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Mutagenic effect of gamma rays and EMS on nodulation, yield and yield traits on lentil

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ABSTRACT

The pure and healthy seeds of lentil var. K 75 were irradiated with Gamma-rays at different doses. The treated seeds were sown for raising M_1, M_2 and M_3 generations. The significant differences for polygenic variability/micro-mutations were found in M_2 and M_3 generations for number of nodules, nodules dry weight, number of pods, grain yield per plant, 100-grain weight and protein content (M_3 only) and significant increase towards positive direction was found for number of nodules, nodule dry weight and protein content (%) in negative direction at lower doses of different treatments, whereas protein content was increased at higher doses. High doses of mutagenic treatments showed high reduction in grain yield per plant in combination treatments.

Key words: Lentil, Mutagen, *Lens culinaris*, Nodulation, Polygenic variability

Lentil (*Lens culinaris* Medik) is one of the important *rabi* pulse crops of southeast Asia. The average yield of lentil is very low as it is cultivated in marginal/poor soil without fertilizer. Being a pulse crop, the nitrogen requirement is substantially met through symbiotic nitrogen fixation. Effective nodulation is essential for proper nitrogen fixation. Nodulation and its component traits have significant effect on yield and quality. Plants having large and more nodules per plant may be capable of fixing greater amount of nitrogen and could be better adopted for higher photosynthetic activity which may increase the yield potential (7). Mutation breeding has been used for improvement of crops by creating new variability, better adaptation and superior symbiotic nitrogen fixing ability where hybridization is difficult. The present investigation was, therefore, undertaken to observe the effect of mutagen on nodulation, yield and its components in lentil var. K 75 in M_2 and M_3 generations.

MATERIALS AND METHODS

The uniform, healthy and dry seeds of lentil variety K 75 (macrosperma) with a moisture content of 10-12 % were treated with gamma rays and ethyle methane sulphonate (EMS) alone and in combination. The doses of gamma rays irradiation were 10, 15, 20, 25 and 30 kR. Five hundred seeds were soaked (each treatment) in distilled water for 6 hours before EMS treatment. The soaked seeds were treated with individual dose of 0.02, 0.03, 0.04 and 0.05 M of EMS solution prepared in phosphate buffer at pH 7. For combination treatments, the gamma rays irradiated seeds were treated with 0.03 M concentration of EMS in same manner as stated earlier. The total treatment combinations including control were 15 *viz.*, 10 kR, 15 kR, 20 kR, 25 kR, 30 kR, 0.02M, 0.03M, 0.04M, 0.05M, 0.03M+10 kR, 0.03M+15 kR, 0.03M+20 kR, 0.03M+25 kR and 0.03M+30 kR. All the mutagen treated seeds along with control were sown at a spacing of 30 cm (row- row) and 5 cm (plant-plant) on the same day in the field to raise M_1 generation at Agriculture Research Farm, Banaras Hindu University, Varanasi during *rabi* 2000-2001. The M_1 plants of each treatment were harvested individually. M_2 generation was raised as plant to row progenies in a randomized block design (RBD) with three replications. All the recommended agronomic cultural practices were followed to maintain a good plant stand for micro-mutation. Data were recorded on 50 randomly selected plants from each treatment and control for number of pods per plant, grain yield per plant, 100-grain weight, number of nodules per plant and nodules dry weight per plant. The bulk seed samples of each treatment excluding mutant lines from all the treatments of M_2 generation were sown for raising M_3 generation in RBD with three replications. The data were recorded for all the traits as in M_2 generation. Estimation of protein content was also carried out from the seeds of M_3 generation by Micro-Kjeldahl method [5].

RESULTS AND DISCUSSION

The induced polygenic variability/micromutations can be estimated in terms of mean and variances of the treated population in M_2 and M_3 generations. The significant variances were observed for all the characters under study (Table 1). The mean values for all the characters shifted in both positive and negative directions in comparison to control in both generations (Tables 2, 3). Lower doses of gamma rays (10, 15 kR) and EMS (0.02, 0.03 M) treatments increased the number of nodules, nodules dry weight, number of pods per plant and 100 - grain weight in M_2 and M_3 generations, whereas higher doses of mutagens reduced the mean values for all the characters except number of nodules per plant (0.04, 0.05M EMS). Similar effect of mutagens at lower doses was reported in other crops (1, 9). Significant increase was noticed for number of nodules per plant in 10, 15 kR γ-ray treatments, 0.05M EMS treatment and 0.03M+10kR combination treatment in M_2 generation. Similar observations were reported in various crops *viz.*, soybean (4, 8) and in mungbean (2, 11). The mutagenic treatment did not show any significant increase in

Table 1. Analysis of variance (mean square) for different characters in M_2 and M_3 generations of lentil variety K 75

Source	D.f	M_2 generation					M_3 generation					
		Pods plant^{-1}	Grain yield plant^{-1} (g)	100-grain weight (g)	Number of nodules plant^{-1}	Nodule dry weight plant^{-1} (mg)	Pods plant^{-1}	Grain yield plant^{-1} (g)	100-grain weight (g)	Number of nodules plant^{-1}	Nodule dry weight plant^{-1} (mg)	Protein content (%)
Replications	2	320.08	0.07	0.03	2.31	17.93	340.45	0.12	0.02	13.32	11.07	0.38
Treatments	14	1271.57**	2.16*	0.11*	210.83*	460.16*	1160.91*	2.10*	0.10*	229.97*	392.56*	6.63*
Error	28	169.26	0.36	0.02	16.8	65.09	183.86	0.28	0.02	13.60	81.62	1.37

*Significant at 1% level.

grain yield per plant. Most of the treatments showed reduction in grain yield per plant but few treatments (10, 20kR, 0.02M) showed (non-significant)improvement in grain yield in both the generations. Positive shift in mean and variability for pods and grain yield per plant were also observed in chickpea and lentil [3, 6]. Protein content increased with the increase in doses of gamma rays treatments upto 25kR in M_3 generation, as compared to control. However, the increase in protein content was non-significant, except at 25kR gamma rays treatment. Lower doses of gamma rays, EMS and combination treatments reduced the protein content but the reduction was significant only at 10kR gamma rays. In general, CV for protein content increased with the increase in dose of the treatments. High CV was observed at 0.04M EMS treatment.

Increase in variability was found with increase in doses of mutagenic treatment. In general, the magnitude of variability (CV) was higher in M_2 than M_3 generation (Tables 2, 3). High doses of gamma rays and EMS as well as their combination treatments were more effective for inducing variability. Similar results were reported in other pulse crops [9, 10]. Magnitude of variability was higher in M_2 than in M_3 generation, hence selection would be more effective in M_2 generation for most of the traits. The decrease in variability in M_3 generation occurred because of increase in the frequency of genetic death due to homozygosity of harmful genes in M_3 generation (12). Mean values for number of nodules and nodules dry weight per plant were found more in M_3 than M_2 generation in few treatments. Thus, selection for nitrogen fixing traits (number of nodules/ plant and nodule dry weight/plant) would be more effective in M_3 than in M_2 generation. The probable cause of the increase in variability of nitrogen fixing traits in M_3 generation as compared to M_2 would be probably because in heterozygous state, the genetic variability remains in latent condition in M_2 generation whereas it is exposed in later generation (M_3) due to increase in homozygosity at different loci. The increase in genetic variability in M_3 compared to M_2 generation may be attributed due to the segregation (7). Exploitation of these variations in breeding programme for

Table 2. Mean and variance for different characters in M_2 generation of lentil variety K 75

Treatment	Pods plant^{-1}		Grain yield plant^{-1} (g)		100- grain weight (g)		Number of nodules plant^{-1}		Nodule dry weight plant^{-1} (mg)	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Control	90.67	19.68	3.90	19.62	2.73	9.39	26.42	17.37	56.12	18.01
Gamma rays (kR)										
10	106.52	30.19	4.14	23.06	2.82	11.36	37.99*	26.34	64.27	21.47
15	98.42	33.29	3.73	25.06	2.80	14.76	37.68*	20.55	66.81	22.76
20	92.48	28.19	4.22	30.14	2.74	21.04	24.37	28.41	58.79	24.30
25	80.77	32.27	2.98	35.81	2.51	18.34	22.31	23.82	42.12*	25.22
30	79.70	27.94	2.77*	34.10	2.41*	20.42	20.41	24.26	36.31*	30.33
EMS (M)										
0.02	109.35	23.29	3.82	25.66	2.81	11.13	32.64	21.93	68.54	18.12
0.03	109.65	26.68	3.61	25.07	2.78	14.67	26.57	22.70	55.21	25.25
0.04	84.72	29.32	3.31	28.80	2.59	17.96	23.11	25.92	45.38	39.42
0.05	84.63	29.92	3.78	26.81	2.70	18.46	33.71*	21.85	54.41	20.93
EMS + Gamma rays (M + kR)										
0.03+10	86.55	29.53	3.51	25.60	2.66	12.97	33.43*	21.54	53.11	25.65
0.03 +15	90.42	33.51	3.64	28.70	2.68	16.31	35.52*	22.34*	47.24	23.81
0.03 +20	62.53*	36.48	2.56*	33.26	2.35*	19.21	22.60	24.23	30.84*	30.68
0.03+ 25	76.38	39.60	2.89*	37.77	2.45*	21.61	24.62	26.98	33.25*	33.40
0.03 +30	55.86*	33.34	2.44*	34.30	2.21*	24.25	18.59*	39.69	35.63*	24.32
SE	10.62		0.49		0.11		3.35		6.59	
CD at 5%	21.75		1.00		0.22		6.86		13.50	

* Significant at 5%

Table 3. Mean and variance for different characters in M_3 generation of lentil variety K 75

Treatment	Pods plant^{-1}		Grain yield Plant^{-1} (g)		100-grain weight (g)		Number of Nodules plant^{-1}		Nodule dry weight plant^{-1} (mg)		Protein content (%)	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Control	98.23	16.65	4.13	16.23	2.75	7.62	27.38	15.97	53.22	16.22	23.80	3.21
Gamma rays (kR)												
10	115.12	24.33	3.98	20.94	2.86	10.08	40.46*	19.53	75.11*	18.44	20.80*	4.03
15	101.62	30.16	4.15	22.36	2.79	13.59	34.32*	18.20	78.34*	20.67	22.30	4.93
20	98.53	27.22	4.32	32.42	2.76	15.29	29.12	30.79	60.21	23.26	24.74	6.74
25	84.61	33.64	3.13*	34.68	2.56	17.40	27.38	25.45	48.07	27.22	26.82*	7.34
30	75.67*	24.33	2.78*	30.49	2.43*	18.73	24.11	20.87	42.41	28.45	23.94	6.37
EMS (M)												
0.02	108.67	22.20	4.04	20.28	2.81	10.04	34.00*	18.63	60.54	20.48	21.67*	4.32
0.03	110.73	23.82	4.24	22.36	2.78	13.62	29.54	24.11	64.81	28.39	22.66	4.51
0.04	89.89	27.82	3.27	25.91	2.55*	15.02	28.52	25.32	41.23	25.86	24.20	7.42
0.05	94.85	29.54	3.97	26.34	2.71	16.21	37.13*	23.62	56.10	21.29	23.58	6.37
EMS + Gamma rays (M + kR)												
0.03+10	90.38	27.92	3.61	18.34	2.70	10.99	38.13*	20.42	61.42	24.38	23.92	4.49
0.03 +15	92.93	29.13	3.89	25.24	2.74	14.35	30.53	19.26	59.36	27.42	24.50	6.38
0.03 +20	69.66*	32.88	2.70*	26.58	2.37*	16.67	24.50	24.27	37.48*	29.52	24.40	5.35
0.03+ 25	79.74	38.84	2.96*	33.31	2.46*	18.97	25.18	27.95	38.10*	25.66	25.07	6.74
0.03+30	64.67*	37.04	2.61*	30.26	2.26*	21.40	20.32*	34.83	32.19*	26.82	24.90	6.23
SE	11.07		0.43		0.10		3.01		7.38		0.96	
CD at 5%	22.67		0.88		0.23		6.16		15.11		1.97	

* Significant at 5%

the improvement of lentil through selection in M_2 and onward generations would be more effective for increasing grain yield and nitrogen fixing traits as induced variation provided greater scope. The present study concluded that gamma rays and EMS were effective in inducing polygenic variability for the characters under study.

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