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RELATIONSHIP OF INHERITANCE OF A HIGH PALMITIC MUTATION AND PLANT HEIGHT IN SUNFLOWER

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SUMMARY

Pleiotropic effect of a high pamitic (*p*) and high oleic (*Ol*) mutations in sunflower seed oil was investigated in VK580 near-isogenic lines in field conditions. It was found that the *p* mutation decreased plant height by 41 cm (32%), number of leaves by 4 (14%) and the period of emergence-flowering by 2 days (4%). The *Ol* mutation significantly increased plant height by 4 cm (3%).

In addition, relationship between inheritance of high palmitic mutation and plant height in the case of selfing of F_2 plants was observed in the cross VK850 (*p*) × VK508 (*Ol*). The correlation coefficient was r=-0.54 with linear equation y=154.49-1.95x. The average plant height of the high palmitic homozygotes in the segregated F_2 population was lower and estimated at 109 cm as compared with 138 cm in the other plants (LSD_{05}=3 cm). Thus, a negative effect of the high palmitic mutation on plant height was proved beyond doubt. A question remains whether this phenomenon relates to a gene linkage or true pleiotropy.

Key words: near-isogenic lines, sunflower, fatty acid, mutations

INTRODUCTION

Effect of sunflower mutants deviating in the fatty acid composition of seed oil on agronomic characters has been studied in several research programs.

The most important paper on this problem was dedicated to the performance of near-isogenic, high and low oleic hybrids of sunflower (Fernandez-Martinez *et al.*, 1993). The isogenic counterparts of four inbred lines, RHA271, RHA274, HA89 and HAJ152, showed no influence of the *Ol* mutation obtained by Soldatov (1976) on plant height, number of leaves, head diameter, days to flowering, self-compatibility and oil content in seeds. On the other hand, the *Ol* mutation had positive effects on seed yield, oil content and above-ground biomass and negative effects on the days to

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flowering, self-compatibility and seed germination. Agronomic trait × genetic background interaction was also observed (Fernandez-Martinez *et al.*, 1993).

A high palmitic mutation of the line 275 HP was obtained for the first time after γ-ray treatment of seeds of the OP variety Zarya (Ivanov *et al.*, 1988). No influence on other traits was reported for this mutation. The same observation was done with the high palmitic mutation of the line CAS-5 after seed irradiation with X-rays (Mancha *et al.*, 1994; Osorio *et al.*, 1995). Conversely, another high palmitic mutant, P-20, obtained by chemical mutagenesis after treatment of the seeds with ethylmethanesulfonate (EMS), failed to germinate in the M_3 generation indicating the existence of a lethal factor in the homozygote (Mancha *et al.*, 1994). In addition, a new high palmitic mutation was induced in sunflower using nitrosoethylurea (NEU) within a mutagenesis breeding program (Kyrychenko, 2002).

The inheritance of the high palmitic mutation in CAS-5 was controlled by one or three genes depending on the parents involved in the crosses (Perez-Vich *et al.*, 1999).

In the genetic research conducted at VNIIMK, Russia, the high palmitic genotypes failed to propagate three times. That happened in the M_3 generation, after treatment of the seeds of the OP variety Yubileiny 60 with NEU, in I_2 of K2222 and I_1 of N°429934 accessions in the VIR collection. Later, an inbred line of sunflower, LG30, with high level of palmitic acid in seed oil was developed when screening within a set of *cms*-lines from Ukrainian germplasm followed by crossing and selfing (Demurin, 2003; Efimenko *et al.*, 2005).

The present research has focused on the influence of both the high oleic and the high palmitic mutations of VNIIMK genetic collection on several morphological characters of the sunflower plants.

MATERIALS AND METHODS

The VK580 near-isogenic lines from the genetic collection of VNIIMK were involved in the research. VK580 is a normal restorer line. VK508 possesses a high oleic mutation (87%), VK850 a high palmitic mutation (24%) and VK805 a-double high oleic (65%) and a high palmitic (20%) mutations. The high palmitic mutation draws origin from the inbred line LG30.

Plants were grown and self-pollinated in an experiment field of VNIIMK, Krasnodar, in summers of 2007-2009, at the 70×35 cm population density. Seed emergence in field conditions of both high palmitic isogenic counterparts, VK850 and VK805, were quite low. At the V6 stage, plants were thinned to get optimum population density. Crossings were made following hand-emasculation.

Fatty acid composition of seed oil was determined by gas chromatography.

RESULTS AND DISCUSSION

Pleiotropic effect of the high pamitic (*p*) and high oleic (*Ol*) mutations in sunflower seed oil was observed in near-isogenic lines derived from VK580 genetic base. The observations were done under field conditions during three years (Table 1). It was found that the *p* mutation decreased plant height by 41 cm (32%), number of leaves by 4 (14%) and the period of emergence-flowering by 2 days (4%). The *Ol* mutation only caused a significant increase in plant height, by 4 cm (3%).

Table 1: Mean values and differences from standard genotype (st) of morphometric traits of sunflower isolines across three years.

Genotype	Plant height, cm		Period emergence-flowering, days		Number of leaves	
	mean	±st	mean	±st	mean	±st
VK580 (st)	127	0	54	0	28	0
VK508 *Ol*	131	+4*	54	0	29	+1
VK850 *p*	86	-41*	56	+2*	24	-4*
VK805 *Ol, p*	89	-38*	55	+1*	26	-2*

* - significant difference, $p < 0.05$

The high palmitic and oleic mutations were found to considerably influence plant height, their joint effect being responsible for 46% of the total trait variability (Table 2). Moreover, the influences of all factors, including genotype, year, and the genotype×year interaction, were significant for all characters. The factor of year affected the period of emergence-flowering and the number of leaves by 83 and 73%, respectively.

Table 2: Influence of the studied factors on the analysis of variance for the morphometric traits of VK580 isolines for three years.

Factor	Plant height	Period emergence-flowering	Number of leaves
Genotype	0.46	0.07	0.11
Year	0.43	0.83	0.73
Genotype × year	0.03	0.02	0.06
Error	0.08	0.08	0.10

In order to verify the negative effect of the high palmitic mutation on the plant height in the isolines, inheritance analysis was carried out (Figure 1).

The F_1 seed in the cross of two counterparts, VK508 × VK850, showed a normal low palmitic acid content to be a partial dominant trait with the dominance degree d=-0,4. The mean palmitic content values in the parents were 3 and 21%, respectively, whereas the F_1 seed showed the value of 9%.

The analysis of individual F_2 seeds indicated that the palmitic acid content clearly segregated in two phenotypic classes: the normal low and intermediate levels taken together (4-10%) and high palmitic level (17-19%). The distribution of 36:4 in the F_2 seeds fitted the ratio of 15:1, favoring the hypothesis that the high palmitic mutation was controled by two recessive genes ($\chi^2_{15:1}$=0.96, p>0.05). A portion of the F_2 seed was used to grow F_2 plants which were selfed to produce F_3 seeds.

The F_3 seed bulk from F_2 heads were expected to segregate in two phenotypic classes: the normal low and intermediate level taken together (4-17%) and high palmitic level (18-23%). The 173:15 distribution of the palmitic acid content in the F_2 heads also fitted the ratio of 15:1 ($\chi^2_{15:1}$=0.96, p>0.05).

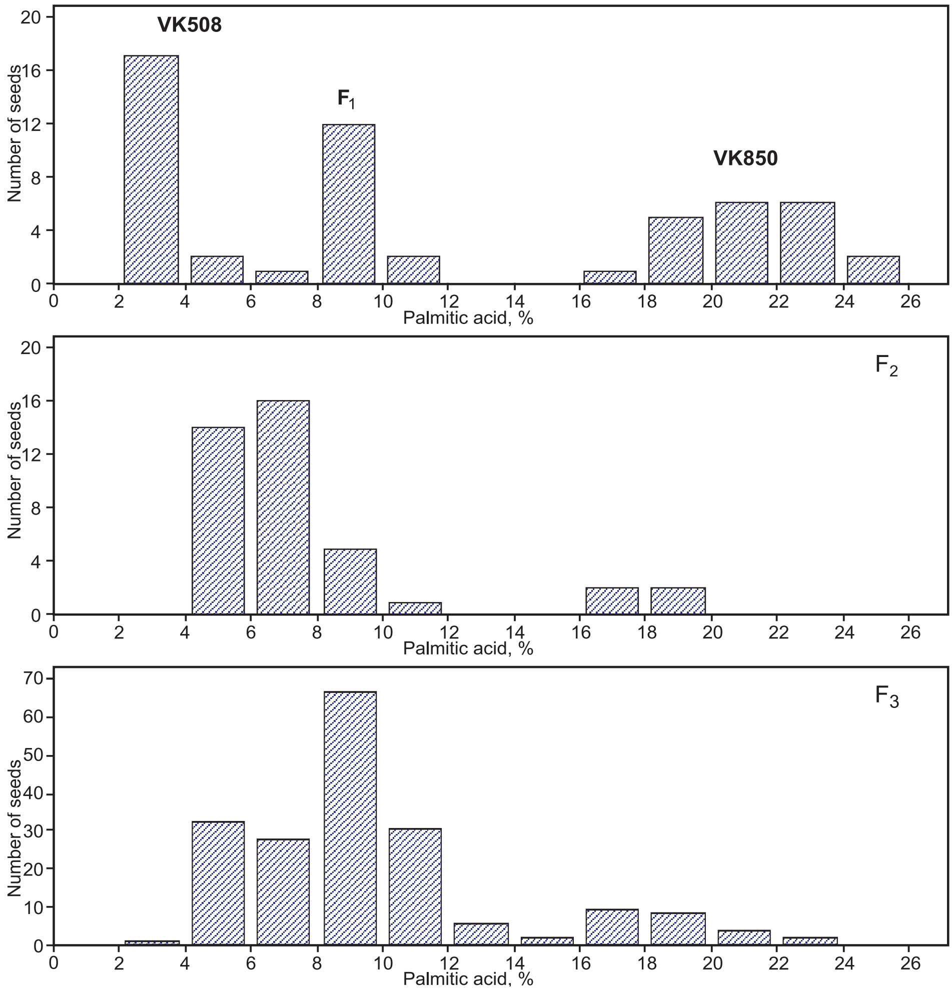

Figure 1: Frequency distributions of palmitic acid content in individual seeds of parents, F_1, F_2 and F_3 seed bulk (selfed heads of F_2 plants)

A relationship was observed between the inheritance of high palmitic mutation and plant height when selfing F_2 plants of the cross VK850 × VK508. The correlation coefficient between these traits was r=-0.54 with linear regression equation y=154.49-1.95x. An average plant height of the high palmitic homozygotes (15 plants) in the segregated F_2 population was estimated at 109 cm, which was significantly below the 138 cm for the other 173 plants (LSD_{05}=3 cm). The difference between the two heights of F_2 plants, which amounted to 29 cm, corresponded to the height differences among the parents.

CONCLUSIONS

The negative effect of the high palmitic mutation on plant height was proved beyond doubt with both near-isogenic lines and by the inheritance analysis. The question remains whether this phenomenon relates to a gene linkage or true pleiotropy. In the case of co-segregation, it should be clarified which gene that controls the palmitic acid content is linked with genes that control plant height.

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