Transactions of the Illinois Academy of Science
(1988), Volume 81, 1 and 2, pp. 39-44

NONCOMPETITIVE EFFECTS OF MORNING GLORY ON THE GROWTH OF SOYBEANS

Don R. La Bonte* and Roger L. Darding
Department of Botany
Eastern Illinois University
Charleston, IL 61920

ABSTRACT

Soybean fields with a significant morning glory (*Ipomea lacunosa* L.) weed infestation often show a marked reduction in yield. These reductions are often attributed to competition for nutrients, water and sunlight, but noncompetitive phytotoxins contained within morning glory plants may also adversely affect soybean yields. A series of studies were performed which identify morning glory leaf leachate and root exudate as significantly reducing growth of soybean (*Glycine max* (L.) Merrill) plants. In addition, ground shoot and root extracts significantly reduced germination of soybean seed.

INTRODUCTION

Morning glory (*Ipomoea hederacea* (L.) Jacq. and *I. purpurea* (L.) Roth.) has been identified in a number of field experiements (Oliver and Frans, 1976; Wilson and Cole, 1966) to have an adverse effect on the growth and development of soybean (*Glycine max* (L.) Merrill) plants. Field experiments such as these measure the total competitive and noncompetitive effects a weed has on a crop. Resulting yield reductions are commonly attributed to competition for water, nutrients and sunlight between the crop species and the weed. In certain situations, noncompetitive (allelopathic) factors should also be considered to more fully explain the eco-physiological situation. Allelopathy is a term describing a plant which exudes phytotoxic chemicals into the environment which can inhibit the growth and

*Present address: University of Illinois, Dept. of Horticulture, Urbana, IL.

development of other species (Muller, 1966). In ecological situations, a particular species which is able to inhibit the growth and development of another species would have a definite selective advantage over that species.

Plant phytotoxins can be either volatile or water soluble in nature. Volatile phytotoxins from certain shrubs have been shown to have an adverse effect on annual grasses and forbes in drier habitats (Muller, 1965), while water soluble phytotoxins are more prominent in wetter habitats (Morgan and Tukey, 1964).

Water soluble phytotoxins commonly are released into the environment through leachates from leaves (Rassmussen and Rice, 1971), exudates from roots (Bell and Koeppe, 1972), and accumulated organic matter (Abdul-Wahad and Rice, 1967). Organic matter is not always directly phytotoxic, but first must be decomposed by an intermediate microorganism (Patrick, 1955).

In the present study, techniques were developed to determine whether morning glory emits phytotoxins which have an effect on the germination and growth of soybeans. The sources of morning glory phytotoxins to be investigated include organic matter, leaf leachate and root exudates.

MATERIALS AND METHODS

All plants were grown under greenhouse conditions in 15 cm plastic pots filled with clay loam soil. The photoperiod was extended for morning glory (*Ipomoea lacunosa* L.) to 13 hours with a 40 watt Duro-lite, Vita-lite fluorescent light. The average daily temperature was 20° C.

SEED GERMINATION EXPERIMENT — The extracts were prepared by taking shoot parts (all material 1 cm above highest root) and roots of six-week-old morning glory plants and pulverizing each portion in a Waring blender at a concentration of 50 g/l of deionized water for 90 seconds. The respective extracts were then stirred for four hours before filtering through Whatman's No. 1 filter paper. One 25 ml portion of each extract was immediately tested in separate petri plates containing 55 soybean seeds on absorbent toweling. In conjunction, a deionized water control was similarly constructed. The remaining extracts were allowed to stand for one week in dilution tubes at 25° C before testing as above. All soybean seeds were germinated in an incubator set at 24° C for 72 hours before weighing radicles. Three replications were conducted.

LEAF LEACHATE EXPERIMENT — The shoots of 60 three-week-old morning glory plants were submerged in one liter of water for one hour. Twenty-five pots containing one one-week-old soybean plant were watered with 40 ml of the leachate when the soil was visually dry (approximately every three days). After five weeks of treatment, the shoots, roots and root nodules were harvested and air dried for three days before weighing. A control was run under similar conditions with the omission of the morning glory plants.

ROOT EXUDATION EXPERIMENT — Twenty-five pots containing two two-week-old morning glory plants were watered until enough excess water drained out to saturate the soil of 25 pots containing one one-week-old soybean plant when the soil was visually dry (approximately every three days). After five weeks of treatment, the shoots, roots and root nodules were harvested and air dried for three days before weighing. A control was run under similar conditions with the omission of the morning glory plants.

RESULTS AND DISCUSSION

Studies involving adverse effects of weed infestations in a crop typically do not describe the nature of this plant-plant interaction (Oliver and Frans, 1976; Wilson and Cole, 1966). Although competitive factors are predominant in most situations, noncompetitive factors may contribute to reductions in growth and development of a crop plant. In order to understand these interactions, the crop species must be grown separately from the weed to eliminate any competitive effects, and experimental techniques should identify whether microbes actually create the phytotoxins from plant material and their possible role in degradation.

The seed germination experiment was designed as both a bioassay to determine whether phytotoxins exist in dried morning glory plants and to emulate a possible field condition in which phytotoxins contained in morning glory organic material may inhibit the germination of soybean seed. The results of this experiment (Fig. 1) suggest that shoot extract from five-week plants significantly reduced germination by 11% and radicle weight by 17%, while root extracts significantly reduced germination 11% and radicle weight by 13% in comparison to the control. In contrast, no significant difference for either parameter was noted for extracts that were allowed to stand for one week when compared with the control.

The results suggest that phytotoxins are present in both the shoots and roots of morning glory in approximately the same concentration, but these phytotoxins likely auto-decompose or bacteria or fungi degrade the phytotoxin. Attempts have been made (Bendall, 1975) to control the effects of microbial action from a standpoint that microbes actually produce toxins (Norstadt and McCalla, 1963; Patrick, 1955) from plant material, but the technique utilized in this present study suggests that microbes can decompose the phytotoxins if the extracts are allowed to stand. This technique also minimizes experimental error introduced by physiological drought, since week-old extract, minus the phytotoxin, did not affect any of the parameters measured when compared with the control. Changes in pH could also influence results, but the pH for all extracts was found to be neutral.

Based on the results of this experiment, morning glory organic matter does contain phytotoxins, but these toxins would likely decompose in the soil and not affect germination of soybean seeds under field conditions. These results do not preclude the possible deleterious effects of phytotoxins that are leached from leaves and roots of living morning glory. The next two experiments investigate the role leaf leachates and root exudates have on soybean growth.

Morning glory is a climbing vine that grows intimately among soybean plants. Phytotoxins contained within the leaves of morning glory may leach into the soil during rain and are subsequently taken up by soybean plants. Results of the leaf leachate experiment (Fig. 2) reflect a significant decrease in soybean root weight (40%) and nodule weight (23%) in comparison to the control. No significant difference was noted in shoot weight. These results suggest that phytotoxins contained within leaves of morning glory are capable of leaching and have an adverse effect on at least two of the parameters measured.

Finally, root exudates have also been implicated in containing phytotoxins (Fay and Duke, 1977; Friedman and Horowitz, 1971) in a number of species. A drainage-type watering apparatus was utilized in this study to examine possible phytotoxic effects of root exudates (Bell and Koeppe, 1972). Results (Fig. 3) reflect

a significant decrease in soybean root weight (22%), shoot weight (14%) and nodule weight (31%) in comparison to the control. Results suggest that phytotoxins are exuded from roots of morning glory and have an adverse effect on all parameters measured.

In conclusion, morning glory leaf leachate and root exudate are likely to contain phytotoxins which have an inhibitory effect on the growth of soybean plants. These phytotoxins contained in living morning glory plants may inhibit growth of soybean plants under field conditions, but further studies need to be conducted to substantiate this. Additional studies include the possible role of microbes in degradation of the phytotoxins contained in the organic matter, and the possible effect these phytotoxins have on the *Rhizobium* contained within the nodules.

LITERATURE CITED

Abdul-Wahad, A.S. and E.L. Rice. 1967. Plant inhibition by Johnson grass and its possible significance in old-field succession. Bull. Torrey Bot. Club. 94:486-497.

Bell, D.T. and D.E. Koeppe. 1972. Noncompetitive effects of giant foxtail on the growth of corn. Agron. J. 64:321-325.

Bendall, G.M. 1975. The allelopathic activity of California thistle (*Cirsium arvense* (L.) Scop) in Tasmania. Weed Res. 15:77-81.

Fay, P.K. and W.B. Duke. 1977. An assessment of allelopathic potential in *Avena* germ plasm. Weed Sci. 25:224-28.

Friedman, O.T. and M. Horowitz. 1971. Biologically active substances in subterranean parts of purple nutsedge. Weed Sci. 19:398-401.

Morgan, J.V. and H.B. Tukey, Jr. 1964. Characterization of leachate from plant foliage. Plant Physiol. 39:590-593.

Muller, C.H. 1965. Inhibitory terpenes volatilized from *Salvia* shrubs. Bull. Torrey Bot. Club. 92:38-45.

Muller, C.H. 1966. The role of chemical inhibition (allelopathy) in vegetational composition. Bull. Torrey Bot. Club. 93:321-351.

Norstadt, F.A. and T.M. McCalla. 1963. Phytotoxic substances from a species of *Penicillium*. Science. 140:410-411.

Oliver, L.R., R.E. Frans and R.E. Talbert. 1976. Competition between tall morning glory and soybean. Weed Sci. 24:482-487.

Patrick, Z.A. 1955. The peach replant problem in Ontario. II. Toxic substances from microbial decomposition products of peach root residues. Can. J. of Bot. 33:461-468.

Rassmussen, J.A. and E.L. Rice. 1971. Allelopathic effects of *Sporobolus pyramidatus* on vegetational patterning. Am. Mid. Nat. 86:309-326.

Wilson, H.P. and R.H. Cole. 1966. Morning glory competition in soybeans. Weeds. 14:49-51.

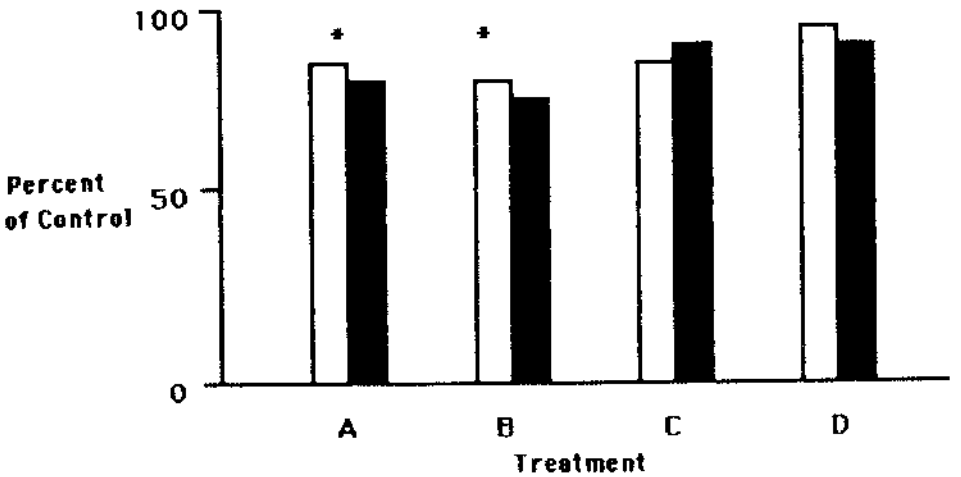

Figure 1. Phytotoxic effects of morning glory root and shoot extracts on soybean germination (white bars) and radicle weight (black bars). (A) root extract; (B) shoot extract; (C) one week-old root extract; (D) one-week-old shoot extract. * Significant difference at P = .05.

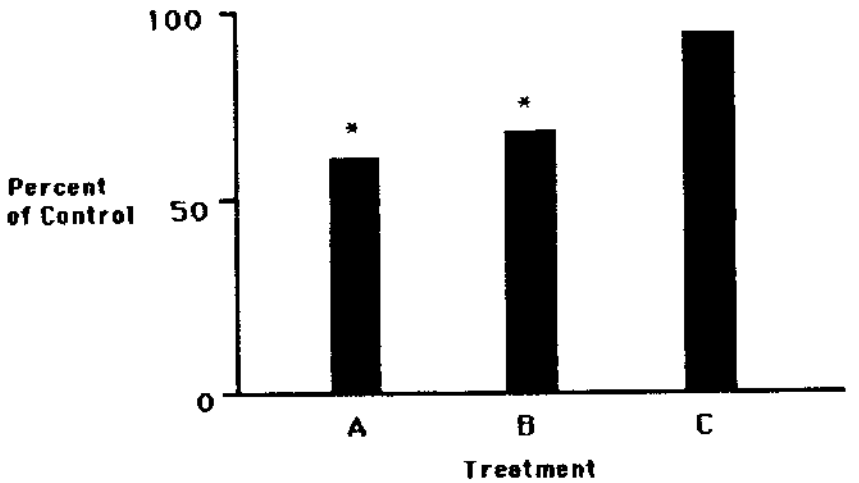

Figure 2. Phytotoxic effects of morning glory leaf leachate on soybean. (A) dry weight of roots; (B) dry weight of root nodules; (C) dry weight of shoot parts. * Significant difference at P = .05.

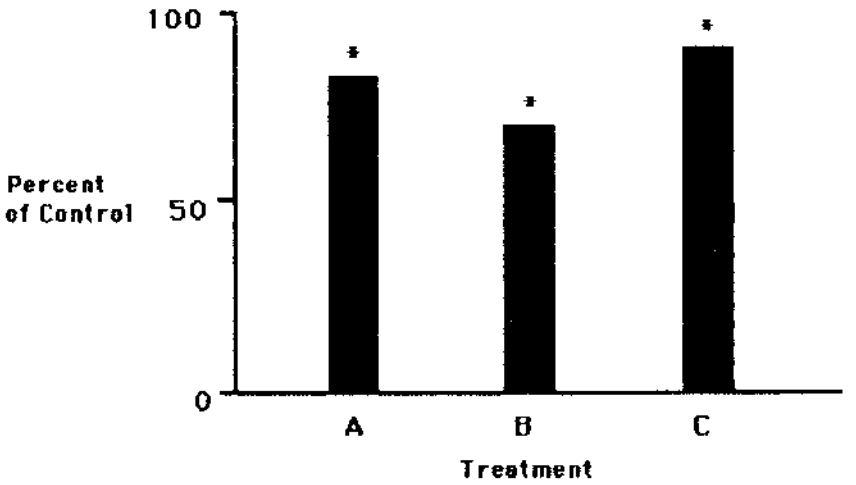

Figure 3. Phytotoxic effects of morning glory root exudations on soybean. (A) dry weight of roots; (B) dry weight of root nodules; (C) dry weight of shoot parts. *Significant difference at P = .05.