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# Impact of gamma radiations on seed germination and morphological characteristics of pea (*Pisum sativum* L.)

**Akash Barela, Sudhanshu Jain, Sushma Tiwari, Shivangi Rahangdale and Praveen Singh**

## Abstract
The present study was conducted to examine the impacts of gamma irradiation on seed germination and morphological traits of *Pisum sativum* L. For this purpose, dry and healthy seeds of *Pisum sativum* were exposed to different doses of gamma radiations *viz.* 150Gy and 200Gy at the Bhabha Atomic Research Center (BARC). The result showed that the gamma irradiation affected germination percentage, plant survival and morphological characteristics such as plant height, pod number, pod length, seed number and grain weight. It was observed that all the trait showed decreasing trend in there mean value with the increasing intensity of gamma irradiation. However, in 150Gy irradiation dose showed the slightly increase in plant height with respect to control set. The highest doses of gamma rays 200Gy exposure caused death of all seedlings and no seed germination was observed.

**Keywords:** *Pisum sativum*, gamma radiation, germination, morphology

## Introduction
*Pisum sativum* L. belonging to the family Fabaceae is one of the most important vegetable in the world as well as in India. The plant has been widely grown as a cool season vegetable crop and consumed extensively worldwide as a rich source of protein, carbohydrates, vitamins and minerals important in human nutrition. *Pisum sativum* is an annual plant, with a life cycle of two to four months. It has a unique ability to enrich the soil, like many legumes and contains symbiotic bacteria Rhizobia within root nodules. Gamma rays are one of the most prominent ionization radiations that cause disruption of the normal processes of the cell ultimately affecting crop yield. The mean productivity of field pea is around 911 kg/ha (Nepolian *et al.*, 2019) [12]. The effect of these radiations is dose dependent, as these rays stimulate growth in plants at low dose (Safadi and Simon, 1990) [14].

These radiations cause changes in the physiology, morphology, anatomy and biochemistry of the plants (Kim *et al.*, 2004) [10]. In plant improvement programs the irradiation of seeds may cause genetic variability that may enable plant breeders to select new genotypes with improved characteristics such as precocity, salinity tolerance, grain yield and quality (Ashraf *et al.*, 2003) [3]. Gamma radiation can be also useful for the alteration of physiological characters (Kiong *et al.*, 2008) [11]. This present study was conducted to determine the effects of gamma radiation on *Pisum sativum* with respect to seed germination and some physiological characteristics.

## Materials and Methods
### Plant Material
The experimental material comprised of three genotypes of green pea *viz.*, Arkel, Kashinandani and PSM-3 were irradiated with gamma radiation. Arkel is introduced from England in 1970. It is an early maturing and dwarf variety. It is highly susceptible to powdery mildew and rust. Kashi Nandini is an early maturing variety develops at IIVR, Varanasi in 2006 through hybridization (P-1542×VT-2-1) followed by pedigree selection. PSM-3 is developed from cross between Arkel×GC141 at Pantnagar.

The dry and healthy seeds of three genotypes of green pea *viz.*, Arkel, Kashinandani and PSM-3 with moisture content 16% were irradiated with gamma radiation derived from $Co^{60}$ source at 2 doses i.e. 150Gy and 200Gy at Bhabha Atomic Research Center, Mumbai. Six treatment with three control were laid into randomized block design at Research Farm, Krishi Vigyan

Kendra during *rabi* 2018-19. Eighty seeds of each dose were sown in pots after irradiation, ten seeds per pot. Observation is recorded on morphological traits *viz.* seed germination, plant height (cm), plant survival, number of pods per plant, number of seeds per plant, pod length (cm) and 100 seed weight (gm) and compared with control. Seed germination and morphological traits were recorded from seedling to seedling in each treatment and compared with the control. The mean germination percentage was calculated by counting the seedlings that emerged in each pot divided by the total number of seeds sowed.

$$\text{Germination \%} = \frac{\text{No. of seed germinated}}{\text{No. of seed sown}} \times 100$$

Plant height was recorded on 60th day of germination by measuring the root and shoot
lengths for each treatment and control. The height was measured from the base of the plant to the tip of flag leaf. Plant injury was measured in terms of reduction in plant height with respect to control. The data for the remaining parameters was collected by randomly selecting sample plants from each treatment, and the recorded data was subjected to statistical analysis to determine the magnitude of caused variations. The surviving plants in different treatments and control were counted at the time of maturity and the plant survival was computed as percentage of the germinated seeds in the field. The following formula was used to calculate the percentage of inhibition, injury or reduction.

$$\text{Injury \%} = \frac{\text{Control} - \text{Treated Seed}}{\text{Control}} \times 100$$

Standard deviation was computed by applying the following formula.

$$SD = \sqrt{\frac{1}{n}\Sigma(X_i - \underline{X})^2}$$

Where $\underline{X}$ = mean of observations involved
$X_i$ = Observations
n = Number of observation

## Results and Discussion

### Seed Germination and Plant Survival Percentage

The computed data on seed germination (%), plant survival (%), plant lethality (%) and plant injury (%) was summarized in table 1. On the sixth day, seed germination was observed in both control and treated plants. All the mutagenic treatments caused significant reduction in germination as compared to control. In general, higher dose had more drastic effect than lower dose. Linear reduction in germination percentage was observed, with increasing dose of radiation. All the mutagens showed distinct dose effect. 200Gy on Arkel variety of pea recorded lowest 45 per cent germination which was comparable to the 150Gy dose which gave 53 per cent germination. Ariraman *et al.* (2014) [2] found reduced seed germination percentage and seedling growth due to raise in doses/concentration of gamma-ray and EMS. The 150Gy dose of gamma-rays on PSM-3 variety of gamma-rays showed minimum effect with 60.0% germination over 0GY. However, the lower doses of gamma-rays in KashiNandini caused comparable damage of 53% and 50% germination, respectively.

The plant survival percentage revealed some definite pattern regarding the various plant parameters recorded in M1 generation. Among different doses higher dose 200Gy caused more post germination lethality than lower dose. Maximum reduction in plant survival was observed with the highest dose of gamma-rays (200Gy) and minimum with the lowest dose of gamma-rays (150Gy) with survival of 42 and 80 per cent, respectively. Many studies on the stimulative effects of gamma radiation that affect seed germination and plant survival were reported by Ahmed and Qureshi, (1992) [1]; Cemalettin *et al.*, (2006) [5] and Borzouei *et al.*, (2010) [4]. The results of Kiong *et al.*, (2008) [11] have shown that survival of plants to maturity depends on the nature and extent of chromosomal damage.

With increased radiation dose, the incidence of chromosomal damage may increase, resulting in reduced germination potential and plant growth and survival. The results of this investigation revealed that gamma rays have a negative impact on seed germination and plant survival.

**Table 1:** Effect of different gamma irradiation doses on different traits of pea

| Variety | Doses | Germination (%) | Survival (%) | Lethality (%) | Injured (%) |
|---|---|---|---|---|---|
| Arkel | 0Gy | 85 | 100 | 0 | 0 |
| | 150Gy | 41 | 58 | 26 | 16 |
| | 200Gy | 36 | 53 | 30 | 16 |
| Kashi Nandini | 0Gy | 80 | 95 | 0 | 5 |
| | 150Gy | 46 | 38 | 38 | 23 |
| | 200Gy | 36 | 42 | 32 | 25 |
| PSM-3 | 0Gy | 80 | 100 | 0 | 0 |
| | 150Gy | 53 | 80 | 14 | 6 |
| | 200Gy | 40 | 60 | 26 | 14 |

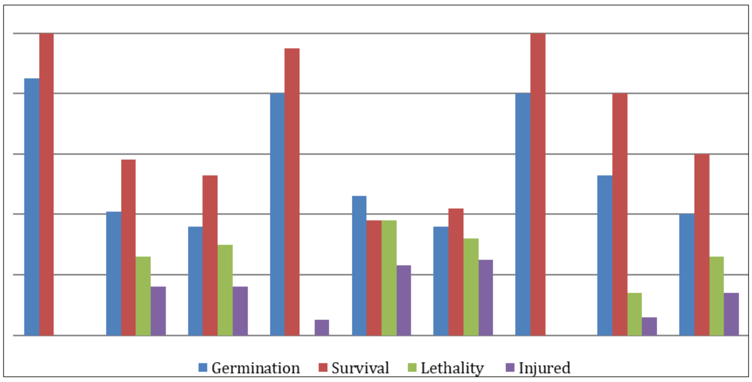


**Fig 1:** Graphical representation of effect of different doses of gamma irradiation on pea

**Effect of Gamma Irradiation on Plant Height (cm)**

The immediate effect of mutagenic treatments was also reflected in lower plant height recorded at 60 days after germination (Table-2). When compared to the control, all of the mutagenic treatments resulted in a significant reduction in plant height. With a larger dose of radiation, the reduction in plant height was more pronounced. However, lower dose of gamma rays were found to be the least effective in reducing plant height. The mean value of plant height was 51.69 cm. Reduction in plant height was maximum of 45.45cm and 47.59cm in Arkel and Kashi Nandini with the highest doses of gamma radiation (200Gy), respectively, in comparison to 60.67cm and 51.4cm in their control. It was obvious that the lower dose of gamma-rays (150Gy) caused almost similar reduction in plant height. Minimum reduction in plant height was noticed with the lower dose of gamma-rays (150Gy) in Kashi Nandini variety. Arkel at 200Gy, Kashi Nandini at 200Gy, PSM-3 at 150Gy, Arkel 150Gy and Kashi Nandini at 150Gy were significantly shorter in plant height at maturity. Irfaq & Nawab (2001) [8] and Chaudhary (2002) [6] reported decrease in average plant height in response to gamma irradiation.

**Effect of Gamma Irradiation on Number of Pods per Plant**

The mean number of pods per plant at maturity stage of different varieties is given in table 2. The highest number of green pods per plant was found in variety which was followed by compared to each other genotypes. Lowest number of green pods was observed under Kashi Nandini X 200Gy gamma-irradiation (9.21). PSM-3 at 200Gy, PSM-3, Kashi Nandini at 150Gy, PSM-3 at 150Gy and Arkel at 150Gy showed significantly higher number of pods as compared to other treatments. The total number of pods per plant was affected by the higher gamma ray exposure. Similar results were reported by Choudhary and Agrawal (2014) [7].

**Effect of Gamma Irradiation on Pod Length (cm)**

Maximum mean value of green pod length (7.95) was recorded in control Arkel and the minimum mean value of pod length (6.58) was measured in 200Gy Arkel treated plants of gamma radiations (Table 2). The mean number of pod length showed constant decrease with the increasing dose of gamma rays with the exception in PSM-3 X 200Gy (7.05). Similar result was reported by Shamsi and Sofajy, (1980) [15].

**Effect of Gamma Irradiation on Number of Seeds/Pod**

The mean seed number per pod reduced in some mutagenized populations, but it increased in PSM-3 at 150Gy (7.03) and 200Gy (7.05) gamma irradiations with respect to control 0Gy of PSM-3 (6.67). The maximum mean value of number of seeds per pod was measured in control Arkel X 0Gy (7.30) followed by gamma irradiation dose PSM-3 X 200Gy (7.05) and finally the lowest mean value of number of seeds per pod at Arkel X 200Gy (5.24) summarized in table 2. The number of seeds per plant was affected by various exposures of gamma rays with compared to control (Figure 2). Irfaq & Nawab (2001) [8] observed the regular decrease in the trait with the increasing intensity of gamma radiations.

**Effect of Gamma Irradiation on 100 Seed Weight (gm)**

Different exposures of gamma rays shows continuously decrease (Figure 2) in the mean values of the 100 seed weight of genotypes except PSM 3 presented in table 2. Maximum weight of 100 seed weight was received in control (0Gy) of Kashi Nandini (22.26) followed by Arkel (22.01) and PSM-3 (21.76) compared to each other varieties. Minimum 100 seed weight was observed in Kashi Nandini X 200Gy (14.35) which was followed by Kashi Nandini X 150Gy (14.54). The mean value of 100 seed weight 19.43. The same result was observed by Irfaq and Nawab (2001) [8]. However, Khah and Verma (2015) [9] observed increase in the average 100 seed weight at 15 kR radiation dose in their study.

**Table 2:** The Plant Height, Pod Number/Plant, 100 Seed Weight, Seed Number per Pod, and Pod Length (cm) of *Pisum sativum* at Various Doses of Gamma Radiation

| Treatment combination | Plant Height (cm) Mean | Pods per plant Mean | 100 Seed Weight (gm) Mean | No. of seeds per pod Mean | Pod Length (cm) Mean |
|---|---|---|---|---|---|
| Arkel | 60.67 | 13.07 | 22.01 | 7.3 | 7.95 |
| Arkel 150Gy | 49.38 | 13.08 | 17.72 | 5.5 | 6.68 |
| Arkel 200Gy | 45.45 | 12.04 | 17.75 | 5.24 | 6.58 |
| Kashi Nandini | 51.4 | 10.73 | 22.26 | 6.5 | 7.67 |
| Kashi Nandini 150Gy | 49.47 | 14.94 | 14.54 | 5.76 | 7.05 |
| Kashi Nandini 200Gy | 47.59 | 9.21 | 14.35 | 5.68 | 6.78 |
| PSM 3 | 52.27 | 15.2 | 21.76 | 6.67 | 7.1 |
| PSM 3 150Gy | 48.53 | 13.47 | 21.92 | 7.03 | 6.97 |
| PSM 3 200Gy | 60.43 | 15.22 | 21.86 | 7.05 | 7.05 |
| Mean | 51.69 | 13.00 | 19.35 | 6.30 | 7.09 |
| S.E(m) | 0.67 | 0.52 | 0.06 | 0.05 | 0.04 |
| CD 5% | 1.94 | 1.51 | 0.17 | 0.15 | 0.12 |

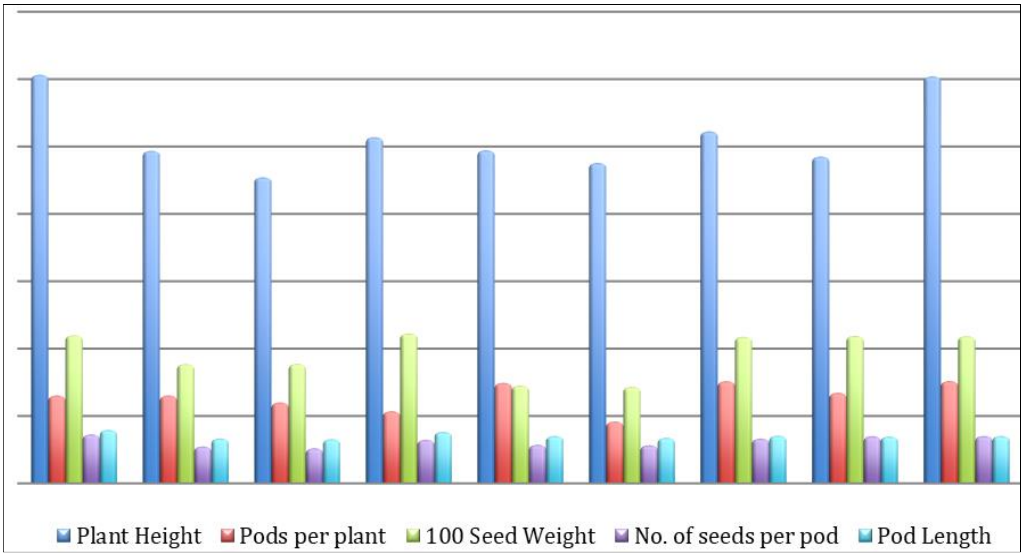


**Fig 2:** Graphical representation of effect of gamma irradiation on different traits of pea

## Conclusion

Gamma rays are a type of ionizing radiation that can affect plant growth and cause to produce mutation in plants with specific abnormalities. Large amount of genetic variability has been generated through physical mutagenesis induced by gamma rays, which may be of immense value for improvement in pea. Both the doses of gamma rays recorded a lower mean for the most of the characters of all the varieties under study in comparison to the control except variety PSM-3 where 150Gy dose for number of pods/plant, number of seeds per plant and 100 seed weight per plant and 200Gy dose for seedling height at 25 days recorded higher mean than control. With an increase in the dose of gamma rays there was decrease in the mutation frequency in all the varieties as a result, 150Gy dose of gamma rays produced higher frequency of mutations than 200Gy. From the present investigation it can be concluded that 150 Gy dose of gamma rays can be safely used for induction of desirable mutations in pea.

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