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Studies on effects of gamma ray doses on germination in pigeonpea [*Cajanus cajan* (L.) Millspaugh] under laboratory and field conditions

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Abstract
An experiment was conducted during *kharif* 2014 at Punjab Agricultural University, Ludhiana to study the effects of two doses (300 Gy and 400 Gy) of gamma rays on germination percent of pigeonpea. Seeds of pigeonpea variety AL 201 were treated at Bhabha Atomic Research Centre (BARC), Mumbai using two doses viz. 300 Gy and 400 Gy of gamma radiations. The data on germination of treated seeds as well as control (untreated) were recorded under laboratory and field conditions. The germination data on obtained from laboratory experiment showed that germination percent in control was 90% whereas in two treatments of gamma radiations i.e. 300 Gy and 400 Gy, it was 60% and 49%, respectively thus there was an inhibitory effect of increasing mutagen dose on the germination of seeds. Under field conditions, in control treatment, per cent germination was 89% whereas for 300 Gy treatment, it was 56% and for 400 Gy it was 47%, respectively. Thus under field condition also there is an inhibitory effect of increasing mutagen dose on the germination of seeds.

Keywords: Gamma rays, pigeonpea, germination, field and laboratory

Introduction
Pigeonpea [*Cajanus cajan* (L.) Millspaugh] which is once considered as an orphan crop is now second most important food legume crop of India after chickpea. Due to continuous breeding efforts by several public and private organizations there has been a considerable improvement in the production of pigeonpea. But still the productivity of pigeonpea is low which results in increase in its price and reduction in per capita availability. There is an urgent need to develop new varieties of pigeonpea, which are not only high yielding but also have early maturity and other quality traits. Though there is enough genetic variability present in the secondary and tertiary gene pool of pigeonpea but it is very tough to exploit this variability as the crossing between cultivated and wild type pigeonpea has very low success rate and even if the hybrids form are mostly sterile. Hence, there is need to focus on other methods of crop improvement to creates genetic variability. Induced mutagenesis can be an ideal strategy for crop improvement in such cases (Gaur *et al.* 2016) [5]. In pulses a number of varieties have been developed by using mutation breeding (Ahloowalia *et al.* 2004 and Solanki *et al.* 2011) [1, 8]. Gamma rays are one of the most useful and widely used physical mutagen. During the past few decades, gamma rays had been successfully used to develop the useful varieties in cereals, pulses, oilseed and ornamental crops. Gamma rays, being high energy ionising radiation are known to cause extensive damage to DNA molecules by making strand breaks and disturbing sugar and bases. Such lethal effects of these mutagens can cause conversion of functional genes into non-functional ones. Hence present study was conducted to understand the effects of gamma rays on the germination percent of pigeonpea.

Materials and Methods
The present investigation was undertaken in the experimental field area of Pulses Section and laboratory of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, during *kharif* season of 2014. Dry seeds of pigeonpea variety AL 201 were treated at Bhabha Atomic Research Centre (BARC), Mumbai using already standardized doses viz. 300 Gy and 400 Gy gamma radiations. For each dose of gamma rays 600 seeds were treated. Untreated seeds of parent variety AL 201 were used as control.

These treated seeds were used to grow M_1 generation. The germination data of treated seeds were recorded under laboratory and field conditions. Untreated seeds of parent variety AL 201 were used as control for comparison under both laboratory and field conditions.

Germination percentage under laboratory conditions

Under laboratory conditions 100 mutagen treated seeds (M_1) of both the treatments i.e. 300 Gy and 400 Gy along with control were placed on moist germination papers in Petri dishes using distilled water. Germination count was taken after 7 days. The percent seed germination was calculated as follows.

$$\% \text{ seed germination} = \frac{\text{Number of seeds germinated in Petri dishes}}{\text{Total number of seeds}} \times 100$$

Germination percentage under field conditions

In case of field conditions, 500 M_1 seeds of both the treatments i.e. 300 Gy and 400 Gy were sown to raise M_1 generation. The data for germination per cent were taken 15 days after sowing in the field. The per cent seed germination was calculated as follows.

$$\% \text{ seed germination} = \frac{\text{Number of seeds germinated in field}}{\text{Total number of seeds sown}} \times 100$$

Results and Discussion

The experimental results for the effects of gamma rays on percent seed germination were as discussed under both laboratory as well as under field conditions.

Percent seed germination under laboratory conditions

The data on percent seed germination of gamma rays treated seeds of pigeonpea variety AL 201 was recorded and presented in Table 1. The results indicated that the per cent seed germination in both the doses of gamma rays i.e. 300 Gy and 400 kR was drastically reduced than the control. Within the treatment, the germination percent decreased with increase in dose of gamma rays i.e. there was an inhibitory effect of increasing mutagen dose on the germination of seeds. The germination data obtained from laboratory experiment showed that per cent germination in control was 90% whereas in two treatments of gamma radiations i.e. 300 Gy and 400 Gy, it was 60% and 49%, respectively.

Percent seed germination under field conditions

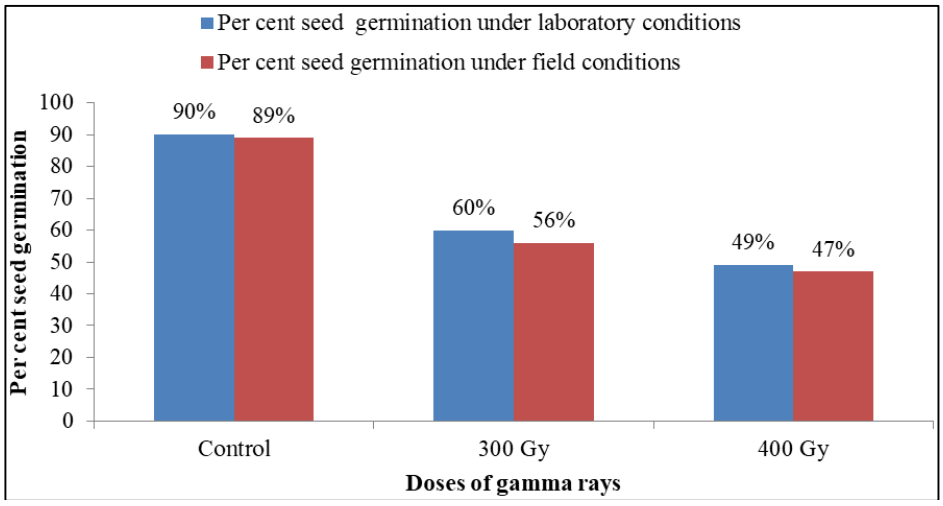
In field, 500 seeds treated with 300 Gy and 400 Gy gamma radiations were sown along with untreated control. The data for germination per cent were taken 15 days after sowing in the field. In control treatment, per cent germination was 89% whereas for 300 Gy treatment, it was 56% and for 400 Gy it was 47% (Table 2). This reduction in per cent seed germination may be due to the fact that gamma rays, being high energy ionising radiation are known to cause extensive damage to DNA molecules by making strand breaks and disturbing sugar and bases. Such lethal effects of these mutagens can cause conversion of functional genes into non-functional ones. Similar kind of results were also reported by Ariraman *et al.* (2014) [1], Giri (2014) [6], Biradar (2004) [3], Shinde (2007) [5] and Desai & Rao (2014) [4].

Table 1: Effects of gamma rays treatment on per cent seed germination under laboratory conditions in M_1 generation in pigeonpea

S. No	Treatments	Number of seeds placed	Number of seeds germinated	Seed germination (%)
1	Control	100	90	90
2	Gamma rays (300 Gy)	100	60	60
3	Gamma rays (400 Gy)	100	49	49

Table 2: Effects of gamma rays on per cent seed germination under field conditions in M_1 generation in pigeonpea

S. No	Treatments	Total number of seeds sown	Number of seeds germinated	Seed germination (%)
1	Control	100	89	89
2	Gamma rays (300 Gy)	500	280	56
3	Gamma rays (400 Gy)	500	235	47



Graph showing the comparison of germination percent under laboratory and field condition at two doses (300 Gy & 400 Gy) of gamma rays

Seed germination in AL 201 (Parent)

Germination in seeds treated with 300 kR dose of gamma rays

Germination in seeds treated with 400 Gy dose of gamma rays

Field view of M_1 generation plants

Conclusion

The effect of mutagen on the per cent seed germination was studied in M_1 generation under both laboratory as well as field condition. The observations indicated that the gamma rays had an inhibitory effect on the per cent seed germination of pigeonpea. The negative effect was more severe with increasing dose of the mutagen. Under laboratory conditions, the germination per cent was reduced to 60% in case of 300 Gy treatment and 49% in 400 Gy treatment as compared to control where it was 90%. Similar trend was obtained under field conditions where the seeds treated with 300 Gy dose had 56% and 400 Gy dose had 47% germination as compared to control where it was 89%.

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