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INHERITANCE OF THE FATTY ACID COMPOSITION OF OIL IN SOME SUNFLOWER LINES

Nikolova,V., P.Ivanov

Institute for Wheat and Sunflower "Dobrudja" near Gen. Toshevo, BULGARIA

SUMMARY

The inheritance of fatty acid composition in F_1 seed and of their progenies (F_2) is studied. It is established that the oil quality of F_1 seeds is determined by the joint action of the embryo genome and the female parent genome, but in different combinations a specific degree of expression of those factors is observed. In F_2 progeny of F_1 and RF_1 seeds the accumulation of different fatty acids is determined by the seed genome and because of that the composition of the oil is identical. In some crosses a partial dominance is observed of the low and high content of linoleic, oleic and palmitic acids. In all crosses the stearic acid content super-dominates toward the parent with a higher value.

Key words: sunflower, fatty acid composition, inheritance

INTRODUCTION

The genotype influence of the female plant and the embryo genotype on the faty acid composition accumulated in oil of the seeds determines the breeding procedure used in conducting a selection to a definite fatty acid composition of the oil. This is especially necessary when single seeds with preserved viability are used for analysis. In carrying out reciprocal crosses between high linoleic and high oleic lines, Miller & Zimmerman (1983) found a presence of female effect in the inheritance of the oleic acid content, as the seeds of these crosses were different in its content by 13%. In the study of Fick (1984) the observations cited are confirmed and a conclusion is also made that the high content of the oleic acid is controlled by one partially dominant gene in the presence of a considerable female influence. In further publications of Miller et al., (1987); Fernandez–Martinez &Knowles (1987); and Fernandez–Martinez et al., (1989), a hypothesis was formed that high oleic acid content is controlled by three dominant complementary genes OL_1, OL_2 and OL_3 and by the action of one additional gene which modifies the high content of the oleic acid.

This study is undertaken to determine the effect of the female plant and the embryo-genotype on the seeds of reciprocal crosses produced in the year of pollination and the seeds of their F_1 progenies (F_2 seeds), in some lines of our selection distinguished significantly by different fatty acid composition.

MATERIAL AND METHODS

The experiments are based on two high linoleic and two high oleic lines each used as donors of these qualities through crossing with other lines. The line 1418HL is produced after self–pollination and selection in the population of the variety VNIIMK 6540; the line 1778HL is developed from hybrid materials of lines 1183x881. The high oleic line

Pc4HO originates from variety Pervenetz; the second high oleic line 654HO is produced after a seed treatment of the variety Peredovic with nitrosoethylurea in concentration 0.03%. The castration of the female plants is made by the aqueous solution of gibberelic acid (33mg/l), when the inflorescences size is 1.0–1.5 cm. The solution is applied three times, by a sprayer, every two days. The fatty acid composition is determined by gas chromatography. The statistics was made according to Genchev et al., (1975).

RESULTS AND DISCUSSION

The lines selected for crossing (Table 1) differed significantly in relation to the content of unsaturated fatty acids – linoleic and oleic. The linoleic acid content in seeds from the reciprocal crosses was different than that of the female line. Besides, this content was different among the reciprocals and it is evident that it is not controlled only by the genome of the embryos, and is considerably affected by the genotype of the female parent.

Table 1. Seed fatty acid composition of inbred lines and some hybrids between these (F_1 embryo), Harvest 1983

Parent and cross	Fatty acid,%			
	Linoleic	Oleic	Stearic	Palmitic
1418HL	72.0	18.1	2.9	7.0
1778HL	73.4	17.3	2.5	6.8
Pc4HO	17.5	76.1	2.4	4.0
654HO	2.3	88.3	4.8	4.6
1418HL x Pc4HO	37.3	53.7	3.8	5.2
Pc4HO x 1418HL	15.4	77.7	1.7	5.2
1418HL x 654HO	54.6	33.7	6.2	5.5
654HO x 1418HL	35.1	53.1	4.6	7.2
1778HL x Pc4HO	45.8	44.2	3.4	6.6
Pc4HO x 1778HL	36.6	55.8	2.6	5.0
1778HL x 654HO	53.1	33.3	4.6	9.0
654HO x 1778HL	9.3	80.7	3.7	6.3

Table 2. Seed fatty acid composition of inbred lines and their F_1 progenies (F_2 embryo), Harvest 1984

Parent and cross	Fatty acid							
	Linoleic		Oleic		Stearic		Palmitic	
	$\bar{x}$,%	d/a	$\bar{x}$,%	d/a	$\bar{x}$,%	d/a	$\bar{x}$,%	d/a
1418HL	72.2		18,.6		2.7		6.5	
1778HL	73.4		17.8		2.3		6.5	
Pc4HO	17.5		77.5		1.2		3.8	
654HO	1.4		90.3		4.6		3.7	
1418HL x Pc4HO	52.9	0.29	34.4	–0.47	5.5	4.70	7.2	1.56
1418HL x 654HO	39.6	0.08	47.3	–0.20	6.9	3.37	6.2	0.79
1778HL x Pc4HO	39.8	–0.20	53.0	0.18	3.0	2.00	4.2	–0.69
1778HL x 654HO	35.1	–0.07	54.6	0.01	5.2	1.50	5.1	0.07
Pc4HO x 1418HL	53.9	0.33	36.0	–0.41	4.4	3.20	5.7	0.44
Pc4HO x 1778HL	39.7	–0.21	53.3	0.19	3.0	2.00	4.0	–0.85

The content of linoleic acid in oil of the parent lines studied in 1984 (Table 2) ranged from 1.4% (in line 654H0) to 73.4% (in line 1778HL). The seeds from the F_1 hybrid plants differed considerably. The lowest content was found in the F_2 seeds of the hybrid combination 1778HL x 654HO. and the highest one–in the combination Pc4HO x 1418HL.

The values of linoleic acid content did not differ significantly in the F_1 progenies (F_2 seeds) of the reciprocal crosses. This confirms the conclusion that the fatty acid composition of F_1 seeds is partially under the mother plant effect and there is a lack of cytoplasmic influence on the quality of F_2 seeds.

The linoleic acid content was higher than the average of the parents (MP) for the F_2 seeds of the crosses involving the line 1418HL, and the degree of dominance varied from 0,08 to 0,33. In combinations with the line 1778HL, the linoleic acid content in the hybrid seeds was lower than the mean parental values and as a result of this the relations d/a were also negative, from –0.07 to –0.02. For the two groups the lowest values for d/a were also produced with the line 654H0. These data show the specific response of the genotypes studied and support the studies of Fernandes–Martinez & Knowles (1987); Voskoboinik & Tkatchenko (1987).

The oleic acid content in the hybrid seeds also differed substantially from that of the parent lines. Its values also differed in reciprocal crosses. In that case the conclusion is that the oleic acid content is not determined only by the embryogenotype, but is also controlled by the genotype of the female plant (Table 1). The mean values for the oleic acid content of F_2 hybid seeds harvested in 1984 (Table 2) did not differ considerably one from the other. These results again indicate a lack of significant cytoplasmic influence determining the synthesis of this acid.

The oleic acid content in the hybrid seeds involving the line 1418HL was lower than the mean parent values, and d/a was from –0.20 to –0.47, respectively. In contrast to these cases, in the combinations with the line 1778HL the oleic acid content was higher than the mean parent values, and the relations d/a varied from 0.01 to 0.19. The smallest difference between the values of the hybrid and the average parental characteristics was obtained in combinations with the of line 654HO.

In the hybrids 1418HL x Pc4H0 and 1418HLx 654HO, the seeds from the reciprocal crosses differed in the content of stearic scid from 1.6 to 2.1% (Table 1). The values for the content of the same acid in F_1 seeds were also different from these of the female parent except the cross 654HO x 1418HL, where the values were 4.8 and 4.6%. These results indicate that the stearic acid content is not controlled completely by the embryo genome, and is also largely effected by the female parent. The data from 1984 (Table 2) show that in all hybrid combinations the stearic acid content was higher than their respective mean parental values and the relations d/a varied from 1.50 to 4.70.

The data of the palmitic acid inheritance show (Table 1) that its quantity is not controlled completely by the embryo genotype and is determined largely by the genotype of the female parent. According to the data from the analysis of the F_2 seeds (Table 2) it is seen that the line 1418HL in its combinations exerts a positive effect on the accumulation of palmitic acid. The relations d/a were positive and varied from 0.44 to 1.56. The effect exercised by the line 1778Hl was different. The accumulation of palmitic acid in the combinations with this line was lower than the mean parental values in the two

crosses, and in the third combinations its superiority was very weakly expressed.

The results summarized in this study suggest that the content of the four fatty acids mentioned in all crosses here is not under a similar genetic control. These results correspond to those obtained for flax (Yermanos & Knowles, 1962), soyabean (Brim et al., 1968) and rapeseed (Thomas & Kondra, 1973).

The comparison of F_1 and RF_1 progenies (F_2 seeds) in sunflower indicates clearly that there is not a significant cytoplasmic influence on the content of any one of the investigated fatty acids. The results for the rapeseed are also similar concerning the content of the oleic, linoleic and linolenic acids (Thomas & Kondra, 1973; Kondra & Thomas, 1975).

In the F_1 sunflower hybrids, depending on the combination of the lines crossed, the nature of inheritance of the quantitative characters studied, differed and this determined the sunflower oil quality of F_2 seed produced. In some crosses, partial dominance of the low or high content of linoleic, oleic and palmitic acid was observed. In all crosses the stearic acid content expresses dominance over the mean parental values.

REFERENCES

Brim,C.A., W.M.Shutz, F.I.Collins (1968) Maternal Effect on Fatty Acid Composition and Oil Content of Soybeans, *Glycine max* (L.) Merril., Crop Sci., vol.8, 517–518.

Fernandez–Martinez,J., P.F.Knowles (1987) Inheritance of Seed Fatty Acid Composition in a Cross Between Domesticated and Wild Annual Sunflower Genet.Agr., vol.41, 83–95.

Fernandez–Martinez,J., A.Jimenez, J.Dominguez, J.M.Garica, R.Garces, M.Mancha (1989) Genetic Analysis of the High Oleic Acid Content in Cultivated Sunflower (*Helianthus annuus* L.) Euphytica, vol.41, 39–51.

Fick,G.N. (1984) Inheritance of High Oleic Acid in the Seed Oil of Sunflower. In: Proc. Sunflower Research Workshop. Bismarck, ND. 1 February, National Sunflower Association, Bismarck, N.D. 9–10.

Genchev,G., E.Marinkov, V.Jovcheva, A.Ognianova (1975) Biometrichny metody v rastenievadstvoto, geneticata y selekciata. Sofia, Zemizdat.

Kondra,Z.P., P.M.Thomas 1975) Inheritance of Oleic, Linoleic and Linolenic Acid in Seed Oil of Rape Seed (*Brassica napus*). Can. J. Plant Sci., vol.55, 205–210.

Miller,J.F., D.C.Zimmerman (1983) Inheritance of High Oleic Fatty Acid Content in Sunflower. In: Proc. Sunflower Research Workshop, Fargo, ND. 26 January, National Sunflower Association. Bismarck, ND, 10–11.

Miller,J.F., D.C.Zimmerman, B.A.Vick (1987) Genetic Control of High Oleic Acid Content in Sunflower Oil. Crop Sci., vol.27, 923–926.

Thomas,P.M., Z.P.Kondra (1973) Maternal Effect on the Oleic, Linoleic and Linolenic Acid Content of Rape Seed Oil. Can. J. Plant Sci., vol.53, 221–225.

Voskoboinik,L.K., P.I.Tkatchenko (1987) Nasledovanie sodergania oleinovoy kislota, v masle semjan gibridov podsolnechnika. NTB VNIIMK, vip.4, 7–10.

Yermanos,D.M., P.I.Knowles (1962) Fatty Acid Composition of the Oil in Crossed Seed of Flax. Crop Sci., vol.8, 109–111.

HERENCIA DE LA COMPOSICION DE ACTDOS GRASOS DEL ACEITE EN ALGUNAS LINEAS DE GIRASOL

RESUMEN

La herencia de la composición de ácidos grasos en la F_1 y sus descendencias F_2 son estudiadas. Se ha establecido que la calidad de aceite de las semillas F_1 es determinada conjuntamente por la acción del genotipo del embrion y del parental femenino, pero en diferentes combinaciones se observa un grado de expresión específico de esos factores. En semillas de las descendencias de la F_1, F_2 y RF_1 la acumulación de los diferentes ácidos grasos es determinada por el genotipo de la semilla y debido a esto la composición del aceite es idéntica.

En algunos de los cruces una dominancia parcial del alto contenido en linoleico, oleico y palmitico es observada. En todos los cruces el ácido esteárico expresa superdominancia hacia el parental de valores más altos.

HÉRITABILITÉ DE LA COMPOSITION EN ACIDES GRAS DE L'HUILE CHEZ QUELQUES LIGNÉES DE TOURNESOL.

RÉSUMÉ:

L'héritabilitéde la composition des graines en acides gras chez les F-1 et chez leurs descandences (F-2) a été étudiée. Il a été établi que la qualité de l'huile dans les graines de première génération est déterminée par l'action conjointe du gènome de l'embryon et du gènome du parent femelle mais dans les différentes combinaisons étudiées, l'expression de ces facteurs s'observe suivant divers degrés. Au sein de la descendance F-2 de la F-1, et dans les graines de RF-1 l'accumulation des différents acides gras est déterminée par le génome de la graine et de ce fait la composition en huile est identique. Dans certains des croisements une dominance partielle est observée pour les faibles et les fortes teneur en acides linoléiques, oléiques et palmitiques. Dans tous les croisements, la teneur en acide stéarique présente une super dominance par rapport à la plus forte valeur des parents.