SELF-STERILITY AND INCOMPATIBILITY IN SUNFLOWER

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SUMMARY

Lines of sunflower developed from crosses between cultivated Heliantus annuus and H. bolanderi and H. exilis, were studied with the aim to find out mechanisms of self-sterility and incompatibility related to a certain scarcity of the yield in some year.

Since 1983, for three generations, plants were self-and free-pollinted and the self/free ratio (S/O) was analyzed in a breeding program. For some lines there was a response to the selection and linear regression of progeny means on the parents was found. Some progenies of plants with S/O values close to zero had a bimodal ditribution for S/O values and a complementary interaction model gave a quite good fitting.

Incompatibility was studied observing the number of achenes obtained after pollinating by hand sectors of washed capitules with pollen of different plants. Differences were found in most of the crosses studied. The process of fertilization was confirmed observing the pollen tube development. In some cases of incompatibility pollen grains did not adhere to stigma papillae as appears by scanning microscope; in others traces of pollen tubes were blocked mainly into the stigma tissues and in the upper part of the style. In compatible crosses traces were observed at the base of the style ten minutes after pollination, by fluorescence microscope, but not clear relationships were found between number of traces and achenes developed.

INTRODUCTION

Seed set in sunflower represents a basic problem for the yield of some varieties in certain years (Segale et al., 1980; Smith et al. 1980; Vranceanu, 1974). Many reports have been given in the last decade and mechanisms of self-sterility and incompatibility are envisaged to be the cause of poor seed set. Vranceanu (1974) and Smith et al. (1980) pointed out the climatic conditions as affecting pollen fertility and Luciano et al. (1965) found low values of narrow heritability in self-incompatibility and a large variation due to the locations. Segala et al. (1980) reported that 50% of the self-fertility is related to the self-compatibility and studying the degree of self-incompatibility by the ratio self/free pollination found a heritability value of 0.66.

Incompatibility in sunflower occurs frequently as reported by Heiser et al. (1969) and data given by Fernandez-Martinez and Knowles (1978) suggest a sporophytic system because of the reciprocal differences in a diallel cross set.
Sunflower lines were developed at the University of Padova using serpentine sunflowers(Jain et al., 1977) and some of them, promising for agronomic traits such as head diameter, plant height, disease resistance, resulted in very few seed set. Supported by Italian C.N.R., a study has been carried out to find out mechanisms of self-sterility and incompatibility which could affect the grain yield.
In this paper we report the main results concerning 1) the behaviour of self-sterility in three generations evaluated by self/free pollination the same capitule as done by Leclercq (1980); 2) the degree of compatibility in several cross combinations and 3) the relationship between observations by scanning and fluorescence microscope and data of fertility.

MATERIALS AND METHODS

The study was carried out at the experimental farm of the University on 16 lines obtained after five generations from crossing weedy and cultivated Helianthus annuus, H. bolanderi and H. exilis. Previous meiotic observations confirmed a quite regular chromosome pairing. Starting in 1983 each of about 300 plants was free pollinated during the first days of flowering then self-pollinated bagging into a nylon-cotton tissue. A crown of pins was placed in each head for distinguish the two areas. The ratio self/outcross (S/O) was obtained after weighting the seed and referring to the unity of surface of capitule.
Since 1984 controlled pollinations were made by hand on sectors of heads on plants grown in insect-proof isolators, therefore no bag was placed on the flowers. Own pollen grains were washed out with water before pollinations and pollen fertility was checked by lactophenolcottonblue.
Pollen germination on the stigmas for some combinations was studied by a scanning microscope at different times after pollinations (10', 20', 30'; 60',120', 180'; overnight). The development of pollen tube into the stigmas and styles at different times was observed by fluorescence microscope according to Zeven and Van Heemert (1970) and traces were studied in 4 to 6 styles for each cross combination.

RESULTS

In summer 1983 among 165 plants 65, belonging to all 16 lines with the exception of only one, were self-sterile (S/O = 0). In most lines S/O data were distributed asymmetrically with modal value

around the lower classes and ranging up to unity. In only one line distribution was quite normal. The next two generations during either 1984 or 1985 and 1986 were developed from seed obtained either by free pollination in plants S/O = 0 or by selfing, thus half and full sib families were analyzed. In six out of 8 lines there was clear response to the selection. Self-sterile plants were obtained prevalently from low S/O plants and still an asymmetric distribution was observed. From progenies of plants with S/O = 0 none reached values as high as unity. On the other side, few full sib families developed from plants with high S/O were predominantly self-fertile but some plants had S/O values ranging from 0 to 1. In three lines the regression coefficients for two next generations (mother plants and progeny means) were significant with slopes of 0.59, 0.57 and 1.21 indicating additivity for self-fertility. This fact shows that S/O value is selectable. However for two lines there was an increasead of self-fertile plants in the next generations so their distributions showed two picks corrisponding to 0 and 1 values of S/O. For these lines the effect of additivity was very low, but a complementary epistatic model involving two alleles at two loci gave a quite good fitting.

Compatibility on 43 mother plants and more then 100 combinations involving 2 to 6 sectors of large capitules resulted in at least 1 to 3 achenes in all sectors. However, with exclusion of these sectors, the ratios in seed number due to the different degree of compatibility reached values as high as 18 in the combination 2-22-1 x 5-22-1.

Observations by scanning microscope of the stigmas pollinated at different time showed no clear pattern in pollen tube development. In some cases of incompatibility pollen grains did not adhere stigma papillae. However, no relationship was found between seed set and number of pollen grains sticked to the stigma.

By fluorescence microscope it was observed that in most florets block of pollen tube occurs in the outer layers of stigma tissues, but in few cases of low compatibility traces can reach the top of the styles. In 84 crosses between 4 to 7 plants for each of five families combined according to a complete diallel scheme coefficient of correlation between seed density and number of traces at the base of the style was 0.014. Also an index which takes into consideration the number of traces into stigmas did not give significant results (r=-0.05). Correlations between seed density and number of traces were improved ("r" up to 0.86) when homogeneous (i.e.inside each family combinations) were studied. In this case, however, because of the few crosses (4 to 7) rarely they reached the significance level.

CONCLUSION

Although the lines studied at the meiosis resulted to have a normal chromosome pairing it cannot be excluded that unfixed variation is still present in such material developed recently from different sunflower species. This fact can explain the various behaviours of self-fertility and incompatibility as observed through breeding experiments and direct observations on pollen germination.

In some lines self-sterility as evaluated by S/O ratio seems to be controlled by few genes. A classic complementary non allelic interaction which gives 9:7 ratio fits quite well 0 and 1 S/O ratio classes. Some problem of penetrance in gene expression can explain few cases of intermediate S/O values. A larger examination of families possibly improves this analysis.

A breeder's approach has given promising results showing a linearity in the behaviour in next generations and in three lines significant regression has clearly indicated additivity in gene action and a certain quote of selectable variation.

The block of self-sterility has not been investigated but it should be the same that concerns incompatibility between different plants. From the present analysis it is not possible to find only one pattern which however would occur in a well stabilized material. In some cases gene exchange is precluded on top of the stigma, but mainly on the first layers of the stigma and some in the apical part into the style. The lack of correlation between traces of pollen tubes at the style base and the number of achenes developed suggestes a strategy in fertilization, that means there are specific interaction between pollen and tissues of pistil. In fact when such relationship is analyzed on less heterogeneous combinations there is a right pattern.

ACKNOWLEDGMENTS

This research has been supported by the National Research Council throught the Special Project IPRA (Productivity enhancement of Agricultural Resources). Publication no.

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