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GAMMA-RAY INDUCED POLLEN STERILITY IN CASTOR

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Introduction

The application of spontaneous male sterility in hybrid seed production and the studies on mechanism of male sterility have received much attention during the past three decades. New sources of male sterility are expected to be obtained by interspecific crosses and induced mutations. The present investigation deals with the effect of gamma rays as a source to induce male sterility in castor (*Ricinus communis* L.), an important oil seed crop.

Materials and Methods

The experiment was conducted on *Ricinus communis* L. var. Aruna at R. B. S. College Agricultural Research Station, Bichpuri, Agra. The dry seeds were irradiated with 12.5, 25, 50, 75, 100, 125 and 150 kR gamma rays with the help of Cobalt 60, at the Division of Genetics, Indian Agricultural Research Institute, New Delhi.

The irradiated and unirradiated seeds were sown in the fields in 7 replications. Each replication consisted of seven rows five meters long. The distance between row to row and plant to plant was one meter. Thus, there were 35 plants in each replication.

The individual plants raised from irradiated seeds were selfed and the seeds were sown in separate replications to study M_1 generation. These were selfed and seeds of individual plants were sown to M_2 generation. Pollen viability of plants thus raised was tested at regular intervals by the staining procedure after Alexander[1]. The data obtained were statistically analysed for standard deviation and a 't' test was applied for finding out the differences between the means of treated and untreated plants at 1% level. The complete male sterile plants obtained in M_2 generation were crossed with the control plants to study their mode of inheritance in F_1 and F_2 generations. The data were analysed statistically.

Results and Discussion

The extent of pollen sterility of plants raised from unirradiated and gamma-ray irradiated seeds is shown in Table 1.

TABLE 1. Pollen sterility in gamma-ray irradiated plants

Treated/untreated	Pollen sterility*(%)
Untreated (control)	6.71 ± 2.57
Gamma-ray (kR)	
12.5	19.12** ± 2.06
25	21.18** ± 1.91
50	25.19** ± 1.20
75	28.56** ± 5.27
100	29.60** ± 2.21
125	44.56** ± 6.84
150	62.93** ± 4.70

± Standard deviation.

* Mean value of data from 35 plants.

** Significantly different from untreated at 1% level.

It is clear from Table 1 that all the plants raised from gamma-ray irradiated seeds exhibited a significant enhancement in the extent of pollen sterility, and the increase was directly proportional to the increase in the doses of gamma ray. The control plants raised from unirradiated seeds showed only 6.71% pollen sterility. On the other hand, all the plants of the irradiated population exhibited a higher degree of pollen sterility. The plants of the 12.5 kR gamma-ray treated population showed only 19.12% pollen sterility, while the plants of the 150 kR gamma ray irradiation were 62.93% pollen sterile.

The selfed seeds obtained from the gamma-ray irradiated population were sown to obtain M_1 generation. Various degrees of partial pollen sterlity appeared in this population. On the basis of extent of pollen sterility, the plants were classified in four groups, namely normal (N) type of plants exhibiting 0-25% sterility, semi-sterile type a (S.S.a) showing 26-50% sterility, semi-sterile type b (S.S.b) plants showing 51-95% sterility and complete sterile type (C.S.) of plants with 96-100% non-viable pollen grains. Table 2 shows the phenotypes of male sterility in the M_1 generation.

It is evident from Table 2 that the 12.5 and 25 kR gamma-rays irradiated population consisted of only N and S.S.a types of plants, while the 50, 75, 100 and 125 kR irradiated population in the M_1 generationshowed N, S.S.a as well as S.S.b types of plants. However, the 150 kR gamma ray irradiated M_1 plants were either S.S.a or S.S.b type. There were 52, 26.85 and 21.14 percent N, S.S.a and

TABLE 2. Phenotypic expression of male sterility in M_1 generation

Treatment (kR)	Phenotype of M_1 lines No. & (%)				Total observed number
	N	S.S.a	S.S.b	C.S.	
12.5	20(91)	2(9)	0(0)	0(0)	22
25	18(78)	5(22)	0(0)	0(0)	23
50	16(67)	6(25)	2(8)	0(0)	24
75	12(48)	9(36)	4(16)	0(0)	25
100	14(52)	7(26)	6(22)	0(0)	27
125	11(34)	12(38)	9(28)	0(0)	32
150	0(0)	6(27)	16(73)	0(0)	22
Total	91(52)	47(27)	37(21)	0(0)	175
Control	32(100)	0(0)	0(0)	0(0)	32

N = Normal
S.S.a = Semi-sterile a
S.S.b = Semi-sterile b
C.S. = Complete sterile

S.S.b type of plants respectively among 175 plants observed in the M_1 generation. It is also clear from the data presented in the Table 2 that there were 16 S.S.b type plants among 22 M_1 plants obtained by 150 kR gamma-ray irradiation. However, there was no complete male sterile plant in the entire M_1 population.

The inheritance of male sterility from M_1 to M_2 lines is shown in the Table 3. It is evident from Table 3 that from the N type of M_1 plants either N or S.S.a type plants developed in M_2 generation in all the treatments except 100 kR where one S.S.b type plant also appeared. N type of M_1 plants produced a higher number of N type (76.19~95.2%) of plants in the M_2 generation also. The S.S.a type of M_1 plants inherited N, S.S.a and S.S.b type of plants in the M_2 generation and this consisted of higher percentage of S.S.a type, followed by N type. The percentage of S.S.a type in the M_2 population developed from the same type of M_1 plants ranged between 20~66.6. Similarly, S.S.b type of M_1 plants produced N, S.S.a and S.S.b type of plants in the M_2 generation and the percentage of S.S.b type (11.76~59.37) was much higher than the other phenotypes. The percentage of S.S.b type in M_2 developed from the same type of M_1 generation increased with the increase in the doses of gamma-ray. It was interesting to note that S.S.b type of plants in the 150 kR irradiated M_1 generation produced three complete male sterile (C.S.) plants in M_2 generation. The percentage, however, was 9.37 and their frequency in the total M_2 population was 0.72%. It is also clear from Table 3 that apart from three C.S. type of plants among the total M_2 population of 411 there were 203 (49.39%) N, 154 (37.47%) S.S.a and 51 (12.41%) S.S.b type of plants. Another interesting feature of the present study was the screening of three perfect

TABLE 3. Inheritance of male sterility from M_1 to M_2 lines

Treatment (kR)	Phenotype of M_1 lines	Phenotype of M_2 lines No. & (%)				Total
		N	S.S.a	S.S.b	C.S.	
12.5	N	20(95)	1(5)	0(0)	0(0)	21
	S.S.a	11(44)	13(52)	1(4)	0(0)	25
25	N	19(83)	4(17)	0(0)	0(0)	23
	S.S.a	14(54)	10(38)	2(8)	0(0)	26
50	N	18(82)	4(18)	0(0)	0(0)	22
	S.S.a	7(23)	20(67)	3(10)	0(0)	30
	S.S.b	16(47)	14(41)	4(12)	0(0)	34
75	N	21(88)	3(13)	0(0)	0(0)	24
	S.S.a	18(72)	5(20)	2(8)	0(0)	25
	S.S.b	10(32)	15(48)	6(19)	0(0)	31
100	N	16(76)	4(19)	1(5)	0(0)	21
	S.S.a	17(47)	16(44)	3(8)	0(0)	36
	S.S.b	4(17)	14(58)	6(25)	0(0)	24
150	S.S.a	12(32)	21(57)	4(11)	0(0)	37
	S.S.b	0(0)	10(31)	19(59)	3(9)	32
Total	–	203(49.4)	154(37.5)	51(12.4)	3(0.7)	411
Control	N	25(100)	(0)	(0)	(0)	25

female mutants from the 100 and the 125 kR gamma-ray irradiated population. Their mode of inheritance and yield is being published elsewhere.

The mode of inheritance of three complete male sterile plants ($GRCS_1$, $GRCS_2$ and $GRCS_3$) obtained from the M_2 generation of the 150 kR irradiated population was studied by crossing them with unirradiated (control) plants (Table 4).

It is evident from Table 4 that the F_1 population of the cross between complete sterile and control consisted of only N type : F_1 normal plants were selfed and their F_2 progenies were N as well as C.S. type. The frequencies of C.S. mutants and N type plants in three F_2 populations tested for goodness-of-fit to an assumed ratio of 3 N : 1 C.S. The Chi-square values obtained from these tests indicated that C.S. character is controlled by a single recessive gene.

Table 5 shows the number of days taken for first pistillate flowering, node position bearing pistillate flower, number of pistillate flowers, number of fruits and seeds (result of hand pollination with control) in male sterile mutants and control.

As is clear from Table 5 the complete male sterile mutants $GRCS_1$, $GRCS_2$

TABLE 4. Segregation of male sterility in F_2 populations of mutants × control fit to 3 : 1

a. F_2 populations :

Parent	F_1	Total F_2 plants	N	C.S.	χ^2	p
$GRCS_1$ × control	N	34	24	10	0.353	0.50−0.70
$GRCS_2$ × control	N	25	19	6	0.013	0.90−0.95
$GRCS_3$ × control	N	30	21	9	0.4	0.50−0.70
Total		89	64	25		

b. χ^2-analysis :

	df	χ^2	p
Pooled χ^2	1	0.453	0.50−0.70
Heterogeneity χ^2	2	0.313	0.80−0.90
Total χ^2	3	0.766	0.80−0.90

TABLE 5. Number of days taken for first pistillate flowering, node position of first pistillate flower, number of pistillate flowers, number of fruits and seeds in male sterile mutants

	$GRCS_1$	$GRCS_2$	$GRCS_3$	Control
1. No. of days taken for first pistillate flowering	108.4 ±3.83	106.1 ±3.36	109.4 ±3.21	107.2 ±1.78
2. Node position of first pistillate flower	4.50 ±0.95	4.33 ±0.94	3.80 ±0.97	3.16 ±1.14
3. No. of pistillate flower	236.83 ±12.24	245.66 ±11.01	281.91 ±9.36	218.41 ±8.73
4. *No. of fruits	217.36 ±11.23	208.21 ±21.24	241.34 ±26.70	206.10 ±11.95
5. No. of seeds	502.25 ±43.01	497.31 ±15.10	522.74 ±30.89	573.20 ±31.27

* Result of hand pollination with control.

and $GRCS_3$ take a more or less similar period for first pistillate flowering, but the node position of first pistillate flower is slightly increased. On the other hand, the number of pistillate flowers, fruits and seeds in the mutants was higher than that in control plants.

Genic male sterility has been reported to occur spontaneously as well as being artifically induced by X-rays, chemical mutagens and gamma-rays in a wide variety of plants. The male sterile mutants in castor obtained during the course of the present investigation will be used for hybrid seed production and crop improvement.

Summary

The effects of 12.5, 25, 50, 75, 100, 125 and 150 kR gamma-rays on pollen sterility in castor (*Ricinus communis* L.) were studied. The plants raised from irradiated seeds exhibited a high degree of pollen sterility compared to that of unirradiated ones. The plants obtained from seeds irradiated with 150 kR were 62.93% male sterile. The M_2 generations exhibited partial pollen sterility of various degrees including three complete male sterile mutants in the M_2 generation of the 150 kR irradiated populations. The mode of inheritance of male sterility in these mutants was found to be monogenic recessive.

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