GAMMA RAY-INDUCED MORPHOLOGICAL ABNORMALITIES IN *SOLANUM NIGRUM* COMPLEX

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Abstract

Diploids and tetraploids showed retardation in vegetative growth with the increase in irradiation dose. Tetraploids of 50 krad treatment were stunted and the leaves showed enhancement of anthocyanin in early stages. Size and shape of stomata and trichomes were least affected. In general, the size of the fruits and number of seeds per fruit decreased with the increase of dose.

Introduction

Gamma irradiation is known to induce cytological, physiological and biochemical changes in plants which are usually reflected as morphogentetic abnormalities (see Gunckel, 1957, 1965; Gunckel & Sparrow, 1954). However, the literature on morphological aspects in response to gamma irradiation in a species complex is meagre. Chandel & Singh (1982, 1983) reported floral abnormalities induced by gmma rays in *Solanum nigrum* complex. The present paper describes the effects of different doses of gamma rays on a few other morphological features in the three ploidy groups of *Solanum nigrum* complex, viz., diploid, tetraploid and hexaploid.

Material and methods

Selection of material and the methods of treatments, etc. followed have already been described earlier (Chandel & Singh, 1983).

Observations

General habit—General habits of the plants grown from irradiated seeds were to an extent similar to those of the control in diploids and hexaploids, though a few diploids, showed more spreading condition. On the other hand, tetraploid plants of higher doses differed much from the controls and at 50 krad they remained stunted. Many of the leaves also showed light green pigmentation and formation of chlorotic areas. This feature recovered with the maturity of the plants. Exomorphic characters of stems of plants of treatments, in general, were similar to those of the control and no distinctly marked variability was seen.

Leaf—Various types of leaf abnormalities like shape, size and colour were observed in diploid, tetraploid and hexaploid plants at various treatments. The frequency of abnormalities was, however, greater at higher doses. Leaf abnormalities were more marked in the first and second nodal leaves as compared to subsequently formed ones. Out of the three ploidy groups, tetraploids were most affected, while diploids were least affected.

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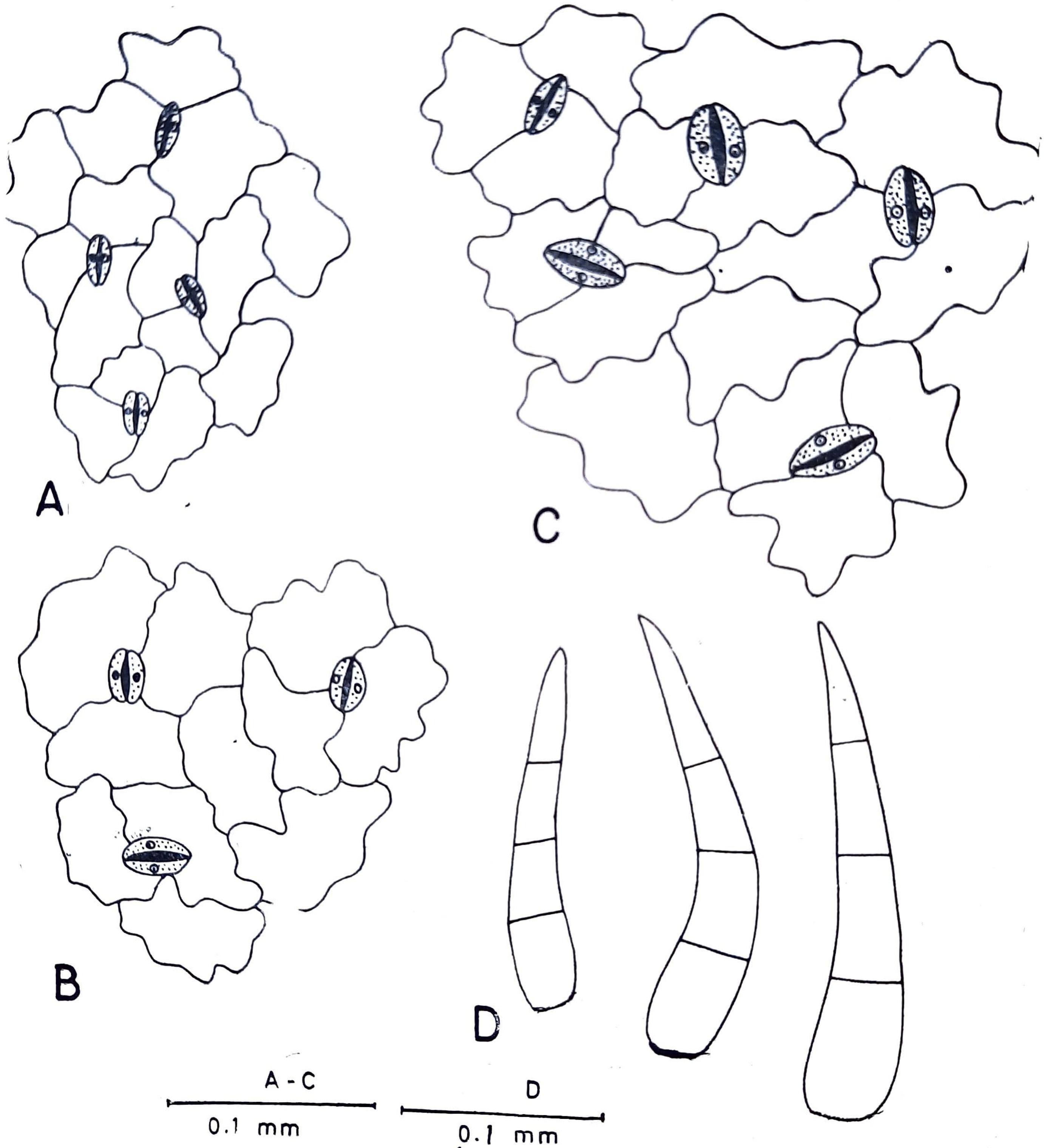
Among the various abnormalities. irregular development of leaf blade, its furcation, distorted venation, lobed apex and curvature in the leaves were the common features. Round, reniform. obovate, unequally lobed and various other unusual forms of leaves were also seen (Text-fig. 1). Dwarfing and premature abscission were common features. Early formed leaves (treated with 50 krad) and cotyledons of tetraploids (20, 30, 40 and 50 krads) exhibited dominance of anthocyanin.



Text-fig. 2. A-D. Stomata and hairs of different ploidy groups in control. A, Diploid; B, Tetraploid; C, Hexaploid; D, hair of diploid, tetraploid and hexaploids respectively. Hair of diploids on extreme left.

Size of stomata differs in different ploidy group; it increases with the increase of ploidy level (Fig. 2 A, B, C). On the other hand, the frequency of stomata is inversely proportional to the ploidy level, i.e. it decreases with the increase of ploidy. Data regarding size and frequency of stomata are given in Table 1. There was no discernible effect of gamma radiation on size and shape of the stomata and the trichomes.

Table 1—Size and frequency of stomata of different ploidy group of Solanum nigrum in relation to gamma treatment.

Treatment	Diploid		Tetraploid		Hexaploid	
	Size in μm l × b	Average frequency at × 400	Size in μm l × b	Average frequency at × 400	Size in μm l × b	Average frequency at × 400
1. Control	26.04 × 17.34	27	34.7 × 21.7	23	39.06 × 26.04	18
2. 10 krad	,, ,,	27	,, ,,	23	,, ,,	18
3. 20 ,,	,, ,,	27	,, ,,	23	,, ,,	18
4. 30 ,,	,, ,,	27	,, ,,	23	,, ,,	18
5. 40 ,,	,, ,,	27	,, ,,	23	— —	—
6. 50 ,,	— —	—	,, ,,	23	— —	—

l = length; b = breadth

The stomata are of the Crucifer or Ranunculous types. The guard cells are surrounded by 3 to 4 subsidiary cells. The walls of the subsidiary cells are sinuate. Except for the size and frequency, the structure of stomata is identical in all the ploidy groups (Fig. 2A, B, C). The trichomes are simple, multicellular and uniseriate with tapering ends. Shape of the trichomes is similar in all the ploidy groups except the size which increases with the increase in ploidy level (Fig. 2D). Trichomes are on an average 122.5, 175.0, and 227.5 μm long in diploid, tetraploid and hexaploid respectively.

Fruit and seed—Fruits obtained from plants after treatment were not much affected. There was no marked change in the shape and colour of the fruits, but variation in their size was seen. With the increase of dosage, fruits of diploids and tetraploids became gradually smaller and lighter in weight, whereas those of hexaploids were least affected. Tetraploid fruits obtained from 50 krad treatment were shrivelled and much reduced in size.

In treatments, the number of berries per umbel was almost the same as in the control. However, in tetraploids treated with 50 krad dose the number was reduced to 3 or 4.

Generally, with the increase of dose, the number of seeds per fruit decreased. This was more true in diploid and tetraploid plants. Tetraploids of 50 krad treatment had only 5 to 10 seeds as compared to 40 to 45 seeds in the control (Table 2). So far as the weight and number of seeds per berry were concerned, hexaploids were least affected with gamma irradiation (Table 2).

Table 2—Number of seeds per berry and weight per hundred seed in different ploidy group in relation to gamma treatments.

Treatment	Diploid		Tetraploid		Hexaploid	
	Number per berry	Wt. per hundred seeds in mg	Number per berry	Wt. per hundred seeds in mg	Number per berry	Wt. per hundred seeds in mg
1. Control	60—65	30.0	40—45	70.0	60—70	90.0
2. 10 krad	60—65	30.0	40—45	70.0	60—70	90.0
3. 20 ,,	60—65	30.0	40—45	70.2	60—70	90.1
4. 30 ,,	50—60	30.0	35—40	70.0	60—70	90.1
5. 40 ,,	15—40	29.4	25—30	60.1	—	—
6. 50 ,,	—	—	5—10	50.2	—	—

In general, there was hardly any noticeable difference in the morphology of seeds, but differences were seen in colour and weight. Seeds obtained from the diploid and tetraploid plants treated with higher doses were generally weak, asymmetrical, constricted and variable in size in comparison to the control. Many of the seeds were dark brown in colour. Generally, the seeds obtained from plants treated with higher doses were of poor quality and did not germinate. Hexaploid seeds were least affected and were almost of the same shape and size as in the control plants.

Discussion

Plants obtained from irradiated seeds showed varying morphological changes in leaves, seeds and fruits. The plants of diploid and hexaploid were found to be more or less similar to those of control, but tetraploid plants of 50 krad treatment were stunted and showed domination of anthocyanin pigmentation in their leaves which recovered with the maturity of the plants. Stunted growth as a response to gamma irradiation is also reported in tetraploid *Capsicum annuum* by Indira and Abraham (1977). Several reasons have been suggested as a cause of stunting; destruction or inhibition of terminal meristems, destruction of auxin or its synthesis, disturbance in nutritional level, failure of assimilation mechanism or inhibition of mitosis or chromosomal damage leading to secondary physiological changes.

The leaves produced on plants after irradiation showed various types of variabilities which included change in their form and texture. Hagen and Gunckel (1958), in case of *Nicotiana glauca* and *N. landsdorfii* and their interspecific hybrid, have suggested that morphological changes in response to radiation are due to changes in the free amino acid content. According to Irvine (1940), leaf abnormalities may be due to disturbances in phytochromes, and according to Pelc and Howard (1956), abnormalities are due to inhibition of DNA synthesis.

Leaves of tetraploids showed enhancement of anthocyanin and poor green colouration at higher doses. It has been suggested that plants treated with gamma rays commonly show enhancement of anthocyanin and chlorotic areas on leaves (Gunckel & Sparrow, 1954; Natarajan, 1964; Gunckel, 1965; Mathew & Abraham, 1978). The marked decrease in the chlorophyll of the leaves of tetraploids is probably due to mutation of genes controlling chlorophyll synthesis while anthocyanin formation is due to destruction of some enzymes through ionizing radiation (Sparrow *et al.*, 1968).

Size of stomata and hair increases with the increase of ploidy level, but the frequency of stomata decreases with the increase of ploidy level. There is no apparent effect of radiation on the size, shape and number of stomata and hair. Increased size of stomata in induced polyploids has also been observed by Dehsi and Saini (1973) in sunflower and Indira and Abraham (1977) in tetraploid *Capsicum annum.*

No marked effect of gamma radiation in the general morphology of fruits has been observed during the present study, but with the increase of dose rates the reduction in size was seen which was more in tetraploids at 50 krad treatment. Chauhan *et al.* (1975) have also reported reduction in berry size and number in tetraploid *Solanum khasianum* with the increase of dose rate.

Marked effect on seed-set, size, colour and viability of seeds was recorded at higher, doses of treatments in diploids and tetraploids. Natarajan *et al.* (1958), Mackey (1958) and Bhaskaran and Swaminathan (1962) have also reported poor seed-set with the increase of ploidy in wheat series, but in the present study it was found that seed-set decreased up to tetraploid level at different doses, while in hexaploids seed-set was not affected and was almost similar to control. The poor seed-set in tetraploids may be due to greater meiotic abnormalities leading to pollen and ovular sterility.

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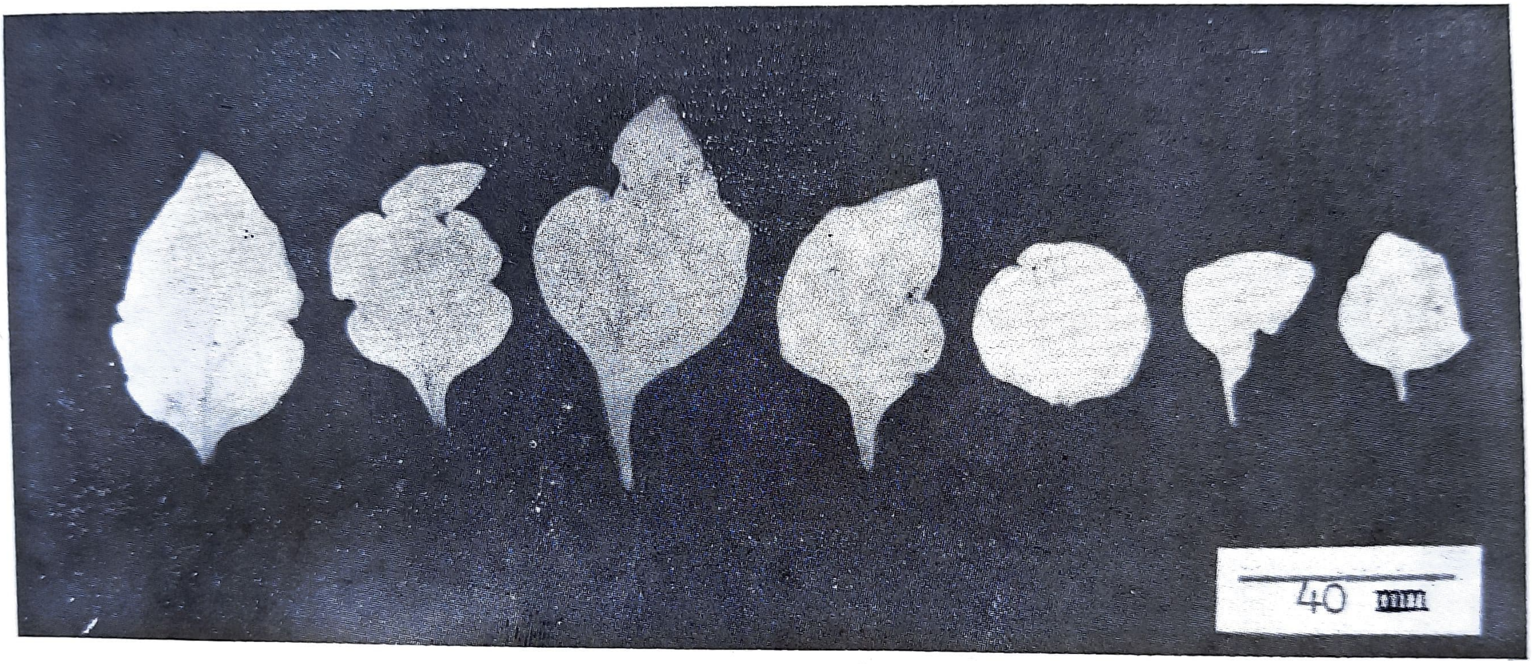
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Explanation of Plate

1. Leaf shape variabilities under different doses of gamma rays. The extreme left leaf is control.