J. Soils and Crops 29 (2) 268-273, December 2019

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)
NAAS Rating - 4.46
Scientific Journal Impact Factor - 7.375

EFFECT OF GAMMA RAYS ON QUANTITATIVE TRAITS IN M_2 GENERATION OF LATHYRUS (*Lathyrus sativus* L.)

V. T. Chavan[1], Shanti R. Patil[2],Shubhangi K. Maraskole[3], Vandana S. Madke[4], Sapana B. Baviskar[5] and Vandana B. Kalamkar[6]

ABSTRACT

An experiment on induction of mutation in lathyrus by gamma rays was conducted by using treated seeds of lathyrus cv. NLK-73 with 150, 200, 250, 300 and 350 Gy doses of gamma rays in non-replicated trial along with control. The treated material along with untreated control were sown in M_1 generation and the seeds collected from individual plant of M_1 generation were used to raise M_2 generation during *rabi* 2017 and 2018 respectively. Observations on morphological traits and biometrical traits were recorded on each and every plant in each treatment and data were subjected to statistical analysis.Germination and mortality percentage were recorded in M_1 and M_2 generation and observed reduction in germination percentage and increase in mortality as compared to control.In M_2 generation number of branches plant^{-1} increased significantly in all the treatments as compared to control. Days to first flower increased in 250 Gy, 200 Gy and 300 Gy while, decreased in 150 Gy and 350 Gy over the control.Days to maturity and number of pods plant^{-1}were observed to increase in 250 Gy and 300 Gy and decreased in 150 Gy, 200 Gy and 350 Gy over the control.Plant height increased in 150 Gy and 250 Gy while, decreased in 200 Gy, 300 Gy and 350 Gy over control.Number of pods plant^{-1} increased in 250 Gy and 300 Gy while, decreased in 150, 200 and 350 Gy over control.100 seed weight increased in 250 Gy, 300 Gy and 350 Gy while, decreased in 150 Gy and 200 Gy over control.Grain yield plant^{-1} was found to increase in 150 Gy, 250 Gy and 300 Gy and decreased in 200 Gy and 350 Gy treatments as compared to control.Significant variation among the treatments for all the mutants were recorded in M_2 generation of Lathyrus and hence, offers scope for identifying mutants.

(Key words: Lathyrus, Gamma rays, Mutation, M_2 generation)

INTRODUCTION

The *Lathyrus sativus* (L.) (2n = 14) is an annual herb and one of the pulse crop rich in protein content (28%) next to soybean locally called as grass pea, khesari dal, peavine or chanamatra. It belongs to family Leguminoceae, sub family Papilionoideae and genus Lathyrus with 130 species occurring all over temperate region of Northern hemisphere and the higher altitude of tropical Africa. In India, besides the ornamental *Lathyrus odoratus*, the only other species cultivated is *Lathyrus sativus* which yield the khesari dal. The edible *Lathyrus sativus* originated in the West Central Asia Mediterranean region and North India was its center of domestication. The plant is considered as a great boon against drought, floods, hails and various pests. The plant is strongly drought resistant, due to a very hardy and penetrating root system and can be grown on a wide range of soil types, including very poor soils. Being a legume, it fixes atmospheric nitrogen through root nodules, part of which could be available to succeeding crop.It is mostly sown in standing crop of paddy as a 'Utera' or 'Paira' crop in *rabi* season.

The lathyrus plant type is considered to be strongly drought resistant (Tripathy *et al*., 2011) and grows luxuriantly without any cultivation input. Besides this Lathyrus contains toxic alkaloid which causes paralysis of lower limbs known as Lathyrism. The continuous consumptions of this pulse that too in undercooked condition of low temperature causes paralysis.

Though the various improved varieties of lathyrus are developed by research scientists but area and average productivity of India is quite low in comparison to other countries. Grasspea is important pulse crop due to high protein (28-32%), next to soybean (42%). Therefore, to meet

1 and 3. P. G. Students, Agril. Botany Section, College of Agriculture, Nagpur, India
2. Professor (CAS), Agril. Botany Section, College of Agriculture, Nagpur, India
4 and 5. Asstt. Professors, Agril. Botany Section, College of Agriculture, Nagpur, India
6. Sr. Res. Assistant, Agril. Botany Section, College of Agriculture, Nagpur, India

the protein need of large population of country different breeding strategies are being used in this crop to increase economic yield.Mutation is a sudden heritable change in the characteristics of an organism other than those due to mendelian segregation and recombinations. Mutations are the rare events mostly recessive to wild type, often associated with deleterious or lethal effects and are inducible by a variety of external agents called mutagen.Spontaneous mutations occurs naturally but are of rare occurrence and their frequency is also very low. Therefore, they don't solve the problems of breeder. The different genetical and breeding problems can be solved by inducing the artificial mutations in the organism and plants. Therefore, the technique of mutation breeding has been adopted as a valuable supplement to conventional breeding to create additional genetic variability. The variability created through these mutations is utilized for further crop improvement.

The main objective behind selecting a pulse crop for mutation breeding is that pulses are rich in protein and protein is the basis of life. It is the main component of brain, blood, bone, muscles and skin. Hence, the importance of protein in human nutrition needs no elaboration.Thus, the breeding approach for the improvement of this crop is towards developing cultivars with high protein content, high yield and low neurotoxin. There are different methods to achieve these objectives of which mutation breeding is one of the efficient method. Hence, this experiment was planned and executed with the objective to study the effect of gamma rays on quantitative traits in M_2 generation of lathyrus.

MATERIALS AND METHODS

In the present investigation dry, healthy and genetically pure seeds of *Lathyrus sativus* cv NLK-73 (high yielding cultivar) were obtained from Agril. Botany section, College of Agriculture, Nagpur. Six different lots of 500 seeds of Lathyrus seed cultivar NLK-73 were made. Out of these five lots of seeds were sent to Bhabha Atomic Reasearch Centre, Trombay, for irradiation with five different doses of gamma rays i.e. 150 Gy, 200 Gy, 250 Gy, 300 Gy and 350 Gy (Co60 at BARC Trombay, Mumbai) and used for raising M_1 during *Rabi* 2017 and individual plant in each treatment were harvested separately. The harvested seed were used to raise M_2 generation in *rabi* 2018 and mutants were identified.

M_2 generation was raised in *rabi* 2018. Fifteen hundred seeds of each treatment from M_1 generation were sown to raise M_2 population. The sowing was undertaken on the fertile and well levelled piece of land in the field of Agril. Botany section, College of Agriculture, Nagpur. The M_2 population was observed for different parameters besides scoring of different mutants. The treated populations were carefully screened for all morphological characters.The observations on the following traits were recorded on germination per cent and mortality per cent (in M_1 and M_2), days to first flower, days to maturity, plant height (cm), number of branches plant^{-1}, number of pods plant^{-1}, 100 seed weight (g) and grain yield plant^{-1} (g) (in M_2) on each and every plant in each treatment except for germination per cent and mortality per cent on which plot wise observations were recorded.Germination count was taken 12 days after sowing and was reported in percentage. Germination percentage was calculated as per the formula given below

$$\text{Germination \%} = \frac{\text{Total number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

The number of plants which failed to survive upto flowering from the date of germination were counted and mortality percentage was calculated as per the formula given below:

$$\text{Mortality \%} = \frac{\text{Number of plants failed to survive upto flowering}}{\text{Number of seeds germinated}} \times 100$$

The data recorded were analysed statistically as described by Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

The effect of various treatments of gamma rays on germination in M_1 and M_2 generations are presented in table 1. Reduced germination per cent in all the treatments was observed in M_1 generation as compared to control. The germination percentage in M_1 generation ranged from 38.25 (T_5 – 350 Gy) to 87.50 (T_6 - control) per cent. Reduction of germination percentage was highest in T_5 – 350 Gy (38.25%) followed by T_4 – 300 Gy (39.50%) of M_1 generation while, lowest reduction in T_1 -150 Gy (46.75%) as compared to control. In M_2 generation, simillar pattern of reduced germination was observed as in M_1 generation. The germination percentage in M_2 generation ranged from 51.27 (T_5 – 350 Gy) to 88.60 (T_6 - control) per cent. Reduction of germination percentage was highest in T_5 – 350 Gy (51.27%) followed by T_4 – 300 Gy (53.07%) of M_1 generation while, lowest reduction in T_1 -150 Gy (58.60%) as compared to control.The results on germination per cent revealed that gamma rays reduced the germination in M_1 and M_2 generation with increasing dose of gamma rays clearly indicating that gamma rays as mutagen have induced an inhibitory effect on seed germination. The germination percentage increased in M_2 as compared to M_1. The reduction in germination may be either due to genetic cause or inhibition of physiological process in cell by mutagen. In accordance to this result Kusmiyati *et al*. (2018) and Kankal *et al*. (2018) also observed that higher doses of gamma rays significantly reduced germination percentage of the first and final count in soybean.

The data on mortality of seedling as affected due to different doses of gamma rays in M_1 and M_2 generation are presented in table 1.The effect was recorded as mortality in percentage. Increasing the dose of gamma rays caused increase in mortality of seedling in both M_1 and M_2 generation.Data in table 1 reveals that the maximum mortality was recorded in T_5 – 350 Gy (48.39%) and minimum in T_1 – 150 Gy (31.56%) as compared to their respective control (8.57%) in M_1 generation. In M_2 generation the maximum mortality was recorded in T_5 – 350 Gy (32.51%) while minimum in T_1 – 150 Gy (28.67%) as compared to their respective control (7.22%). Increased doses of treatment of gamma rays had exerted increasing effect over the character.The results on mortality per cent revealed that mortality per cent was more in gamma rays treatments as compared to control. It was also found that mortality increased in M_1 and M_2 generation with increase in doses of gamma rays treatment. The prime cause of mortality was physiological imbalance or different types of chromosomal aberrations as reported by Aditya *et al.* (2017). In accordance to the above result, Ahire *et al.* (2005) in soybean reported that high lethality may be attributed to the injuries caused by mutagenic treatments of gamma rays. Similar to the results Beltagi *et al.* (2006) also observed that under highest dose of gamma irradiation the seedling immerged but it did not continue growth and indicated 100 per cent lethality and the low dose significantly reduced the shoot length and leaf area in common bean. Aditya *et al.* (2017) in soybean also observed and reported increase in mortality per cent with the increase in the dose of gamma rays treatment.

Data regarding effect of different gamma rays treatments on days to flowering in M_2 generation are presented in table 1.It is observed from the table that the maximum mean value for days to first flower initiation was in T_3 – 250 Gy (62.20 days) while, the minimum days to flowering was recorded in T_1 – 150 Gy (61.26 days) as compared to their respective controls (61.65 days). Maximum range for days to first flower initiation was observed in T_2 - 200 Gy, T_3 – 250 Gy and T_4 -300 Gy (21 days) and minimum range in T_1 – 150 Gy (11 days) as compared to control (13 days).The coefficient of variation increased in all the treatments for days to first flower initiation as compared to control. The maximum coefficient of variation was observed in T_3 – 250 Gy (8.44%) followed by T_4 – 300 Gy (7.64%), T_2 – 200 Gy (5.63%), T_5 – 350 Gy (5.45%) while, the minimum in T_1 – 150 Gy (4.30%) as compared to control (3.99%).The results on days to first flower initiation revealed that time taken for flowering was more in control as compared to gamma rays treatments. The results showed that gamma irradiation affected days to flower initiation, statistical results revealed that all the doses kept their rate parallel to control which was observed from the mean values and coefficient of variation. In accordance to this result Khan *et al.* (2018) reported that gamma irradiation non-significantly affected days to flower initiation in pea.

Data regarding effect of different gamma rays treatments on days to maturity in M_2 generation are presented in table 1.It is observed from the table that the maximum mean value for days to maturity was in T_3 – 250 Gy (118.25 days) and was statistically significant, while the minimum days to maturity was recorded in T_1 – 150 Gy (110.65 days) as compared to their respective controls (115.25 days). Maximum range for days to maturity was observed in T_3 – 250 Gy (27 days) and minimum range in T_1 – 150 Gy (12 days) as compared to control (11 days).The coefficient of variation increased in all the treatments for days to maturity as compared to control. The maximum coefficient of variation was observed in T_3 – 250 Gy (4.25%) followed by T_4 – 300 Gy (3.97%), T_2 – 200 Gy (3.58%) and T_5 – 350 Gy (2.98%) while, the minimum in T_1 – 150 Gy (2.74%) as compared to control (2.39%). The extent of coefficient of variation is low for this trait.The results on days to maturity revealed that the mean value of days to maturity increased in some treatments and decreased in some treatments. Similar to this result Patil *et al.* (2011) reported in soybean that in the higher doses of mutagen and their combinations, days required to maturity were found to be significantly increased. Khan *et al.* (2018) also observed and reported that increase in the radiation dose of gamma rays delayed maturity in pea.

Plant height is an important measure of growth. It is one of the visible measurement and is a function of the internode and leaf emergence, since leaves are born on stem. Leaf area development and biomass production shows a close relationship with plant height. The data regarding the effect of gamma rays on plant height are presented in table 1.Mean plant height increased significantly in all the treatments except T_4 300 Gy and T_5 350 Gy as compared to control. Maximum plant height was observed in T_1 -150 Gy (89.84 cm) followed by T_3 -250 Gy (84.63 cm) while, the minimum in T_5 –350 Gy (56.97 cm) as compared to control (82.60 cm). The maximum mean range for plant height was recorded in T_3 – 250 Gy (118 cm) and minimum range was recorded in T_1 – 150 Gy (85 cm) as compared to control (58 cm).The coefficient of variation for the plant height increased in all the treatments as compared to the control. The maximum variation was in T_4 – 300 Gy (42.77%) followed by T_3 – 250 Gy (34.16%) and T_2 – 200 Gy (25.95%) and minimum in T_5 – 350 Gy (21.29%) and T_1 – 150 Gy (19.93%) as compared to control (17.22%) respectively. The range for the coefficient of variation was 19.93% to 42.77%.The data on plant height indicated that mean height reduced in higher doses and increased in lower doses of gamma rays. Gamma rays induced reduction in plant height, may be due to destruction or damage to apical meristem, hampered respiratory enzyme synthesis and reduction in level of amylase activity and due to temporary suspension of cell division or delay in mitosis according to Khan *et al.*(2 018). Lande *et al.* (2 018). They mentioned that ionising radiation causes inactivation of growth regulators that lead to delayed growth of plants and believed that the delay in height of the plant may be due to an increase in the production of active radicals that are responsible for lethality or due to the increase in gross structural chromosomal changes induced by radiation. Similar to this result Rybinski *et al.* (2006)

reported that in M_2 progeny of lathyrus, plant height for cultivar Krab ranged from 104.2 to 111.5 cm, and that of the mutant from 89.9 to 129.4 cm. Alikamanoglu *et al.* (2011) also reported decrease in plant height in inverse proportion of dose.

The data on number of branches plant^{-1} was recorded at harvest stage and are presented in table 1. Significant variation was observed for this trait.The highest mean value for this character was recorded in T_3 -250 Gy (4.48) and the lowest in T_5 – 350 Gy (3.90). In general the number of branches increased in all the treatments as compared to their control (4.15) except T_5 -350 Gy. Maximum range for number of branches plant^{-1} was noticed in T_2 – 200 Gy, T_3 – 250 Gy and T_4 – 300 Gy (7) followed by T_1 – 150 Gy and T_5 – 350 Gy (6) as compared to control (2).The variability studies showed that the coefficient of variation increased against their control in all the treatments. The coefficient of variation for the character ranged from 25.29% to 29.85% as compared to control (16.16%). The highest variation was recorded in T_3 – 250 Gy (29.85%) followed by T_4 – 300 Gy (27.63%) and T_2 – 200 Gy (27.20%) and the lowest in T_1 – 150 Gy (26.04%) and T_5 – 350 Gy (25.29%).The data revealed that increase in dose of gamma rays lead to increase in number of branches plant^{-1} with increase in dose of gamma rays except for T_5 – 350 Gy. Similar to this result Usharani and Kumar (2015) reported that the mean values for number of primary branches in blackgram decreased below the control in most of the treatments. Aditya *et al.* (2017) observed that the coefficient of variance for number of branches plant^{-1} was highest in 50 Gy followed by 150 Gy, 200 Gy, 100 Gy, 400 Gy and control in decreasing order.Data on variation caused due to different gamma rays treatment on number of pods plant^{-1} are presented in table 1.The coefficient of variation increased in all the treatments for number of pods plant^{-1} as compared to control. The maximum coefficient of variation was observed in T_3 – 250 Gy (80.40%) while, the minimum in T_1 – 150 Gy (51.31%). The range of coefficient of variation in treated population was 51.31% to 80.40%.The result on number of pods plant^{-1} revealed that the mean number of pods plant^{-1} increased in T_3 – 250 Gy and T_4 – 300 Gy and decreased in other treatments as compared to control. But the wide range of variation observed in all the treatments indicated the presence of high, within treatment variation. In accordance to this result Rybinski *et al.* (2006) reported a wide variation for number of pods plant^{-1} in selected grasspea mutants. The number of pods plant^{-1} ranged from 56.2 to 69.8 for cv Krab and 37.1 to 95.4 in their mutants. Badr *et al.* (2014) also noticed that the number of pods plant^{-1} were significantly increased in cowpea varieties treated with gamma radiation as compared to control. Aditya *et al.* (2017) reported in soybean that the standard deviation values and coefficient of variation increased in radiation doses in comparison to control. Khan *et al.* (2018) reported that number of pods plant^{-1} decreased significantly in some treatment of gamma irradiation in pea while increased significantly in some treatments.

Data regarding effect of different doses of gamma rays on 100 seed weight in M_2 generation are presented in table 1. The mean value for 100 seed weight showed significant difference. The maximum mean value for the character was observed in T_4 – 300 Gy (9.99 g) and minimum in T_1 – 150 Gy (8.69 g) and control showed a mean value of 9.67 g. Highest range for this trait was recorded in T_3 – 250 Gy (13.6 g) and lowest range in T_1 – 150 Gy (6.33 g) as compared to control (4.6 g).The coefficient of variation increased in all the treatments for 100 seed weight as compared to control. The maximum coefficient of variation was observed in T_4 – 300 Gy (14.68%) while, the minimum in T_1 – 150 Gy (11.29%). The range of coefficient of variation in treated population was 11.29% to 14.68% as compared to control (11.26).The results on 100 seed weight revealed that gamma rays treatment resulted in increase in mean 100 seed weight in all the treatments except T_1 – 150 Gy and T_2 -200 Gy as compared to control. In contrary to this result Waghmare and Mehara (2000) reported significant reduction in 100 grain weight in grasspea irradiated with gamma rays. Similar to this results Usharani and Kumar (2015) also reported that the mean value for 100 seed weight decreased below the control in most of the treatments.

Data regarding effect of different gamma rays doses on grain yield plant^{-1} in M_2 generation are presented in table 1. The mean value for grain yield plant^{-1} showed significant difference. The maximum mean value for the characters was observed in T_3 – 250 Gy (26.89 g) and minimum in T_5 – 350 Gy (14.77 g) and control showed a mean value of 19.18 g. Highest range for this trait was recorded in T_3 – 250 Gy (92.00 g) and lowest range in T_1 – 150 Gy (41.9 g) as compared to control (30.2 g). The coefficient of variation increased in all the treatments for number of grain yield plant^{-1} as compared to control. The maximum coefficient of variation was observed in T_4 – 300 Gy (62.30%) while, the minimum in T_1 – 150 Gy (56.31%). The range of coefficient of variation in treated population was 56.31% to 62.30% as compared to control (17.26%). The result on grain yield plant^{-1} revealed that the mean grain yield plant^{-1} increased in most of treatments viz., T_1 – 150 Gy, T_3 – 250 Gy and T_4 – 300 Gy and decreased in some treatments i.e., T_2 – 200 Gy and T_5 – 350 Gy as compared to control. But the wide range of variation observed in all the treatments indicated the presence of high, within treatment variation. In accordance to this result Aney (2013) reported significant variability in yield in gamma irradiated population of pea. In contrary to this Usharani and Kumar (2015) observed decrease in mean values for single plant yield below control in most of the treatments and more than control in some treatments. Aditya *et al.* (2017) also reported that seed yield plant^{-1} in variety BSS-2 of soybean showed maximum mean in control closely followed by 50 Gy, 100 Gy and 150 Gy, while it decreased in higher doses.

The results obtained in this study revealed that germination per cent was reduced and mortality per cent increased in M_1 and M_2 generation. In M_2 generation number

Table 1. Effect of gamma ray on quantitative traits in M_2 generation

Treatments	Parameters	Doses of gamma rays					
		T_1 (150 Gy)	T_2 (200 Gy)	T_3 (250 Gy)	T_4 (300 Gy)	T_5 (350 Gy)	T_6 (Control)
Germination %	M_1	46.75	43.50	42.25	39.50	38.25	87.50
	M_2	58.60	56.60	54.73	53.07	51.27	88.60
Mortality %	M_1	31.56	33.18	39.23	40.93	48.39	8.57
	M_2	28.67	29.09	29.84	31.03	32.51	7.22
Days to first flower (Days)	Range	11	21	21	21	16	13
	Mean	61.26	61.66	62.20	61.87	61.52	61.65
	SD	2.63	3.47	5.25	4.73	3.35	2.46
	CV (%)	4.30	5.63	8.44	7.64	5.45	3.99
Days to maturity (Days)	Range	12	17	27	19	16	11
	Mean	110.65	114.28	118.25	117.48	114.24	115.25
	SD	3.03	4.09	5.03	4.66	3.40	2.75
	CV (%)	2.74	3.58	4.25	3.97	2.98	2.39
Plant height (cm)	Range	85	96	118	104	95	58
	Mean	89.84	80.61	84.63	73.42	56.97	82.60
	SD	17.91	21.96	30.69	31.40	17.59	14.22
	CV (%)	19.93	25.95	34.16	42.77	21.29	17.22
Number of branches plant^{-1}	Range	6	7	7	7	6	2
	Mean	4.17	4.26	4.48	4.30	3.90	4.15
	SD	1.09	1.16	1.34	1.19	0.99	0.67
	CV (%)	26.04	27.20	29.85	27.63	25.29	16.16
Number of pods plant^{-1}	Range	265	370	469	416	232	177
	Mean	80.17	91.31	115.20	115.00	58.31	109.13
	SD	41.14	55.48	92.62	79.05	30.99	14.74
	CV (%)	51.31	60.76	80.40	68.74	53.14	13.51
100 seed weight (g)	Range	6.33	7.80	9.00	7.10	8.10	4.60
	Mean	8.69	9.54	9.92	9.99	9.90	9.67
	SD	0.98	1.19	1.36	1.47	1.25	1.09
	CV (%)	11.29	12.51	13.73	14.68	12.59	11.26
Grain yield plant^{-1} (g)	Range	41.9	66.8	92.00	91.70	64.10	30.20
	Mean	24.39	18.03	26.89	26.86	14.77	19.18
	SD	13.73	10.82	16.39	16.73	8.79	3.31
	CV (%)	56.31	60.02	60.98	62.30	59.48	17.26

of branches plant^{-1}increased significantly in all the treatments as compared to control. Days to first flower was increased in 250 Gy, 200 Gy and 300 Gy while, decreased in 150 Gy and 350 Gy over the control. Days to maturity and number of pods plant^{-1} was increased in 250 Gy and 300 Gy while, decreased in 150 Gy, 200 Gy and 350 Gy over the control. Plant height was increased in 150 Gy and 250 Gy while, decreased in 200 Gy, 300 Gy and 350 Gy over control. Number of pods plant^{-1} was increased in 250 Gy and 300 Gy while, decreased in 150, 200 and 350 Gy over control. 100 seed weight was increased in 250 Gy, 300 Gy and 350 Gy while, decreased in 150 Gy and 200 Gy over control. Grain yield plant^{-1} increased in 150 Gy, 250 Gy and 300 Gy while, decreased in 200 Gy and 350 Gy treatments as compared to control.

REFERENCES

Aditya, K., N. Verma, N. Srivastava, M. Chakraborty and K. Prasad, 2017. Effect of gamma rays on seed germination, plant survival and quantitative characters on two varieties of soybean (*Glycine max.* (L.) Merrill.) in M_1 generation. Asian J. Sci. and Tech. **08**(11) : 6763 - 6768.

Ahire, D. D., R. J. Thengane, J. G. Manjaya, M. George and S. V. Bhide, 2005. Induced mutations in soybean[*Glycine max*(L.) Merr.] Cv. MACS 450. Soybean Res. **3** : 1- 8.

Alikamanoglu, S., O. Yaycili and A. Sen, 2011. Effect of gamma radiation on growth factors, biochemical parameters and accumulation of trace elements in soybean plants (*Glycine max* L. Merrill). Biol. Trace Elem. Res. **141** : 283 - 295.

Aney, A. 2013. Effect of gamma irradiation on yield attributing characters in two varieties of pea (*Pisum sativum* L.). Int. J. Life Sci. **1** (4) : 241 - 247.

Badr, A. F., H. I. S. Ahmed, M. Hamouda, M. Halawa and M. A. Elhiti, 2014. Variation in growth, yield and molecular genetic diversity of M_2. plants of cowpea following exposure to gamma radiation. Life Sci. J. **11**(8) :10 - 19.

Beltagi, M. S., M. A. Ismail and F.H. Mohamed, 2006. Induced salt tolerance in common bean (*Phaseolus vulgaris* L.) by gamma irradiation. Pak. J. Bio. Sci. **9**(6) : 1143 - 1148.

Dwivedi, M. P. and E. G. Prasad, 1964. An epidemiological study of lathyrism in the district of Rewa (M.P.). Indian J. Med. Res. **52** : 81 - 116.

Kankal, G.A., S.K. Dhapke, Shubhangi Maraskole, Shanti R. Patil, D.Y. Upadhyay, S.R. Kamdi and A.V. Navghare, 2018. Selection of desirable mutants in M_3 generation of soybean. J. Soils and Crops **28**(1):177-184.

Khan, W. M., Z. Muhammad, N. Akhtar, T. Burni, A. Younas and N. Umar, 2018. Gamma radiation induced mutation in M_2 generation of pea (*Pisum sativum* L.). Pure Appl. Biol. **7** (2) : 832 - 839.

Kusmiyati, F., Sutarno, M. G. A. Sas and B. Herwibawa, 2018. Mutagenic effects of gamma rays on soybean (*Glycine max* L.) germination and seedlings. IOP Conference : Earth Environ. Sci.**102**: 012 - 059.

Lande, N.H., S.K. Dhapke, S.R. Patil, R.A. Sayyad, K.N. Uikey, V.S. Joyade and G.A. Kankal, 2018. Genetic variability induced by gamma rays in M_2 generation of soybean (*Glycine max* (L) Megrill) J.Soil and crops **28**(1) : 177-184

Panse, V. G. and P.V. Sukhatme, 1954. Statistical Methods for Agricultural Workers. I.C.A.R. Pub. New Delhi. PP. 524.

Patil, A., S. P. Taware and V. M. Raut, 2011. Induced variation in quantitative traits due to physical (ã rays), chemical (EMS) and combined mutagen treatment in soybean [*Glycine max* (L.) Merrill]. Biovigyanam, **11** : 149 - 155.

Rybinski, W., W. Blasczak and J. Fornal, 2006. Seed microstructure and genetic variation of characters in selected grasspea mutants (*Lathyrus sativus* L.). Int. Agrophysics, **20** : 317-326.

Tripathy, S. K., D. Lenka and R. Ranjan, 2011. Maximization of mutation frequency in grasspea (*Lathyrus sativus* L.). Legume Res. **34** (4) : 236-299.

Usharani, K. S. and C. R. Ananda Kumar, 2015. Mutagenic effects of gamma rays and EMS on frequency and spectrum of chlorophyll mutations in urdbean (*Vigna mungo* (L.) Hepper). Indian J. Sci. Tech. **8** (10) : 927-933.

Waghmare, V. and R. B. Mehra, 2000. Induced genetic variability for quantitative characters in grass pea (*Lathyrus sativus* L.). Indian J. Genet. **60** (3) : 232-236.

Rec. on 10.07.2019 & Acc. on 20.07.2019