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GAMETOCIDAL EFFECT OF GIBBERELLIC ACID (GA_3) ON BIOCHEMICAL CHARACTERISTICS OF SUNFLOWER SEEDS

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SUMMARY

Prior to a treatment with GA_3, biochemical characteristics of seed were analyzed in the sterile plants which were subsequently pollinated with pollen of the same line. It was found that the 1000-seed weight was reduced in the treated plants, while the kernel quantity remained unchanged. The kernel oil content and the protein quantity changed in dependence of genotype and vegetation conditions. The fatty acid composition of oil was also changed. It was concluded that the biochemical characteristics of F1 hybrid seeds produced after the sterilization of female plants with GA_3 are not satisfactory. Similar investigations will be conducted on the later generations.

Key words: Sunflower seeds, gibberelic acid, biochemical characteristes.

INTRODUCTION

Numerous literature sources point out advantages of gibberellic acid over the other gametocides (Shuster, 1963; Popov et al., 1965; Spirova, 1969; Anaschenko, 1967, 1968). These studies claimed that in addition to the complete or partial degradation of pollen, the treatment of inflorescences with GA_3 induces typical morphological changes as acceleration of the growth and flowering by several days, elongation of the stem, etc. We could not find reference on the effect of GA_3 on the biochemical characteristics of the treates seeds.

The objective of this paper was to analyze the quality of sunflower seeds after the application of GA_3 for castration of the plants.

MATERIAL AND METHODS

Three lines differing in the fatty acid composition of oil and a line with a high protein content were studied using an aqueous solution of GA_3 at the concentration of 33 mg/l. Plants were sprayed individually when the size of the flower bud was 1.0-1.5 cm in diameter. A half of the experimental plants were treated and the other half were used as a check. The plants were treated in the morning, between 8 and 10 AM, three times at two-day intervals. When ray flowers emerged on the heads, all plants were isolated by a semi-parchment isolator to prevent uncontrolled pollination. During anthesis, pollen was collected from the fertile check plants, separately for each line, and applied three times onto the heads of the corresponding sterile plants, following the dynamics of flowering of the floret zones of the head. All heads were harvested and analyzed separately.

To verify the hereditary character of the changes of the characteristics under observation, a portion of the seeds produced by the treated plants was resown in 1984. The resulting plants were isolated, self-pollinated, and harvested individually.

The contents of oil and protein in the kernel were analyzed according to the methods of Rushkovski and Kjeldahl, respectively (Pleshkov, 1976), the fatty acid composition was analyzed gas chomatographically. The statistical calculations were done according to Snedecor (1961).

RESULTS

The procedure of GA_3 application used in this experiment led to a complete pollen sterility in the florets of the treated heads.

The 1000-seed weight (Table 1) was reduced in the treated plants, in comparison with the check plants, while the kernel size was equal in both groups. The genotypes studied expressed a specific response to the treatment relative their oil content in the kernel. It was reduced in the lines 1418HL and 275HP and it remained unchanged in the other two lines, Pc 4HO and 1642HPr. The data for the protein content in the kernel varied slightly during the two years of study, but the variation was statistically proved in two cases (Pc 4HO and 275HP). In the treated plants, the content of linoleic acid in oil decreased significantly in relation to that in the check, while the content of oleic acid exhibited a reverse tendency. The two-year average increases of oleic acid in 1418HL, Pc4HO, and the high-protein line 1642HPr were 4.7%, 7.3%, and 7.0%, respectively. The data for the saturated fatty acids (stearic and palmitic) did not show statistically significant differences.

Table 1. Efect of GA_3 treatment on some morphological and chemical characteristics of sunflower seeds (the harvest 1982-1983)

Characteristic	1418HL		Pc4HO		275HP		1642HPr	
	C	GA_3	C	GA3	C	GA_3	C	GA_3
1000 seeds weight, g	50.8	39.7^{-c}	63.9	48.0^{-c}	73.2	57.2^{-c}	62.9	47.9^{-c}
Kernel, %	77.3	76.6	79.8	76.7	76.7	76.0	83.4	84.8^{+c}
Oil in the kernel, %	47.6	44.7^{-b}	50.3	49.9	43.9	42.7^{-a}	40.9	41.2
Protein in the kernel, %	31.4	31.0	32.4	31.5^{-a}	30.9	29.7^{-a}	38.5	38.1
Linoleic acid, %	73.5	66.3^{-c}	23.6	16.7^{-c}	55.8	53.9^{-a}	64.2	56.9^{-c}
Oleic acid, %	17.1	21.8^{+c}	68.7	76.0^{+c}	9.1	8.5^{-a}	24.4	31.4^{+c}
Stearic acid,%	2.8	4.3^{+a}	4.0	3.9	2.0	2.1	5.7	6.4
Palmitoleic acid, %	-	-	-	-	4.6	4.9	-	-
Palmitic acid, %	6.6	7.6^{+a}	3.7	3.4	28.5	30.6	5.7	5.3
	C- control GA_3- Plants treated by GA_3							

Not a single biochemical characteristic of the seeds from the 1984 harvest (Table 2) showed a statistical difference for any of the genotypes under study.

Table 2. Variance analysis for the characteristics studied in 1982-1983

Characteristic	Factor A	Factor B	Factor C	A x B	A x C	B x C	A x B x C
1000 seeds weight, g	3828.51^{c}	961.28c	1411.87^{c}	55.68	202.36^{a}	692.13^{c}	22.46
Kernel, %	8.92	142.70^{c}	3.65	1.72	4.36	342.78^{c}	0.67
Oil in the kernel, %	22.56	227.33^{c}	549.90^{c}	3.34	34.22	43.17^{c}	3.06
Protein in the kernel, %	0.36	229.00^{c}	269.78^{c}	0.82	1.05	19.61^{c}	0.69
Linoleic acid, %	859.08^{c}	5824.16^{c}	342.40	74.48	42.15	288.86^{c}	18.34
Oleic acid, %	114.22^{b}	6231.01^{c}	2747.06^{c}	58.74^{b}	43.74	2591.36^{c}	49.67^{a}
Stearic acid,%	3.37^{b}	27.50^{c}	34.37^{c}	2.09^{b}	5.58^{b}	1.08	1.50^{a}
Palmitic acid, %	16.29^{a}	2770.18^{c}	16.30^{a}	17.84^{a}	87.52^{c}	107.11^{c}	0.52

Factor A - GA_3 treatment
B - Genotype
C - Meteorogical conditions

DISCUSSION

The 1000-seed weight is an important economic index which expresses the quantity of dry matter accumulated and which determines the quantity of yield obtained. Regarding its importance in the seed for sowing, this characteristic ensures their rapid and uniform emergence. In this study, GA_3 affected the process of dry matter accumulation negatively since the values of this index were reduced. According to Spirova (1975), the 1000-seed weight of plants treated with GA_3 changes in different directions in dependence of genotype. Depending on the line used, it may be reduced, increased, or may remain unchanged.

The oil content was reduced in the treated plants, but it was unchanged in two check lines. The protein content was reduced in two treated lines. These observations seem to indicate a reduction in the accumulation of reserve matter in the treated seeds. It appears worthwhile to mention that the protein contents in the treated and untreated seeds of the high- protein line 1642HPr were identical.

The variation of the fatty acid composition in oil went in the direction of higher oil saturation in the seeds of the treated plants.

As it is supposed that the studied factors A (GA_3 treatment), B (genotype), and C (meteorological conditions during vegetation period) are mutually interactive and interdependent, an attempt was made to reveal these relationships (Table 3). The direct effect of the three factors on the 1000-seed weight was found to be statististically significant. Interactions existed between factors A x C and B x C. The kernel quantity depended only on the genotype. An important conclusion was drawn, namely, that the changes observed in the oil and proteins accumulated in the kernel, on average for the two years of study, 1982 and 1983, were not due to the effect of GA_3. The dependence of 1000-seed weight and kernel quantity on the genotype and the meteorological conditions during vegetation was found to be positive, as well as the interaction between these two indices. The results for the fatty acid composition of oil indicated that it is determined by the genotype and affected by the meteorological conditions during vegetation and by the influence of GA_3.

Table 3. Morphological and chemical characteristics of seeds produced from the genotypes treated bu GA_3 in the previous generation (the harvest 1984)

Characteristic	1418HL		Pc4HO		275HP	
	C	GA_3	C	GA3	C	GA3
1000 seeds weight, g	53.0	52.0	66.0	63.4	69.2	67.3
Kernel, %	76.7	76.2	66.6	67.3	80.1	79.8
Oil in the kernel, %	51.3	49.8	51.1	49.9	43.1	41.8
Protein in the kernel, %	28.3	29.1	31.8	32.7	31.1	31.9
Linoleic acid, %	73.9	73.1	13.4	13.8	53.0	52.4
Oleic acid, %	17.0	17.6	78.0	76.8	10.8	11.2
Stearic acid,%	3.4	3.0	3.7	5.6	3.9	3.7
Palmitoleic acid, %	-	-	-	-	3.3	2.8
Palmitic acid, %	5.8	6.3	3.1	3.4	39.0	30.0

C - control
GA_3 - Seeds from plants previously treated by GA_3

The study showed that sunflower emasculation by GA_3 can be used as an alternative method for the mechanical separation of anthers in the production of hybrid seed. It can be successfully applied in wide hybridization and for the hybridization analysis in lines of cultivated sunflower, for the study of combining ability. However, it seems that the GA3 sterilization of female plants affects the biochemical characteristics of hybrid seed. This problem will be studied in subsequent generations.

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INFLUENCIA DEL EFECTO GAMETOFITICO DEL ACIDO GIBERELICO (GA_3) SOBRE LAS CARACTERISTICAS BIOQUIMICAS DE LAS SEMILLAS DE GIRASOL

RESUMEN

Las características bioquímicas de las semillas de plantas tratadas con GA_3 se estudió polinizando plantas estériles con polen de plantas fértiles de la misma línea. Se encontró que el peso de 1000 semillas se redujo en plantas tratadas mientras que no hubo cambios en la cantidad de almendra. El contenido de aceite de la almendra y la cantidad de proteina cambió dependiendo del genotipo de las líneas y condiciones de vegetación. La composición de ácidos grasos del aceite cambió también. Se concluyó que las características bioquímicas de las semillas del híbrido producida después de la esterilización de las plantas madre por GA_3 no son recomendables. Tales investigaciones tienen que ser emprendidas en generaciones posteriores.

INFLUENCE DE TRAITEMENT À L'ACIDE GIBBÉRELIQUE (GA_3) SUR LES CARACTÉRISTIQUES BIOCHIMIQUES DE SEMENCES DE TOURNESOL

RESUMÉ

Les caractéristiques biochimiques des graines produites par des plantes traitées à l'acide gibbérélique (GA_3) sont étudiées à partir de plantes stérilisées et pollinisées par le pollen de plantes fertiles du même génotype. Il est trouvé que le poids de 1000 graines est réduit, sans qu'il y ait modification de la quantité de graines. La teneur en huile des graines et la quantité de protéine varie différemment selon le génotype des lignées et les conditions de végétation. La composition en acides gras est également modifiée. On en tire la conclusion que les caractéristiques biochimiques des semences hybrides produites après stérilisation des plantes mères par GA_3 n'est pas recommandé. Des recherches analogues doivent être enterprises sur les générations utitérieures.