INFLUENCE OF POSTIRRADIATION WASHING ON THE GROWTH AND MINERAL CONTENT OF TRIGONELLA FOENUM-GRAECUM L. SEEDLINGS*

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FREEMAN JANICE R. and ABOUL-ELA M. M. The influence of postirradiation washing on the growth and mineral content of Trigonella foenum-graecum L. seedlings. RADIATION BOTANY 13, 185-190, 1973.—A dose of 30 kR gamma radiation to seeds decreased fenugreek bean seedling height, fresh weight, and dry weight, especially as the seedlings grew older. This radiation dose also increased the observed nitrogen content, possibly due to the reduction in dry weight. Changes in phosphorous uptake were insignificant.

A 15 kR dose decreased seedling heights and dry weights but not fresh weights. Intensive washing of nonirradiated seed for 24 hr under running water resulted in reduction of seedling heights, fresh weights and dry weight but not if irradiated. The 15 kR dose, with or without the washing treatment, caused insignificant changes in the nitrogen and phosphorus contents of seedlings.

The washing treatment per se decreased seedling dry weight at all age levels, suggesting that some growth-promoting factor (or factors) was removed by the washing process.

INTRODUCTION

Morphological changes in plants induced by radiation have been studied for many years. Species differences in response to radiation have been cited by investigators such as SPARROW and CHRISTENSEN and SARIC et al. Stimulating effects produced by low dose of radiation have been reported by SHULL and MITCHELL, SAX, and FISCHNICH et al. Several criteria are used to evaluate the effects of radiation on plants, such as seedling height, fresh and dry weights. The extent of changes is related to the size of the dose.

Mineral studies by SMITH indicate that the age of plant tissues is an important factor affecting mineral composition.

Concentrations of nitrogen and phosphorus are greater in younger plants especially in areas of increased metabolism. Only limited study has been done on radiation effects on mineral absorption. VASILY and RYBAKOVA report insignificant effect with doses up to 50,000 R, except for a slight stimulation with doses of 3000-5000 R.

The effect of postirradiation storage of seeds was cited by CONGER et al. in reporting a new class of radiation damage which might have resulted from a radiation-induced unstable chemical species, eliminated if water was added to the system. An intensive postirradiation seed washing may then be protective.

An experiment was designed to test the effect of postirradiation washing on the subsequent growth of fenugreek seedlings...
growth and mineral content of seedlings of fenugreek beans.

MATERIALS AND METHODS

Seeds of fenugreek beans (Trigonella foenum-graecum, L.) with moisture content about 6.9 per cent were exposed to 15 and 30 kR of gamma irradiation from a Co-60 source at room temperature (20°C) and 900 R/min. One half of each irradiated and control seed lots were placed in wet DiSpo growth pouches (10 seeds to a pouch and left in the laboratory for 24 hr) the other half was immediately placed under running tap water at room temperature for a 24-hr period, then placed in the pouches. ("DiSpo pouches" are 6 in. square, plastic containers containing a paper wick which forms a trough on which the seeds are placed.) After the 24 hr, seeds of all treatments, arranged in five replicated randomized blocks, were grown in a growth chamber set (for a 25°C16-hr day at 24 klux; 15°C8-hr night). Equal amounts of water and nutrients (after Hewitt reported in Devlin(?) were given the plants at 3-day intervals.

Seedlings were harvested at intervals of 7, 14, 21 and 28 days. Data was taken on seedling stem heights, fresh weights, and dry weights (entire seedlings oven dried at 70°C for 24 hr). Each lot of dried seedlings were then ground, and nitrogen determined by the Perkin-Elmer Model 240 Elemental Analyzer. Determinations of phosphorus were done on the Perkin-Elmer Model 139 Spectrophotometer at wavelength of 600 μm, following a method adapted from Honda.(18)

RESULTS

Figure 1 shows height and age data for the three exposures (0, 15, 30 kR), washed and unwashed, at four ages. The analysis of variance for the treatments at each age showed that radiation caused significant height reduction, more at high dose than at low, but washing did not significantly reduce heights.

Figure 2 indicates that 7-day old seedlings had decreased fresh weights as a result of high radiation dose. In the 14-day old seedlings, radiation at both levels continued to reduce fresh weight in comparison to the controls, except when the seedlings were from seeds which had received the 15 kR dose and the washing treatment. The washing effect per se appeared to reduce fresh weights if the seeds were not irradiated.

![Figure 1](image)

**Fig. 1.** Fenugreek seedling heights in cm at various ages with indicated treatments. Vertical lines on the abscissa indicate the least significant difference between any two treatment means at the specified age (5 per cent level). Each point is an average of 50 seedlings in 5 replicates.
As the seedlings grew older, the 30 kR dose kept fresh weights significantly reduced as compared to the controls. The lower dose (15 kR) appeared to be recovered in fresh weights particularly at the age of 28 days. Seedling dry weights were significantly reduced at the 7th and 14th day of age as a result of the radiation or the washing effects (main effects), Fig. 3. No significant differences between low and high irradiation doses were
apparent at those ages. At 21 days, a significant
difference between the low and high irradiation
doses appeared besides the above-mentioned
effects. By the 28th day, the differences in dry
weights due to radiation main effect, radiation
dose or washing became highly significant.

Seedlings at ages 7 and 14 days showed slight,
though insignificant differences in nitrogen
content as the result of either irradiation or
washing effects (Fig. 4). At 21 and 28 days,
radiation, but not washing, had a significant
effect on nitrogen content. The nitrogen per-
centages generally decreased with age. There
were insignificant differences in phosphorus
percentages as the result of the radiation or
washing effects between individual treatments
(Fig. 5.).

**DISCUSSION**

Although the injurious radiation effects mea-
sured in height, fresh and dry weights appeared

![Fig. 4. Nitrogen per cent of dry weight of seedlings at the various ages with indicated treatments. Each point is an average of 5 replicates.](image)

![Fig. 5. Phosphorous per cent of dry weight of seedlings at the various ages with indicated treatments. Each point is an average of 5 replicates.](image)
INFLUENCE OF POSTIRRADIATION WASHING

At early seedling age, the damage was manifested more at the high dose and in later age groups. The increase in damage with dose has been reported on other plant species.\(^{(4,11,13,18)}\) The apparent delay in damage was also observed in cowpeas\(^{(18)}\) and sweet clover.\(^{(14)}\) Upon germination, the young growing embryo has the material needed for its growth available in the seed. The damage of radiation becomes apparent later when growth depends on synthesized material\(^{(14,15)}\) and the de novo synthesis has been impaired.\(^{(1)}\) Although the low dose resulted in less damage, there appeared a slight (not statistically significant) fresh weight stimulation at the 28th day. Stimulation effects of light doses of radiation has been reported before,\(^{(18-20,22,23)}\) but this is expected to be dependent on species and actual dose.

The reduction in dry weights by irradiation is attributed to decrease in metabolic rates of the growing seedlings.\(^{(4,11,13)}\) Deceleration of metabolic activity may be the result of alteration in DNA or in the enzymes latent in the seeds.\(^{(8,4,27)}\) The alteration of DNA will result in modifications of the newly synthesized nucleic acids and enzymes\(^{(6,14,24)}\) causing retardation of growth.

Although washing itself did not influence the seedling heights significantly (except in the 15 kR group), it reduced their fresh and dry weights by varied degrees at the different ages. It appears that during washing some factors important in growth are lost by leaching. By the time washing was stopped, seedling radicles emerged 2–3 mm indicating metabolic activity during the washing parallel to that of the unwashed. The washed seed, however, may partly lose some of the water-soluble digested products of the stored carbohydrates and proteins in the running water. This may have resulted in damage to the controls. The reduction may be, in part, the result of larger intercellular spaces in the washed treatments, increase in size of the intercellular spaces in leaves from washing after irradiation was shown in fenugreek beans by Freeman.\(^{(9)}\)

Since the washing did not stimulate recovery at the high irradiation dose, it may be inferred that the repair mechanism at this level was completely destroyed. In fact, the washing added to the damage at that level although not significantly. The recovery of seedlings in the 15 kR group (particularly at later ages) as a result of postirradiation washing is interesting. Somehow the washing neutralized the injurious effect of the low irradiation dose. Posttreatment washing has been reported to reduce the mutagenic effect of some chemicals in barley seed.\(^{(29)}\) Washing may have similarly reduced the mutagenic effect of radiation at this low level. Another possible explanation is that washing removes some of the long lived toxic free radicals or their products which were produced in the seed by irradiation,\(^{(8,28)}\) thus the repair mechanism remained active.

The slight increases in nitrogen percentages in seedlings from irradiated and/or washed groups are manifestations of their decreased dry weight. The higher nitrogen percentages of all groups at younger ages appears to be due to accumulation of nitrogen in active metabolizing areas in young seedlings as suggested by Robertson and Smith.\(^{(21)}\) The older plants usually synthesize carbohydrates faster than nitrogenous compounds, thus resulting in a lower percentage of nitrogen.

The pattern of phosphorous content in relation to seedling age is opposite to that of nitrogen during the 21 days. Phosphorous percentages in dry weights increased with age during that period while nitrogen decreased. Phosphorous compounds continue to accumulate faster than dry weights increase during the same period. The decline in phosphorous percentages in all groups after the 21st day is probably due to slower accumulation rate of phosphorous or faster accumulation rate of dry weights or both. The reasons for the insignificant differences in phosphorous content as a result of irradiation and/or washing are not clear. Insensitivity of phosphorous absorption of wheat seedling roots to damage by X irradiation was reported by Vasilev and Rybalka.\(^{(24)}\) It should be mentioned here that their measurements were made on root tips, where the dry weights of the whole seedlings are not an important factor.

REFERENCES


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