0971-4693/94 US $ 5.00
Allelopathy Journal 5(1): 35-42 (1998)

Inhibitory effects of jackbean (*Canavalia ensiformis* L.) leaf residues on germination and vigour of crops and weeds

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(Received in revised form: July 15, 1997)

ABSTRACT

The effects of jackbean leaf residues incorporated in the soil on germination and seedlings growth of cucumber, radish and some weeds was examined. Trials were carried out under greenhouse conditions to (a) determine the amount of incorporated residue that is inhibitory to two test plants, (b) to determine if decomposition time changes the inhibitory levels of jackbean residues on test plants and (c) to determine the amount of residue that is inhibitory to the weed species. Jackbean leaf residues incorporated in soil at concentration of 2% or higher and allowed to decompose for a period of 0 to 2 weeks before sowing, reduced the initial growth of cucumber and radish and at different concentrations, reduced germination and growth of three weed species. These results suggest the presence of allelopathic components in Jackbean leaves that could affect seed germination and seedling development.

Key words: Allelopathy, *Bidens pilosa, Canavalia ensiformis, Cenchrus echinatus, Cucumis sativus, Eleusine indica, Raphanus sativus, Rottboellia exaltata* and *Sida cordifolia*

INTRODUCTION

Jackbean [*Canavalia ensiformis* (L.) DC] is a leguminous plant belonging to the family Fabaceae, originated in the Old World, where it is cultivated in the humid tropical regions of Africa and Asia, especially in India. The plant was brought to the New World more than a thousand years ago (7). Its seeds contain 22.74% crude protein and 62.26% carbohydrates (1) and thus grown in many places for human and animal consumption. Due to rapid establishment and production of large amounts of green matter per unit area (8 t DM/ha), it is frequently used as green manure in Brazil. The aggressiveness of this species allows it to compete effectively with weeds. Allelopathy and competition for resources essential for plant growth and development could also be the causes of jackbean aggressiveness (6, 8, 11).

The presence of allelopathic properties in jackbean could be a problem for crops grown in jackbean incorporated soil. As the demand for agricultural sustainability increases, it is necessary to overcome any negative effects of residue retention associated with phytotoxicity (2). On the other hand, jackbean could bring benefits by inhibiting weed germination and development. The objective of the present work was, therefore, to study the effects of jackbean leaf residue on germination and early plant growth of two vegetable and five weed species.

MATERIALS AND METHODS

Leaf residues consisted of blade and petioles of jackbean leaves, collected at flowering stage and oven dried with forced air circulation for 96 h at 50°C. The material was then triturated manually to facilitate its incorporation and decomposition in the soil. Triturated jackbean leaves were incorporated to a substrate consisting of a mixture of dark-red Latossol and river sand (3:2 ratio) placed in 1.5 l plastic pots. In trial I, jackbean dry matter was incorporated in to the substrate at concentrations of 0, 1, 2, 3, 4, 5 and 10% (w/w). *Sphagnum* sp (inert matter), incorporated at a concentration of 10% (w/w), was used as a control (9).

In trial II, a substrate containing 2% jackbean residues, prepared as for trial I, was allowed to decompose for 0, 1, 2, 3, 4, 5, 6 and 7 weeks before sowing the test plant seeds. Control pots did not contain leaf residues. Jackbean residues were incorporated on the same day for all treatments and the substrate was kept moist throughout the decomposition periods. The test plants in both these trials were radish (*Raphanus sativus* L. cv. Crimson Gigante) and cucumber (*Cucumis sativus* L. cv. AG 191), which were sown @ 10 seeds per pot at a depth of 1 cm.

In trial III, leaf residues were incorporated into the substrate to obtain concentrations of 0, 0.5, 1, 1.5, 2 and 2.5 % (w/w). Then, 20 seeds of test weed spp. viz., *Sida cordifolia* L., *Bidens pilosa* L., *Rottboellia exaltata* L.f., *Eleusine indica* L. Gaertn and *Cenchrus echinatus* L. were sown separately in each pot and maintained under similar conditions as in other trials. In all trials, seeds were allowed to germinate and grow for 14 days.

The following parameters were evaluated at the end of the experimental period: germination (%) and length and dry weight of shoot and root (trials I, II and III); rate of germination index (trial III). The experimental design for all trials was the completely randomized design (CRD) with three replications. The results were subjected to Bartelet test (the results of length and dry weight were converted to arc sin $\sqrt{x}$ +1.0 and arc sin $\sqrt{x}$+0.5, respectively) and analyzed by the F test with the means compared by the Tukey test at a 5% level of probability.

RESULTS AND DISCUSSION

Soil incorporation of jackbean leaf residue reduced germination of cucumber seeds and initial seedling growth (Table 1). This reduction was directly proportional to the concentration of incorporated material, becoming significant at concentration of 2% or higher for shoot and root length and their respective dry weight. Cucumber seedlings did not developed on substrate containing 5% or higher amounts of leaf residues. Inhibitory effects were also observed in radish, which was more sensitive than cucumber seedlings. Radish seedlings no longer developed at concentrations of incorporated material of 3% or higher (Table 1). Seed germination and plant development in pots containing 10% *Sphagnum*, an inert material, used to mimic a possible effect of jackbean residues on substrate physical characteristics (9), did not differ from the control pots containing only substrate. This indicates jackbean residue did not affect substantially the substrate physical properties. It also reveals a possible allelopathic effect of jackbean on plants under study.

Decomposition of jackbean leaf residues for 0-2 weeks before sowing reduced germination, shoot length and dry weight of cucumber. Root length and dry weight were reduced when residues decomposed for 5 and 1 weeks before sowing, respectively (Table 2). After 4 weeks of decomposition, jackbean leaf residue showed a tendency to lose their inhibitory effects. Radish germination and shoot length (Table 2) were reduced by a 6-weeks incorporation period before sowing. Shoot dry weight was reduced by residues decomposed for a period of 0 to 3 weeks before sowing. Root length and dry weight were reduced when material used had decomposed up to 5 weeks. However, after decomposition for 7 weeks, leaf residues showed a tendency to lose their inhibitory effects, as observed in cucumber. These results suggested the assumptions of mathematical modeling of phytotoxicity caused by plant residues during decomposition (2). Concerning the inhibitory effects, radish was more sensitive to jackbean leaf residues than cucumber, with root length being the most sensitive parameter, as found by others (3, 4).

Rice (10) reported that the effect and the time period of plant residue incorporation depends on the species and age of the incorporated plant, climate and soil conditions, microbial population and receptor plant species. When residues from younger plants were added, toxic substances were produced within relatively shorter period of decomposition. In this study, we used jackbean at flowering stage, because at this stage, its biomass is incorporated into soil as green manure.

Table 1. Effect of jackbean leaf residues incorporation on germination and seedling growth of cucumber and radish

Leaf Incorporation (% w/w)	Germination * (%)	Cucumber				Radish				
		Length (cm)*		Dry weight (g)*		Germination* (%)	Length (cm)*		Dry weight (g)*	
		Shoot	Root	Shoot	Root		Shoot	Root	Shoot	Root
Control	90.00 A	2.57 AB	4.45 A	1.02 B	0.89 ABC	63.92 A	2.75 A	3.81 A	0.81 AB	0.80 A
1	63.43B	2.95 A	3.64 B	1.20 A	1.00 A	26.56B	2.76 A	2.58 B	0.79 AB	0.74 B
2	50.85C	2.42 ABC	1.56 C	0.82 C	0.75 BC	30.99B	1.87 B	1.47 C	0.83 A	0.74 B
3	48.93BC	1.46 BCD	1.15 C	0.79 C	0.72 BC	26.07 B	1.00 C	1.00 C	0.71 B	0.71 B
4	39.15C	1.37 CD	1.26 C	0.73 C	0.72 BC	33.00 B	1.00 C	1.00 C	0.71 B	0.71 B
5	33.00CD	1.00 D	1.00 C	0.71 C	0.71 C	21.14 B	1.00 C	1.00 C	0.71 B	0.71 B
10	15.00D	1.00 D	1.00 C	0.71 C	0.71 C	0.00 B	1.00 C	1.00 C	0.71 B	0.74 B
10% (*Sphagnum)*	61.71 B	2.98 A	3.25 B	1.08 AB	0.90 AB	50.85 A	2.95 A	2.82 B	0.82 A	0.74 B
LSD (P<5%)	20.35	1.15	0.80	0.15	0.19	14.87	0.44	0.87	0.11	0.05

* Angular transformed values

Means within a column with same letter are not significantly different (P<5%) from each other, according to Turkey test

Table 2. Effect of decomposition period of jackbean leaf residues on germination and seedling growth of cucumber and radish

Decomposition periods (Weeks)	Cucumber					Radish				
	Germination * (%)	Length (cm)*		Dry weight (g)*		Germination * (%)	Length (cm)*		Dry weight (g)*	
		Shoot	Root	Shoot	Root		Shoot	Root	Shoot	Root
Control	90.00 A	3.19 A	4.66 A	1.53 AB	1.35 A	57.32 A	2.34 A	2.87 AB	1.28 AB	1.24 A
0	29.62 BC	1.66 B	1.37 DE	1.09 B	1.06 A	21.50 BCD	1.21 C	1.07 C	0.88 AB	0.71 B
1	16.63 C	1.62 B	1.17 E	1.06 B	0.88 A	4.05 D	1.00 C	1.00 C	0.71 B	0.71 B
2	31.56 BC	1.79 B	1.65 DE	1.09 B	1.07 A	4.05 D	1.00 C	1.00 C	0.71 B	0.71 B
3	75.28 A	2.74 AB	2.59 BC	1.39 AB	1.28 A	13.96 CD	1.69 ABC	1.51 BC	0.88 AB	0.88 AB
4	78.03 A	2.88 AB	2.62 CD	1.45 AB	1.32 A	36.50 ABC	1.53 ABC	1.54 BC	1.07 AB	1.06 AB
5	66.54 AB	2.76 AB	2.34 CD	1.39 AB	1.28 A	18.83 BCD	1.41 BC	1.11 C	1.05 AB	0.88 AB
6	90.00 A	3.62 A	3.63 A	1.58 AB	1.31 A	28.45 ABCD	2.40 AB	1.46 ABC	1.25 AB	0.88 AB
7	90.00 A	3.61 A	3.77 A	1.66 A	1.36 A	49.45 AB	2.54 A	3.30 A	1.30 A	1.24 A
LSD (P<5%)	38.76	1.29	1.09	0.56	0.52	31.72	1.05	1.49	0.58	0.50

* Angular transformed values

Means within a column with same letter are not significantly different (P<5%) from each other, according to Turkey test

Table 3. Effect of jackbean leaf residues concentration on germination and seedling growth of *Sida cordifolia, Bidens pilosa, Rottboellia exaltata* and *Cenchrus echinatus* weeds

Concentration (%)	Germination (%)*	Speed of germination index	Root length (cm)	Dry weight (g)		Germination (%)*	Speed of germination index	Root length (cm)	Dry weight (g)	
				Shoot	Root				Shoot	Root
	Sida cordifolia					*Bidens pilosa*				
0.0	47.65 A	190.00 A	13.75 A	0.12 A	0.02 A	59.20 A	223.00 A	14.25 A	0.16 A	0.08 A
0.5	16.72 B	41.25 B	8.50 AB	0.02 B	0.01 AB	42.04 AB	112.50 B	13.50 A	0.13 AB	0.06 AB
1.0	0.00 B	8.50 B	0.00 B	0.00 B	0.00 B	26.96 B	55.00 B	15.00 A	0.06 B	0.03 B
1.5	3.23 B	11.75 B	6.50 AB	0.01 B	0.00 B	24.45 B	24.50 B	13.75 A	0.04 B	0.03 B
2.0	0.00 B	15.50 B	0.00 B	0.00 B	0.00 B	29.08 B	47.50 B	14.87 A	0.07 B	0.03 B
2.5	3.23 B	11.75 B	0.00 B	0.00 B	0.00 B	22.50 B	30.75 B	15.25 A	0.04 B	0.03 B
LSD (P<5%)	19.09	80.37	9.01	0.48	0.01	25.72	91.60	5.30	0.09	0.04
	Rottboellia exaltata					*Cenchrus echinatus*				
0.0	21.70	38.75	31.00	0.09	0.08	12.92 A	7.75	11.25 B	0.04 B	0.06
0.5	22.92	44.75	24.25	0.16	0.09	27.96 AB	32.50	20.00 A	0.19 AB	0.07
1.0	16.76	38.00	28.75	0.10	0.05	42.07 A	47.50	19.00 AB	0.27 A	0.12
1.5	12.45	26.25	23.00	0.06	0.06	37.63 A	33.25	21.75 A	0.17 AB	0.08
2.0	9.87	18.50	18.50	0.04	0.04	44.20 A	54.50	20.00 A	0.24 A	0.13
2.5	6.46	15.25	18.37	0.04	0.04	34.03 A	39.75	20.50 A	0.15 AB	0.11
LSD (P<5%)	18.10	44.09	20.47	0.14	0.08	22.05	49.32	8.39	0.18	0.12

* Angular transformed values

Means within a column with same letter are not significantly different (P<5%) from each other, according to Tukey test

In trial III, incorporation of jackbean at concentrations from 0.5% to 2.5% reduced the rate and percentage of germination of *Sida cordifolia*, but no difference was observed among the concentrations (Table 3). The same effect was observed on seedling vigour. Jackbean residues reduced root length and shoot weight and inhibited germination of *Bidens pilosa* at concentrations above 1%. Germination rate was lower at a concentrations greater than 0.5% (Table 3). It did not affect root length but reduced the shoot and root dry weight at similar concentration. Jackbean leaf residues reduced germination and speed index of *Rottboellia exaltata* at concentrations above 1% (Table 3). However, at concentrations above 2%, root length and shoot and root dry weight were reduced. At this concentration, inhibitory effects were also seen in *Eleusine indica* in germination percentage but above 0.5 %, jackbean promoted shoot and root growth (Table 4). At 0.5 % and above leaf residue, promoted the speed index and germination of *Cenchrus echinatus* (Table 3). The same effect was seen in seedlings vigour, wherein Jackbean residues increased the length and weight of the roots.

Table 4. Effect of jackbean leaf residues concentration on germination and seedling growth of *Eleusine indica*

Concentration (%)	Germination (%)*	Speed of germination index	Root length (cm)	Dry weight (g)	
				Shoot	Root
0.0	66.26 AB	140.50 AB	8.75 B	0.04 B	0.05
0.5	74.20 A	188.00 A	15.50 A	0.17 AB	0.22
1.0	55.26 ABC	99.75 AB	17.00 A	0.16 AB	0.13
1.5	44.87 ABC	62.25 AB	18.25 A	0.16 AB	0.13
2.0	27.05 C	31.75 B	16.75 A	0.13 AB	0.12
2.5	32.81 BC	41.00 B	17.75 A	0.20 A	0.15
LSD (P<5%)	38.16	142.29	5.03	0.13	0.16

* Angular transformed values
Means within a column with same letter are not significantly different ($p < 5\%$) from each other, according to Tukey test

We found that incorporation of jackbean leaf residues, at concentrations of 2% or higher and decomposed for 0-2 weeks before sowing affects both cucumber and radish germination and seedlings growth, demonstrating an allelopathic effect of this legume on the test plants. Radish was found to be a better indicator of these effects. The same inhibitory effects were observed on *Sida cordifolia, Bidens pilosa* and *Rottboelia exaltata*. Leaf

residues promoted growth of *Eleusine indica* but did not affect *Cenchrus echinatus*. This apparent allelopathic selectivity has also been reported by Lovett (5), in *Sorghum bicolor* residues.

ACKNOWLEDGEMENT

Authors are thankful to Dr. Silvio Lopes for the suggestions and corrections.

REFERENCES

1. Alcantara, P.B. and Bufarah, G. (1979). *Plantas Forrageiras, Gramineas e Leguminosas.* Sao Paulo: Nobel. 150 pp.
2. An, M., Johnson, I.R. and Lovett, J.V. (1996). Mathematical modeling of allelopathy: I. Phytotoxicity caused by plant residues during decomposition. *Allelopathy Journal* **3:** 33-41.
3. Kimber, R.W.L. (1973a). Phytotoxicity From Plant Residues. II. The effect of time of rotting of straw from some grasses and legumes on the growth of wheat seedlings. *Plant and Soil* **38:** 347-361.
4. Kimber, R.W.L. (1973b). Phytotoxicity From Plant Residues. III. The relative effect of toxins and nitrogen immobilization on the germination and growth of wheat. *Plant and Soil* **38:** 543-555.
5. Lovett, J.V. (1986). Allelopathy: the Australian experience. In: *The Science of Allelopathy* (Eds., A.R. Putnam and C.S. Tang) pp. 75-79. New York: Wiley Interscience.
6. Magalhaes, A.C. and Franco, C.M. (1962). Toxicidade do feijao-de-porco sobre a tiririca. *Bragantia* **21:** 53-58.
7. National Academy of Science. (1979). *Tropical Legumes: Resources For The Future.* pp. 54-59. Washington: National Academy of Science.
8. Neme, N.A. (1960). Combate a tiririca. *O Agronomico* **12:** 5-6.
9. Qasem, J.R. and Hill, T.A. (1989). On difficulties with allelopathy methodology. *Weed Research* **29:** 345-347.
10. Rice, E.L. (1984). *Allelopathy.* 2nd ed., New York: Academic Press, 424 pp.
11. Rodrigues, L.R. de A., Rodrigues, T.J.D. and Reis, R.A. (1992). *Alelopatia em Plantas Forrageiras.* Jaboticabal: FUNEP. 18p. (Bulletin).