Plant Physiol. (1972) 50, 303–304

Short Communication

False Broomrape: A Physiological Disorder Caused by Growth-Regulator Imbalance[1]

Received for publication February 7, 1972

JAMES L. HAMILTON AND RICHIE H. LOWE
Plant Science Research Division, Agricultural Research Service, United States Department of Agriculture, Department of Agronomy, University of Kentucky, Lexington, Kentucky 40506

FOLKE SKOOG
Institute of Plant Development, Birge Hall, University of Wisconsin, Madison, Wisconsin 53706

ABSTRACT

False broomrape on tobacco (*Nicotiana tabacum*) can be induced by applying cytokinins to the roots, by causing an increase in the cytokinin-auxin ratio in the roots, by removing the apical and auxillary buds, or by applying extracts from tobacco with false broomrape to the roots of healthy plants. It can be prevented by treating debudded plants with auxin.

False broomrape is a widely distributed root disorder of tobacco in this and other countries. Symptoms of the disorder are white succulent outgrowths which first appear as tumor-like protuberances on the roots (4). They may form on any of the roots, but are more numerous on the tap root. Outgrowths usually develop into leafy shoots if they emerge through the surface of the soil (Fig. 1). The first few leaves are badly deformed, but succeeding leaves often are normal. False broomrape may appear at any time, but it is mostly observed during the later stages of the growing season.

Several investigators have suggested possible causes of this root disorder, including viruses, bacteria, and other organisms. Valleau (8) thought it might have been caused by a growth-regulating substance associated with newly introduced chemical treatments of tobacco, but rejected this idea when he could not produce the symptoms experimentally with the employed chemicals. He (9) then suggested that false broomrape may be caused by *Corynebacterium fascians* because the symptoms resembled those of leaf gall, but he also rejected this hypothesis when he was unable to induce the disorder by infecting plants with that organism. Dukes *et al.* (1) were able to transfer the disorder from diseased to normal plants. False broomrape tissue was ground in a buffer solution, and roots that had been injured with carborundum were immersed into the slurry before being planted in fumigated soil. All the treated plants developed false broomrape. Although the disorder could be reproduced, no causal organism could be isolated.

In callus and excised stem tissue cultures of tobacco, morphogenesis has been shown to be regulated by cytokinins and auxins and can be controlled by the relative concentrations of these two hormones supplied to the medium (7). Bud formation is induced by high cytokinin-auxin ratio and root formation by low cytokinin-auxin ratios. The same type of quantitative regulation has been found in tissues of several other dicotyledonous and monocotyledonous plants and can apply also to the initiation and development of adventitious buds and roots (3). There is some evidence that environmental

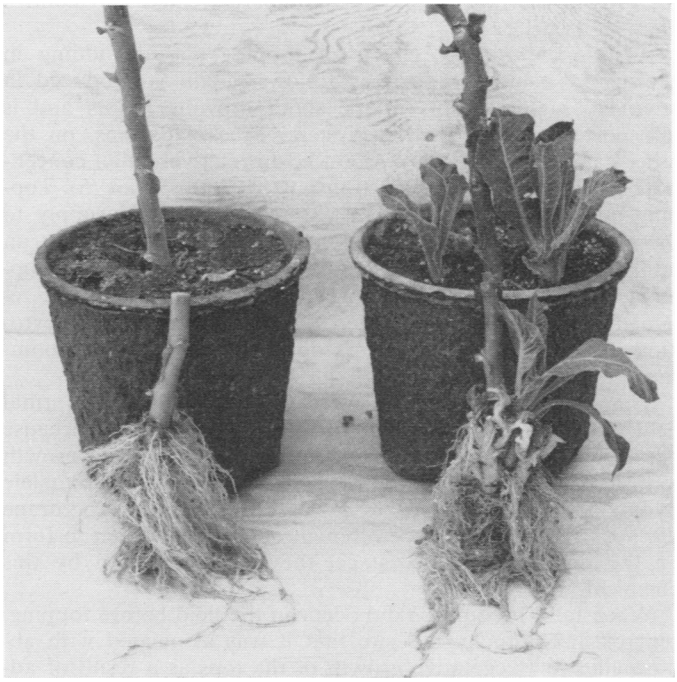

FIG. 1. False broomrape produced on tobacco roots. Left: control plant, not topped and not suckered; right: plants topped and all visible buds removed daily. Plants in front are duplicate plants with soil washed from roots.

[1] Cooperative investigation of the Plant Science Research Division, Agricultural Research Service, United States Department of Agriculture. Contribution from the Department of Agronomy, University of Kentucky, and the Department of Botany, University of Wisconsin.

control of regeneration of buds and roots, as by day length and/or temperature regimes in begonia cuttings (2), relates to the endogenous levels of these hormones. Consequently, we have examined the etiology of false broomrape in terms of changes in hormone balance.

We have produced false broomrape on plants grown in soil and in nutrient solutions in the greenhouse as follows:

1. The plants were topped and all visible buds were removed each day (including adventitious buds when they formed).
2. The plants were topped and treated with "contact sucker control material."
3. Plants with injured root systems (damaged by rubbing the roots with carborundum) were soaked in a 10 mg/l kinetin solution for 3 hr prior to planting in soil.
4. The plants were grown in nutrient solution containing 1, 3, 6, or 10 mg/l of kinetin.
5. The plants were grown in nutrient solution with added extract from false broomrape tissue.

The sucker control material contained 4% of a 1-octanol and 1-decanol mixture and was applied to the top of the stalk. Extract from false broomrape tissue was obtained by grinding 100 g of tissue and extracting with 1 liter of 80% (v/v) ethanol. The extract was dried, redissolved in water, and added to the nutrient solution to give a concentration equivalent to 10 g of broomrape tissue per liter.

False broomrape developed in all plants treated as described under paragraphs 1 to 5 above, and none in untreated control plants. Thirty treated and 30 control plants were used in each experiment for 1 and 2 above. There were five control plants and five plants for each treatment for 3 to 5 above. In nutrient solutions, the roots developed small tumors which then formed abnormal shoots, but they did not form the large white succulent outgrowths which were found in the root systems of soil-grown plants.

In the topped and debudded plants topping and daily debudding, which resulted in false broomrape, also stimulated the growth of the root system (compare treated and control plants in Fig. 1).

A rationale for the effects of topping and debudding in causing false broomrape is as follows: auxin is produced in relatively high amounts in the shoot growing points and is transported toward the root system. Free cytokinins, on the other hand, apparently are produced in relatively high concentrations in the roots and are transported to the shoot (5). Topping and debudding, therefore, decrease the auxin supply to the root system to such an extent that it no longer exerts an inhibiting action on meristematic activity and bud development, while at the same time cytokinins will tend to be retained in the roots. Both effects contribute to a high cytokinin:auxin ratio, which favors development of false broomrape.

This interpretation fits in with observations from normal field practices. In the past, false broomrape was rare because hand suckering or no suckering allowed enough sucker growth to keep the cytokinin-auxin ratio sufficiently low. When maleic hydrazide was applied visible development of false broomrape did not occur, because, even though outgrowths began to form on the roots at an early stage, they were inhibited by this chemical.

When false broomrape did occur in the field before topping, records in Kentucky indicate that it was associated with abnormally slow vegetative growth of the tops as a result of adverse environmental conditions or injury to the plants. We believe that false broomrape has increased in recent years as a consequence of the better contact sucker control methods which have been adopted.

In a sucker control (field) test carried out at the University of Kentucky, W. O. Atkinson found that false broomrape developed in all plants in which the contact sucker control material was effective, and did not develop in plants in which the suckers were not controlled. The importance of the correlative action of apical growing points presumably mediated by auxins already has been shown by Skok (6), who experimentally induced tumors in the lower portion of tobacco plants by systematically removing the growing points from the apical portion of the plants.

Further evidence that false broomrape is caused by an abnormally high cytokinin-auxin ratio is the fact that it was brought on by applying a cytokinin (kinetin) to the injured root systems of intact plants and was prevented by adding an auxin (indoleacetic acid, 100 mg/g) in lanolin paste to the cut ends of the stems of topped and debudded plants.

The development of false broomrape by treatments of root systems in nutrient solution either with kinetin or with an extract from false broomrape tissue suggests that a chemical, rather than a microorganism, was the causal agent.

Aseptic techniques were not used in the experiments under procedure 3 in which kinetin was supplied to the injured root system before planting, but the same soil mix and potting procedures were used for treated and control plants. The fact that all kinetin-treated and no control plants developed the disease points to the chemical as the causal agent.

The presence of exceptionally high cytokinin contents in false broomrape tissue (Hamilton, unpublished) may be interpreted to support this view and to account for effective transfer of the disease by soaking injured root systems in slurries of ground up false broomrape tissues in the experiments by Dukes *et al.* (1). However, the participation of microorganisms or viruses is not excluded. They may promote the disorder by serving as sources of exogenous cytokinins and other growth factors in the rhizosphere, or they may stimulate the synthesis of cytokinins in the root system, so that in either case an abnormally high cytokinin-auxin ratio conducive to false broomrape development is achieved.

LITERATURE CITED

1. Dukes, P. D., S. F. Jenkins, and R. W. Toler. 1963. An improved inoculation technique for transmission of false broomrape to flue-cured tobacco. Plant Dis. Rep. 47: 895–896.
2. Heide, O. M. 1965. Interaction of temperature auxins and kinins in the regeneration ability of begonia leaf cuttings. Plant Physiol. 18: 891–920.
3. Hilderbrandt, A. C. 1970. Growth and differentiation of plant cell cultures. *In:* H. A. Padykula, ed., Control Mechanisms in the Expression of Cellular Phenotypes, Vol. 9. Symp. Int. Soc. Cell Biology. Academic Press, New York. pp. 147–167.
4. Lucas, G. B. 1965. Diseases of Tobacco, Chap. 53. The Scarecrow Press, Inc., New York. pp. 734–737.
5. Mothes, K. and L. Engelbrecht. 1963. On the activity of a kinetin-like root factor. Life Sci. 2: 852–857.
6. Skok, J. 1967. Tumor and teratoma induction in tobacco plants by debudding. Plant Physiol. 42: 767–773.
7. Skoog, F. and C. O. Miller. 1957. Chemical regulation of growth and organ formation in plant tissues cultured *in vitro*. Symp. Soc. Exp. Biol. 11: 118–131.
8. Valleau, W. D. 1953. False broomrape and leaf curl: two new tobacco diseases in Kentucky. Plant Dis. Rep. 37: 538–539.
9. Valleau, W. D. 1954. Ky. Agr. Exp. Sta. Cir. 522.