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Screening for high productive salt tolerant mutant M_4 lines in chickpea(*Cicer arietinum* L.)

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ABSTRACT

Genetic improvement through induced mutation has been very effective in improvement of crops. Seeds of three popular chickpea variety namely BGM 408, B115 and JG 315 were treated with 10,20 and 30 kR of gamma rays. Then treated seeds with their respective control(0 kR gamma rays) were sown in the field of Calcutta University experimental farm,Baruipur (with no salinity) in three consecutive years to raise M_1, M_2 and M_3 generations respectively.Some M_3 lines having higher yield potential were subjected to grow as M_4 lines in salt stressed field (5-7ds m^{-1}) of Hingalganj,South 24 Parganas. Finally, some promising salt tolerant lines with improved seed yield were selected which have a good promise for coastal saline belt after releasing as a variety.

Key words: Chickpea, Gamma rays, Induced mutation, Salinity, Seed yield.

INTRODUCTION

Mutation breeding is a very good tool to create new genetic variability. Mutation breeding offers a great scope and promise for generating useful variability (Sinha and Lal,2007). Many useful mutants have been evolved in pulse crop through mutation breeding which fulfil desirable breeding objectives. In leguminous crop, such as chickpea, improved cultivars are developed through conventional breeding methods. But in a global scale little concentrated efforts have been made for its genetic improvement. Induced mutation can play role in renewal as well as augmentation of the natural variability to some extent. Extensive studies on induced variations through mutation in cereal crops have been undertaken, but very few reports are available in chickpea (Srivastava *et al.*,1973;Kharkwal,1998),which is covering more than 50% area among the pulse crops. Objective of the present study was to create variability in an existing chickpea population in favor of salinity tolerance. Salinity tolerance was measured in terms of yield and yield related traits under saline stress condition. Effective mutagenesis means, production of maximum desirable changes accompanied by least undesirable changes (Pathania and Sood,2007).Gamma rays are known to influence plant growth and development by inducing cytological, genetical, morphological, physiological and biochemical changes (Gunckel and Sparrow,1961). Acharya *et al.*, (2007) made improvement in medicinal and nutritional properties of fenugreek.

MATERIALS AND METHODS

Three popular chickpea genotypes namely BGM 408,B 115, and JG 315 were selected for applying the mutagenic treatment. Physical mutagens, gamma rays was used as mutagenic treatment. Dry seeds of 10-12% moisture content were exposed to 10, 20 and 30kR doses of gamma rays. The irradiation was done at the rate of 1.087kR /min in the gamma irradiation cell of Saha Institute of Nuclear Physics (SINP), Salt Lake. The treated seeds including control(without mutagenic treatment)were sown in randomised block design with three replications as M_1 in the Calcutta University experimental farm at Baruipur, South 24 paraganas(normal location,without salinity) in the year 2009-10.Two rows were used for each treatment and also for the control. Distance between row to row was of 30cm and plant to plant was 20cm. Normal cultivation practices were followed without application of fertilizer. Several characters like germination and survival percentage, plant height, branches/plant, pods/plant, pod length, seeds/pod,100 seed weight, seed yield/plant and harvest index were taken. All healthy and normal looking plants for each treatment were advanced to raise M_2 generation next season in the same location. Cultivation practices were followed as in M_1 generation. The plants were harvested separately and after harvest the similar parameters like M_1 generation were recorded and some M_2 plants were selected on the basis of yield and yield related characters. They were referred as lines. Thus M_3 generation comprises of number of lines from M_2 generation for each treatment for each of the three genotypes. M_3 lines were evaluated based on the same parameters as in

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M_1. Some promising M_3 plants were selected on the basis of yield and yield related attributes which were referred as M_4 lines. They were grown in the salinity prone (5-7ds m^{-1}) farming field of Hingalganj, South 24 paraganas,West Bengal in *rabi* season of 2012-2013. Experimental design and inter culture operations like M_1 generation were followed and parameters like M_1 generation were recorded. Finally some salt tolerant high yielding mutant chickpea lines were selected.

RESULTS AND DISCUSSION

M_1 generation: Mean,sd and cv were calculated and presented in Table 1. Among the parameters studied in M_1 generation , germination and survival percentage, plant height ,pods per plant,100 seed weight, seed yield per plant and harvest index were gradually reduced with increasing dose of gamma rays. Reduction of germination percentage was also recorded by Sharma and Sharma (1982) in lentil and Khan *et al.*,(1993) in mungbean. Such decrease in germination in high dose of gamma rays in chickpea may be due to enhance production of active radicals which may cause seed lethality. Reduction of plant height was also reported in number of pulse crop in M_1 generation by Sinha and Lal (2007) in lentil and Khan *et al.*, (1993) in mungbean . Such decrease in germination in high dose of gamma rays in chickpea may be due to enhance production of active radicals which may cause seed lethality . Sinha and Bharati (1990) in blackgram, Popa (1991) in pea, Singh and Yadav (1991) in greengram, Ahmed and Yaqoob (1993) in mungbean reported reduction of plant height with increasing dose of gamma rays. It was assumed that plant height was reduced due to inhibition of certain growth hormones. Sinha and Lal (2007) reported gradual reduction of seed yield in M_1 generation in Lentil. On the contrary branches/plant, pod length and seeds /pod were found unaffected or less affected.

The above discussion by and large demonstrates the potentiality of mutagenic treatment for inducing variability in M_1 generation. But the magnitude of variation differed for all the characters in either of the genotype. It was noticed that pods/plant and seed yield/plant were the most drastically affected traits in M_1 generation.

M_2 generation: Mean ,sd and cv were calculated and given in Table 2. Similar trend of results like M_1 generation were noticed in M_2 generation also. The better performing M_2 lines were selected on the basis of mean yield and yield related characters and sown in field to raise M_3 generation.

M_3 generation-Selected M_3 lines: Several individual plants were identified from M_3 generation on the basis of yield and yield related traits(Table 3). The treated individuals registered plant height more or less similar to that of the control. Maximum plant height was recorded in 10 and 20 kR doses for all the genotypes. The maximum branch number was recorded for individuals from different treatment doses in all the genotypes. The pods/plant also revealed similar results. The highest pod number was from 20kR dose treated

Table 1: Mean,Standard deviation(sd) and coefficient of variation(cv) of different agromorphological characters in M_1 generation

Variety	Treatment	G%	S%	Plant height			Branches/plant			Pods/plant			Pod length			Seeds/pod			100 seed weight			Seed yield/plant			Harvest index		
				Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv
BGM 408	**Control**	98	90	45.5	5.98	13.12	3.0	1.07	35.63	56.29	11.71	20.8	1.26	0.05	3.94	1.57	0.49	31.49	10.52	0.66	6.23	5.87	1.07	18.27	40.65	0.54	1.33
	10kR	90	85	36.32	5.17	14.23	3.45	1.08	31.14	20.36	8.83	43.38	1.16	0.09	7.57	1.45	0.5	34.23	7.93	0.59	7.44	2.25	0.58	25.78	31.13	6.09	19.57
	20 kR	75	60	37.85	7.8	20.6	3.36	1.06	31.74	10.18	4.93	48.45	1.07	0.07	6.99	1.36	0.48	35.28	7.55	0.66	8.69	1.23	0.33	26.71	22.36	3.23	14.43
	30 kR	60	55	39.9	1.8	4.51	3.4	1.01	29.99	9.8	3.31	33.78	1.06	0.8	7.55	1.4	0.49	34.99	6.4	0.49	7.65	1.26	0.21	16.34	21.08	3.83	18.16
B 115	**Control**	93	90	37.83	3.94	10.41	3.56	1.27	35.73	72.38	6.58	9.09	1.43	0.08	5.26	1.5	0.5	33.33	11	0.87	7.87	8.03	1.23	15.32	43.31	1.82	4.21
	10 kR	80	75	30.77	10.4	33.8	2.88	0.99	34.4	6.44	2.91	45.16	1.14	0.05	4.34	1.44	0.49	34.4	8.44	0.68	8.11	2.22	0.71	32.02	24.8	3.43	13.82
	20 kR	76	70	33.42	8.19	24.51	2.88	0.99	34.4	12.44	5.21	41.86	1.04	0.07	6.56	1.22	0.41	34.01	7.44	0.96	12.84	1.97	0.07	3.39	21.89	3	13.7
	30 kR	65	60	33.67	6.38	18.95	3.07	1.03	33.62	10.57	6.06	57.29	1.1	0.13	11.4	1.21	0.41	33.79	6.79	0.17	0.41	1.66	0.32	19.58	18.43	3.22	17.49
JG 315	**Control**	99	95	38.84	5.79	14.9	2.6	0.48	18.84	12.4	1.85	14.96	1.04	0.05	4.71	1.2	0.4	33.33	5.8	0.4	6.9	1.6	0.11	6.85	23.2	3.87	16.67
	10 kR	90	80	38.84	7.45	19.19	2.57	0.72	28.32	11.57	2.61	22.56	1.1	0.08	6.87	1.28	0.45	35.13	5.43	0.49	9.12	1.21	0.21	17.29	20.29	0.45	2.23
	20 kR	75	70	38.32	4.84	12.63	3.66	1.4	30.15	8.67	1.97	22.75	1.05	0.05	4.76	1.16	0.37	31.94	5.17	0.37	7.21	1.17	0.17	14.57	22.17	4.67	21.07
	30 kR	60	50	33.23	5.3	15.95	3.0	0.81	27.21	5.67	2.49	44.02	1.03	0.05	4.56	1.33	0.47	35.35	4.33	0.94	21.76	1.2	0.22	18	18.33	2.36	12.86

- G%=Germination percentage
- S%=Survival percentage
- sd=Standard deviation
- cv=Coefficient of variation

Table 2: Mean, Standard deviation(sd) and Coefficient of variation(cv)of M_2 generation plants.

Variety	Treatment	G%	S%	Plant height			Branches/plant			Pods/plant			Pod length			Seeds/pod100			Seed weight			Seed yield/plant			Harvest index		
				Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv	Mean	sd	cv
BGM 408	**0 kR**	**92.5**	**90.33**	62.6	3.07	4.91	7	1.67	23.9	68.2	21.27	31.19	1.34	0.1	7.61	1.6	0.49	30.62	29.23	7.56	25.88	31.94	16.97	53.14	51.18	1.85	3.61
	10 kR	**89.2**	**87.56**	57.76	9	15.58	6.05	3.06	50.62	31.77	21.84	68.74	1.32	0.16	12.49	1.53	0.4	25.98	32.4	15.73	48.56	15.63	13.07	83.65	53.28	11.43	21.45
	20 kR	**75.4**	**73.55**	52.13	5.67	10.88	7.4	2.87	38.79	23.8	6.45	27.11	1.51	0.78	51.28	1.89	0.16	8.51	20.55	4.07	19.81	9.04	2.67	29.51	54.78	7.102	12.96
	30 kR	**60.5**	**57.4**	50.1	13.82	27.58	5.2	2.4	46.15	19.33	17.84	92.27	1.08	0.45	41.31	0.98	0.41	41.69	25.21	14.12	56.04	6.91	10.28	148.75	40.27	20.98	52.11
B 115	**0 kR**	**93**	**90**	66.92	66.79	99.8	11.55	11.92	103.28	82.45	93.72	113.66	1.76	1.17	66.08	1.55	1.04	67.58	26.38	28.95	109.72	30.17	37.96	125.81	55.96	14.87	26.58
	10 kR	**90.2**	**88.33**	62.8	8.9	14.17	9.78	5.57	56.95	61.72	46.27	74.96	1.36	0.24	17.43	1.61	0.38	23.45	27.79	15.37	55.32	30.49	28.82	94.52	59.96	17.8	29.69
	20 kR	**73.6**	**70.5**	66.91	6.47	9.67	9.32	4.95	53.1	55.82	32.89	58.93	1.46	0.12	8.19	1.59	0.29	18.13	33.19	10.65	32.09	30.1	22.27	73.98	68.49	14.09	20.58
	30 kR	**62.7**	**59.66**	59.01	8.92	15.11	8.13	3.61	44.46	46.19	23.35	50.56	1.44	0.1	7.28	1.97	2.2	111.45	31.52	11.32	35.19	24.79	15.01	60.56	54.05	14.14	26.16
JG 315	**0 kR**	**95.2**	**90.2**	66.69	5.86	8.78	7.75	2.59	33.37	83	17.68	21.31	1.64	0.09	5.23	1.95	0.09	4.44	20.04	2.01	10.04	32.57	8.53	26.21	55.14	9.12	16.53
	10 kR	**85.6**	**80.75**	61.38	6.56	10.69	8.54	3.75	43.92	52	24.87	47.83	1.21	0.14	11.91	1.64	0.55	33.57	25.52	9.63	37.76	27.52	17.47	63.49	54.27	20.27	37.35
	20 kR	**80.33**	**75.25**	59.06	11.59	19.62	12.63	5.6	44.36	61	32.25	52.87	1.2	0.38	31.67	1.71	0.44	25.44	31.85	8.94	28.08	34.5	21.14	61.28	56.37	16.41	29.1
	30 kR	**75.5**	**60.35**	54.38	8.84	16.26	4.89	2.02	41.41	19.33	11.93	61.68	1.29	0.08	6.14	1.48	0.25	16.81	27.57	8.96	32.52	7.48	5.09	68.07	35.04	15.13	43.18

- G%=Germination percentage
- S%=Survival percentage
- sd=Standard deviation
- cv=Coefficient of variation

individual for JG 315 and 20kR line for BGM 408.In case of pod length and seeds/pod no huge variation was observed. There was not much variation for the 100 seed weight for the treated and the non-treated individuals. But in the 10 kR dose of the genotype JG 315 highest 100 seed weight was recorded. Maximum seed yield per plant was produced by many treated lines from 10,20 and 30 kR in all of the genotypes. These selected individual were tested for salinity tolerance in the saline prone areas of Hingalganj in the next season and they were referred as M_4 lines.

M_4 Generation

i. Grouping of mean : Observations are presented in Table 4. In case of plant height almost all of the treatments showed negative shift, except 20 kR dose of JG 315. In case of branches/plant 30 kR dose of B115 and 20 kR dose of JG 315 exhibited positive shift. Positive shift in pods/plant was only observed in 20 kR and 30 kR dose of JG 315.Pod length exhibited no change from mean in higher frequency. In case of Seeds/pod 20 kR dose of JG 315 exhibited positive shift in higher frequency. Among all the characters studied 100 seed weight disclosed positive shift in appreciabily higher frequency in almost all of the treatments in all the genotype, suggesting the occurrence of lines of higher seed mass potentiality. In case of seed yield 20 kR dose of JG 315 exhibited positive shift from mean indicating that selection is possible from these lines. Harvest index mostly negatively shifted from mean, indicating that biomass production was greatly hampered. Such shift in mean was observed in Lentil (Sharma and Sharma,1982).

ii. Selection and characterization of M_4 selected lines : Several individual were identified from the selected superior lines of M_4. Different plant attributes including seed yield per plant of these individuals are presented in Table 5. Majority of the individuals were from 10kR and 20kR treated population. These individuals produced very high seed yield per plant than their respective controls. Five individuals were identified from 20 kR dose of JG 315,two individuals were identified from 10 kR dose of B 115 and two individuals from 10 kR dose of BGM 408.So,total nine individuals were selected. Most of the treated individual showed more number of branches/plant, pods/plant and seed yield over the control.The lower dose of gamma radiation would thus likely to create useful and desirable mutants with high seed yield potentiality in chickpea genotypes. The usefulness of low dose of gamma radiation was also reported by Singh *et al.* (1998), Chopra (2005) and Bentota, (2006). So these individuals have a great potentiality for cultivation in coastal areas after releasing as a variety. Thus in a nutshell the mutagenic treatments had pronounced effects on the yield attributing traits and it shows signs of improvement than that of control.

Table 3: Selected promising M_3 lines: Their agro-morphological characters and seed yield

Genotypes	Old line No.in M_3	New Line No. in M_4	Dose	Characters							
				Plant height (cm)	Branches/ plant	Pods/plant	Pod length(cm)	Seeds/pod	100 seed weight (gm)	Seed yield(gm)	Harvest index
BGM 408	$M_3L_1P_3$	M_4 L_1	Control	61	9	75	1.64	1.8	6.46	9.42	28.76
	$-L_3P_9$	$-$ L_2	10 kR	51	6	37	1.64	1.7	7.32	8.2	34.74
	$-L_4P_{10}$	$-L_3$		63	13	65	1.78	2	6.5	7.18	27.18
	$-L_5P_{13}$	$-L_4$		52	8	80	1.64	1.6	7.2	8.93	30.68
	$-L_6P_3$	$-L_5$		63	5	78	1.6	1.7	7.11	9.65	38.29
	$-L_7P_5$	$-L_6$		61	9	86	1.6	2	6.69	11.54	43.56
	$-L_8P_7$	$-L_7$		65	6	92	1.6	2	6.43	11.83	38.41
	$-L_9P_2$	$-L_8$		45	11	80	1.57	2.2	5.61	9.87	31.0
	$-L_{10}P_1$	$-L_9$		62	6	43	1.57	1.8	12.36	9.57	26
	$-L_{11}P_{12}$	$-L_{10}$		56	8	80	1.9	2.6	5.15	10.7	38.52
	$-L_{13}P_6$	$-L_{11}$		49	8	81	1.7	1.6	8.2	10.63	42.8
	$-L_{14}P_6$	$-L_{12}$		58	9	77	2	1.8	7.5	9.98	39.25
	$-L_{19}P_3$	$-L_{13}$		57	6	84	1.4	1.6	6.7	9.1	38.8
	$-L_{20}P_2$	$-L_{14}$		51	7	105	1.5	1	8.46	8.88	27.2
	$-L_{21}P_3$	$-L_{15}$	20kR	54	11	125	1.6	2	9.72	22.7	50.8
	$-L_{22}P_3$	$-L_{16}$		44	11	72	1.53	1.4	9.13	9.20	41.4
	$-L_{23}P_5$	$-L_{17}$		44	10	97	1.6	2	5.75	11.16	36
	$-L_{24}P_3$	$-L_{18}$		51.8	9	96	1.5	1.6	7.0	10.8	37.8
	$-L_{25}P_4$	$-L_{19}$	30kR	49	10	83	1.7	1.4	8.4	9.83	32.5
	$-L_{27}P_9$	$-L_{20}$		48.2	13	81	1.7	2	7.16	11.6	33.5
B 115	$M_3L_{29}P_5$	M_4L_{21}	Control	51	10	31	1.7	2.4	5.8	10.2	38.0
	$-L_{30}P_{15}$	$-L_{22}$	10 kR	59	6	74	1.6	1.6	7.7	9.12	35.3
	$-L_{31}P_6$	$-L_{23}$		54	4	62	1.9	2	7.29	9.05	36.2
	$-L_{32}P_9$	$-L_{24}$		64	8	69	1.4	1.4	8.4	8.13	25.5
	$-L_{33}P_2$	$-L_{25}$		52	7	71	1.6	2	7.4	10.58	40.69
	$-L_{35}P_1$	$-L_{26}$		55	8	69	2	2.1	7.9	10.23	35.67
	$-L_{42}P_5$	$-L_{27}$		60	9	69	1.7	2	6.4	8.98	33.5
	$-L_{43}P_2$	$-L_{28}$		63	6	79	1.5	1.6	7.7	9.7	34.1
	$-L_{44}P_2$	$-L_{29}$		68	8	82	1.6	1.6	8.2	10.76	30.65
	$-L_{46}P_1$	$-L_{30}$		60	9	78	1.5	1.6	7.9	9.96	34.9
	$-L_{47}P_1$	$-L_{31}$		50	8	78	1.6	2	6.7	10.47	29.7
	$-L_{48}P_3$	$-L_{32}$		60.1	6	95	1.6	1.8	6.1	10.6	32.6
	$-L_{49}P_4$	$-L_{33}$		64	5	84	1.6	1.6	6.8	7.86	29.1
	$-L_{52}P_6$	$-L_{34}$		60	8	64	1.6	2	7.2	9.22	39.7
	$-L_{53}P_4$	$-L_{35}$		61	9	89	1.7	1.6	8.3	11.83	38.4
	$-L_{55}P_{10}$	$-L_{36}$		52	12	84	1.4	1.6	8.4	11.39	43.8
	$-L_{56}P_{12}$	$-L_{37}$		55	6	67	1.6	1.6	8.5	9.15	81.6
	$-L_{60}P_5$	$-L_{38}$		47	15	79	1.7	1.8	6.9	11.69	31.6
	$-L_{60}P_{13}$	$-L_{39}$		53	14	90	1.7	1.2	9.7	10.55	32.6

continue Table 3............

continue Table 3.........

	$-L_{62}P_{12}$	$-L_{40}$	20 kR	59	6	93	1.5	1.6	11.4	10.52	31.7
	$-L_{63}P_{5}$	$-L_{41}$		49	8	76	1.6	1.8	6.1	8.43	36.0
	$-L_{67}P_{6}$	$-L_{42}$		59	6	72	1.4	1.4	8.6	8.67	39.0
	$-L_{76}P_{5}$	$-L_{43}$	30 kR	48	7	99	1.3	1.2	7.7	9.23	30.3
	$-L_{77}P_{4}$	$-L_{44}$		42.5	9	79	1.7	1.8	6.3	8.96	38.7
	$-L_{78}P_{3}$	$-L_{45}$		49	7	69	1.6	1.8	5.6	9.15	61.5
	$-L_{79}P_{2}$	$-L_{46}$		48	9	73	1.5	1.4	9.1	9.40	48.7
	$-L_{80}P_{7}$	$-L_{47}$		43	5	86	1.6	1.6	7.1	9.9	41.5
JG 315	$M_3L_{82}P_5$	M_4L_{49}	Control	49	6	78	1.4	1.4	4.4	9.68	22.0
	$-L_{84}P_{5}$	$-L_{50}$	10 kR	51.5	9	41	1.3	1.2	20.7	10.19	42.4
	$-L_{87}P_{3}$	$-L_{51}$		39	6	71	1.6	2	5.9	8.51	39.6
	$-L_{88}P_{8}$	$-L_{52}$		51	8	71	1.6	2	6.5	9.27	35.6
	$-L_{90}P_{8}$	$-L_{53}$		51	9	98	1.4	1.6	6.3	9.91	30.9
	$-L_{93}P_{3}$	$-L_{54}$		45	8	90	1.3	1.6	6.6	9.62	27.9
	$-L_{93}P_{7}$	$-L_{55}$		38	10	85	1.6	2	6.0	10.33	40.35
	$-L_{94}P_{4}$	$-L_{56}$		51	8	88	1.5	1.6	7.7	10.46	54.8
	$-L_{96}P_{7}$	$-L_{57}$		57	5	88	1.7	2	6.15	10.82	20.83
	$-L_{97}P_{2}$	$-L_{58}$	20 kR	48	8	71	1.8	2.2	5.6	8.79	29.8
	$-L_{99}P_{6}$	$-L_{59}$		57	7	90	1.5	1.6	8.0	10.20	37.8
	$-L_{100}P_{4}$	$-L_{60}$		46	8	80	1.8	2	5.6	9	31.6
	$-L_{101}P_{5}$	$-L_{61}$		60	7	103	1.8	1.4	8.1	11.73	36.28
	$-L_{104}P_{9}$	$-L_{62}$		51	7	92	1.5	1.4	7.4	9.55	36.7
	$-L_{105}P_{6}$	$-L_{63}$		58	7	80	1.6	2.4	5.4	10.47	37.9
	$-L_{106}P_{2}$	$-L_{64}$		57	6	78	1.6	1.4	9.7	10.63	45.0
	$-L_{107}P_{1}$	$-L_{65}$		52	3	109	1.7	1.8	4.5	8.84	55.2
	$-L_{108}P_{7}$	$-L_{66}$		61	9	86	1.8	1.8	7.3	11.40	22

Table 4: Grouping of means for eight different characters in M_4 generation

Genotypes	Dose	Plant Height			Branches/plant			Pods/plant			Pod length			Seeds/pod			100 seed weight			Seed yield/plant			Harvest index		
		-	No change	+	-	No change	+	-	No change	+	-	No change	+	-	No change	+	-	No change	+	-	No change	+	-	No change	+
BGM 408	**10** kR	17	0	0	17	0	0	17	0	0	17	0	0	15	0	2	11	0	6	17	0	0	17	0	0
B115	**10** kR	47	0	0	44	0	3	43	0	4	41	4	2	26	21	0	29	2	16	47	0	0	42	0	5
	20 kR	5	0	0	5	0	0	5	0	0	1	4	0	4	1	0	2	3	0	5	0	0	5	0	0
	30 kR	6	0	0	0	0	1	6	0	0	2	4	0	5	1	0	4	0	2	6	0	0	6	0	0
JG 315	**20** kR	44	5	2	29	19	3	31	9	11	4	48	0	19	2	30	30	13	8	43	4	4	51	0	0
	30 kR	7	3	0	2	8	0	5	3	2	0	10	0	3	1	6	6	3	1	10	0	0	10	0	0

Table 5: Selected promising M_4 individuals: Their agro-morphological characters and seed yield

Genotype	Old Line No. (M_4)	New Line No. (M_5)	Dose	Characters							
				Plant height (cm)	Branches/ plant	Pods/plant	Pod length (cm)	Seeds/pod	100 seed weight (gm)	Seed yield/ (gm)	Harvest index
JG 315			Control	35	5	52	1.4	1.8	5.1	5.0	19.25
	$M_4L_{58}P_1$	M_5L_1	20kR	34	8	74	1.5	2	5.75	7.62	17.2
	$M_4L_{59}P_3$	$-L_2$		35	11	85	1.6	2	5.8	10.4	30.3
	$M_4L_{64}P_1$	$-L_3$		39	8	60	1.7	1.8	6	8.26	33.6
	$M_4L_{65}P_2$	$-L_4$		39	6	75	1.6	2	5.1	7.46	17
	$M_4L_{70}P_1$	$-L_5$		36	10	79	1.5	2	3.5	8.73	15.6
B 115			Control	32	5	35	1.5	1.4	4.1	3.2	15.23
	$M_4L_{39}P_3$	$-L_6$	10 kR	39	9	95	1.6	1.4	4.8	7.95	34.1
	$M_4L_{45}P_1$	$-L_7$		36	5	38	1.4	1.5	3.8	7.75	10.8
BGM 408			Control	38	3	45	1.4	1.5	5.0	4.5	25.3
	$M_4L_6P_6$	$-L_8$	10kR	39	5	70	1.5	1.8	7.04	11.26	33.29
	$M_4L_{19}P_{10}$	$-L_9$		42	6	65	1.6	2	8.14	10.85	30.28

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