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EFFECT OF DIFFERENT CYTOPLASMS ON SEED OIL CONCENTRATION IN SUNFLOWER

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Summary

Reciprocal crosses were made among three high-oil and two low-oil inbred lines of sunflower (Helianthus annuus L.) possessing male sterile and normal cytoplasms to examine the effect of cytoplasm on oil percentage of F_1 seed. Maternal influence was also determined.

Oil percentage of dehulled F_1 seed produced by plants with sterile cytoplasms was not different from the oil percentage of seed produced by plants with normal cytoplasm. Thus, the male sterile cytoplasm now used in the production of F_1 hybrid sunflower seed in the USA does not appear to limit or enhance oil percentage.

Maternal influence (genotypic and cytoplasmic effects) on oil percentage was determined in all comparisons of reciprocal dehulled F_1 seeds. Cytoplasmic effect was not indicated as an important factor of maternal influence in sunflower based on differences in oil percentage.

Introduction

Studies by DUVICK (1958), BLICKENSTAFF et al (1958), FLEMING et al (1960), JOSEPHSON and KINCER (1962), DUVICK (1965), SINGH (1965), HUNTER and GAMBLE (1968), GARWOOD et al (1970), FLEMING et al (1971), and GOOD and HORNER (1974) have indicated that agronomic plant characters in maize (Zea mays L.) such as plant and ear height, seed yield, oil percentage and quality of seed, and disease reaction may be influenced by the cytoplasm. GARWOOD et al (1970) observed that oil percentage of maize grain is affected only slightly by the cytoplasm. He attributes much of the observed variation to maternal influence.

Variation in the influence of dissimilar cytoplasms on oil concentration is suspected because of the presence of distinct cytoplasmic organelles, primarily the mitochondria and chloroplasts (STUMPF and JAMES, 1963). The individuality of the mitochondria and chloroplasts is expressed by the presence of extra-nuclear DNA specific for these organelles (GRANICK and GIBOR, 1967).

The male sterile cytoplasm derived from Helianthus petiolaris L. (the only source used for hybrid seed production in the U.S.) has been largely assumed to have an effect on oil concentration similar to that of the fertile or normal cytoplasm of H. annuus L. There is no information for confirmation. The pur-

pose of this study was to determine the contribution of cytoplasmic effect as a proposition of total maternal effect on oil percentage of sunflower seed.

Materials and Methods

Sunflower inbred high oil (HO) and low oil (LO) A (cms) and B (maintainer) lines were used to study maternal and cytoplasmic effects on seed oil concentration. Inbred HO lines HA 303 and VS 14-2-1 were selections from Voshod, and P 165 T-1 was from Peredovik. The LO lines HA 124 and CM 361 were from VNIIMK sources. All lines were selected from oilseed varieties.

The plants were grown in 1.6 m rows spaced 0.9 m apart with approximately 30 cm between plants within rows. The inbred lines were selected at random from the breeding nursery at Fargo, ND, grown in cooperation with the North Dakota Agricultural Experiment Station, in 1977. The A and B lines were grown in adjacent single-row plots. A randomized complete block design with a factorial arrangement was used.

Maternal effect on seed oil percentage was studied from reciprocal crosses of HO and LO lines. One-half of the head of an HO A line plant was pollinated with pollen from a LO B line plant, and the other half was pollinated from pollen from its maintainer HO B line plant. The head of an HO B line plant was hand emasculated. Then, one-half of the head was pollinated with pollen from a LO B line plant and the other half was self-pollinated. The reciprocal procedure was followed for the LO A line and B line plants. Each cross was replicated four times. The head was harvested and each half was threshed separately. Oil percentage of the dehulled F_1 seed was determined using nuclear magnetic resonance.

Cytoplasmic effect on seed oil percentage was studied from dehulled F_1 seeds of the A and B inbred lines which were genotypically similar but cytoplasmically different.

Results

The mean oil percentages of dehulled F_1 seeds from reciprocal crosses are shown in Table 1. The mean seed oil concentration of the cms HO lines was 56.4 percent and that of the normal HO lines was 56.5 percent. Seed oil concentrations of the cms LO lines and normal LO lines were 50.3 percent and 49.7 percent, respectively. The difference in seed oil percentage between A and B lines was not significant.

The reciprocal crosses of the HO and LO lines with mean seed oil concentrations of 56.4 percent and 50.0 percent, respectively, differed significantly. No differences in mean seed oil percentage were observed within the lines of HO/LO or LO/HO crosses, and no significant interactions were noted.

Discussion

GARWOOD et al (1970) stated that differences between reciprocal crosses can be attributed to physiological effect, the cytoplasm contributed by the female parent, and gene dosage effects associated with the endosperm. The endosperm in sunflower is negligible at maturity; therefore, the latter factor is of minor importance. Since inbred lines were used the physiological effect was assumed to be similar for all individuals within lines. (Physiological effect is used synonymously with genotypic effect.) Because of the genotypic homogeneity of the A and B lines, any observable difference in seed oil percentage between these lines could be related to the effect of the cytoplasm of the female parent.

Maternal effect on seed oil percentage in sunflower was observed by FICK (1975), and T.E. THOMPSON (personal communication), and is confirmed in this study. Seed oil percentage was similar to that of the maternal parent in all cases of the reciprocal crosses made between the HO and LO lines.

FICK (1975) suggested that the cytoplasm may have an influence on oil content since oil synthesis occurs in the cytoplasm (STUMPF and JAMES, 1963). Significant differences were not observed among the lines with male sterile and normal cytoplasm in this study. These results agree with the conclusions of WAGNER (1969) and GARWOOD et al (1970) that cytoplasmic effects on oil content in maize grain are present but not significant.

Apparently genotypic factors are primarily responsible for seed oil concentration in sunflower as in maize grain (GARWOOD et al, 1970). Further, the genotypic factor of the maternal parent, rather than the genotypic factor of the embryo, is important in influencing oil concentration because the seed oil percentage of the F_2 embryo followed the maternal midparent value (FICK, 1975). The embryo appears to be a sink for oil accumulation.

Since the cytoplasmic effect on seed oil content at present concentrations appears small in studies to date, it may be obscured by the genotypic effect. Assuming the threshold level for seed oil concentration has not been reached as yet, more research may be needed in the future to reexamine cytoplasmic influence.

We conclude that the male sterile cytoplasm of H. petiolaris L. does not significantly influence oil concentration of sunflower seed borne on the F_1 hybrid plants now produced on farms of North America.

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Table 1. Mean oil percentage of dehulled F_1 seed from reciprocal crosses of high oil (HO) and low oil (LO) sunflower inbred lines.

Cross ♀	♂	Oil percentage	Female Line† X	Female oil_type† X
High oil lines as female				
cms HA 303 (HO)	Low Oil pollen (LO)	56.4		
cms HA 303 (HO)	HA 303 maintainer (HO)	58.3		
emasculated HA 303 (HO)	Low Oil pollen (LO)	55.7		
HA 303 (HO) self-pollinated	♀	57.7		
			57.0a	
cms VS14-2-1 (HO)	Low Oil pollen (LO)	53.8		
cms VS14-2-1 (HO)	VS14-2-1 maintainer (HO)	55.0		
emasculated VS14-2-1 (HO)	Low Oil pollen (LO)	55.4		
VS14-2-1 (HO) self-pollinated	♀	56.0	55.1a	
cms P165T-1 (HO)	Low Oil pollen (LO)	57.6		
cms P165T-1 (HO)	P165T-1 maintainer	57.2		
emasculated P165T-1 (HO)	Low Oil pollen (LO)	57.1		
P165T-1 (HO) self-pollinated	♀	56.8		
			57.2a	
				56.4a
Low Oil lines as female				
cms HA 124 (LO)	High Oil pollen (HO)	50.2		
cms HA 124 (LO)	HA 124 maintainer (HO)	51.2		
emasculated HA 124	High Oil pollen (HO)	51.0		
HA 124 (LO) self-pollinated	♀	51.6		
			51.0b	
cms CM 361 (LO)	High Oil pollen (HO)	48.7		
cms CM 361 (LO)	CM 361 maintainer (HO)	51.0		
emasculated CM 361 (LO)	High Oil pollen (HO)	47.5		
CM 361 (LO) self-pollinated	♀	48.3		
			48.9b	
				50.0b

	†
Mean of cms crosses	53.3a
Mean of emasculated crosses	53.3a
Mean of cms/maintainer crosses	54.6a
Mean of self-pollinations	54.1a
C.V. = 4.34%	

Least significant differences are at the 1% probability level and means are different if followed by a different letter.