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INHERITANCE OF CHLOROPHYLL DEFICIENCY IN SUNFLOWER

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SUMMARY

The observations in this paper indicate that a new chlorophyll-deficient mutation has been found in sunflower. The mutant is characterized by having a lutescens-like phenotype during the early stages. However, in later stages, the plants have a light green color and they not only reach the reproductive stage, but also give a normal seed set. The objective of this paper was to determine the mode of inheritance of this new chlorophyll-deficient mutation.

Different crosses were made between normal and mutant plants to obtain the F_1, F_2 and BC_1F_1 generations. The ratio of the observed phenotypes in the different segregating progenies investigated were chi-square tested for goodness of fit and heterogeneity.

All these results suggest that this new chlorophyll-deficient mutation is controlled by a recessive nuclear gene. The symbol **lgr-1** (*light green-1*) is proposed to designate this recessive allele.

Key words: ***Helianthus annuus*, chlorophyll-deficiency, inheritance, recessive gene, sunflower**

INTRODUCTION

Chlorophyll-deficient mutant plants can contribute to understanding the functioning of their photosynthetic apparatus as well as their genetic control. In sunflower, *Helianthus annuus* L., different chlorotic mutants are known (Leclercq, 1968; Mihaljčević, 1992a, 1992b; Joshi and Giriraj, 1995; Fambrini and Pugliesi, 1996), some of which have been induced after treatment with mutagenic agents, while others have appeared spontaneously.

According to the type of chlorosis shown by plants, mutants have been classified as: albino (white seedlings, with no chlorophyll), xanta (yellowish seedlings, very little or no chlorophyll), lutescens (yellowish seedlings, green cotyledons), chlorina-apicalis (yellowish cotyledons, first leaves green and the following ones yellow-

ish), and virescent (leaves have stripes with no chlorophyll) (Vrânceanu, 1977; Fambrini and Pugliesi, 1996). In all instances in which seedlings are yellowish or albino, the mutants have severe limitations to complete their life cycle. They never, or hardly ever, reach the reproductive stage.

Most of the genetic studies conducted with these materials have shown that different recessive genes control the expression of the chlorotic mutants in each case (Leclercq, 1968; Škaloud and Kovačik, 1978; Mihaljčević, 1992a; Fambrini and Pugliesi, 1996). Mihaljčević (1992b) also showed that cytoplasmic genes influenced the expression of chlorophyll-deficient plants in sunflower.

The results obtained in this research indicate that a new chlorophyll-deficient mutant has been found in sunflower. It is characterized by having a lutescens-like phenotype during the early stages (Figure 1). However, in later stages, the plants acquire a light green colour and they not only reach the reproductive stage (Figure 2), but also give normal seed set.

The aim of this work was to determine the mode of inheritance of this new chlorophyll-deficient mutation.

MATERIAL AND METHODS

The material used in the present study was a population of plants of Yugoslav origin obtained from the Iowa Germplasm Bank of Ames (USA), and identified under the code number PI 471077. This population was segregating for dwarfness genes. In 1992 an inbreeding program was initiated to obtain dwarf inbred lines. The chlorophyll-deficient mutants appeared after selfing some plants of the original population.

To determine the mode of inheritance of this new character, different crosses were made between normal and mutant plants to obtain the F_1, F_2 and BC_1F_1 generations. The ratio of the observed phenotypes in the different segregating progenies investigated were chi-square tested for goodness of fit and heterogeneity.

RESULTS AND DISCUSSION

Mutant plants always produced mutant progenies after self-pollination.

When six normal plants were self-pollinated, different results were obtained: one normal plant produced twelve normal individuals and four mutants, while the other five only gave normal plants.

Three ***normal x mutant*** genotypic combinations (crosses) produced two normal uniform F_1 progenies and one segregating F_1 progeny (50% normal : 50% mutant). Five ***mutant x normal*** genotypic combinations (crosses) produced three normal uniform F_1s and two segregating F_1 progenies (50% normal : 50% mutant). These reciprocal crosses did not show any difference in all the progenies studied.

*Figure 1: Phenotype of chlorophyll-deficient seedlings of sunflower at different stages. Mutant seedlings have green cotyledons **(a)** and yellowish leaves **(a, b)***

Figure 2: Sunflower plants showing the light-green (left) and normal (right) phenotypes

According to these results, it can be deduced that the chlorophyll deficiency detected in PI 471077 has a recessive character which is not controlled by cytoplasmic factors.

Table 1: Number of normal and mutant plants obtained in the F_2 generation and chi-square analysis

Cross	Family #	F_2 generation		
		Normal	Mutant	chi-square value (3:1)(*)
Normal x mutant	1	16	2	1.85 NS
Mutant x normal	1	48	19	0.40 NS
	2	37	10	0.35 NS
	3	19	5	0.22 NS
Pooled		104	34	0.97 NS
Heterogeneity				0.006 NS

* $\chi^2_{(0.05;\ 1DF)} = 3.84$, NS= not significant

Table 2: Number of normal and mutant plants obtained in BC_1F_1 generation and chi-square analysis

Cross	Family #	BC_1F_1 generation		
		Normal	Mutant	chi-square value (1:1)(*)
Mutant x (mutant x normal)	1	18	28	2.17 NS
(Normal x mutant) x mutant	1	33	38	0.35 NS
(Mutant x normal) x mutant	1	17	22	0.64 NS
	2	9	10	0.05 NS
	3	47	35	1.75 NS
Pooled		73	67	2.44 NS
Heterogeneity				0.25 NS

* $\chi^2_{(0.05;\ 1DF)} = 3.84$, NS= not significant

The results obtained in the F_2 and BC_1F_1 generations are presented in Tables 1 and 2, respectively. Based on the number of normal and mutant plants recorded in these segregating progenies, the genetic hypothesis considering the segregation of one recessive gene was proposed and was tested by the chi-square analysis. The results of these analyses indicated a good fit to 3:1 (F_2) and 1:1 (BC_1F_1) ratio of normal : mutant plants. The chi-square of heterogeneity was not significant in both analyses; therefore, the three F_2 populations on the one hand and the three BC_1F_1 families on the other were analyzed together. The combined chi-square analysis also showed a good fit to the 3:1 and 1:1 phenotypic ratio of normal : mutant plants.

CONCLUSIONS

All these results suggest that this new chlorophyll-deficient mutation is controlled by a recessive nuclear gene. The symbol **lgr-1** (*light green-1*) is proposed to designate this recessive allele.

Given that the mutant plants identified in this research are capable of producing seed, they could be of use in studying the source-sink relationship.

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HERENCIA DE UNA DEFICIENCIA DE CLOROFILA EN EL GIRASOL

RESUME

Las observaciones del presente trabajo indican que se ha encontrado un nuevo mutante de girasol. En los primeros estadios, las plántulas presentan el tipo "lutescente", pero en estadios posteriores, las plantas presentan un color verde claro y alcanzan luego el estado reproductivo, produciendo semillas. El objetivo de este trabajo fue conocer el modo de herencia de este carácter. Se realizaron cruzamientos recíprocos entre plantas mutantes y normales y además, se autofecundaron plantas de ambos fenotipos. Algunas plantas F_1 normales, provenientes del cruzamiento entre plantas normales y mutantes, fueron cruzadas con mutantes para obtener semillas BC_1 F_1 y otras fueron autofecundadas con el fin de producir semillas F_2. Las proporciones de los fenotipos encontradas en las progenies se ajustaron a un modelo de segregación de un gen nuclear, donde el carácter mutante es recesivo. Se propone el símbolo **lgr-1** para el alelo que controla este carácter.

HÉRÉDITÉ D' UNE DÉFICIENCE CHLOROPHYLLIÈNNE CHEZ LE TOURNESOL

RESUME

Un nouveau mutant de tournesol a été trouvé. Dans les premiers stades, les plantules presentent le type "lutescens", mais après, les plantes deviennent verte claire et arrivent jusqu'au stade reproductive. L'objectif poursuivis dans notre étude était de connaître la hérédité de ce caractère. On a fait des croisements réciproques entre plantes mutantes et normales et en plus, des autofécondations de deux phénotypes. Quelques plantes F_1 normales, qui proviennent du croisement entre plantes normales et mutantes, ont été croisées avec des plantes mutantes pour obtenir semences BC_1F_1 et des autres ont été autofécondées pour produire des semences F_2. Les proportions des phénotypes trouvés dans des descendances a ajusté un modèle de segrégation d' un gène nucléaire, où le caractère mutant est récessif. Le symbole **lgr-1** est proposé pour l'allèle qui contrôle ce caractère.