CERTAIN RADIATION-INDUCED MORPHOLOGICAL ABNORMALITIES IN *CROTALARIA JUNCEA* L.

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Abstract

The X_1, P_1 and S_1 progenies of *Crotalaria juncea* L. raised from the seeds exposed to X-rays, beta-rays from P^{32} and S^{35} have been studied.

A large number of morphological abnormalities like fasciation, lateral and base branching of the stems, splitting of leaves, sectorial chimaera and flowers with abnormal parts, etc., have been recorded.

The nature and significance of these abnormalities have been briefly discussed and it has been suggested that many of these abnormalities are non-genetical, arising as a result of physiological disbalance caused by the irradiation.

Introduction

The importance of radiations in induced mutagenesis and crop improvement needs no emphasis. Various types of radiations like X-rays, beta-rays, γ-rays, ultraviolet rays and neutrons are now being used in a variety of crop plants all over the world and in many cases significant results have been obtained.

In *Crotalaria juncea* L., which is an important substitute fibre crop of India, the work was started with a similar view to isolate economic mutants with higher yield and/or better quality of the fibre.

The present paper deals with certain interesting morphological abnormalities, hitherto not recorded in this plant, obtained in the course of a preliminary dose trial experiment.

Material and Methods

Seeds from a pure strain of *C. juncea* were exposed to the following radiation treatments at the atmospheric temperature and moisture conditions.

(*i*) X-rays—from a Philips Contact and Cavity Therapy apparatus working at 50 Kv and 2 mA, at three different doses, viz.,

(a) 5,000 r
(b) 10,000 r
(c) 15,000 r

(*ii*) Beta rays—from radioisotopes of Sulphur and Phosphorus (in aqueous medium) obtained through Messrs. Philips India (Private) Ltd., as follows :

(a) P^{32}—Initial activity 572.0 μc for 2 durations, viz., 24 and 48 hours.

(b) S^{35}—At an initial activity of 909.0 μc for 24 and 48 hours durations.

Seeds thus treated, were washed to remove the superficial isotope and were grown in pots as well as under field conditions and the data with regard to germination, mortality, height of plants, branching, flowering and yield, etc., were taken. However, in the present note, it is proposed only to deal with the various types of morphological abnormalities noted.

Morphological Abnormalities and Discussion

During the course of these investigations, it was observed that there were a larger number of abnormalities in plants arising out of P^{32} treatments, fewer in X-ray and very few in S^{35} treated progenies, suggesting thereby that as compared to the other treatments, P^{32} produces more morphological abnormalities in *Crotalaria*.

(a) *Stem abnormalities :*

(*i*) The most frequent abnormality of the stem was the occurrence of "fasciation", resulting in a flattened or bilateral growth of the stem. Fig. 1 shows a characteristically fasciated stem of *C. juncea*. It was found that in cases of excessive fasciation, the stem tends to split up into two or three parts. Besides, in such plants, there is a clustering of the leaves near the apex. Generally, there is an increase in the number of leaves and the phyllotaxy is changed.

Such fasciations of stem and petioles following exposure to X-radiation have been recorded by Singh *et al.* (1939) in cotton and others in sunflower, tomato and cosmos. Beal (1949) recorded the phenomenon in species of *Digitalis* when treated with C^{14} and Sparrow and Singleton (1953) in *Xanthium* as a result of gamma radiations. White (1948) has reviewed the extensive literature on causes and occurrence of fasciation in plants both under natural and experimental conditions.

(*ii*) *Branching of the stem :* Lateral branching of the stem in the treated progenies, has also been found to be a character of irradiation. Jhonson (1936) in *Neurophila, Phlox, Helianthus, Lycopersicon,* Stanton and Sinclair (1951) in potato and Gunckel *et al.* (1953) recorded it in *Tradescantia.*

In the present investigations, it was found that in *C. juncea*, the induced branching is of two types :

(a) Excessive lateral branching, which although might be advantageous for the grain crops, is harmful in this crop as this type of branching breaks the fibre. This character was present both in X-irradiated and P^{32} treated progenies.

(b) Branching from the bottom is a desirable character in fibre yielding plants and was recorded only in the X-ray treated progenies. This increases the yield of fibre/plant, as each branch serves the purpose of a whole plant.

Fig. 2 represents a view of the treated progenies showing a plant with such branching. Fig. 3 depicts the unbranched stems of the 'control'.

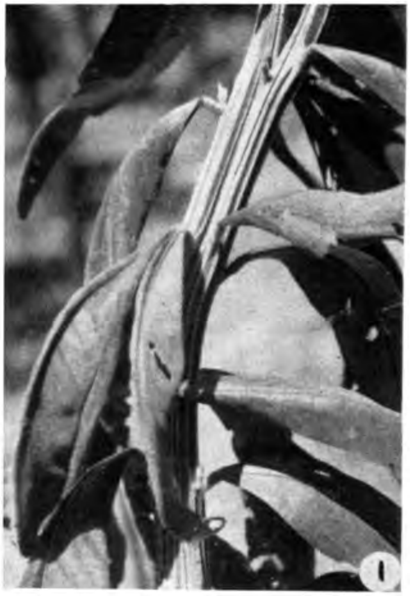
(b) *Leaf abnormalities :*

As in the case of the stem, in the leaves also a number of morphological abnormalities were noted in the both X-ray and P^{32} treatments. The abnormalities recorded in course of present observations were :

(*i*) *Crinkled Leaves :* In a single case in the population treated with 10,000 r of X-rays, a plant with crinkled and downy leaves (Fig. 4) was recorded. The leaves were smaller, more compact and of a darker shade, with a slightly twisted appearance. Fig. 5 shows the normal leaf character in this plant (control). Such crinkled leaves, following radiations have been recorded in *Lycopersicon* by Jhonson (1931) and others.

(*ii*) *Bifurcation of the leaves :* Bifurcation or forking of the leaves is yet another common response of plant to radiations. In course of present investigations, partially or completely bifurcated leaves were recorded in the P^{32} treated progenies. Fig. 6 shows the forking of the leaf tip, while Fig. 7 shows the whole lamina and a part of the petiole split into two.

Forking of the lamina and petiole is known to occur in nature in a number of plants, *e.g.*, *Jasminum, Lonicera, Nyctanthes* and other genera of dicots (Bhatnagar, 1957). In *Crotalaria,* however, there is no previous record of leaf forking in nature.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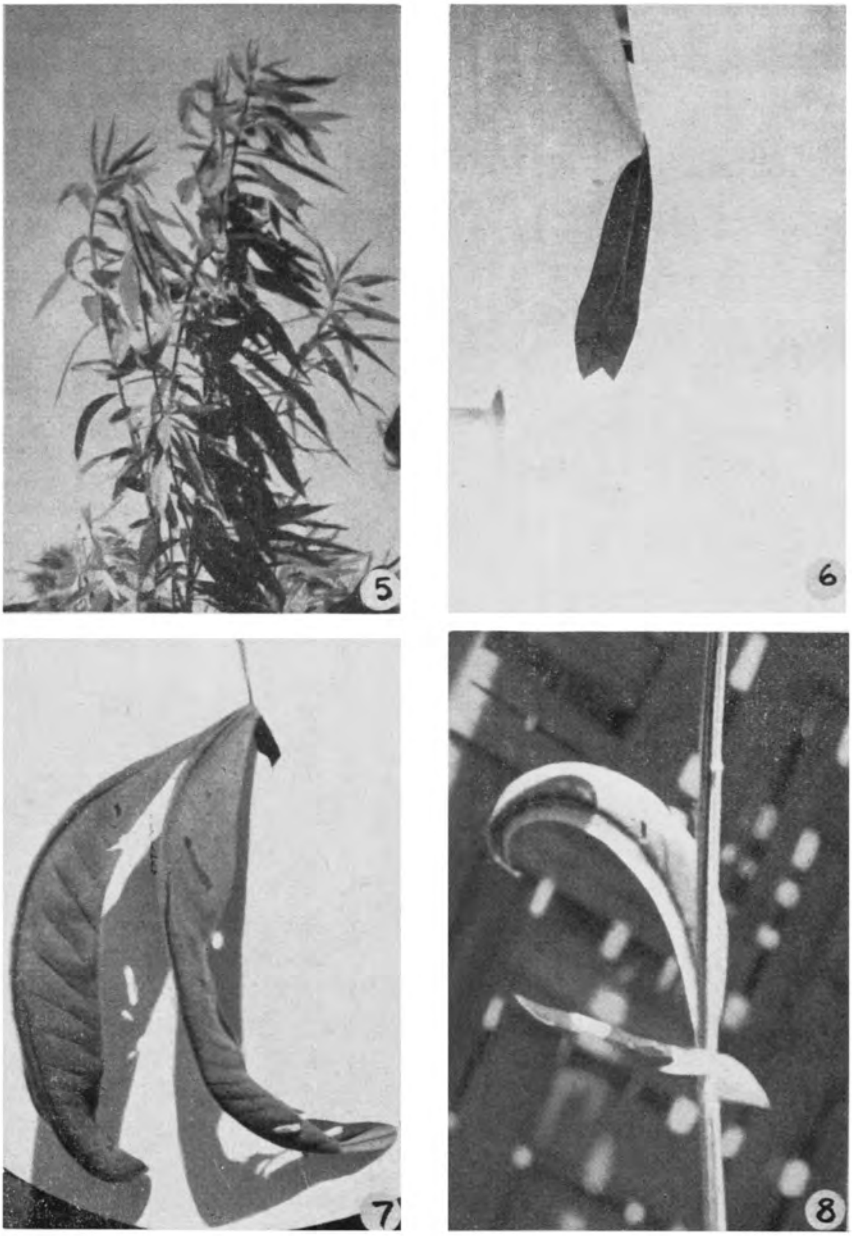
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Likewise, forking of leaves due to radiations has been reported by Jhonson (1926) in *Helianthus* and Haskins and Moore (1935) in X-irradiated plants of *Citrus*, resulting in the development of partially or completely bifoliate and trifoliate leaves which co-exist with the normal ones on the same plant. Gunckel *et al.* (1953) have, similarly, recorded dissected leaves in X-irradiated plants of *Tradescantia paludosa* and Sparrow and Singleton (1953), in *Xanthium* following chronic gamma exposure.

The observations suggest that the forked leaves arise as a result of physiologiocal disturbances caused by irradiation, which in turn affect the development and differentiation of leaves and other parts and as such do not seem to be of much evolutionary significance.

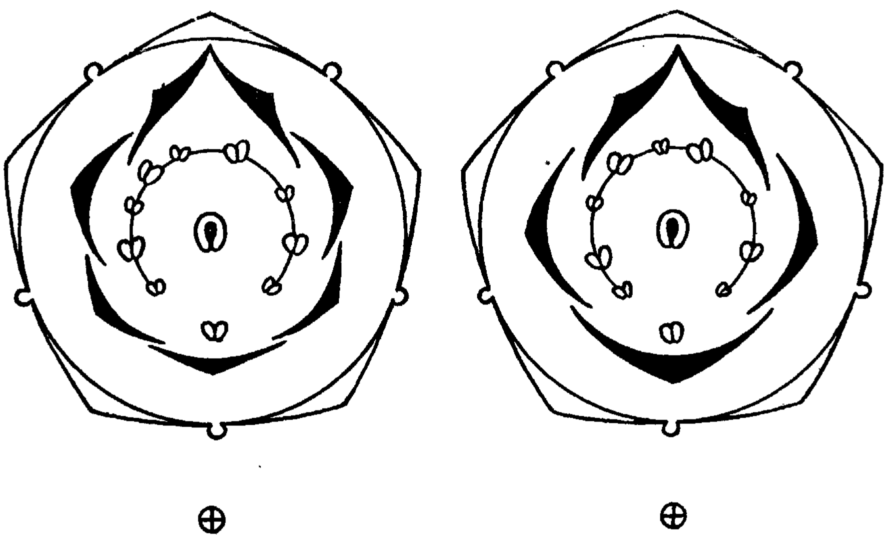
(*iii*) *Leaf chimaera :* Somatic mutations are known to be frequent in irradiated progenies. In the present case a small chimaeral twig bearing leaves was recorded in 10,000r X-ray treatment. One part of the leaves was normal green (Fig. 8). There is no previous record of naturally occurring chimaeras in *Crotalaria*. The present case resembles the condition met with in sectorial chimaeras.

(c) *Floral abnormalities :*

The golden yellow flowers of *Crotalaria juncea*, are the normal papilionaceous type, comprising of a large standard, two wings and a keel. There are 10 stamens and a monocarpellary ovary. The whole flower is enclosed by a single whorl of 5 gamosepalous calyx.

A number of floral abnormalities like the phylloidy of the floral parts, proliferation, adhesion and fasciation of the floral structures are, however, known to occur in nature in low frequency (Bose and Misra, 1938). But entirely different type of abnormalities were recorded in course of investigations on beta-irradiated progenies of this plant.

(*i*) *Abnormal floral parts :* In a single plant raised from P^{32} treated seeds, a flower was observed to possess three standards instead of the normal one (Fig. 9 and 10). The other parts of the flower were normal. Thus the organisation of the flower was altered as follows (Text-fig. 1) :

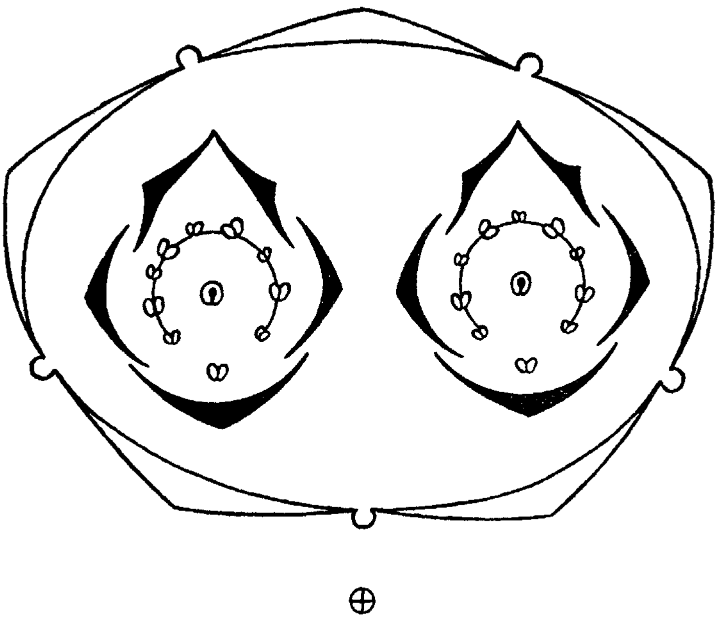


Text-fig. 1

Such an occurrence of extra one or two or the suppression of certain floral members has been reported to arise as a result radiation treatment by a number of workers. The most interesting examples are those in *Tradescantia* (Gunckel *et al.*, 1953 and Sparrow and Singleton, 1953).

(*ii*) *Double flower* : In the same plant still another interesting abnormality was the occurrence of two complete flowers enclosed in a single whorl of calyx. Fig. 11 is the photograph showing the double flower on a normal pedicel, while Fig. 12 shows the double nature of the ovary in the same.

The detailed floral structure may therefore, be shown as follows (Text-fig. 2) :

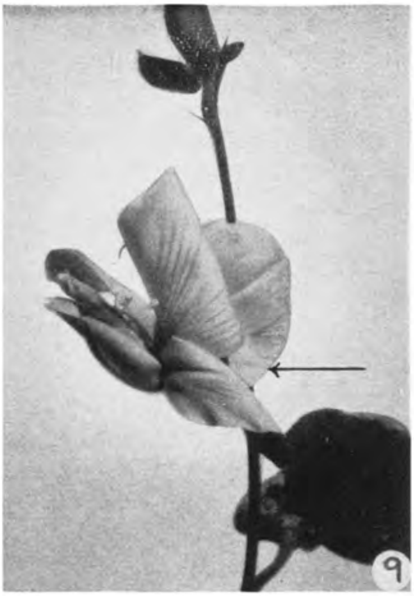


Text-fig. 2

According to Jhonson (1926), who recorded a large number of abnormalities in X-irradiated *Helianthus*, fasciation of the floral axis is responsible for the formation of extra members in a flower or double flowers. But the present view is that this could be expalined on the basis of excessive proliferation of the plant parts arising due to physiological disturbance caused by irradiation.

(*iii*) *Supression of the flower and rupture of the keel :* In certain cases in the P^{32} treated progeny, the flower-buds were found to develop normally, which did not open in the end. In such cases, the keel which normally persists till long after fertilisation, was found to rupture with the stigma protruding out. However, no fruits were formed in such flowers.

(*iv*) *Change in the colour of standard :* The S^{32} treated progenies were marked by the absence of the gross morphological abnormalities enumerated earlier. However, in some plants of this treatment, it was noted that the colour of the flowers had changed appreciably over the control. In all these cases, the dorsal surface of the standard developed a bright crimson colour. These plants maintained this character till the end and no normal coloured flowers were found to occur on these plants.



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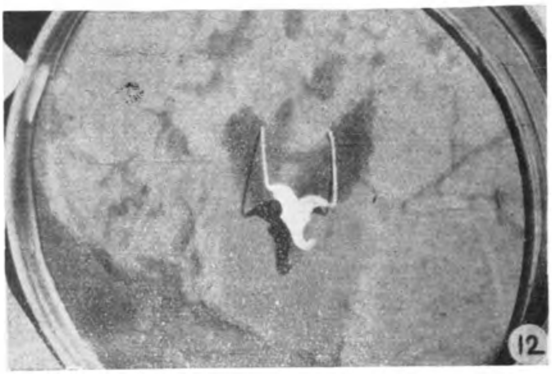

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Such changes in the colour of the flowers, etc., unlike other morphological abnormalities may sometimes be genetical in nature. Lawrence and Strugess (1957) in a recent paper, have advanced a hypothesis explaining the evolution of flower colour in *Streptocarpus* through the successive mutation of genes, their becoming dominant and finally epistatic to their predecessors. If this hypothesis is correct, the variations in the flower colours of certain irradiated plants may be explained on the basis of mutation of the gene or genes controlling the expression of pigment, as a result of this treatment. However, some of the radiation-induced colour variations are supposed to be chimaeral in nature, e.g., the red colour induced in carnation (*Dianthus caryophyllus*) by the X-rays (Sagawa and Mehlqvist, 1956), whiles till others are believed to be arising as a result of mutations or deletions, e.g. in *Antirrhinum majus* through chronic gamma irradiation (Sparrow and Pond, 1956). Similar change of colour in flowers has also been reported by other workers.

The occurrence of abnormal flowers side by side with normal ones on the same plant, together with the fact that most of these abnormalities are not passed on to the subsequent generations, has led Nickson (1952) and Gunckel *et al.* (1953) to suggest that the physiological disturbances caused by irradiations are responsible for the morphological abnormalities described. These physiological effects may be caused by the damage or inactivation of the enzymes, substrates, hormones or physico-chemical changes in the permeability and viscosity of the cytoplasms, etc. It also seems that as the dose of irradition is not so high as to destroy the vital substances, the plant continues its life-cycle with certain abnormal features. Physiological action of the radiation on the cytoplasm has also been held responsible for the histological changes in the stems and petioles of the irradiated progenies of plant (Beal, 1949).

The investigations on the anatomical and cytological aspects of these abnormalities are in progress, while the study of inheritance of these characters in subsequent generations is also being taken up.

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