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Gamma Ray Induced Macro-Mutations in Greengram [*Vigna radiata* (L.) Wilczek]

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Abstract Genetically pure, uniform and dry seeds of greengram[*Vigna radiata* (L.) Wilczek] varieties Sujata and TARM-1 were treated with gamma radiation of variable doses (20, 30, 40, 50 and 60 kR) to assess the extent of macro-mutations induced in the M_2 generation and their scope for future use in plant improvement programme. The irradiated seeds were sown in the M_1 field with their respective controls and harvested in bulk to raise the M_2 generation in Randomised Block Design(RBD) with three replications. Wide spectrum of chlorophyll and morphological macromutants were observed in M_2 generation. Among the chlorophyll macro-mutants, chlorina was the most frequent in both cultivars. Among the morphological macromutants, quadrifoliate was observed in highest frequency in variety Sujata and more poded type mutants in variety TARM-1. Number of macro-mutations induced increased with rise in doses. The frequency of morphological mutation was higher in variety Sujata as compared to variety TARM-1 suggesting higher sensitivity of the variety Sujata to gamma irradiation.

Keywords Gamma Irradiation, Greengram, Chlorophyll Mutation, Morphological Mutation

1. Introduction

Green gram,[*Vigna radiata* (L.) Wilczek] is one of the important short duration pulse crop of India and known for its excellent source of high quality protein. Unfortunately, the per capita availability of pulses in India has declined from 65.5g per capita/day to 31.6g per capita/day in the past five decades as against the demand of 80g per capita/day[1]. In view of above, increase in production and productivity of this crop is very crucial to meet the protein requirement of especially under-nourished people depending on vegetable protein.

Induced mutagenesis plays an important role in improvement of crops like green gram where a large part of genetic variability has been eroded due to its continuous cultivation in marginal and sub-marginal land and its adaption to survival fitness rather than yield. Further, hybridization in this crop is difficult due to its small cleistogamous flower.

Physical mutagens namely X-rays, gamma rays, fast neutrons, thermal neutrons, ultraviolet light and beta radiations have been frequently used for induction of mutations for crop improvement. So far, 3218 number of crop varieties has been developed through induced mutagenesis[2]. In India, 343 mutant cultivars belonging to 57 plant species have been released out of which 15 varieties belong to the green gram[2,3].

Based on above, the present experiment was undertaken to induce mutation using gamma irradiation and to assess the frequency and spectrum of macro-mutations appeared in the M_2 generation and their scope of use in future crop improvement programme.

2. Materials and Methods

Genetically pure, uniform and dry seeds (10% moisture content) of two green gram varieties Sujata and TARM-1 were taken for induction of mutation using gamma irradiation. For the purpose, seeds of both varieties were irradiated with gamma rays of five different doses (20, 30, 40, 50 and 60 kR) at the BARC, Trombay. Treated seeds were sown in two series of experiments in the M_1 generation. One set of experiment was conducted in laboratory to study the seedling response to mutagenic treatments and the other was conducted in the Instructional Farm of Orissa University of Agriculture and Technology at Jajpur, Odisha. Bulked seeds of all the M_1 plants from each treatment were used to raise the M_2 generation in RCBD with three replications. Observations on macro-mutations *viz*., chlorophyll and morphological mutations were recorded from the day of emergence till the plants attained physiological maturity. The spectrum and frequency of chlorophyll mutations

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observed in various levels of mutagen treated populations were estimated following standard procedure[4].

3. Results and Discussions

3.1. Chlorophyll Macro-mutation

Macro-mutations are generally used to evaluate the genetic effects of various mutagens. Chlorophyll mutations are employed as markers for the evaluation of gene action of mutagenic factors in inducing mutation[5]. It was also reported that the appearance of more number of viridis type could be attributed to the involvement of polygenes in chlorophyll formation.

In the present investigation, wide spectrum of chlorophyll mutations were observed in mutagen treated populations of both varieties in M_2 generation (Table 1). Chlorophyll macro-mutations *viz*., chlorina, xantha, albina, viridis and sectorial were observed in mutagen treated populations of both varieties. No such mutation was observed in the controls. Similar results were also reported earlier [6,7,8,9,10,11]. Among different types of chlorophyll mutations, chlorina was the most frequent (2.15 per cent in Sujata and 2.28 per cent in TARM-1) in both cultivars suggesting high mutability of the gene controlling the phenotype. The albina and sectorial types appeared in least frequency in Sujata and TARM-1 varieties, respectively. The frequency of chlorophyll mutation in different mutagenic treated population varied from 2.15 per cent to 4.00 per cent in Sujata and 2.14 per cent to 4.94 per cent in variety TARM-1 (Fig.1). Average frequency of chlorophyll mutation observed in variety Sujata (3.30 per cent) was lower in comparison to that in TARM-1 (3.59 per cent) suggesting variation in sensitivity of varieties to gamma irradiation. In both the varieties, the number of chlorophyll mutation decreased with rise in dose of gamma irradiation except in 50 kR mutagenic treatment. The minimum chlorophyll mutation (2.15 per cent) was observed in 40 kR mutagenic treatments of variety Sujata where as the same (2.14 per cent) was observed at 60 kR dose in case of variety TARM-1. This could be due to increased biological damage (injury, lethality, sterility etc.) at higher doses. Similar trend in mutagenesis have been reported earlier by many workers in different crops[12,13]. Though there was no significant difference in the spectrum of chlorophyll mutation in both varieties, quantitative variation in the chlorophyll mutation frequency of different types in different doses of gamma rays was noticed and this suggests the differential response of genotype and genes to the dose of mutagenic treatment. Similar differential response of varieties to mutagens and variation in frequency of chlorophyll frequency was also observed earlier by many workers[7,10,13,14].

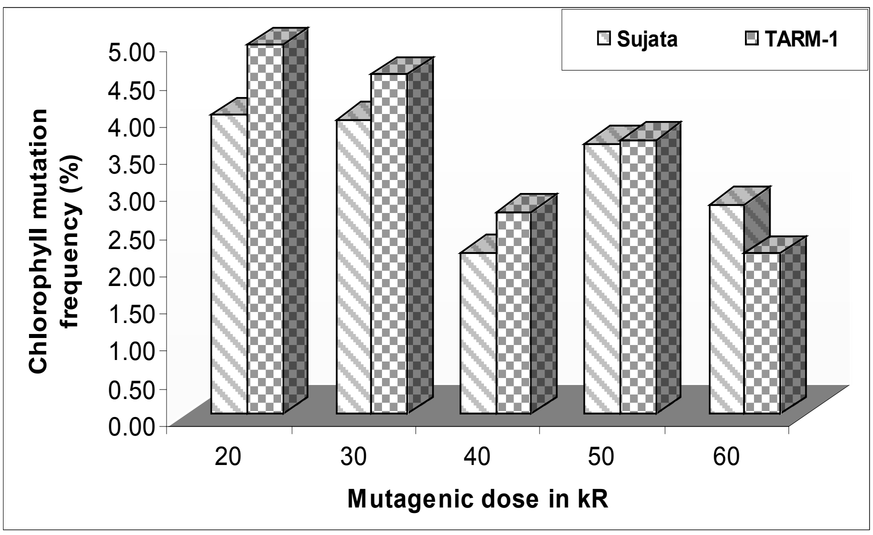

Figure 1. Chlorophyll mutation frequency (%) in variety Sujata and TARM-1

Table 1. Spectrum and frequency of different chlorophyll macromutations in M_2 generation

Treatments	Sujata							TARM-1						
	20 kR	30 kR	40 kR	50 kR	60 kR	Total	Average	20 kR	30 kR	40 kR	50 kR	60 kR	Total	Average
No. of M_2 plants	1250	1120	1254	1080	964	6948	-	1256	1145	1262	1010	1124	7117	-
Chlorina	38	32	16	24	12	122	24.40	42	37	22	18	13	132	26.40
Xantha	4	3	2	2	3	14	2.80	4	2	2	3	1	12	2.40
Albina	2	2	1	4	2	11	2.20	2	4	-	1	1	8	1.60
Viridis	5	6	6	8	8	33	6.60	12	7	9	13	8	49	9.80
Sectorial	1	1	2	1	2	7	1.40	2	2	1	2	1	8	1.60
Total	50	44	27	39	27	187	37.40	62	52	34	37	24	209	41.80
Frequency (%)	4.00	3.93	2.15	3.61	2.80	16.49	3.30	4.94	4.54	2.69	3.66	2.14	17.97	3.59

3.2. Morphological Macro-mutation

Different types of morphological mutations viz. unifoliate, bifoliate, quadrifoliate, pentafoliate, tall, dwarf, trailing type, early, late, profusely branched, more poded, erect branch type, serrated leaf, modified inflorescence and simple leaf type observed in mutagenic treated populations of both the varieties (Table 2). Both varieties differed as regards to the quantity and spectrum of morphological mutations induced. No such morphological mutation was observed in the controls. Similar spectrum of morphological mutations have been reported earlier by many workers[7,9,10,15,16]. Among different types of morphological mutations, the most frequent types were quadrifoliate in variety Sujata and more poded type plants in variety TARM-1 indicating high mutability of the gene for the character. The morphological mutations like trailing type, modified inflorescence and simple leaf mutants appeared in least frequency in variety Sujata while deeply serrated leaf and simple leaf mutant were least frequent in variety TARM-1. The frequency of morphological mutations in different treatments varied from 3.84 per cent to 6.22 per cent in variety Sujata and 1.83 per cent to 4.36 per cent in variety TARM-1 (Fig.2). Considering the two varieties, the frequency of morphological mutation was more in variety Sujata (4.88 per cent) as compared to variety TARM-1 (3.27 per cent) suggesting higher sensitivity of the variety Sujata to gamma irradiation.

Dose dependant increase in frequency of morphological mutations was observed in both the varieties indicating positive relationship between dose of mutagenic treatment and frequency of morphological mutations. Different frequencies of morphological mutations in variable doses of gamma treatment in both varieties suggested differential response of varieties to dose of mutagenic treatment. Similar differential induction of morphological mutation in different doses of mutagen as well as in different varieties have been reported earlier by many workers in different crops including green gram[7,10,11,13,17,18,19,20,21,22,23]. In the present investigation mutants with modified inflorescence were observed in the mutagen treated populations of both varieties, similar type of morphological mutant was also reported earlier in Pea in the name of Sine-Floribus[24]. The frequency of morphological mutations increased with rise in dose of gamma irradiation in both the varieties. The frequency of morphological mutation varied in different doses of gamma treated population suggesting differential response of varieties to the mutagenic treatment and was in conformity with earlier findings.

Table 2. Spectrum and frequency of important morphological macromutations in M_2 generation

Treatments	Sujata							TARM-1						
	20 kR	30 kR	40 kR	50 kR	60kR	Total	Average	20 kR	30 kR	40 kR	50 kR	60 kR	Total	Average
Unifoliate	1	2	-	1	1	5	1.0	1	1	3	2	1	8	1.6
Bifoliate	-	-	1	2	-	3	0.6	1	-	2	-	-	3	0.6
Quadrifoliate	13	11	18	14	9	65	13.0	2	6	5	12	2	27	5.4
Pentafoliate	2	3	7	5	3	20	4.0	2	4	-	5	3	14	2.8
Tall	-	-	3	6	8	17	3.4	-	2	5	-	9	16	3.2
Dwarf	11	6	9	4	6	36	7.2	-	-	4	3	7	14	2.8
Trailing	-	-	-	1		1	0.2	-	-	-	2	-	2	0.4
Early	5	6	13	8	5	37	7.4	2	-	4	2	4	12	2.4
Late	7	3	2	5	9	26	5.2	3	9	4	6	8	30	6.0
Profuse branches	-	2	-	4	3	9	1.8	-	2	4	-	3	9	1.8
More podded	9	11	9	7	13	49	9.8	10	8	9	4	11	42	8.4
Erect bunch type	-	-	1		1	2	0.4	-	1		2	1	4	0.8
Deeply serrated leaf	-	-	-	1	-	1	0.2	-	-	-	-	-	0	0
Slightly serrated leaf	-	-	-	-	1	1	0.2	-	1	-	1	-	2	0.4
Modified inflorescence	-	-	-	-	1	1	0.2	2	1	1	-	-	4	0.8
Simple leaf	-	-	-	-	-	0	0	-	-	-	-	-	0	0
Total	48	44	63	58	60	273	54.6	23	35	41	39	49	187	37.4
Frequency (%)	3.84	3.93	5.02	5.37	6.22	24.4	4.88	1.83	3.06	3.25	3.86	4.36	16.36	3.27

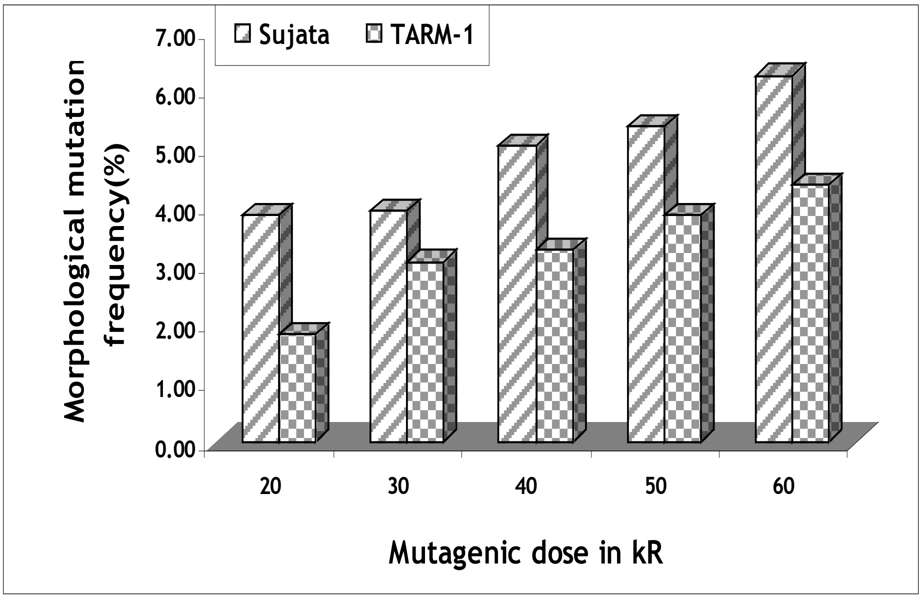

Figure 2. Morphological mutation frequency (%) in variety Sujata and TARM-1

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