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Research Article

Effect of Gamma Irradiation on Yield Attributing Characters in Two Varieties of Pea (*Pisum sativum* L.)

Avinash Aney

Plant Biotechnology Laboratory, Post Graduate Teaching Department of Botany, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur-440 033, (M.S.) India

Address for Correspondence Email: aney_avinash10@rediffmail.com

ABSTRACT

Seeds of two varieties of *Pisum sativum, P. sativum* var. *hortense* (garden pea) and var. *arvense* (field pea) were subjected to different doses of gamma irradiation to evaluate the effect on yield attributing characters. The effect of mutagen was studied with regard to percent germination, plant height, maturation period, number of branches, and number of flowers per plant, number of pods per plant, pod size, number of seeds per pod and per plant, weight of 100 dried seeds, and number of seeds per 100 grm. Data recorded from the population raised exhibited significant variability in different characters. Most of the physiological parameters viz. percent germination, maturation period and number of flowers showed dose dependent decrease in irradiated plants. Lower doses of gamma irradiation had stimulatory effect on yield attributing parameters such as number of pods per plant, number of seeds per plant, and pod size, in both the varieties. *P. sativum* var. *arvense* (leafy) was found to be high yielding than var. *hortense* (leafless) and the genotype of first variety was observed to be more sensitive to gamma irradiation than the latter.

KEYWORDS

Pisum sativum, gamma irradiation, yield, sensitivity, mutagens, genotype

INTRODUCTION

Pisum is one of the important pulses belonging to the family Papilionaceae, comprising seven species with their different varieties. The genus is rich source of protein, but is mostly cultivated for its edible purposes. Methionine, cysteine and tryptophan content of dry peas is reported to be 0.30, 0.124 & 0.039 % respectively (Gupta and Das, 1955). Protein and carbohydrate content is reported to be 19.7 & 56.6 % in dried peas respectively (Cherian, *et al*, 1955). It has medicinal properties too. The extracted pea oil contains m-xylohydroquinone which is used to diminish spermatogenesis in males. It is nontoxic and has no abortifacient action. It can also be used as an oral contraceptive (Sanyal, 1960). The extract obtained from testa of pea seeds is a potent hyperglycemic and reported to be effective in lowering blood-sugar level (Mukerji, 1957).

The plants are cultivated annual herbs, suitable in climatic conditions of western Maharashtra and Vidharbha region and are easy for cultivation process, with many cultivars easily available in this region. Two main kinds of peas recognized are *P. sativum* var. *hortense* (garden pea) and *P. sativum* var. *arvense* (field pea) which are cultivated throughout the country. *P. sativum* var. *hortense* is leafless but with large foliaceous stipules and all leaflets are modified into tendrils. Earlier reports of gamma irradiation showed adverse effect on morphological, floral, yield attributing characters and pollen viability which can be transferred to next generations. But the selective mutagenic treatments with low physiological effects and strong genetical effects are desirable. Mutation spectrum with chemical mutagens is greater than physical mutagens in *Pisum*. Mutation processes are found to be more important in breeding of pea plants. Eight different varieties of pea are reported to be more sensitive to gamma irradiation (Fierlinger *et al*, 1966). Mutation breeding by using radiations has been proved to be an important tool in introducing different desirable characters of agronomic values. Irradiation of plant materials by gamma rays is widely used to induce mutations at the genetic level which alters number of biochemical processes leading to the desirable changes in the genotype. Primary injury to plant material due to gamma irradiation is a physiological damage which is mainly restricted to M_1 generation. It can be identified and measured cytologically as well as from the response of the whole organism, especially growth retardation and at higher doses, the death (Sparrow, 1961). In view of the earlier reports, it was of interest to undertake the present investigation, to study the effect of different doses of gamma irradiation on the yield attributing characters to assess the sensitivity of gamma rays and to induce the alteration in the genotype to enhance the variability of agronomic traits in both the varieties selected.

MATERIALS AND METHODS

The present investigation was carried out during 1998 to 2000 at research field, Department of Botany, Vidharbha Mahaviyalya, Amravati. The seeds of both the varieties were obtained from Pulses Research Unit, Post Graduate Institute of Dr. Panjabrao Krishi Vidyapeeth, Akola (M.S.). Healthy and uniform sized seeds of both the varieties were selected and subjected to gamma irradiation doses from 50 Gy to 250 Gy, at an interval of 50 Gy, from Co^{60} source of 'gamma chamber', USIC, Nagpur University, Nagpur. 100 seeds from each sample of different doses were kept to count % germination, root length and seedling growth to decide LD_{50}. 150 Gy dose was found to be LD_{50} for both the varieties. Two lower doses (50 Gy & 100 Gy) and two higher (200 Gy & 250 Gy) were selected for final experimentation. 100 seeds of each sample of gamma irradiated and control of both the varieties were sown in experimental plot in triplicate sets, to raise the M_1population. Healthy, mature plants from control and irradiated were observed for external morphology and yield attributing characters, at regular intervals. Data on maturation period, plant height and yield attributing characters were recorded from 25 randomly selected matured plants from each dose along with control and mean of each was calculated. All obtained data was subjected to the statistical analysis for mean, standard error by using Graphpad Prism 4 software.

RESULTS AND DISCUSSION

The effect of different doses of gamma irradiation depicted in Tables 1 and 2 clearly revealed that with the increase in dose rate, percentage seed germination was decreased, in both the varieties. The maximum % germination in control of both the varieties was found to be 93.33 %. However, there was gradual decline in both the varieties with increase in dose rate. Percent germination was significantly decreased at higher doses and was almost reduced below 50 % as to that of control. Katyayani *et al* (1980) observed the drastic reduction in % germination at higher doses of gamma irradiation in *Phaseolus aureus* Roxb. Similar results were reported by Sushil Kumar *et al* (1997) in pea. They concluded that the effect of mutagens on seeds is expressed through delayed emergence of roots, reduction in vigour, low metabolic and enzymatic activity, losses of membrane integrity and finally loss of germinnability. This might suggest that germination is a radio sensitive phenomenon.

Plant height is an argonomically important character. The height of mature plants was measured at the time of commencement of flowering. The control plants in both the varieties attained almost the same height. The data presented in Tables 1 & 2 on plant height reveled that the increasing irradiation doses caused gradual decrease in plant height, in both the varieties. Lower doses showed slight reduction, but this parameter was significantly affected at higher doses. Choudhary and Dnyansagar (1980), Ramesh and Reddi (2002) also reported the dose dependent decrease in plant height in gamma irradiated plants of *Allium sativum* L. and three cultivars of *Oryza sativa* L. respectively. Gamma rays induced reduction in plant height may be due to destruction or damage to apical meristem (Patel and Saha, 1974), hampered respiratory enzyme synthesis and reduction in the level of amylase activity (Reddy and Vidyavathi, 1985) and to temporary suspension of cell division or delay in mitosis. Machaiah and Vakil (1979) mentioned that ionizing radiation causes inactivation of growth regulators leading to retarded plant growth. Selim *et al* (1974) opined that retardation in plant height may be due to an increase in the production of active radicals that are responsible for lethality or due to increase in radiation-induced gross structural chromosomal changes.

Number of branches in leafless var. *hortense* was less (5.0) as to that of leafy var. *arvense* (10.33). The data recorded in the present investigation on number of branches per plant showed no effect at 50 Gy dose, and were equal to the control in both the varieties, but this parameter was gradually decreased from 100 Gy onwards. The number of branches in var. *arvense* was found to be significantly affected at higher doses of gamma irradiation. The results are in agreement with those of Gonge and Kale (1996), in gamma rays induced M_2 population of Okra. Verma *et al* (1999) noted dose dependent reduction in plant height and number of branches produced per plant.

P. sativum var. *arvense* is comparatively early flowering than var. *hortense*. The data depicted on maturation period clearly indicated that gamma rays played a part in delaying flowering and maturity duration in both the varieties. It exhibited dose dependent delay in maturation period. Mutants with changes in flowering and maturity time have been reported by many workers because, generally due to radiation, flowering and maturity is late (Gustafsson, 1947 and Kawal, 1963). The delayed in flowering and late maturation caused by radiation may be due to number of different factors which are reported to induce destruction (Smith and Kerstein, 1942), production of diffusible growth reducing substances (Mackey, 1951), inhibition of DNA synthesis (Mikaelsen, 1968), and gross chromosomal changes (Sax, 1955). The prolongation of maturation period observed in gamma rays treatment in the present investigation may be due to one or more reasons mentioned above. Verma *et al* (1999) obtained the same results of delay in flowering and maturation period due to gamma irradiation in three varieties of *Lens culinaris*.

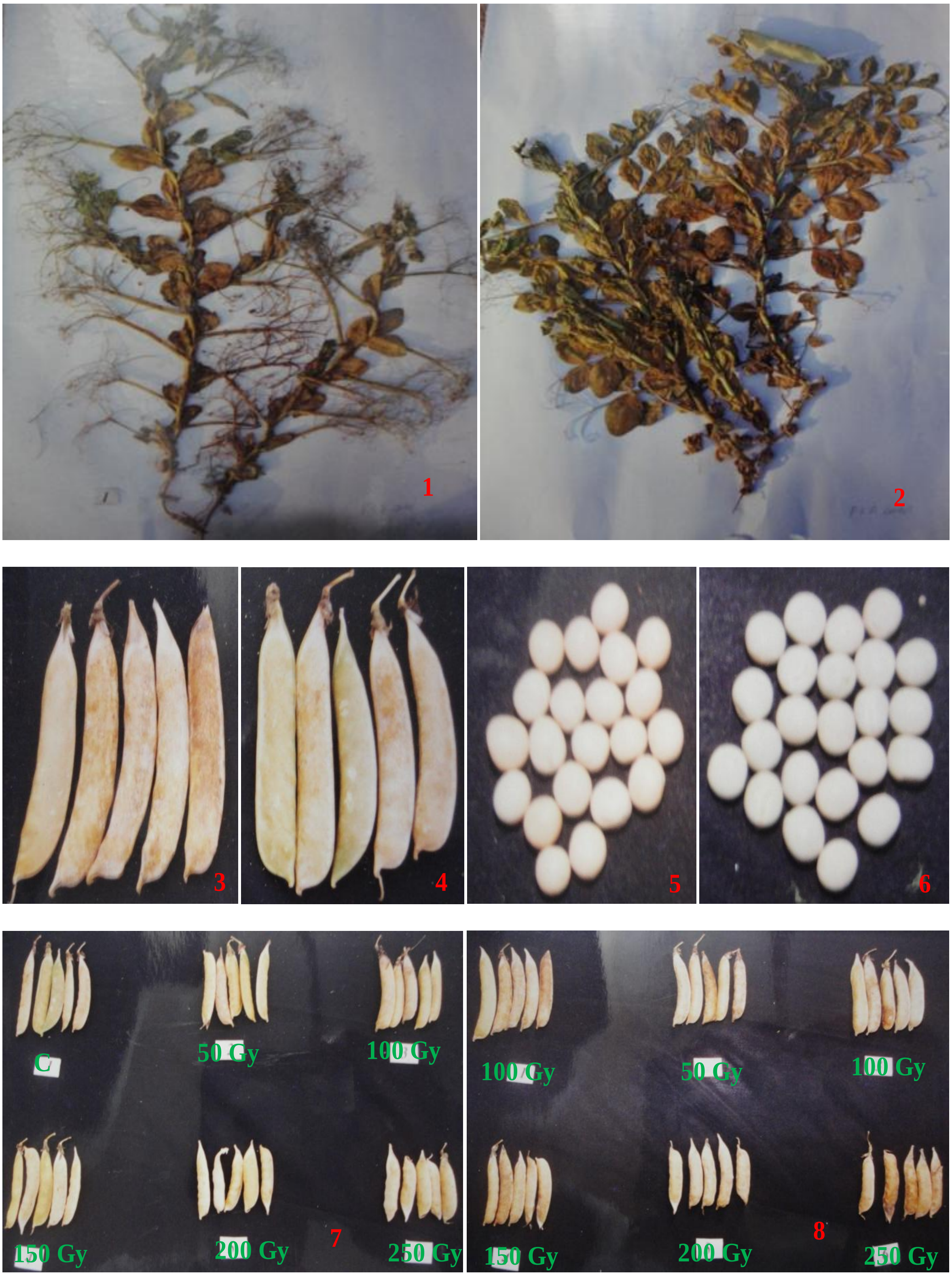

Fig. 1: (1-8): 1. Control plant var. *hortense* ; **2**. Control plant var. *arvense*; **3**. Pods in var. *hortense* ; **4.** Pods in var *arvense* ; **5.** Seeds in var. *hortense*; **6.** Seeds in var. *arvense* ; **7.** Effect of gamma irradiation on size of pods in var. *hortense*; **8.** Effect of gamma irradiation on size of pod in var. *arvense*.

Table No. 1. Effect of different doses of gamma irradiation on yield attributing characters in *Pisum sativum* var. *hortense*

Dose	% Germ.	Pl. ht. at maturity	No. of branches	Maturation Period in days	No. of Flrs./pl.	No. of Pods/Pl.	Pod size in cm.		No. of Seeds/ pod	No. of Seeds/ pl.	Wt. of 100 Seeds	No. of Seeds/ 100 grm.
							Ln.	Br.				
Control	**93.33** ± 0.666	**42.65** ± 0.682	**5.00** ± 0.000	**56.00** ± 0.505	**30.00** ± 1.155	**25.67** ± 0.333	**7.23** ± 0.029	**1.36** ± 0.011	**6.00** ± 0.000	**148.00** ± 2.309	**28.65** ± 0.238	**355.33** ± 4.807
50 Gy	**81.67** ± 0.888	**41.13** ± 1.122	**5.00** ± 0.000	**60.33** ± 1.269	**34.00** ± 1.155	**31.00** ± 1.155	**7.29** ± 0.029	**1.38** ± 0.030	**5.67** ± 0.333	**172.67** ± 2.906	**27.76** ± 0.099	**369.00** ± 1.000
100 Gy	**72.00** ± 1.155	**38.56** ± 2.376	**4.33** ± 0.333	**63.00** ± 0.294	**24.67** ± 0.666	**21.00** ± 0.577	**6.61** ± 0.075	**1.24** ± 0.011	**5.33** ± 0.333	**126.67** ± 3.528	**26.67** ± 0.205	**375.67** ± 0.881
150 Gy	**75.67** ± 0.881	**31.04** ± 0.424	**4.67** ± 0.333	**70.67** ± 0.284	**21.00** ± 0.577	**17.00** ± 0.577	**6.03** ± 0.055	**1.18** ± 0.014	**4.33** ± 0.333	**91.33** ± 2.906	**24.53** ± 0.340	**397.67** ± 2.186
200 Gy	**49.00** ± 0.577	**26.91** ± 0.210	**4.00** ± 0.000	**73.33** ± 0.540	**16.00** ± 0.577	**13.33** ± 0.333	**4.63** ± 0.191	**1.07** ± 0.057	**4.00** ± 0.577	**60.00** ± 4.163	**30.10** ± 1.390	**337.33** ± 17.680
250 Gy	**40.67** ± 1.202	**21.91** ± 0.132	**4.00** ± 0.000	**82.33** ± 0.706	**12.00** ± 0.577	**10.00** ± 0.577	**4.12** ± 0.078	**0.97** ± 0.065	**3.33** ± 0.333	**28.67** ± 2.404	**23.18** ± 0.537	**404.33** ± 5.840

Abbreviation: cm.= Centimeter, Flrs.= Flowers, Germ.= Germination, grm.= Grams, Gy = Gray, ht.= Height, No.=Number, % = Percentage, Pl.= Plant, ± = Standard error, var. = Variety, Wt.=Weight.

Table No. 2. Effect of different doses of gamma irradiation on yield attributing characters in *Pisum sativum* var. *arvense*

Dose	% Germ.	Pl. ht. at maturity	No. of branches	Maturation Period in days	No. of Flrs./pl.	No. of Pods/Pl.	Pod size in cm.		No. of Seeds/ pod	No. of Seeds/pl.	Wt. of 100 Seeds	No. of Seeds/ 100 grm.
							Ln.	Br.				
Control	**93.33** ± 0.889	**42.65** ± 0.749	**10.33** ± 0.881	**52.00** ± 1.155	**37.67** ± 1.453	**31.67** ± 0.881	**7.35** ±0.017	**1.24** ± 0.020	**7.00** ± 0.000	**224.67** ± 4.055	**30.84** ± 0.131	**327.67** ± 1.856
50 Gy	**85.33** ± 1.764	**44.18** ± 0.306	**10.33** ± 0.333	**55.33** ± 4.055	**41.67** ± 1.453	**37.00** ± 1.202	**7.13** ±0.013	**1.23** ± 0.006	**6.33** ± 0.333	**240.33** ± 5.548	**31.43** ± 0.292	**322.00** ± 3.055
100 Gy	**77.33** ± 1.764	**36.28** ± 0.454	**8.67** ± 0.333	**59.00** ± 1.528	**44.33** ± 1.202	**38.67** ± 1.202	**6.51** ±0.040	**1.11** ± 0.006	**5.67** ± 0.333	**243.33** ± 6.360	**29.38** ± 0.129	**343.00** ± 2.646
150 Gy	**75.33** ± 3.528	**32.98** ± 0.419	**7.67** ± 0.333	**64.00** ± 1.155	**30.00** ± 1.155	**24.67** ± 0.881	**6.13** ±0.046	**1.07** ± 0.029	**4.67** ± 0.333	**119.67** ± 9.207	**27.93** ± 0.090	**364.00** ± 4.163
200 Gy	**49.33** ± 1.333	**26.17** ± 0.103	**6.33** ± 0.333	**67.00** ± 2.646	**22.33** ± 0.881	**17.67** ± 0.881	**5.15** ±0.035	**0.93** ± 0.029	**4.33** ± 0.333	**89.33** ± 9.615	**27.45** ± 0.128	**371.33** ± 2.404
250 Gy	**45.00** ± 2.082	**20.35** ± 1.114	**5.67** ± 0.333	**78.67** ± 1.764	**16.33** ± 0.881	**12.67** ±0.881	**4.75** ±0.048	**0.85** ± 0.013	**3.67** ± 0.333	**55.67** ± 2.333	**26.77** ± 0.109	**381.33** ± 1.202

Abbreviation: cm.= Centimeter, Flrs.= Flowers, Germ.= Germination, grm.= Grams, Gy = Gray, ht.= Height, No.=Number, % = Percentage, Pl.= Plant, ± = Standard error, var. = Variety, Wt.=Weight.

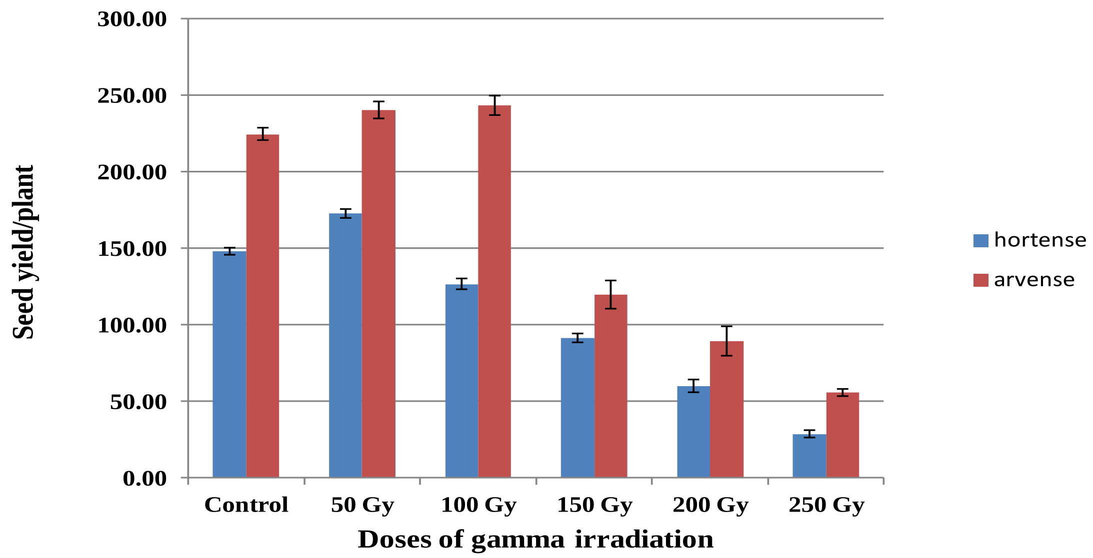

Fig. 2: Effect of different doses of gamma irradiation on no. of Seed yield/plant in *Pisum sativum* var. *hortense* & var. *arvense.*

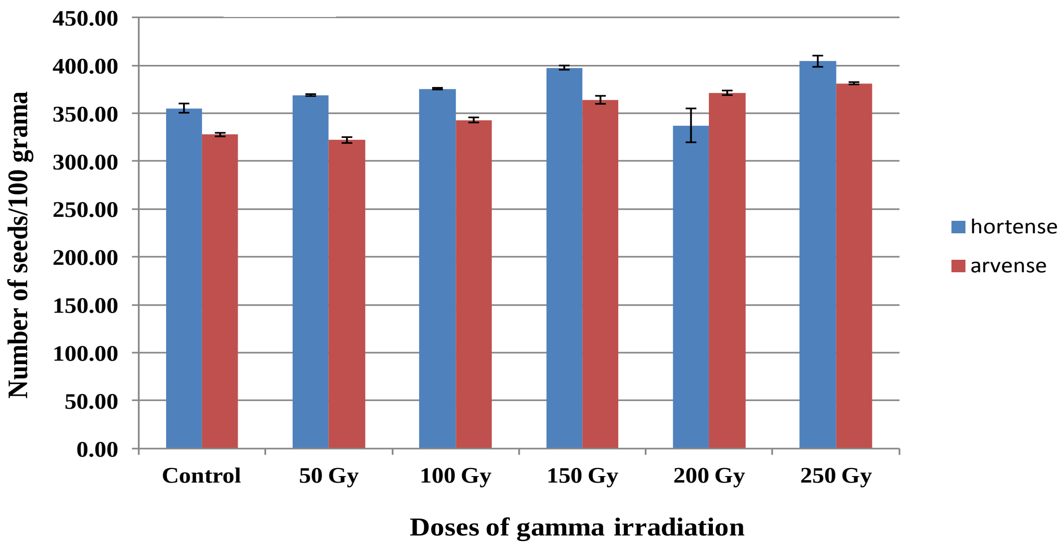

Fig. 3: Effect of different doses of gamma irradiation on no. of Seed /100 gram in *Pisum sativum* var. *hortense* & var. *arvense.*

Pod size in both the varieties at lower doses did not deviate much as to that in control, but showed gradual decrease at 150 Gy dose onwards. Katyayani *et al* (1980) also reported the reduction in pod size in gamma irradiated plants of *Phaeolus aureus*.

Data on characters related to yielding ability in two varieties of pea, as a result of gamma irradiation is depicted in Tables 1 & 2. Control plants of var. *arvense* bear more number of flowers, more number of pods, more number of seeds per plant, more seed yield per plant than var. *hortense*. This indicates that var. *arvense* (leafy) is better than var. *hortense* as far as the yield ability is concerned. Gamma irradiation displayed stimulatory effect on seed yield per plant at lower doses (Figs. 2 & 3). The parameters viz. number of flowers, number of pods and seed yield per plant exhibited positive correlation. Number of flowers, number of pods and seed yield per plant was found to be increased at 50 Gy dose in var. *hortense* but in var. *arvense,* 50 and 100 Gy dose showed stimulatory effect as regards to these parameters. Khan *et al* (1999) screened out the high yielding mutants in chemical mutagens induced progeny of *Vigna radiate* and reported the increase in number of pods produced per plant and total seed yield at lower doses of chemical mutagens in *Vigna radiata.* Kamla *et al* (1983) observed the stimulatory effect of gamma irradiation at lower doses on number of capsules per plant in *Sesamum indicum.* They observed the wide range of variability for the characters related to yield. Gustafsson (1954) and Gregory (1957) reported that positive yield mutants are very rare in mutagen induced populations. Singh and Harihar Ram (1988), Rao *et al* (1985) and Mahajan *et al* (1997) reported the occurrence of low yield characters as an effect of gamma radiation in pigeon pea plants.

Data on weight of 100 seeds and number of seeds per 100 gms. revealed that, these two parameters are negatively correlated. 100 seeds weight showed gradual decrease and number of seeds per 100 grm. increased with increase in dose upto 150 Gy. Weight of 100 seeds was maximum at 200 Gy and again decreased significantly at 250 Gy dose in var. *hortense*. Lower dose 50 Gy had stimulatory effect on weight of seeds in var. *arvense* and was gradually reduced at higher doses. Number of seeds per 100 grm increased gradually because perhaps the seed size in both varieties increased due to higher doses. Sharma *et al* (1982) reported the positive correlation between grain yield and its attributes like plant height, number of flowers, pod length, pod number and size and test weight. Paroda and Joshi (1970), Knott and Talukdar (1971) reported in wheat that the number of grains per spike and unit grain weight are negatively correlated. Khamankar (1989) also reported same results on gamma irradiated breed wheat population in M_3 generation.

The treated plants of var. *arvense* (leafy and high yielding) were affected more than that of var. *hortense* (leafless and low yielding), at higher doses. Reduction in photosynthetic area in var. *hortense* and different doses of gamma irradiation might be the probable reasons for decrease in yield. Kene and Charjan (1999) reported the influence of photosynthetic area and efficiency on grain yield in soybean. Chako *et al* (1982) obtained the same results on different mango varieties. The significant deviations in the yield attributing characters of the two varieties under study provide sufficient scope for further improvement of this economic crop for different agronomic traits through mutagenesis.

CONCLUSION

In conclusion it can be said that *P. sativum* var. *arvense* (leafy) was found to be high yielding than var. *hortense* (leafless). Both the varieties showed dose dependent decrease in most of the yield attributing characters, but the genotype of var. *arvense* is observed more sensitive to the doses of gamma irradiation than var. *hortense*. The significant deviations in the yield attributing characters of the two varieties under study provide sufficient scope for further improvement of this economic crop for different agronomic traits through mutagenesis.

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