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RESEARCH ARTICLE

EFFECT OF GAMMA RAYS ON SEED GERMINATION, PLANT SURVIVAL AND QUANTITATIVE CHARACTERS ON TWO VARIETIES OF SOYBEAN (*Glycine max.* (L.) Merrill.) IN M1 GENERATION

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ABSTRACT

A study was undertaken on induced mutagenesis with two varieties of Soybean, BSS-2 and RKS- 18. The mutagen used was Gamma rays (50,100,150,200 and 400 Gy). A difference was observed between the varieties BSS-2 and RKS-18 in the degree of tolerance to the mutagens. Germination and survival percentage in both the varieties was lower as compared to control. Reduction in germination percentage was associated with increase in dose of mutagen in both varieties BSS-2 and RKS-18. Germination percentage was higher in the variety BSS-2 as compared to RKS-18, while a higher survival percentage of the seedlings was recorded in RKS-18 which showed a higher genetic damage in the variety BSS-2. In variety BSS-2 at 100 Gy dose a higher survival percentage 94.6% was recorded as compared to lower dose 50Gy while in RKS- 18 the lower dose of 50 Gy (79.4) showed much higher survival percentage in comparison to higher dose of 100 and 150 Gy.

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) also known as golden bean is an important oilseed crop. The productivity of soybean in India is much low in comparison with the world average. The main attributes identified for low productivity are limited genetic diversity, narrow genetic base of Indian soybean varieties and stagnant genetic potential for yield (Tiwari, 2003). Narrowing down of the genetic base is due to the repeated use of few parents for breeding programmes (Satyavathi *et al.,* 2003). At this context, widening of genetic base is a major concern and challenge put forward to the Indian soybean breeders. The classical breeding methods have got limited application in soybean as its small fragile flowers and complete self fertility impose limitation on the success of hybridization programme. So mutation breeding appears to play an important role in the improvement of this important pulse – cum oil seed crop. Earlier mutation breeding work in Soybean crop has yielded in identification of many mutant lines with desirable traits like high germination and survival percentage (Rahman *et al.,* 1994). Improvement in either single or few economic traits and quality characters can be achieved with the help of induced mutation within the shortest possible time (Manjaya and Nandanwar, 2007).

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Therefore, the present investigation was undertaken to study the effect of physical mutagen (Gamma rays) on some quantitative traits at different doses of two varieties of Soybean BSS-2 and RKS-18 in M1 generation. Though variation in M1 generation is less important in obtaining suitable gene mutations, they are considered as indication in measuring efficiency of mutagen treatments (Plesnik, 1993).

MATERIALS AND METHODS

Two varieties, BSS-2 and RKS-18 of Soybean formed the materials for the present investigation. Dry (9-12%) moisture and healthy seeds were obtained from Birsa Agricultural University, Ranchi and exposed to 50,100,150,200 and 400Gy Gamma rays. Irradiation was done using the Cobalt 60 sources in Gamma chamber at Bhabha Atomic and Research Centre, Mumbai. In Kharif 2014, two thousand (2000) treated seeds of two varieties of Soybean BSS-2 & RKS-18 irradiated with five (5) different doses of γ-rays (50Gy, 100Gy, 150Gy, 200Gy & 400Gy) were sown along with untreated control seeds in the single plot design at research farm of Birsa Agricultural University, Kanke, and Ranchi. The soil type of the experimental site was lateritic with the pH 5.8. In this region Soybean cultivation is mainly dependent on monsoon rains. The climate of this place is subtropical type and the average annual rainfall of this area is approximately 1400 mm and it is mostly erratic and punctured with occasional dry spells. Nearly 80% of the total rainfall comes during four monsoons months

(mid June to mid October).Data were recorded on germination %, survival % lethality %, (30 days after sowing and at flowering) and injury percentage. Likewise variations in quantitative characters were also observed in untreated control as well as treated plants throughout the life span of the plant.

RESULTS AND DISCUSION

Detailed observation on all the M1 plants in 50 Gy, 100 Gy, 150 Gy, 200 Gy and 400 Gy doses of gamma rays and control of both the varieties viz. BSS-2 and RKS-18 were recorded for germination percent, survival percent, lethality percent and injury percent were recorded (Table 1 and Fig.1). Observations for quantitative characters were also recorded (Table 2).

Germination percent

Initial germination was recorded after 10 days of sowing both in control and in irradiated seeds of the varieties BBS-2 and RKS-18 in M1. Result observed in both the varieties BSS-2 and RKS-18 indicated that seed germination percent decreased with an increasing dose of gamma rays clearly indicating that gamma rays as mutagen have induced an inhibitory effect on seed germination. Chaudhary and Singh (1980), Satpute and Fultambkar (2012) reported similar results in Soybean. A similar result of dose dependent germination percent reduction in other crops was reported by different workers viz. Kumar *et al.* (2009) in Cowpea, Roy, Sagade and Apparao (2011) and Bhoslae (2013) in Urdbean. The reduction in germination may be either due to genetic cause or inhibition of physiological process in cell by mutagen. In present investigation the variety BSS-2 was found more sensitive to gamma rays as compared to variety the RKS-18. Similar mutagenic sensitivity has been reported by Kothekar in Mothbean (1992).

Survival percent

In M1 the number of plants surviving at the maturity of both the varieties , BSS-2and RKS-18 was recorded and have been presented in Table 1. A study of data recorded revealed that there was marked decrease in survival percentage in BSS-2 at higher doses of gamma rays except at 100Gy where maximum survival percent was observed. Maximum mortality was observed ay 400Gy. In the variety RKS-18 there was remarkable decrease in survival percentage of plants at higher doses (200 Gy and 400 Gy) of gamma radiation. Similar inverse relationship was reported in M1 generation by Chopde (1976), Kharkwal (1978) in Chickpea. Satpute and Kothekar (1996) in Safflower. Potdukhe and Narkhede (2002), Kole *et al.* (2003) in *Zinnia*, Biradar (2004) in Pegionpea, Shrama *et al.* (2006) in Urdbean, Barbhat and Dhumal (2009) in Kulthi - 1, Sagade and Apparoa (2011) in Urdbean, Bhosale *et al.* (2013) in Urdbean and Bashir *et al.* (2013) in Fenugreek. Gaul (1964) opinioned that chromosomal and extra chromosomal injury might had lead to disturbances at physiological and cytological level leading to decrease in survival percent.

Lethality percent

In the variety, BSS-2 lethality percent increased with increase in dose of gamma rays except 100 Gy which showed reduction in lethality percent and recorded lowest lethality percent (5.35), while highest lethality percent (76.71) was recorded in 400 Gy dose.

In the variety, RKS-18 lethality percent increased parallel with the increase in dose of gamma rays. With slight difference in lethality percentage, 200 Gy (41.34) and 400 Gy (50) recorded maximum lethality, while lowest lethality percent was recorded in 50 Gy (12.50). Similar result was reported by several workers. Ehrenberg (1955), Siddiqui and Swaminathan (1968), Kirmani (1992), Nilan *et al.* (1969) proposed that prime cause of lethality is physiological imbalances or different types of chromosomal aberrations.

Injury percent

Injury percent was recorded by reduction in plant height over control. Injury percent in the variety, BSS-2 showed a random change in the value without following a particular trend. Highest injury percent value was recorded in 200 Gy (14.47), followed by 400 Gy (12.69) while lowest injury percent value was recorded in 50 Gy (1.69). In the variety, RKS-18 highest injury percent value (7.84) was recorded in two doses (100 Gy and 150 Gy) of gamma rays followed by 400 Gy (5.88), 50 Gy (1.96) while it was zero (o) in 200 Gy. Injury percent dose not follow a dose dependent increase or decrease, it was erratic. Similar result was reported by Venkatachalam and Jayabalan (1997) in Groundnut, Khan *et al.* (2000) in Greengram.

The reduction in plant height may be ascribed to different factors. Markeen *et al.* (2007) was in the opinion that reduction in plant height or seedling growth with higher dose of Sodium azide, may be due to gross injury caused at cellular level either due to gene controlled bio- chemical process or acute chromosomal aberration or both or may be due to slow rate of division of meristematic cells at shoot apex and arresting of mitotic cycle. Observations for nine quantitative characters viz. plant height, number of branches per plant, pod length, number of pods plant, number of seeds per pod, 100 seed weight, seed yield per pod, days to 50 percent flowering and days to plant maturity were recorded. Mean, coefficient of variance, and standard deviation were calculated for all the nine quantitative characters in both the soybean varieties (Table 2).

Days to 50% flowering

In the variety, BSS-2 there was very slight decrease in the mean values for days to 50 percent flowering in radiation doses compared to that of control while the mean values in 50 Gy, 200 Gy and 400 Gy were similar (40 days). Highest mean value for days to 50 percent flowering was recorded in 100Gy (42 days). A comparison of estimates of variance showed that the variance increased in radiation doses compared to control for days to 50 percent flowering. In general, the estimates of standard deviation were higher in radiation treatments in comparison to control for days to 50 percent flowering. Highest standard deviation value was recorded in 150 Gy while lowest was recorded in 100 Gy radiation dose. In the variety, RKS-18 highest mean value for number of days to 50 percent flowering was recorded in control. There was gradual decrease in the mean value of days to 50 percent flowering with increase in dose of Gamma rays. Lowest mean value (42 days) was recorded in higher doses (200 & 400Gy). The estimates of coefficient of variance and standard deviation in general were lower in radiation doses than that of control and their highest values were recorded in 50 Gy, while lowest values were observed in 400Gy.

Table 1. Effect of gamma rays on germination%, survival%, lethality% and injury %in two variety BSS-2 and RKS-18 of Soybean in M1 generation

Variety	DOSE	Total seeds sown	Total rows planted	Total rows germinated	Plant population	Plant population at maturity	Germination% (G%)	Survival% (S%)	Survival Reduction (Lethality%) L	Seedling Height Reduction over control (Injury %) I
BSS - 2	Control	2000	50	45	1910	1885	95.5	98.6	-	-
	50 Gy	2000	50	42	1835	1457	91.7	79.4	20.60	1.69
	100 Gy	2000	50	37	1439	1362	71.9	94.6	5.35	8.89
	150 Gy	2000	50	27	948	654	47.4	68.9	31.01	4.74
	200 Gy	2000	50	32	1145	449	57.2	39.2	60.79	14.47
	400 Gy	2000	50	21	438	102	21.9	23.2	76.71	12.69
RKS - 18	Control	2000	50	42	1650	1520	82.5	92.1	-	-
	50 Gy	2000	50	31	704	616	35.2	87.5	12.50	1.96
	100 Gy	2000	50	27	689	461	34.4	66.9	33.09	7.84
	150 Gy	2000	50	22	537	275	26.8	51.2	48.79	7.84
	200 Gy	2000	50	19	411	200	20.5	48.6	51.34	0
	400 Gy	2000	50	13	58	29	2.9	50	50	5.88

Table 2. Mean, Standard deviation, Coefficient of variability, of two varieties BSS- 2 and RKS-18 of Soybean in M1 generation

		BSS – 2						RKS-18					
	DOSE	Control	50 Gy	100Gy	150 Gy	200 Gy	400 Gy	control	50 Gy	100Gy	150 Gy	200 Gy	400 Gy
Days to 50 percent flowering	Mean	43	40	42	41	40	40	47	46	43	43	42	42
	SD	1.79	2.61	1.8	2.9	2.21	2.15	3.08	2.24	1.94	1.93	1.98	1.77
	CV(%)	3.19	6.8	3.25	8.4	4.9	4.64	9.5	5.01	3.76	3.73	3.92	3.14
Days to maturity	Mean	107	109	109	112	114	115	114	117	121	125	120	120
	SD	1.58	3.76	3.71	3.71	3.38	3.25	3.44	3.06	3.4	2.94	4.95	4.94
	CV(%)	2.51	14.16	13.76	13.75	11.43	10.57	11.83	9.34	11.59	8.67	24.49	24.38
Plant Height	Mean	58.68	58	53.7	56.2	50.46	51.51	51	50	47	47	51	48
	SD	2.57	2.06	2.6	2.98	4.94	4.7	2.97	3.08	3.81	3.21	2.79	2.57
	CV(%)	6.64	3.55	4.84	5.3	9.78	9.19	5.82	6.16	8.1	6.82	5.47	5.35
No. of Branches/ Plant	Mean	3.68	3	2.8	2.46	2.93	2.37	2	2	2	2	2	2
	SD	0.8	0.53	0.67	0.74	0.79	0.51	0.82	0.59	0.8	0.46	0.51	0.44
	CV(%)	21.73	31	23.92	30.08	26.96	21.24	41	29.5	40	23	25.5	22
Pod Length	Mean	3.56	3	2.87	2.8	3.06	2.61	3	3	3	3	3	3
	SD	0.46	0.53	0.17	0.57	0.2	0.23	0.37	0.42	0.43	0.32	0.35	0.39
	CV(%)	12.92	17.66	5.92	20.35	6.53	8.81	12.3	14	14.3	10.6	11.6	13
No. of Pods/ Plant	Mean	31.6	28	30.4	29.2	27.9	24.6	35	34	33	31	33	31
	SD	2.85	3.38	3.67	4.37	3.36	2.87	1.64	1.3	2.62	1.41	1.95	2.47
	CV(%)	9.08	12.07	12.07	14.92	12.02	11.85	4.68	7.93	4.54	5.9	7.96	3.82
No. of seeds/ pods	Mean	3	3.33	3.4	3.33	3.27	3.25	3	3	3	3	3	3
	SD	0.58	0.49	0.51	0.49	0.46	0.46	0.61	0.59	0.45	0.54	0.51	0.47
	CV(%)	0.33	0.24	0.26	0.24	0.21	0.21	20.3	19.6	15	18	17	15.6
100 seed weight	Mean	11.31	11.23	10.06	10.67	10.28	9.56	10.2	10	9.8	9.8	9.7	9.6
	SD	2.09	0.71	0.37	0.62	0.41	0.26	0.26	0.37	0.37	0.44	0.21	0.27
	CV(%)	4.37	6.32	3.68	5.81	3.99	2.71	2.54	3.7	3.77	4.48	2.16	2.81
Seed Yield/ plant	Mean	11.03	10.56	10.38	10.28	9.41	8.26	10.72	12.01	11.36	10.2	10.3	9.89
	SD	2.33	2.72	1.94	1.84	1.92	0.36	2.15	1.94	1.67	1.58	1.31	2.04
	CV(%)	5.43	7.4	3.78	3.4	3.69	0.13	4.61	3.76	2.79	2.51	1.71	4.18

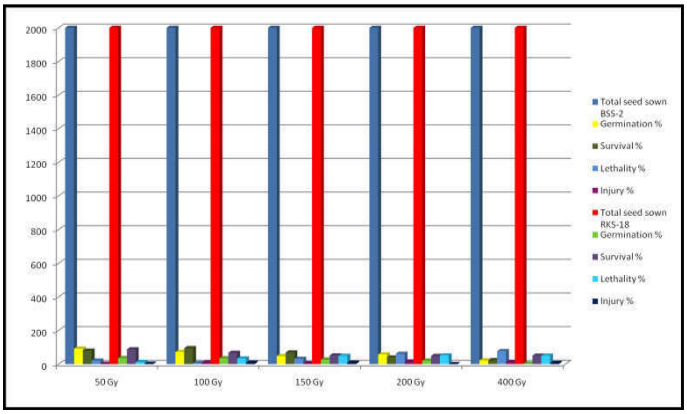

Fig. 1. Effect of gamma rays on germination%, survival% , lethality% and injury %in two variety BSS-2 and RKS-18 of Soybean in M1 generation

Days to maturity

In the variety BSS-2 mean value of days to maturity showed positive deviation and increased parallel with the increase in dose of gamma rays. Highest mean value was recorded in 400 Gy (115 days) while lowest mean value (107 days) was recorded in control. The estimates of standard deviation and coefficient of variance were higher in radiation treatments than the control. Among the treatments highest coefficient of variance and standard deviation values were recorded in lower dose (50Gy) while lowest coefficients of variance and standard deviation values were recorded in higher dose of 400 Gy. The lowest coefficient of variance and standard deviation values were recorded in control.

In the varietyRKS-18 the mean values for days to maturity were higher in radiation doses compared to control. The mean values for days to maturity was only 114 days in control .Among treatments highest mean value of (125 days) was recorded in 150 Gy and lowest (117 days) was in 50Gy.. The values of coefficient of variance values for days to maturity showed a random change. Higher dose (200 Gy and 400 Gy) recorded higher coefficient of variance values (24.49 and 24.38) than control (11.83) while lowest (8.67) was recorded in 150 Gy. Similarly the standard deviation values were also higher in higher radiation doses (200 Gy and 400 Gy) than control.

Plant height

In the variety BSS-2, there was slight decrease in the mean values for plant height in 200Gy and 400 Gy doses of Gamma rays, while it was same in control and 50 Gy. The coefficient of variance for plant height was higher in 200 Gy followed by 400 Gy and control .There was considerable decreasing trend in C.V values with decrease in dose of gamma rays from 150Gy to 50Gy. For the character plant height, highest value of standard deviation was recorded in 200 Gy followed by 400Gy, 150Gy, 100Gy, control & 50Gy in decreasing order. In the variety RKS-18, maximum value of mean for plant height was observed in control as well as in 200 Gy dose of gamma radiation. There was a slight decrease in the mean values in the remaining doses. The estimates of co efficient of variance for plant height were higher in radiation treatments in comparison to control, except in 200 Gy and 400 Gy which showed slight lower value of co-efficient of variance than control. Maximum value of standard deviation was recorded in 100Gy followed by 150Gy, 50Gy, control, 200Gy and 400Gy in decreasing order.

Number of branches per plant

In the variety BSS-2 the mean value for number of branches per plant was highest in control and lowest in 400 Gy. The coefficient of variance for number of branches per plant was highest in 50 Gy followed by 150 Gy, 200 Gy, 100 Gy, 400 Gy and control in decreasing order. For the character number of branches per plant, standard deviation value increased with increase in dose (up to 200 Gy). In the variety, RKS-18 the mean value for number of branches per plant was same in all the doses of gamma radiation as well as in control. The character number of branches per plant showed highest co efficient of variance and standard deviation in control followed by 100 Gy,50 Gy, 200 Gy, 150 Gy and 400 Gy in decreasing order.

Pod length

In the variety BSS-2 the character pod length had maximum mean value in control while the mean value decreased with increasing dose of gamma radiation except at 200 Gy which had the highest mean value among the treatments. For the character pod length, maximum co efficient of variance and standard deviation was recorded in 150 Gy, closely followed by 50 Gy and control. There was a drastic decrease in co efficient of variance & standard deviation in rest of the treatment doses. In the variety RKS- 18 the mean values for the character pod length was same in control as well as in all the doses radiation treatment. The co efficient of variance and standard deviation values for pod length were lowest in 150 Gy, while the highest co-efficient of variance and standard deviation were recorded in 50 Gy and 100 Gy with almost identical values followed by 400 Gy control and 200 Gy in decreasing order.

Number of pods per plant

The highest mean for the character pod per plant in the BSS-2 was observed in control (31.6).The mean value showed decreasing trend with increase in treatment dose of irradiation from 100 Gy to 400 Gy, while in 50 Gy, the mean value was almost similar as in 200 Gy (27.9) dose. A comparison of estimates of co efficient of variance obtained, revealed that the variance increased in radiation doses in comparison to control for the character number of pods per plant. Similarly the standard deviation value was also higher in radiation doses in comparison to control. In the variety RKS-18, the highest mean value for, number of pods per plant was observed in control, followed by 50Gy, 100Gy and 200Gy. The minimum value was recorded in 150Gy & 400Gy with similar values. The estimate of co- efficient of variance was maximum in 200Gy followed by 50Gy, 150Gy, control, 100Gy and 400Gy. The standard deviation values for number of pods per plant were higher in radiation treatments in comparison to control except in 50 Gy and 150 Gy.

Number of seeds per pod

In the variety BSS-2 the mean value for number of seeds per pod showed decreasing trend with the increase in dose of gamma rays, while the highest mean value was scored in

100Gy dose .The minimum mean value was found in control (3.0). The co efficient of variance as well as the value of standard deviation for the character of seeds per pod was maximum in control. There were decreasing trend in their values with increase in dose of irradiation from 100Gy to 200Gy. The values of co- efficient & standard deviation at 50Gy were same as at 150Gy, while these two values at 400Gy were identical as 200Gy. In the variety, RKS-18 the mean value for character number of seeds per pod were same in control and all the radiation doses. The co-efficient of variance was maximum in control in comparison to all the radiation treatments. Similar observations were also recorded for the values of standard deviation.

100 seed weight

In the variety, BSS-2 the mean value for the character 100 seed weight was maximum in control, while it decreased with increasing doses of gamma radiation. For 100 seed weight, the maximum value of co-efficient of variance was recorded in 50Gy, followed by 150Gy, control, 200Gy,100Gy and 400Gy in decreasing order, while the value of standard deviation was maximum in control for the 100 seed weight followed by 50Gy, 150Gy, 200Gy, 100Gy and 400Gy in decreasing order.
In the variety RKS-18, maximum mean value was recorded in control for the character 100 seed weight. There was slight reduction in mean values with increased dose of Gamma rays. The estimates of co efficient of variance were higher in radiation treatments in comparison to control except 200Gy with minimum co efficient of variance. Similar trend of observations was recorded for the values of standard deviation for 100 seed weight

Yield per plant

In the variety BSS-2 seed yield per plant showed maximum mean in control closely followed by 50 Gy, 100 Gy and 150 Gy, while it decreased in higher doses (200 Gy and 400 Gy). The highest value of co efficient of variance and standard deviation for seed yield per plant was recorded in lower dose (50Gy) followed by control, 100Gy, 200Gy, 150Gy and 400Gy in decreasing order. In the variety RKS- 18 the maximum value of mean for the character yield per plant was recorded in 50Gy followed by 100Gy, control, 200Gy, 150Gy and 400Gy in decreasing order. The highest co efficient of variance for yield per plant was observed in control followed by 400Gy. There was decrease in values of co efficient of variance with increase in radiation doses from 50Gy to 200Gy. Similar trend of observations was recorded in standard deviation values for yield per plant.

Conclusion

Percent seed germination and seedling growth was found inhibited due to increasing dose of mutagen. Similar trend was also observed in survival percentage also**.** All the mutagen treatment except some brought about decrease in the plant height, number of primary branches per plant, days required for flowering, number of pods per plant, pod length, number of seeds per pod and seed yield per plant in both the varieties BSS-2 and RKS-18. Almost all report on induced mutation studies in different crop plants have revealed physical damage in M1 generation thereby inducing change in quantitative characters. The results observed are in conformity with the findings of Bolbhat *et al.* (2012) in two varieties of Horsegram in M1 generation. Other similar findings were of Misra (1992) in Blackgram, Rakshit and Singh (2001) in Mungbean and Urdbean, Rybinski (2003) in Grampea, Patil *et al.* (2004) in Soybean, Sharma *et al.* (2005) in Urdbean and Senapathi *et al.* (2008) in Blackgram. The probable reason may be that genes responsible for diverse types of traits, which are distributed throughout the genome, might have been affected by mutagens which resulted in different types of micro mutations (Senapati *et al.,* 2008, Bollhat, 2011 and Dhumal and Bolbhat (2012).

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