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USE OF GAMMA RAYS TO INDUCE POWDERY-MILDEW RESISTANT MUTANTS IN FLAX

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ABSTRACT

This work was carried out to induce powdery-mildew resistant mutants in flax with the desirable agronomic traits by using gamma rays The relative resistance of 19 flax genotypes to powdery mildew was evaluated under both field and greenhouse conditions. Some of the genotypes showed almost the same performance in greenhouse and field tests, which may indicate that their performance was stable and insensitive to changes in environmental conditions. Dry seeds of the powdery-mildew highly susceptible flax cultivar Sakha-1 were exposed to the following doses of gamma rays: 0, 200, 300, 400, 500, 600, and 700 Gray (Gy). Powdery-mildew resistant single plants (0-5% disease severity) were selected and individually harvested at M_1 generation. Disease severity was also recorded for M_2 lines to determine resistant ones. Of the powdery-mildew resistant lines, 40 showed stable performances over two successive growing seasons, and these were selected for further study. From M_2 pooled resistant population, the best performing 50 plants, in terms of yield and yield components, were selected based on a selection index.

Key words: ***Flax, Mutation, Gamma ray, Irradiation, Powdery mildew, Selection index.***

INTRODUCTION

Powdery mildew of flax is caused by *Oidium lini* Skoric. The Fungus attacks all aboveground parts of flax cultivar. In Egypt, it occurs wherever flax is cultivated when moisture condition and temperature are favorable. Early infections may cause severe defoliation of the flax plant and reduce yield and quality. The symptoms are characterized by a white powdery mass of mycelia that starts as small spots and rapidly spreads to cover the entire leaf surface. Currently, this disease is considered the most common, conspicuous, widespread, and easily recognized foliar disease of flax (Mansour *et al* 1999). Resistance is not available in commercially grown flax cultivars. Therefore, in years when environmental conditions favor the development of the disease, foliar application of fungicides has become the only commercially available management practice for the disease (Aly *et al* 1994). However, complete dependence on fungicides for the disease control carries risks for the producers, in that accurate coverage and distribution of fungicides may not be achieved and there are potential problems with correct timing of applications. Furthermore, increasing concern for the environment will likely mean greater regulation of fungicide usage (Pearce *et al.* 1996). Use of cultivars with Powdery mildew resistance can resolve all these problems. Therefore there is a need to improve powdery mildew resistant flax cultivars.

Genetic variation for powdery mildew resistance has been identified in some flax experimental genotypes (Aly *et al* 2001). Powdery mildew resistance in flax is controlled by major genes affected by some modifiers (Islam 1992 and Ashry *et al* 2002). The conventional method for developing powdery mildew-resistant cultivars is to cross between resistant genotypes and the commercial cultivars. However, this method is laborious and time consuming.

Mutation breeding is one of the methods that can be used for improving field crops when it is accompanied with careful selection through successive generations. Gamma irradiation was previously used to induce some useful mutants in relation to yield and yield components in flax (Baker *et al* 1984, Lateef and Nizam 1985, Abo-Hegazi 1990, Amer *et al* 1993 and 1994). Induced mutations for disease resistance, was efficiently used in wheat (Dyck *et al* 1993), in mungbean (Surjeet *et al* 1991) and in peanut (Venkatachalan and Jayobalan 1997).

The use of discriminate function for plant selection was first proposed by Smith (1936). He suggested that a better way of exploiting genetic correlation with several traits having high heritability is to construct an index, called selection index, which combines information on all the characters associated with the dependant variables. Selection index involves a selection criterion based on a combination of measurements on various characters. The best known selection indices involve discriminate function based on the relative economic importance of the various characters. This technique provides information on yield components and thus aids in indirect selection for the improvement of yield. The desirable genotypes are discriminated from the undesirable ones, based on the combinations of various characters. Hazel (1943) developed a simultaneous selection model based on the approach of path analysis. The estimation of selection index is based on the estimates of genotypic and phenotypic variances and covariances of the characters involved in the index (Singh 2004).

In the present study, gamma rays were used to induce powdery-mildew resistant mutants in the commercial variety Sakha-1 with the desirable agronomic traits.

MATERIALS AND METHODS

Greenhouse evaluation for powdery mildew resistance

Seeds of 19 flax genotypes (Table1) were planted on 15 November 2001 in a natural soil dispended in 25-cm diameter clay pots (25-seeds/pot). The pots were distributed on greenhouse benches in a randomized complete block design of three replicates. Powdery mildew (PM) was allowed to develop naturally. Disease incidence (DI) and disease severity (DS) were rated visually on 25 April 2002 according to (Nutter *et al* 1991). DI was measured as percentage of infected plants/pot. DS was measured as percentage of infected leaves/plant in a random sample of ten plants.

Field evaluation for PM resistance

An experiment was conducted at Giza Agricultural Research Station consisted of a randomized complete block design of three replicates. Plots were 2x3 meters ($6m^2$) and consisted of ten rows spaced 20-cm apart. Seeds of each of the 19 flax genotypes were sown by hand at a rate of 70 gm/plot. Planting date was 10 November 2001. DI and DS were measured as previously mentioned in greenhouse evaluation.

Induction of flax mutants and their evaluation for PM resistance

The recently released flax commercial variety Sakha-1; was used to induce mutant lines. Dry seeds were exposed to gamma rays doses; Zero, 200, 300, 400, 500, 600 and 700 (Gray) GY emitted from cobalt-60 (Co^{60}) at the National Center for Research and Irradiation technology. Six hundred twenty five seeds for each dose were planted in natural soil dispended in 25-cm diameter clay pots (25-seeds/pot). The pots were distributed randomly outdoors. PM was allowed to develop naturally. DS was recorded on each single plant at M_1 generation. Fifty-four highly resistant single plants were selected and individually harvested. DS on these plants ranged from 0-5%. M_2 seeds for each selected plant were separately sown in the successive season. DS was also recorded for M_2 lines. The highly resistant M_2 lines were considered stable mutants for PM resistance and kept for evaluating their agronomic traits. The other M_2 lines, which showed DS>5% were considered susceptible, hence, they were excluded.

Yield and yield components were recorded for each of the stable mutants. The yield components/plant included; mean plant height (PH), mean technical stem length (TSL), mean fruiting zone length (FZ), no. of basal branches/plant (BB), no. of capsules/plant (no. C), seed yield/plant (SY), seed index (SI) and straw yield/plant (St. Y).

Statistical analysis

Arithmetic mean, standard error and LSD value for the studied traits were calculated. Multiple linear regressions was estimated and used to deduce the selection index based on eight agronomic traits according to the following formula:

$$I= a + b_1x_2 + b_2x_2 + b_3x_3 + b_4x_4 + \ldots\ldots + b_nx_n$$

Where:

a= intercept

b= regression coefficient (slope)

x= the estimated character for a genotype.

Selection index was used to select the family and individuals that exhibited the best performance among studied mutant lines.

RESULTS AND DISCUSSION

Reaction of the 19 flax genotypes to PM

The relative resistance of 19 flax genotypes to PM was evaluated under both field and greenhouse conditions. The precision of field evaluation for genetic resistance is adversely affected by environmental variation and heterogeneous levels of natural inoculation. In addition, field evaluation is expensive. Thus, screening of genotypes for disease resistance under greenhouse conditions would overcome these difficulties and improve the selection process. Therefore, the tested genotypes were screened for PM resistance under both greenhouse and field conditions. Natural conditions and levels of inoculation of both tests resulted in high levels of flax PM, and all the 19 genotypes under evaluation were symptomatic (Table 1). Some of the tested genotypes showed inconsistent performance from one test to another, which may indicate the occurrence of genotype X environment interaction. For example, Istru and Daniela tended to be less susceptible under greenhouse conditions, while, genotype 2465/113 showed higher susceptibility in the greenhouse test.

Table 1. Disease ratings for 19 flax genotypes under greenhouse and field condition (2001/2002).

Genotype	Greenhouse		Field	
	Disease incidence	Disease severity	Disease incidence	Disease severity
Alba	98.33	94.49	90.67	84.58
Ariana	99.00	95.44	--	--
Blinka	93.33	89.18	--	--
Bombay	47.67	81.29	76.00	45.53
Jitka	95.33	93.97	86.67	77.33
Midian	59.67	61.16	--	--
Gentiana	89.00	89.14	--	--
Istru	60.00	44.34	82.67	83.94
Daniela	62.33	39.82	85.33	86.50
Texa	100.00	99.51	--	--
Vaiking	86.67	92.65	88.00	75.35
Wiera	82.33	86.48	--	--
2465/113	100.00	100.00	85.33	87.17
282/189/16	75.33	88.50	86.67	90.42
Jawhar	80.00	92.07	88.00	62.54
Sakha-1	89.00	93.40	80.00	86.82
Sakha-2	99.33	98.68	87.33	80.80
Giza-7	98.33	93.65	84.00	87.26
Giza-8	98.67	98.11	92.00	93.48
LSD ($P \leq 0.05$)	15.14	16.02	N.S	24.47
LSD ($P \leq 0.01$)	20.26	21.44	N.S	33.16

On the other hand, some of the genotypes showed almost the same performance in greenhouse and field tests, which may indicate that their performance was stable and insensitive to changes in environmental conditions. Sakha-1 was highly susceptible in both greenhouse and field tests. Therefore, this cultivar was a good candidate to test the possibility of inducing PM-resistant mutations from a susceptible cultivar

Induction of resistance from a susceptible variety

Fifty four plants were selected in M_2 from 4375 tested plants. Of the 54 PM-resistant mutants, forty (70.07%) mutants were stable -that is, they maintained the same level of high resistance in both seasons (Table2).

Table 2. List of the selected flax mutants and their disease assessments over two successive seasons.

Genotypes	Seasons		Genotypes	Seasons	
	2002-2003	2003-2004		2002-2003	2003-2004
Sakh1	S	S	2/40	R	R
			3/40	R	R
1/20	R	R	4/40	R	R
2/20	R	R	5/40	R	R
3/20	R	R	6/40	R	R
4/20	R	R	7/40	R	R
5/20	R	S	8/40	R	S
6/20	R	R	9/40	R	S
7/20	R	R			
8/20	R	R	1/50	R	R
			2/50	R	S
1/30	R	R	3/50	R	R
2/30	R	R	4/50	R	S
3/30	R	R	5/50	R	R
4/30	R	R	6/50	R	R
5/30	R	R	7/50	R	R
6/30	R	R	8/50	R	R
7/20	R	R	9/50	R	S
8/20	R	R			
9/30	R	S	1/60	R	R
10/30	R	S	2/60	R	S
11/30	R	S	3/60	R	R
12/30	R	R			
13/30	R	R	1/70	R	R
14/30	R	R	2/70	R	S
15/30	R	R	3/70	R	S
16/30	R	R	4/70	R	S
17/30	R	R	5/70	R	R
18/30	R	R			
			6/70	R	S
1/40	R	R	7/70	R	R

Different yield related traits were measured for each of the forty resistant M_2 lines. Mean values for different yield component traits are presented in Table (3). Significant differences were observed among the studied mutant lines for all studied traits except fruiting zone length. Estimated mean value for plant height/plant exhibited significant differences among mutant lines and varied from 64.60 cm for mutant no. 27 to 43.60 cm for mutant 35. Some mutants were superior to the parental line, Sakha-1 but with non significant difference. The same behavior was observed for technical stem length, seed yield/plant, seed index and straw yield/plant. On the other hand, number of capsules/plant and number of basal branches/plant showed significant differences among the forty studied mutants.

Table 3. Means of the studied agronomic traits for 40 family produced by gamma irradiation (M_2 generation).

Gamma ray doses	Families	Trait								Selection index	
		P.H.	T.L.	F.Z.L	no.C	B.B.	S.Y.	S.I.	St.Y	index	rank
control	Sakha-1	51.30	45.20	6.10	3.00	1.00	1.41	6.75	2.07	98.75	2
200Gy	1	51.50	44.50	7.00	17.40	1.40	1.75	6.37	2.10	96.82	3
	2	56.20	46.40	8.50	5.80	1.00	2.01	6.34	1.93	87.30	4
	3	53.10	46.20	13.30	1.50	2.50	1.71	5.50	1.38	57.84	11
	4	45.30	39.20	6.10	4.10	1.10	1.50	6.40	1.30	53.26	13
	5	50.90	40.20	8.40	5.10	1.90	2.10	6.50	1.47	52.39	14
	6	52.90	42.20	10.20	9.60	1.90	1.32	5.66	1.64	69.27	9
	7	49.00	44.4	4.70	1.80	1.00	0.82	6.45	0.57	38.32	29
	8	52.20	45.60	5.80	5.10	1.70	1.45	6.65	0.70	41.97	28
	9	47.00	41.60	6.60	5.10	3.30	1.41	7.08	0.48	37.28	32
300Gy	10	57.10	48.00	9.10	3.10	2.20	1.12	6.56	0.57	50.90	17
	11	46.80	40.10	6.70	4.20	2.00	1.44	5.47	0.44	32.44	35
	12	50.20	50.20	13.20	2.00	2.10	0.22	4.75	0.70	75.56	5
	13	50.20	50.20	7.50	4.00	2.00	1.61	4.51	0.67	50.91	16
	14	48.00	48.00	10.20	3.20	2.10	1.32	7.35	0.59	51.44	15
	15	47.00	47.0	9.70	3.20	2.70	1.08	7.43	0.69	23.19	38
	1	52.80	52.80	6.60	2.20	2.00	0.56	3.48	0.74	70.15	8
	17	50.40	50.40	7.20	2.80	2.00	1.09	7.11	0.64	53.75	12
	18	60.80	55.40	5.80	2.90	2.00	1.14	5.29	0.72	99.42	1
	19	53.50	45.70	8.20	4.10	2.30	6.33	4.33	0.59	47.35	23
	20	45.00	37.50	8.40	6.30	2.50	1.74	6.30	0.49	31.94	36
	21	52.10	45.10	6.70	3.90	3.10	1.17	8.02	0.52	50.36	19
	22	59.60	52.20	7.301	4.80	2.509	0.92	5.75	0.57	48.64	21
400Gy	23	50.50	42.00	8.60	5.90	2.60	1.81	5.38	0.58	15.07	39
	24	59.20	42.70	14.40	6.70	2.30	1.69	5.80	0.59	48.41	22
	25	51.50	44.30	10.80	7.70	2.30	3.02	7.06	0.53	45.79	24
	26	64.40	53.50	10.90	4.40	2.60	1.69	8.20	1.01	70.65	7
	27	61.80	52.10	8.70	6.90	2.10	2.32	7.10	1.04	61.31	10
	28	57.50	52.60	4.90	1.10	2.80	0.24	2.09	0.93	72.10	6
	29	46.00	39.90	6.10	5.00	2.90	1.27	5.12	0.56	37.68	31
500Gy	30	44.50	35.00	9.50	4.80	1.60	1.42	7.23	0.68	9.94	40
	31	53.40	45.10	8.30	5.20	1.80	1.15	6.08	0.66	42.28	27
	32	56.10	46.60	8.40	3.40	1.30	1.63	6.11	0.64	44.56	25
	33	51.20	35.70	15.10	6.80	1.60	2.00	6.88	0.40	34.53	34
	34	43.60	35.80	7.80	4.90	1.30	1.15	7.25	0.30	26.03	37
600Gy	35	49.00	42.30	6.70	4.80	1.50	1.64	6.40	0.30	6.51	41
	36	55.60	46.50	9.10	3.108	1.10	1.00	3.75	0.58	43.07	26
	37	54.30	40.30	13.90	7.20	1.00	1.99	6.51	0.51	37.96	30
700Gy	38	55.29	41.42	12.12	9.76	2.20	1.69	6.16	0.49	48.84	20
	39	55.89	44.78	6.11	4.89	2.67	1.20	7.55	0.53	50.73	18
	40	51.14	40.43	10.71	8.20	1.17	1.36	6.784	0.47	34.84	33
LSD (5%)		14.46	14.38	8.63	5.94	1.69	1.50	3.46	1.28		

P.H.= plant height, T.S.I.= technical stem length, F.Z.L.= fruiting zone length, B.B.= number of basal branches/plant, no. C= number of capsules/plant, S.Y.= seed yield/plant, S.I.= seed index and St. Y.= straw yield.

Several mutant lines were superior to the parental line for both traits, but only mutant lines no.39 and 10 exhibited significantly higher values for no. of capsules/plant and no. of basal branches/plant respectively, when compared with the parental line Sakha-1. Selecting the best families according to eight studied traits was achieved using selection index. Linear regression was used to generate selection index value for each studied genotype (Table 3). The forty mutant families in addition to their parental line were arranged in descending order according to the estimated selection index for each one. The parental line Sakha- ranked second while family number 18, which was induced from treating flax seeds with 300Gy, ranked first when compared to other mutant families.

The previously presented data showed significant differences among mutant lines with some mutants exceeding the check variety Sakha-1, but couldn't help in selecting a specific mutant line as the best one of all studied traits, where some mutants were better for a trait but not in the other. It is worthy to mention that all the studied mutant lines were firstly selected as powdery mildew resistant lines.

When taking a deep sight for the recorded data on each individual plant within a given family, it could be observed that variation within the same mutant line was present. This is expected because it is well known that yield component traits are known to be quantitatively inherited and that only one generation is not enough to reach stable lines. Therefore M_2 individuals resulted from all mutant lines were pooled in one population and data were used to select the best fifty M_2 individual plants. Selection was achieved on the basis of eight studied traits and the best 50 individual plants were listed in Table (4). In most improvement programs, there is a need to improve more than one trait at a time. Recognition that improvement of one trait may result in improvement or deterioration in associated traits serves to emphasize the need for simultaneous consideration of all traits which are important in a crop species. Selection indices provide one method for improving two or more traits in a breeding program (Baker 1986). Selection index is a linear function of observable phenotypic values of different traits; each trait is weighed by an index coefficient. Therefore, a selection index was constructed for M_2 population

Table 4. List of the best 50 individual plants and their recorded values for agronomic traits, arranged in descending order according to their estimated seed index.

Plant number	Trait								Rank
	P.H	T.L	F.Z	No. C	B.B.	S.Y.	S.I.	St. Y	
7	40.00	36.00	4.00	4.00	1.00	1.20	6.35	2.15	1
8	50.00	45.00	5.00	4.00	1.00	1.42	6.13	2.43	2
10	50.00	43.00	7.00	6.00	1.00	2.17	6.62	2.41	3
11	53.00	50.00	3.00	8.00	1.00	2.10	6.38	2.25	4
57	60.00	50.00	1.00	12.00	2.00	0.20	5.88	2.14	5
2	45.00	40.00	5.00	3.00	1.00	2.36	6.31	2.36	6
12	43.00	35.00	8.00	3.00	1.00	2.33	6.18	1.61	7
5	60.00	50.00	10.00	11.00	3.00	1.87	6.22	1.86	8
28	54.00	48.00	7.00	8.00	3.00	2.30	5.55	1.16	9
46	44.00	36.00	8.00	3.00	3.00	2.63	6.32	1.41	10
47	48.00	36.00	12.00	6.00	3.00	1.46	6.46	1.43	11
50	49.00	38.00	8.00	6.00	3.00	2.56	6.49	1.32	12
52	48.00	38.00	10.00	5.00	2.00	1.11	5.52	1.42	13
58	57.00	38.00	19.00	10.00	2.00	0.74	5.33	1.52	14
60	52.00	45.00	7.00	18.00	3.00	1.20	5.97	1.61	15
29	50.00	45.00	5.00	2.00	1.00	1.91	5.20	1.03	16
32	50.00	42.00	8.00	7.00	2.00	1.89	6.54	1.36	17
48	57.00	42.00	13.00	5.00	1.00	2.33	6.41	1.55	18
292	57.00	37.00	10.00	3.00	1.00	1.33	7.51	0.83	19
18	45.00	35.00	10.00	4.00	1.00	1.90	6.16	1.36	20
19	60.00	50.00	5.00	8.00	1.00	2.22	6.78	1.75	21
27	55.00	47.00	8.00	4.00	1.00	1.65	5.59	1.56	22
31	45.00	37.00	8.00	3.00	1.00	1.50	6.32	1.21	23
33	55.00	47.00	8.00	7.00	1.00	1.67	6.38	1.42	24
34	40.00	35.00	5.00	3.00	1.00	1.56	6.33	1.23	25
35	40.00	35.00	5.00	3.00	1.00	0.99	6.55	1.18	26
36	45.00	40.00	5.00	4.00	1.00	1.50	6.61	1.53	27
39	47.00	42.00	5.00	5.00	1.00	1.55	6.39	1.32	28
40	43.00	37.00	6.00	3.00	1.00	1.82	6.41	1.29	29
44	42.00	34.00	8.00	2.00	1.00	1.94	6.42	1.28	30
51	55.00	45.00	5.00	12.00	2.00	1.40	5.61	1.62	31
56	45.00	35.00	10.00	3.00	1.00	1.42	5.91	1.47	32
59	52.00	40.00	12.00	12.00	3.00	2.12	5.52	1.86	33
294	50.00	40.00	10.00	10.00	3.00	1.89	7.39	1.21	34
1	55.00	47.00	8.00	9.00	3.00	2.67	6.62	2.13	35
4	57.00	49.00	8.00	4.00	1.00	1.50	6.13	1.91	36
9	55.00	45.00	10.00	5.00	1.00	0.58	6.26	2.12	37
21	51.00	44.00	7.00	7.00	3.00	1.54	5.42	1.52	38
22	60.00	55.00	5.00	10.00	3.00	1.68	5.61	1.69	38
24	55.00	46.00	9.00	13.00	3.00	1.80	5.90	1.33	40
25	53.00	43.00	10.00	9.00	3.00	1.38	5.65	1.39	41
26	53.00	45.00	8.00	9.00	3.00	1.39	5.38	1.48	42
30	55.00	51.00	4.00	5.00	3.00	1.66	5.26	1.48	43
38	45.00	40.00	5.00	4.00	1.00	1.18	6.36	1.36	44
43	64.00	49.00	5.00	11.00	3.00	2.10	6.73	1.52	45
53	48.00	43.00	5.00	4.00	2.00	1.56	5.66	1.54	46
54	60.00	48.00	12.00	16.00	1.00	1.83	5.87	1.38	47
396	57.00	51.00	6.00	3.00	1.00	0.85	6.36	1.92	48
397	53.00	47.00	3.00	5.00	1.00	1.95	6.00	2.04	49
398	53.00	50.00	8.00	4.00	2.00	1.20	6.63	2.36	50

P.H.=plant height, T.S.L.=technical stem length, F.Z.L.=fruiting zone length, B.B.=number of basal branches/plant, no. C=number of capsules/plant, S.Y.=seed yield/plant, S.I.= seed index and St. Y.=straw yield.

Based on individual plant selection, forty-seven plants -out of the fifty selected individuals- exhibited better values, for the studied agronomic traits, than the check variety Sakha-1. The seeds of these plants were selected to be planted and subjected to subsequent selection in the successive generations. The same procedure was used to achieve selection among bread wheat crosses to improve bread wheat production (Abdel-Shafi 2004). The efficiency of selection procedures in early segregating generations were studied by Whan *et al* (1982) who reported that direct selection for grain yield in wheat in early segregating populations proved to be effective. Islam *et al* (1985), reported that certain components of yield, particularly the number of grains per spike, are more heritable than yield itself and are more stable in relation to environmental factors affecting them, which is important for selection in self pollinated crops, as the action of additive genes would be retained through subsequent inbreeding. He added that the effectiveness of early generation selection therefore, depends on the presence of true genetic differences between genotypes in this generation and in their persistence following selection. The visual selection clearly improved grain yield and its components in bread wheat that indicates the importance of selection by breeder in early generations and the importance of constructing selection indices taking into consideration as much as possible of yield component traits (Van Ginkel *et al* 2001). On the other hand, Resqui (1993) mentioned that individual plant selection in early segregating generations for quantitatively inherited traits such as grain yield in wheat had limited success; the most frequent reasons for this failure in wheat include the inability to identify usable genetic variation and large environmental effects. Further studies are needed to determine weather the selected agronomic traits used in the present study are useful and sufficient for constructing selection index in flax or other agronomic traits are needed to be included to fulfill this purpose. In addition more deep investigations is needed concerning nature and inheritance of the selected high number of PM-resistant lines from a susceptible flax variety. In this regard Abdalla (1971) reported the possibility of selecting resistant genotypes from susceptible ones. More over, as resistance in flax is known as recessive character, it is therefore acceptable to obtain resistant mutations from susceptible genotypes by using gamma-ray treatments, because recessives are mainly loss mutations (Islam1992).

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استعمال أشعة جاما لاستحداث طفرات من الكتان مقاومه لمرض البياض الدقيقي

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أجريت الدراسه الحاليه بغرض استحداث طفرات من الكتان مقاومه لمرض البياض الدقيقي و ذات خواص محصوليه مرغوبة، وذلك باستعمال أشعة جاما. قيم ١٩ تركيب وراثي من الكتان تحت ظروف الحقل و الصوبة وذلك من حيث المقاومة النسبية لمرض البياض الدقيقي، أظهرت بعض التراكيب الوراثية نفس المستوي من المقاومة -تقريبا- تحت ظروف كل من الحقل و الصوبة، مما يدل علي أن آداء هذه التراكيب الوراثية يتميز بدرجة عاليه من الثبات وعدم الحساسيه للتغير في الظروف البيئية. أظهرت الدراسة أن الصنف التجاري الحديث سخا-١ (والذي يتميز بصفات جودة عالية من حيث انتاج كل من الألياف والزيت) هو تركيب وراثي مناسب لإستحداث طفرات مقاومه لمرض البياض الدقيقي في الكتان نظرا لما تميز به من درجه عاليه من القابلية للإصابة تحت ظروف الحقل و الصوبة. عرضت البذور الجافة لصنف الكتان سخا-١ للجرعات التاليه من أشعة جاما: صفر، ٢٠٠، ٣٠٠، ٤٠٠، ٥٠٠، ٦٠٠، ٧٠٠ جراي. أنتخبت نباتات الكتان الفردية الشديدة المقاومه للمرض (شدة الاصابة من صفر الي ٥%) وتم الحصول علي بذورها و ذلك في الجيل الاشعاعي الأول. قيمت التراكيب المقاومة أيضا في الجيل الثاني، ومن بين التراكيب المقاومه للمرض انتخب ٤٠ تركيبا تميزت بدرجه ملحوظه من ثبات صفة المقاومة عند اختبارها خلال موسمين متتاليين. استعمل دليل الانتخاب لتحديد أفضل ٥٠ نبات فردي من بين نسل النباتات المقاومة في الجيل الاشعاعي الثاني من حيث المحصول ومكوناته إلي جانب صفة المقاومة للمرض.

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