

# PHYSIOLOGICAL STUDIES ON PLANT GROWTH REGULATORS EXUDED FROM CERTAIN WEEDS

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This thesis has not been previously submitted for  
a degree at this or any other university.

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## P A R T    I

1. INTRODUCTION
2. MATERIALS
3. GENERAL METHODS

## INTRODUCTION

It has been known for centuries that weeds are injurious to cultivated crops. However, the mechanism of such injury has never been adequately explained. It has been interpreted in terms of mineral nutrition or in terms of water competition. Careful studying of such explanation, however, reveals certain weakness especially in some cases. So, it appears that some additional mechanisms are involved in the competition between some weeds and certain cultivated crops.

The liberation of toxic substances from higher plants is often discussed especially in connection with the so-called soil sickness. These substances may affect the subsequent growth of the same or other species.

General reviews concerning the liberation of different organic substances from some higher plants and the effects of one plant upon another included those of Loehwing (1937), Bonner (1950), Borner (1960), Woods (1960), Garb (1961), Rovira (1969) and Tukey (1969).

A short account of this problem is given in the following sub-sections.

As early as 1832, De Candolle noted that plant exudates of certain species appeared to be specially inhibitory to the growth of associated species. He pointed out the inhibition of flax by Euphorbia sp. and of oats by thistles, and postulated the production of specific toxic substances by these weeds. On the basis of these observations, De Candolle (1832) suggested a theory of crop rotation embodying the general idea that each member in a rotation should be a species not inhibited by toxic substances left from the preceding crop. Liebig (1852) supported this theory in the very beginning of his scientific career, but later, as a result of his exhaustive analyses, came to the conclusion that inorganic nutrients are most important for soil productivity. Thus, the idea that toxic excretions from plant roots might be responsible for declining crop yields was superseded.

#### Excretion of Growth Inhibitors from Plant Roots.

There are some accumulated evidence that roots and underground stems of a very wide range of plant species produce specific chemical compounds that are active inhibitors of seed germination and plant growth. It seems highly probable that these compounds are normally excreted into the soil,

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where they may play an important role in the selective suppression of the growth of competing seedlings.

The best known and perhaps most widely discussed work on toxic substances exuded from certain plant roots in soil is that of Schreiner and his co-workers (1908a, b & c; 1910; 1911). They found that in certain soils where fertility had been reduced by cropping some plants for a series of generations, a number of phytotoxic substances had been isolated and found to be picolonic acid, salicylaldehyde, vanillin and dihydroxystearic acid. Pickering (1907 & 1919) showed that, under certain conditions, some grasses can give out toxic substances which inhibit the growth of apple trees. These authors, however, may over-emphasize the importance of toxic materials to explain infertility of soils (Borner, 1960).

Livingston (1923) showed that waters obtained by leaching a bog soils, contain materials which are toxic to the growth of numerous species of plants. Unfortunately, this work produced no evidence that the inhibitors had their origins in the plants grown previously in those soils.

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Van der Veen (1937) showed that the drainage water from soils, in which certain weeds e.g. Salvia, Paspalum, Cynodon, Passiflora and Amaranthus spp. were growing, had a marked inhibitory and toxic effect on the growth of coffee seedlings. He was of the opinion that this effect is due to certain growth inhibitors exuded from roots of such weeds.

Walks (1936) found that the roots of Robinia pseudo-acacia excrete a principle highly inhibitory to other species.

Peach seedlings, when planted in soil which had previously supported a peach orchard, show a decrease in yield and growth. After ruling out nutritional and pathogenic organisms as causative agents, Proebsting and Gilmore (1940) showed that old peach roots can release a substance which is inhibitory to the growth of peach seedlings.

It has been observed that a brome grass (Bromus inermis), after growing several years, attains a condition in which the stand begins to thin out and the plants start to die. Benedict (1941) suggested that this dying out of old brome grass may be due to the accumulation of toxic substances

produced by brome grass roots. He established the presence of a toxic substance in brome grass roots which is inhibitory even in small amounts to growth of brome grass seedlings. Meyers and Anderson (1942) have shown that application of nitrogen can partially overcome the growth inhibition which results from culture of brome grass in soil which has previously supported brome grass. But, they found that well fertilized brome grass soils still give yields much smaller than those obtained from soils in which brome grass has not been previously grown. These results clearly reinforce the conclusion of Benedict.

In the early days of the second war, experiments were started in America on the production of rubber by the guayule plant. In plantations of this plant, mutual antagonisms were obvious since individuals in the center of a block of plants showed much feeber growth than those at the edges. This was not caused by competition for water or nutrients but presumably by toxic root exudates, as roots of adjacent plants did not intermingle but grew out areas unoccupied by other guayule roots. An elaborate series of pot

experiments confirmed this antagonism and the presence of highly toxic material in the soil solution which was identified as trans-cinnamic acid, a normal constituent of the guayule plant (Bonner and Galston, 1944). These observations supported the view that the toxicity of the soil water under normal conditions may be due to an exudation from living roots. The toxic action of this exudate seems to be selective as tomato is only a hundredth as sensitive to it as guayule itself.

Some observations have confirmed the excretion of certain growth inhibitors from various grass roots. The investigations were initiated by the observation that certain species of Brassica germinated and developed very poorly in fields where Agropyron grass was growing well. The extracts of the underground portions of such grass (Agropyron) showed the presence of toxic substances which inhibit the germination and growth of Brassica spp. (Osvold, 1947). This suggested that the well known success of grasses in competition with other species in natural grassland communities might reside in a similar toxin production and led to the study of soil

extracts from such grassland and from agricultural land. A particular meadow, dominated by an almost pure stand of red fescue grass was chosen by Osvoid (1949). The extracts of such soil stopped Brassica seed from germination, whereas similar extracts from cultivated soils had no such effect.

Some evidence has been also obtained that certain crop plants may be mutually inhibitory to each other's growth when grown in close association. Spinach and radish are such a pair, and it has been suggested that the saponins of the spinach and the mustard oils of the radish, may be the inhibitory compounds involved (Schuphan, 1948). Italian rye-grass and red clover are another pair (Mann and Barnes, 1953).

Soils from old Citrus orchards were found to inhibit the growth of young Citrus seedlings while 50 to 175% more growth being made on similar soils from outside the orchard area. Tomato seedlings were not affected in this way indicating that the action of the toxic agent is specific to Citrus itself. Martin (1950) suggested the toxicity of these soils is caused by the accumulation of a growth inhibitor specific for Citrus and excreted by its roots.