



Allelopathic Effects of *Chromolaena Odorata L.* (R. M. King and Robinson – (Awolowo Plant’)) Toxin on Tomatoes (*Lycopersicon esculentum* Mill)

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ABSTRACT: Allelopathic effects of *Chromolaena odorata L.* (R. M. KING AND ROBINSON) aqueous leaf extract and residues incorporated in the soil on the growth and water status of *Lycopersicon esculentum* Mill were studied. Significant growth reductions in *Lycopersicon esculentum* were observed from additions of *C. odorata* aqueous – leaf extract at concentrations as low as 1g fresh weight in 40ml of water. Reduction in growth was accompanied by decreases in leaf water potential. Incorporation of *C. odorata* leaf material into the soil in which *L. esculentum* Mill seedlings were germinated and grown caused significant depression in growth over the 2-week test period with addition of 2g residue to 80g soil. Allelochemicals released from *C. odorata* plants and residue are suggested as a possible explanation for yield reductions in crops in fields where *C. odorata* plants are present. One mechanism of toxic action on seedlings involved interference with water balance. @ JASEM

Effects of leachates from plants, plant extracts and decomposing plant residues have been the focus of several investigators concerned with the role of allelopathy in agriculture. Plant residues often contain a variety of toxins that are known inhibitors of seed germination or seedling growth (Chov and Patrick, 1976; An, *et al* 1997). Recycling crop residue to the soil has been reported to be detrimental to future growth (Rice 1981). Leachates from plants have been shown to suppress seed germination and vegetative propagules, and early seedling growth (Babu and Kandasamy, 1997; Dhawan and Gupta, 1996); and decrease radicle growth (Casado, 1995). The extent of damage to the crop is related to the degree of contact of roots to the leachates or residues (Patrick, 1971). Rice *et al.* (1981) showed that phytotoxicity from a crop might be from indirect effects of micro-organisms and direct toxic actions. Aqueous extract of some plants inhibit seedling growth (Lydon, *et al* 1997); root and shoot growth (Athanassova, 1996); germination (Pratley, *et al.*, 1996); and induce mortality of plants (Eyini, *et al* 1996).

Schon and Einhellig (1980) demonstrated that incorporation of dried sunflower leaf material into the soil; treatment with aqueous extract, root exudates and leaf leachates inhibited germination and growth of grain sorghum (*Sorghum bicolor*). Water-soluble toxic substances could leak from the plant and decomposing residue. Allelopathic interference could be mediated through effects on the water metabolism of a crop. Yield losses would occur if *Chromolaena odorata* toxins reduced the water use efficiency of crops grown in areas of low field moisture. This study examined the effects of aqueous-leaf extracts and leaf residue of *C. odorata*

on the growth and water use of *Lycopersicon esculentum*.

MATERIALS AND METHODS

Growth of seedlings: Tomato seeds were germinated in germination trays for 4 days. Seedlings were transplanted into plastic pots (7.5 diameter x 15 cm depth) and grown in a green house. Soil analysis indicated 92.4% sand, 3.2% silt and 4.4% clay, 0.82% organic carbon, and 1.4% organic matter with a pH about 5.2. Compost was added to each pot as non-inhibitory organic matter. After 2 days of acclimatization, forty uniform tomato seedlings were selected for each treatment group. These seedlings were treated with *Chromolaena odorata* leaf extract for 6 days.

Extract Preparation and Treatment: Ten grams of *C. odorata* leaf was extracted in 10ml of de-ionized water by boiling for 10 minutes and grinding in a blender (Lodhi and Nicijkel, 1973). The extract was filtered through cheesecloth and What man No. 4 filter paper; brought to original volume and added to nutrient media in final ratios of fresh leaf weight to total nutrient of 1:140, 1:80 and 1:40 respectively. The P^H of the solutions was adjusted to 5.2. Respective seedlings were sprayed with different concentrations (1:40, 1:80 and 1:40) of *C. odorata* leaves from the seventh day of planting. Spraying was done with a pressure pump diaphragm sprayer once a day.

Parameters: The parameters studied in this study were water potential (Ψ), pressure potential (Ψ_p), osmotic potential ($\Psi\pi$), dry weight of plants and transpiration rate. Osmotic potential ($\Psi\pi$) was

measured with vapour pressure osmometer (5500x, Wescor, Logan, U T, USA) calibrated daily with a graded series of NaCl solution. Four seedlings were used per treatment group to determine the $\Psi\pi$. Youngest leaf of each seedling was punched in two places with a 7mm borer to obtain 7 leaf discs. Leaf $\Psi\pi$ was determined with the freeze – rupture technique of Auge, *et al* (1995). Petri-dishes lined with filter paper on which leaf discs had been arranged were placed on dry ice for 5 minutes. These were allowed to thaw for 10 minutes and then crushed on a filter paper disc. After equilibration in a sample chamber, the $\Psi\pi$ was then determined.

Water potential (Ψ) was measured in a pressure chamber, according to the method of Soldatini, *et al* (1990). Leaf discs were equilibrated for 2 hours in a pressure – chamber before water potentials were determined. Leaf pressure potential (Ψ_p) was calculated as the difference between Ψ and $\Psi\pi$. shoot and root dry weights were determined using 20 plants from each group after 6 days of treatment. Differences among the dry weights were determined by analysis of variance with Duncan's multiple range test. Data from water parameters were analysed with a t-test. A 6 – day average was also calculated for Ψ , $\Psi\pi$ and Ψ_p respectively.

Chromolaena odorata plants were harvested with their leaves and flowers, air-dried and ground using a

waring blender. The residue was added to an air-dried, silty-clay soil which was sifted mechanically with a sifter of 2mm pore size. The leaf residue was mixed with the soil at rates of 0.5, 1, and 2g per 80g soil, compost manure was added to the control soil. Five tomato seeds were germinated in 80g of soil each pot in the green house. Each pot was watered daily to field capacity. Shoot and root dry weights were obtained from 20 plants per group 14 days after planting. Total water use per plant during the growth period after emergence was computed using the method of Soldatini *et al* (190) and the transpiration ratio (wt:wt) for each test group was determined as the ratio of the average water use (g) per plant to average dry weight (g) per plant. Each series of experiment was duplicated.

RESULTS AND DISCUSSION

Effects of the aqueous extract of *C. odorata* and residue on the growth of *L. esculentum* Mill.

Aqueous leaf extracts of *C. odorata* reduced the dry weight of tomatoes, the degree of reduction being directly related to the extract concentration (Table 1). Further dilution of the original extract may have effects on the growth of tomatoes since the plants treated with 1:40 extract concentration weighed less than the controls.

Table 1: Effects of *Chromolaena odorata* aqueous leaf extracts on the growth of *Lycopersicon esculentum* L.

<i>C. odorata</i>		DRY WEIGHT (mg± S.E.)		
Extract	Shoot	Root	Plant	
Control	80.1 ± 3.2 ^a	33.3 ± 1.5 ^a	113.4 ± 4.7 ^a	
1:140	50.2 ± 2.0 ^a	15.0 ± 1.4 ^a	65.2 ± 6.4 ^b	
1:80	38.5 ± 1.2 ^a	14.5 ± 2.0 ^a	63 ± 3.2 ^b	
1:40	20.1 ± 1.9 ^b	11.7 ± 1.4 ^a	31.8 ± 3.1 ^a	

Values are the means and SE of 20 seedlings, 6 days after treatment.

All values in a column followed by the same letter are not significantly different. $P < 0.05$ according to Duccan's multiple tests.

Table 2: Effects of dried *C. odorata* leave residue in soil on the growth and transpiration rate (TR) of *Lycopersicon esculentum*

<i>C. odorata</i>		DRY WEIGHT (mg ± S. E.)			
Extract	Shoot	Root	Plant	TR	
Control	21.0 ± 1.5 ^a	11.3 ± 0.8 ^a	32.3 ± 2.1 ^a	176	
1:140	18.4 ± 1.29 ^a	09.7 ± 1.4bc	28.1 ± 6.4 ^b	176	
1:80	16.6 ± 1.3 ^a	08.8 ± 0.6 ^b	25.4 ± 1.9 ^b	188	
1:40	12.2 ± 0.9	06.4 ± 0.9 ^c	18.6 ± 1.6	193	

Values are the means and SE of 20 seedlings, 14 days after planting. All values in a column followed by the same letter are not significantly different. $P < 0.05$ according to Duccan's multiple tests.

Many of the tomato leaves treated with 1:40 extract dilution were folded, wilted and showed necrotic

spots and scorched leaf tips by the end of the experiment. Some tomato plants of the 1:80

treatment group developed leaves with marginal burning. Seedlings in all the three treatments showed chlorosis of the youngest leaves and differences in root morphology. Treated tomatoes had shorter, thicker secondary roots than the controls.

Addition of 2g of *C. odorata* leave residue to 80g of soil significantly reduced the dry weight of tomatoes (Table 2). Effects observed on plant weight were probably from inhibition of both root and shoot growth. Roots were visibly shorter, and some of the shoots had scorched leaf tips. Additions of both 0.5g and 1.0g of *C. odorata* suppressed the weight of tomato plants. *C. odorata* extracts and residues incorporated in the soil inhibited the growth and reduced the dry weight of tomato plants.

Compost was added to the control soil as a non-inhibitory organic matter to maintain organic matter consistency. It is likely that, the suppression of

tomato growth in the treatment groups may not be the result of an increase in organic matter but was caused specifically by the presence of *C. odorata* residue. Allelopathic phytotoxins in the residue are a logical explanation for the growth reductions. The concentration – dependent effects observed in growth suppression are characteristic of allelopathic inhibition (Lydon, *et al*, 1997).

Effects of aqueous extracts and residue on the water status of *L. esculentum*: Although most of the dilute treatment did not affect the water potential (Ψ) of tomato plants, it was significantly reduced in the 1:40 treatment (Table 3). Effects on the Ψ became more severe with time, with a correspondent decrease in both osmotic potential and pressure potential of the plants.

Table 3: Effects of dried *C. odorata* aqueous – leaf extract on the water status of *Lycopersicon esculentum*

DAYS OF TREATMENT	<i>C. odorata</i> Leaf Weight			
	Control	1:40	1:80	1:40
Water Potential (Ψ) (bars \pm SE)				
1	-6.4 \pm 3	6.6 \pm 1.0	-6.3 \pm 7	09.2 \pm 1.8
2	-6.1 \pm 9	-4.6 \pm 1.4	6.9 \pm 4	-8.1 \pm 1.6*
3	-6.2 \pm 8	6.0 \pm 1.3	-8.3 \pm 2.8	09.9 \pm 3***
4	-4.5 \pm 10	-6.2 \pm 1.0	-8.1 \pm 0.6	-9.9 \pm 1.2**
5	-4.1 \pm 6	-4.7 \pm 9	-6.5 \pm 1.2	-10.2 \pm 1.5***
6	-4.0 \pm 7	-4.3 \pm 9	-8.6 \pm 1.5	-10.0 \pm 1.8***
6-day mean	05.2 \pm 3	-5.4 \pm 3	-7.5 \pm 7*	-9.6 \pm 1.2***

Osmotic Potential ($\Psi\pi$)(bar \pm SE)

1	-9.3 \pm 7	-8.3 \pm 1.3	-9.3 \pm 7	-10.0 \pm 89
2	-8.5 \pm 1.2	08.6 \pm 4	-12.0 \pm 1.0	-10.2 \pm 3*
3	-8.2 \pm 4	-8.3 \pm 1.1	-10.2 \pm 2	-10.2 \pm 7*
4	-8.9 \pm 1.1	-10.2 \pm 8	-8.8 \pm 5	-12.8 \pm 5*
5	-8.8 \pm 6	-8.6 \pm 8	-8.8 \pm 5	-12.8 \pm 8 **
6	-9.9 \pm 5	-10.1 \pm 1.0	-4.6 \pm 2	-13.2 \pm 1.5*

6- day mean pressure potential (ψ_p)(bar \pm SE)

1	-2.9± 9	-1.7±1.2	-3.0 ± 1.1	-0.8 ± 2.0
2	2.4 ± 6	2.0±1.0	5.1 ± 1.2	2.1 ± 1.9
3	2.0 ± 1.2	2.3±1.0	1.9 ± 2.6	-0.3 ± 1.7
4	4.4 ± 1.1	4.0±1.0	2.5 ± 0.6	-1.0 ± 0.9*
5	4.7 ± 5	3.9±0.5	2.3 ± 1.0	-2.6 ± 1.4**
6	5.4 ± 7	5.8±1.3	4.0 ± 2.1	-3.2 ± 1.6
6-day mean	2.9 ± 5	3.7 ± 0.5	2.1 ± 0.7	-8.6 ± 0.8**

Values are means and SE of 8 seedlings.

* Values significantly different at $P < 0.05$

** $P < 0.01$

*** $P < 0.01$

Table 4: Effects of dried *C. odorata* in soil on the water potential (ψ bars) of *Lycopersicon esculentum*

Days of treatment	Addition of residue to 80g soil			
	Control	0.5	1.0	2.0
9	-3.9 ± 1.3	-3.6 ± 1.7	-4.3 ± 0.9	-5.9 ± 1.3
12	-3.2 ± 1.0	-4.0 ± 1.0	-4.4 ± 1.1	-4.8 ± 1.5
14	-4.5 ± 2.2	-4.4 ± 1.3	-4.3 ± 1.0	-5.9 ± 2.1

Values are the means and SE of 8 seedlings

Total water use was reduced in all treatment groups although transpiration ratio was consistently affected (Table 3). Tomato plants grown in 2g amendments had ψ values 1.5 to 4.8 bars lower than control plants (Table 3). However, they were not statistically different from the controls. The data shows that inhibition of the growth of tomato plants was generally related to changes in the plants water status. Tomato plants inhibited by the 2g of *C. odorata* residue in the soil showed a trend toward lower leaf ψ , but it was not as marked as in the extract experiments. It is not certain whether interference with water balance and water metabolism is the only, or even the primary mode of action of phytotoxic substances from *C. odorata*. However, it is reasonable that any effect on water utilization would interfere with growth. Cotton and Einhellig (1980) reported that soybean seedlings inhibited by aqueous velvet leaf (*Abutilon theophrasli Medic.*) extracts had decreased ψ , and reduced water content. Such effects on water balance may result from the action of known allelochemical that are coumarin or phenolic acid derivatives. Patterson (1981) had reported that t-cinnamic, p-coumaric, vanillic, caffeic, and gallic acids respectively severely reduced photosynthetic rate in soybeans (*Glycine max L.*). Soybeans treated with caffeic, and gallic acids had a significant depression of leaf. It is possible that the allelochemicals effects of *C. odorata* noted in this experiment are caused by phenolic acids and related allelochemicals. Our data indicate that the mechanisms of toxic action involve interference with water balance in the seedlings. These effects may be

magnified when water availability is a critical factor in a field situation.

Presence of *C. odorata* in a field may result in the accumulation of leachates and residues that are toxic to crops, resulting in yield losses. It is therefore important that *C. odorata* be removed as early as they germinate in a farmland where tomato plants are grown.

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