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Allelopathic Effects of Alfalfa Plant Residues on Emergence and Growth of Cucumber Seedlings

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Abstract. **Growth chamber tests demonstrated that alfalfa *(Medicago sativa* L.) residue is toxic to cucumber *(Cucumis sativus* L.) seed germination and seedling growth. Ground alfalfa roots at 0.5% (w/w, dry weight) inhibited germination when added to the growing medium. Alfalfa roots at 0.5% were also toxic to pregerminated cucumber seed. However, cucumber seedlings grew normally if this same medium was watered and incubated for >1 day before planting. Alfalfa particle size in media influenced cucumber performance, with the intermediate size (1 to 2 mm) being lethal to cucumbers.**

Allelopathy describes the inhibiting effect of one plant upon another. Reports of such occurrences are numerous (Rice, 1974). The allelopathic effect of alfalfa is of particular concern since it is widely used in crop rotation. Under laboratory conditions, alfalfa residue inhibited cotton seed germination (Megie et al., 1967). This inhibition may have been caused by ammonia and/or saponins that were released upon alfalfa residue decay in the soil. Reseeding alfalfa into dead areas of an alfalfa field produced erratic stands (Miller, 1983). Residues from several alfalfa cultivars were all equally toxic to germinating alfalfa seed, regardless of saponin content, leading to the conclusion that saponins were not the only cause of the inhibition (Miller, 1983).

While leachates from alfalfa tops and roots inhibited corn seed germination, the root leachate was more inhibitory (Guenzi et al., 1964). Collison (1925) observed that water extracts of wheat straw proved very toxic to barley seedlings and that neither boiling nor filtering the extract through porcelain filters overcame the effect. He further noted that alfalfa extract was even more toxic to seed-

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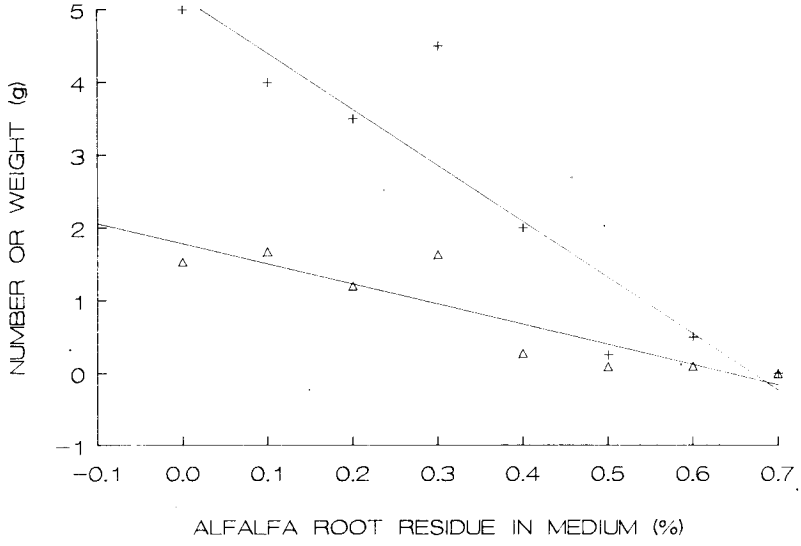

Fig. 1. Effects of alfalfa root particulate content (0.0 to 0.7%) in a growing medium on number (+) and weight (△) per pot of cucumber seedlings. Each point represents the mean of four pots planted with five cucumber seeds. Plant number: Y = 5.17 − 7.71x; F ratio = 59.7**, R^2 = 0.67. Plant weight: Y = 1.97 − 3.05x; F ratio = 66.7**, R^2 = 0.69. Both F ratios significant at P = 0.01.

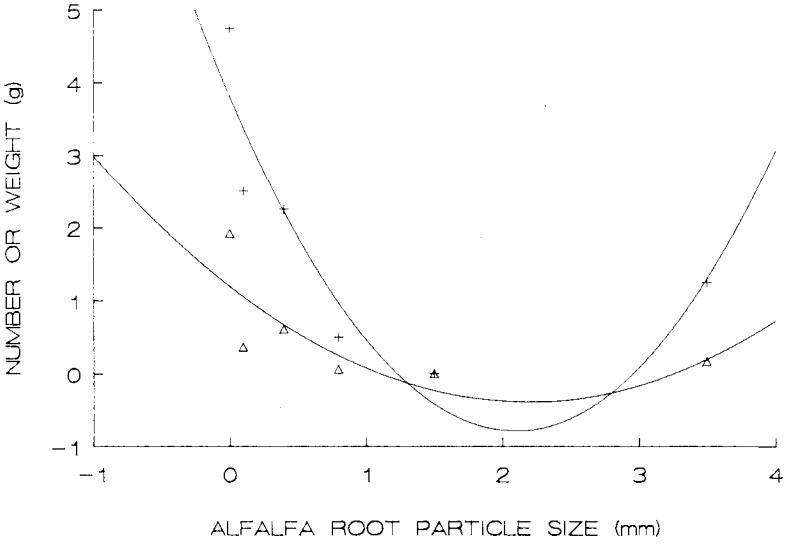

Fig. 2. Effect of alfalfa root particle size on number (+) and weight (△) per plot of cucumber seedlings. Each point represents the mean of four pots planted with five cucumber seeds in which the midpoint of each particle size range was used. Plant number: Y = 3.87 − 4.46x + 1.07x²; F ratio = 12.1**, R^2 = 0.53. Plant weight: Y = 1.23 − 1.5x + 0.34x²; F ratio = 9.3**, R^2 = 0.47. Both F ratios significant at P = 0.01.

lings. In addition to alfalfa, cucumber tops and corn roots have inhibited cucumber seed germination and seedling growth (Ells and McSay, 1983). Since cucumber is occasionally planted in rotation with alfalfa, we investigated the effects of alfalfa root residues on cucumber seed germination and growth.

This paper reports on four experiments that investigated the toxic nature of alfalfa roots on cucumbers. We determined 1) the percentage of alfalfa root particulate required to inhibit cucumber seed germination and/or seedling growth, 2) the effect of particle size on inhibition, 3) the effect of incubation of soil-incorporated alfalfa residue on cucumber germination and/or seedling growth, and 4) the effect of soil-incorporated residue on pregerminated cucumber seed.

A Nunn clay loam (Aridic Argiustoll) with a clay content of 30% was air-dried and mixed with air-dried sand (0.25 to 1.00 mm) to give a 75% sand and 25% soil (w/w) medium. This medium was mixed with oven-dried (70C) alfalfa roots that had passed through a l-mm screen. The medium was not steam-sterilized because this would have killed the microorganisms responsible for producing the suspected inhibitors.

This medium was used to fill four pots (7.5 cm top diameter, 0.180 liter) for each treatment. Five 'Triple Mech' cucumber seeds were sown in each pot. Pots were arranged in a randomized complete block design with four replications in a Percival (Boone, Iowa) MB60 growth chamber. A 14-h photoperiod was used with a 24C day/18C night cycle under a combination of fluorescent and incandescent lights that produced 11 $\mu mol \cdot s^{-1} \cdot m^{-2}$ at the medium surface. The pots were watered daily. After 14 days, seedlings were counted and shoots were cut at the soil level for fresh-weight determination.

Residue concentration. As the alfalfa root content in the medium was increased from 0 to 0.7%, the germination and total fresh weight reached zero, indicating total inhibition of growth at a medium root content of 0.7% (Fig. 1).

Although alfalfa root residue led to reduced emergence, the seedlings that did emerge had no symptoms of injury. Surviving plants sometimes had larger average fresh weights than the controls. This phenomenon could be due to reduced interplant competition, to nutrients released by the decomposition of the alfalfa roots, or to a genetic segregation of an unselected trait.

Particle size. Particles were prepared by coarse-grinding of alfalfa roots followed by sifting. The particle size ranges were: 2 to 5 mm, 1 to 1.9 mm, 0.6 to 0.9 mm, 0.25 to 0.5 mm, and <0.25 mm. The plant residue was added to the soil-sand medium to produce a content of 0.5%. The residue had an inhibitory effect on germination and total fresh weight (Fig. 2). Medium containing particle sizes of <0.25 or 2 to 5 mm had less influence on cucumber performance than the intermediate sizes that proved lethal. Alfalfa flour of particles <0.25 mm in diameter may have decayed so rapidly that the toxins produced had already decomposed before the cucumber seed germinated. In contrast, the larger particles, because of their smaller total surface area, might have decayed so slowly that inhibitors failed to reach toxic levels.

Incubation. A medium (0.5% ground alfalfa roots; 1-mm mesh) was prepared on 5 consecutive days, watered to initiate decay, and placed in the growth chamber. Five seeds were planted in each of the four pots of each treatment on day 5.

Since the R^2 value was only 0.21 for both number and weight of cucumbers, analyses of variance were conducted to show the effect of incubation on toxicity of ground alfalfa roots in the medium. When the medium was allowed to incubate 0 days, there were 2.5 live seedlings per pot with a mean weight of 0.6 g. If incubated for 1 to 5 days, the toxic effect of ground alfalfa roots on cucumber seed germination and seedling growth was not evident. Significantly more and heavier cucumber seedlings were evident among those planted in medium incubated for 1 to 5 days (4.0 to 4.8 live seedlings and 1.4 to 1.8 g per pot) than among those planted in medium receiving no incubation *(P = 0.05).*

Pregermination. Cucumber seed was rolled in wet paper towels on 5 successive days and stored in an unsealed plastic bag in the growth chamber (24C day/18C night). After 5 days, five pregerminated seed were transplanted into each pot. Seed that were pregerminated for 3 to 5 days had grown into seedlings at this time, while those pregerminated for 1 to 2

Table 1. Survival of pregerminated cucumber seed after 14 days when planted in medium with and without 0.5% alfalfa root residue.[z]

Criterion	No alfalfa	Alfalfa	F ratio
Live seedlings (no.)	4.45	1.15	1.01**
Mean weight (g)	1.39	0.16	1.53**

[z]Data are means of 20 pots due to pregermination.
**F ratios significant at $P = 0.01$.

days had not germinated. The medium used for half the pots contained 0.5% ground alfalfa roots, while the medium in the remaining pots contained no alfalfa roots. The nonalfalfa root medium served as a control to determine if mortality was due to transplanting or to alfalfa residue in the comparison medium. The test consisted of 40 pots, five treatments, four replications, and two media. The test was terminated at 14 days.

There were highly significant differences due to medium (Table 1), but no difference due to duration of incubation. The alfalfa residue was as lethal on newly planted seed as it was on 5-day-old seedlings that were transplanted into media containing alfalfa residue. The lethality exhibited in this pregermination study was not due to transplanting since the seedlings transplanted into medium without alfalfa had a survival rate of 89%, whereas those transplanted into medium containing alfalfa had a survival rate of only 23%. We, therefore, conclude that alfalfa residue is not only lethal to newly planted seed, as shown in previous experiments, but to 5-day-old seedlings as well.

These tests have demonstrated the lethality of alfalfa root residue to cucumber seedlings and its ability to inhibit cucumber seed germination. Attention should now be focused on the chemical nature of the inhibitor and its economic significance under field conditions.

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