8 - 18.9
"Sinaloa 2"	15.4 b ± 2.3	12.9 - 18.0
"Teras 77"	13.3 bc ± 2.0	11.5 - 16.1
"Yori 77"	11.3 c ± 1.8	8.6 - 12.5
"Pachequeño"	7.2 d ± 3.0	4.4 - 11.4
"Ciano 27"	6.1 d ± 0.8	5.0 - 6.7

Notas:

1. By the same letter are not significantly different at P = 5%, according to Duncan's multiple range test.

were exposed with the dominant tester (M-T-B-3). Three genotypes, Ciaro 16, Liza 70 and Sinaloa 2, showed percentages of natural cross fertilization of over 15 per cent. The observed natural cross fertilization values were 15.4 ± 2.3%, 16.5 ± 1.7% and 20.1 ± 3.7% for Sinaloa 2, Ciano 16 and Liza 70, respectively. Teras 77 and Yori 77 showed natural outcrossing values of 13.3 ± 2.0% and 11.3 ± 1.8%, respectively. These two genotypes are not statistically different according to Duncan's multiple range test (Table 1).

Statistical analysis of the data indicate differential natural cross fertilization between genotypes. Liza 70, which registered the highest natural cross fertilization value, was significantly different from all the test genotypes (Table 1).

The data obtained in this study demonstrate the magnitude of natural cross fertilization in sesame grown under the conditions of Sonora. These results also confirm that sesame is predominantly a self-pollinated crop with a certain degree of natural outcrossing. The results reported here are similar to those reported by Martinez and Quilantan (10), Rheenen (15, 16) and Brigham (2).

Numerous insect pollinators were observed during the flowering period. In this study, honey bees were frequently observed visiting sesame flowers; Khidir and El Awad (7) reported them, rather that wind, as the most active pollinators in sesame. In general, the flower structure of sesame offers ample opportunities for cross-fertilization by insects. Similar observations were previously made by Rheenen (17).

From the data obtained in this study, it can be concluded that a high percentage of natural cross-fertilization can occur in sesame grown in Sonora. This obviously complicates the problem of maintenance of breeding lines and cultivars and requires isolation between them. This aspect is important in maintaining the purity of varietal characteristics.

Natural cross fertilization in sesame has been reported to vary from 1% to 65% (13). This phenomenon is dependent on genotype, environment and experimental design. It is important, therefore, that each breeding program in a given area determine the extent of natural cross fertilization of this crop. This information would facilitate the identification of an appropriate breeding methodology.

The range of natural cross-fertilization reported in sesame is similar to that reported in faba beans (*Vicia faba* L.) by McVetty and Nugent-Rigby (11). These authors reported a range of 1% - 79% in faba beans, and mentioned that at the lower end of the reported range (1% - 65% for sesame) the species could be handled as a self-pollinated crop, using a pedigree approach. At the upper end of the range, the crop could probably be handled quite satisfactorily as a cross-pollinated species using a recurrent breeding approach to produce improved populations and or synthetics. Similar observations were made by Rheenen (16). Rajan (14) suggested the development of synthetics or composites in sesame as a means of exploiting the high degree of vicinism observed in this crop.

In Sonora, the data indicate that the populations could be handled with the pedigree, bulk and backcross breeding approach. However, in order to avoid genetic shifts in advanced breeding populations, it is necessary to grow sesame populations in isolation. Rheenen (16) and Khidir (6) recommended the use of controlled self-pollination for maintenance of germplasm collections. This can be achieved by covering the upper part of the stem before flowering, which would help reduce natural cross-fertilization in sesame and ensure the maintenance of genetic purity.

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