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Radiosensitivity of Winged Bean and Passion Fruit Seeds on Gamma Irradiation

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Abstract : Seeds of winged bean and passion fruit irradiated with gamma rays at dosages ranging from 10 Kr to 70 Kr and 15 Kr to 25 Kr respectively were germinated in flats in a plant house. Winged bean which had a LD_{50} at 30 Kr to 40 Kr was more tolerant to gamma irradiations when compared to passion fruit which had a LD_{50} at 17.5 Kr to 20 Kr. Irradiations above 40 Kr and 20 Kr were detrimental to winged bean and passion fruit respectively. All the seedlings of winged bean that germinated survived, but in passion fruit there was seedling mortality which increased with irradiation dosage.

1. Introduction

Winged bean *Psophocarpus tetragonolobus* (L) DC and passion fruit *Passiflora edulis* Sims var. *flavicarpa* are two promising tropical horticultural crops of the vegetable and fruit groups respectively, which have a potential for commercial expansion in Sri Lanka. All known cultivars and strains of winged bean are climbing forms that require staking or trellissing, two practices which increase the cost of materials and labour. Flowering being acropetal, they give rise to fruits which mature at different times, resulting in a staggered harvest. While these characteristics would be advantageous in subsistence farming and home garden vegetable culture in developing countries, they are disadvantageous for large-scale commercial farming. The need to induce short erect mutants that could be used to breed short age cultivars which would flower and develop fruits uniformly is therefore evident.

The vigorous vines of passion fruit, also require costly trellissing. Moreover, since the fruit bearing part of a shoot is on the new growth, pruning has to be done periodically to induce new shoot formation in order to ensure continuity of production. While pruning adds to the cost of production, the removal of vegetative growth causes a setback and delays production after the first year. Short internode mutants in passion fruit would enable a grower to increase the density of plants per hectare and also reduce pruning costs without sacrificing the productivity of the plant, thereby increasing the profitability from passion fruit plantings.

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The use of ionising radiations to induce dwarf mutants is well known. A prerequisite for their use is to evaluate radiation sensitivity in order to recognise a suitable dosage range for mutation work which is reported in this paper.

2. Materials and Methods

In winged bean, two irradiation experiments were conducted. In the first study, mixed samples of fresh seeds that were harvested from local cultivated strains were irradiated with 10, 20, 30, 40, 50, 60 and 70 Kr of gamma rays in the Co 60 chamber of the Central Agricultural Research Institute, Peradeniya. A sample of 40 seeds was irradiated at each dosage. When the germination results of the first experiment were known, a second experiment was conducted on seeds of the same batch using a narrower dosage range of 15, 17.5, 20, 22.5, 25, 27.5 and 30 Kr. These seeds were irradiated 25 days after the first one. In both experiments, germination was scored every other day. Seedling height was measured weekly up to 3 weeks in the first experiment.

In passion fruit, freshly extracted seeds of a local selection were air dried in the laboratory at 26°C and 100 seeds each were irradiated 5 days after extraction at 15, 17.5, 20, 22.5 and 25 Kr. Because passion fruit seeds are slow germinators when compared with winged bean their germination was scored weekly.

The irradiated seeds of both species were sown 1 cm deep in wooden flats filled with a mixture of sterilised top soil and sand, at a spacing of 5 cm × 8 cm for winged bean and 5 cm × 2 cm for passion fruit. The flats were maintained in a plant house having diffused sunlight throughout the experimental period. In passion fruit, three classes of seedling vigour were scored on the basis of the time taken to expand the first leaf fully. The flats were watered every morning until germination was completed and once in 2 days thereafter.

3. Results

3.1. Germination

The unirradiated seeds of the first experiment in winged bean had 80% germination. In contrast, seed irradiated with 10 Kr had 92% germination and at 20 and 30 Kr all the seeds germinated (Figure 1). When the dosage was increased to 40 Kr, germination dropped to 50% and still higher dosages were detrimental to the seeds. In the control and all treatments, germination was completed in 9 days. The rate of germination was most rapid in the 10 Kr and 20 Kr treatments and the highest rate was noted during the first day of emergence (Table 1). Germination was slowest in the 40 Kr treatment and its highest rate was recorded on the fifth day after the emergence of the first seedling. In the second experiment where a narrow dosage range was used, germination dropped from a maximum of 70% at 15 Kr to 42% at 30 Kr. A stimulation of germination was however recorded at 25 Kr. Germination in this instance took 15 days to complete. The rate of germination was highest in all treatments between 7 to 13 days after emergence of the first seedling.

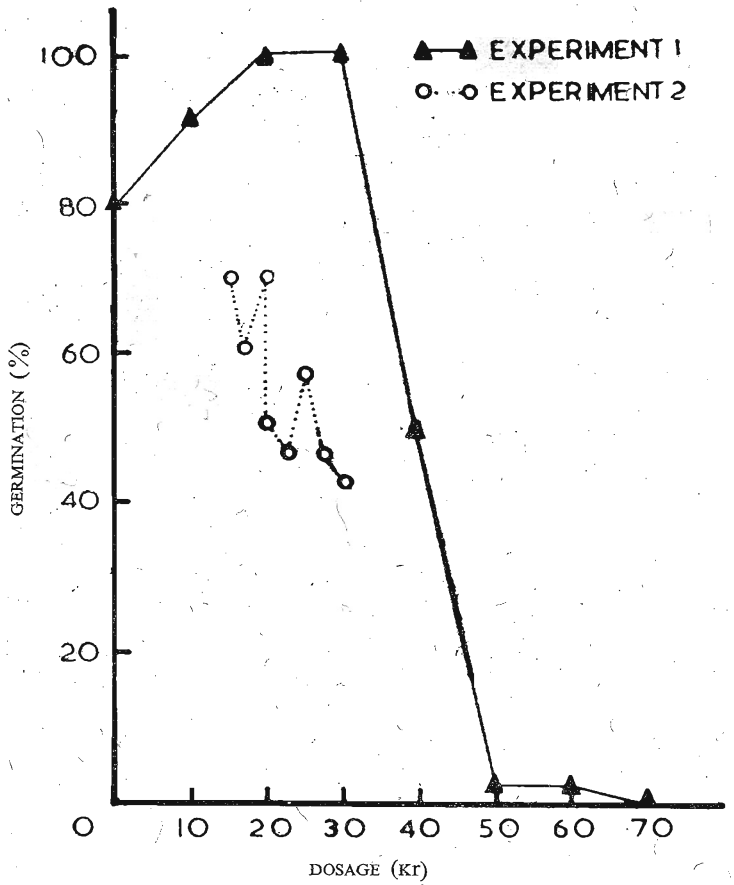

Figure 1. Percentage germination of winged bean seeds at different irradiation dosages.

TABLE 1. Rate of germination of winged bean at two day intervals.

Dosage	Day of germination								Total germinated
	1	3	5	7	9	11	13	15	
EXPERIMENT I									
Control	18	4	8	0	2				32
10 Kr	30	4	2	0	1				37
20 Kr	30	6	2	2	0				40
30 Kr	20	9	8	1	2				40
40 Kr	1	3	9	2	5				20
EXPERIMENT II									
15 Kr	3	3	2	2	6	2	6	4	28
17.5 Kr	0	2	2	10	2	4	2	2	24
20 Kr	3	0	2	3	5	2	3	2	20
22.5 Kr	3	0	1	2	6	3	3	0	18
25 Kr	2	2	2	3	5	6	3	0	23
27.5 Kr	0	2	2	1	4	1	8	0	18
30 Kr	3	2	0	3	2	5	1	1	17

Germination in passion fruit, was highest (79%) in the unirradiated and 15 Kr treatments. At higher dosages, germination decreased to 64, 32, 33 and 20 per cent at 17.5, 20, 22.5 and 25 Kr respectively (Table 2). The rate of germination was highest during the fourth week in all treatments. It's distribution followed a normal curve in the control, 15 Kr and 17.5 Kr treatments.

TABLE 2. Percentage weekly rate of germination of passion fruit

Week	Control	Dosage (Kr)				
		15	17.5	20	22.5	25
2	0	5	1	0	0	0
3	13	11	6	0	0	0
4	63	55	52	26	31	20
5	3	6	5	6	2	0
6	0	2	0	0	0	0
Total (%)	79	79	64	32	33	20

3.2. Seedling height and growth rate in winged bean

In winged bean there was a dosage effect on seedling height which was evident from the first week of growth (Table 3). In Experiment 1, the seedling heights of the control and 10 Kr treatment during the 3 weeks were similar. Above 20 Kr, the dosage effect was more pronounced. At the end of the first week, the height in the 30, 40, 50 and 60 Kr treatments were 6, 3, 2 and 0.1 cm, respectively, compared to 14.5 cm in the control. In the second and third week, the differences in height between the control seedlings and treatments above 20 Kr were more obvious.

The growth rate (cm/day) determined for the first 3 weeks shows that the control, 10 Kr and 20 Kr treatments had comparable growth rates during the first week whereas the rates were lower at higher dosages. During the second and third weeks, the 10 Kr treatment maintained the growth rate of the control but slower growth rates were observed at the higher dosages.

TABLE 3. The effect of increasing dosage on the height and rate of growth of winged bean seedlings during the first three weeks.

Dosage	Height (cm)			Growth rate (cm/day)		
	Week			Week		
	1	2	3	1	2	3
Control	14.5	36	60	2.1	3	3.2
10 Kr	13.5	34	60	1.9	2.9	3.2
20 Kr	13.5	24	46	1.9	2.5	2.7
30 Kr	6	11	28	0.8	0.7	2.3
40 Kr	2	4	13	0.3	0.3	1.3
50 Kr	2	3	4	0.3	0.1	0.1
60 Kr	0.1	1	2	—	0.1	0.1

3.3. Seedling vigour in passion fruit

During early growth, the seedlings were grouped visually into three classes, vigorous, intermediate and slow (Figure 2). Although the germination percentages of the control and 15 Kr treatments were identical (Table 2), the former had a larger proportion of vigorous seedlings at 6 weeks. By the eighth week, all the control seedlings were vigorous. At 17.5 Kr and above, the proportion of slow growers was highest during the sixth week. From the eighth week, the proportion of vigorous seedlings among the surviving seedlings of the 17.5 Kr seedlings increased but at the two highest dosages the proportion of intermediate and slow seedlings among the survivors was still high. In the control, 15 Kr and 17.5 Kr treatments there was a shift of plants from the slow and intermediate classes to the vigorous class as the seedlings became older. This was not evident in the 20 Kr and 22.5 Kr treatments where the survival of the slow growing seedlings was less due to high seedling mortality.

3.4. Seedling survival

In winged bean, of the seeds that germinated, all survived. In passion fruit, however, there was seedling mortality which increased with an increase in dosage (Table 4). The effect was most severe in the 25 Kr treatment in which all the seedlings died by the third week. In the 20 Kr and 22.5 Kr treatments, survivals were 47.4% and 48.4% respectively at 3 weeks after germination. At 5 weeks after germination, survivals were highest in the control (88.2%) and 15 Kr (86%) treatments but in the 20 Kr and 22.5 Kr treatments the survival had reduced further to 21.8% and 27.2%.

TABLE 4. The influence of irradiation treatments on the percentage survival of passion fruit seedlings during the first five weeks of growth.

Week	Control	Dosage (Kr)				
		15	17.5	20	22.5	25
1	100	100	100	100	100	100
2	97.6	98.7	93.7	93.7	75.7	60
3	94.8	94.9	89.5	47.7	48.4	—
4	89.6	91.1	78.1	37.5	33.3	—
5	88.2	86.0	67.1	21.8	27.2	—

3.5. Foliage aberrations in winged bean

Yellow spots were common on the cotyledons of all seedlings of the irradiated treatments. Their frequency and size were smaller in the 10 Kr and 20 Kr treatments compared to the higher doses. Two other leaf aberrancies that were observed in low frequencies were variegation and deformities. In the 10 Kr treatment, the first true leaf had these aberrations. In the 20 Kr and 30 Kr treatments they were confined to the first and second leaves whereas in the 40 Kr treatment they were found in the first three leaves.

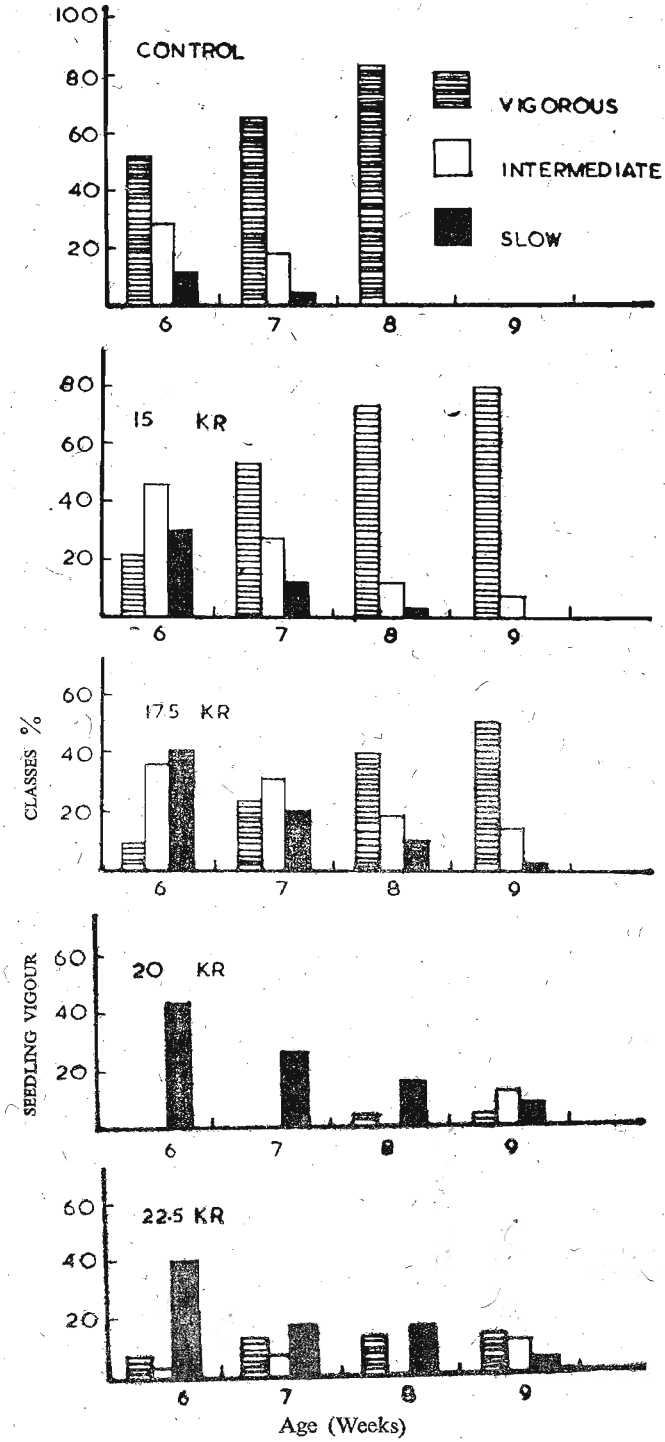

Figure 2. Changes in seedling vigour of passion fruit with age at different irradiation dosages.

4. Discussion

Winged bean and passion fruit showed a differential germination response to irradiation. The former was more tolerant to higher dosages of irradiation than passion fruit. The LD_{50} for winged bean was around 30 Kr to 40 Kr whereas in passion fruit it was between 17.5 Kr to 20 Kr. Differential germination responses to gamma irradiations among different crop species have been reported for castor,[5] jute,[1] red gram,[2] rice[4] and many other species.[3]

In their studies, jute had a high LD_{50} value of 120 Kr whereas red gram and rice had an LD_{50} value of 30 Kr. The ability of seeds, therefore, to tolerate different dosages of gamma irradiation is a species characteristic. But the age of seeds could alter the critical dosage levels, as shown in this study with winged bean, where a delay of 25 days in the second test gave a lower germination even at low irradiations, whereas in the less aged seeds of the first test, low dosages had a stimulatory effect on germination. Age also had an effect on seed vigour (Table 2) where irradiated fresh seeds germinated faster than aged seeds even at high dosages of irradiation.

Irradiation above 20 Kr were detrimental to passion fruit. This confirms the results of Tone and Desai[7] where a similar effect was observed for *P. edulis* and *P. foetida*. A detrimental effect in winged bean however was observed at a much higher dosage of 50 Kr.

Stimulation of germination in winged bean was found in treatments irradiated at 10 Kr to 30 Kr. This was not evident in passion fruit. Since passion fruit has a lower tolerance to gamma irradiation, stimulatory effects if any may show up at lower dosages than the levels used in our study as has been reported by Tone and Desai where dosages of 1 Kr to 2.5 Kr induced higher germination and survival than at higher doses. Stimulation of germination has been reported by the use of gamma irradiation on castor[5] and X-rays on bean[6] at a range of 7 to 14 Kr. Germination *per se* would not be an adequate criterion to determine the critical dosage range in some species. For example, while in winged bean all seeds that germinated survived, it was not so in passion fruit in which the proportion that survived at 5 weeks in the 20 Kr and 22.5 Kr treatments had decreased to 25 per cent of the total that germinated. The ability to survive in irradiated material seems to depend on the rate of growth of the species. Passion fruit being less vigorous as demonstrated during its germination and growth during the first five weeks, appears to succumb more easily to irradiation than the quick germinating and fast growing winged bean. Even in the rapidly growing winged bean, the influence of increased dosages on the vigour of growth during the first three weeks was evident, where irradiations of 30 Kr and above lowered the vigour of growth, but the growth rates were still high enough for the seedlings to pass the critical stage of survival.

In both species, it was found that if the seedlings continued to maintain growth during the initial critical period, they were observed subsequently in the field to pick up growth rapidly and it was difficult to distinguish between the slow growing seedlings of the high dosage irradiation treatments and the control. Apparently the effect of irradiations seems to wear off as the plants grew larger. Due to the slower growth of passion fruit, this effect was observed more clearly, where with time, there was a shift of plants that had slow and intermediate rates of growth to the vigorous category (Figure 2). This observation would suggest that when passion fruit seeds are irradiated for mutation and breeding studies, the intermediate and slow growing seedlings which may be the ones suspect with pronounced dosage effects should receive greater care in the nursery and they should be transplanted in the field later unlike in conventional transplantings.

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