African Journal of Agricultural Research Vol. 7(27), pp. 3952-3956, 17 July, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.2163
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Allelopathic impact of rhizosphere soil of *Tinospora cordifolia* on growth and establishment of some weed plants

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Accepted 21 June, 2012

This experiment was carried out to study various biological and ecological features of *Tinospora cordifolia* and physico-chemical characteristics of its rhizosphere soil, and determine the effect on the growth of some weed plants (that is, *Chenopodium album* L., *Chenopodium murale* L., *Cassia tora* L. and *Cassia sophera* L.). Root length, shoot length and dry weight of seedlings of tested plants decreased significantly when plants were grown in the rhizosphere soil of *T. cordifolia*. The rhizosphere and control soil were analyzed for pH, electrical conductivity, organic carbon, organic matter, available nitrogen, phosphorus, potassium, and micro-nutrients such as sodium, iron, manganese and zinc. The pH of rhizosphere soil decreased compared to control whereas the conductivity, organic carbon and organic matter increased. The presence of a significantly high amount of phenolics in the rhizosphere soil indicates their possible interaction with soil chemical properties. This was also indicated by the correlation analysis between phenolics and various properties.

Key words: Phenolics, rhizosphere soil, *Tinospora cordifolia*.

INTRODUCTION

Tinospora cordifolia is a deciduous climbing shrub found throughout India, Myanmar and Shrilanka. It is commonly called as guduchi or giloy. The stem of *T. cordifolia* is rather succulent with long filiform fleshy aerial roots from the branches. The bark is creamy white to grey, deeply left spirally, and the space in between being spotted with large rosette like lenticels. The leaves are membranous and cordate. The flowers are small and yellow or greenish yellow. In auxiliary and terminal racemes or racemose panicles, the male flowers are clustered and females are usually solitary. The drupes are ovoid, glossy, succulent, red and pea sized. The seeds are curved. Fruits are fleshy and single seeded. Flowers grow during the summer (Anonymous, 1976; Nadkarni and Nadkarni, 1975). The stem of T. cordifolia is one of the constituents of several ayurvedic preparations used in general debility, dyspepsia, fever and urinary diseases.

The stem is bitter, stomachic, diuretic (Nayampalli et al., 1988) stimulates bile secretion, causes constipation, allays thirst, burning sensation, vomiting, enriches the blood and cures jaundice. The extract of its stem is useful in skin diseases (Aiyer and Kolamma, 1963;Raghunathan and Mittra, 1982). The root and stem of *T. cordifolia* are prescribed in combination with other drugs as an antidote to snake bite and scorpion sting (Nadkarni and Nadkarni, 1975; Kirtikar and Basu, 1975; Zhao et al., 1991). Dry barks of *T. cordifolia* have anti-spasmodic and antipyretic (Ikram et al., 1987) properties.

Allelopathy is a mechanism in which chemicals produced by weed plants may increase or decrease the associated plant growth. Molish (1937), coined the term "allelopathy" as an interaction among the plants and the micro-organisms. Rice (1984), defined allelopathy as the effects of one plant (including micro-organisms) on another plant through the release of chemicals into the environments. Allelopathy is an interference mechanism, in which live or dead plant materials release chemical substances, which inhibit or stimulate the associated plant

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Table 1. Elemental analysis of *T. cordifolia* at mature stage.

Elements	Amount of elements /unit dry weight
N (%)	0.654 ± 0.05
K (%)	1.98 ± 0.37
P (%)	0.467 ± 0.30
Ca (%)	31.12 ± 2.54
Mg (%)	8.18 ± 2.19
Na (%)	0.017 ± 0.003
Zn (ppm)	0.31 ± 0.14
Fe (ppm)	13.14 ±1.37
Mn (ppm)	1.06 ± 0.17
Cu (ppm)	0.26 ± 0.04

growth (Harper, 1977; May and Ash, 1990). This study is an attempt to investigate the cause of the invasive nature of *T. cordifolia* and the possible allelopathic effect of the soil from its rhizosphere on growth and establishment of selected weed plants.

MATERIALS AND METHODS

Collection of soil and evaluation of its physico-chemical characteristics

Rhizosphere soil that is, soil in and around the root system (approximately at 5 to 15 cm depth and 10 cm radius) was collected from *T. cordifolia* invaded area in the month of April, 2010. Collection of soil was made from the upper 0 to 15 cm soil profile since 80% of the root system of plant is present in this zone. The experiment was conducted in the month of August, 2010. Soil samples were analyzed for pH, conductivity, phenolics, organic carbon, organic matter and nutrients. The pH and conductivity were measured in a 1: 5 soil water (w/v) paste with the help of digital pH and conductivity meter, respectively. Organic carbon and organic matter were estimated (Walkley and Black, 1934), total phenolics (Swain and Hills, 1959). Available nitrogen from soil was estimated using alkaline potassium permanganate solution as per the method of Association of Official Agricultural Chemists (AOAC), 1960; available phosphorus (Olson et al., 1954), potassium and sodium (Bower and Gschwend, 1952) and also available iron, manganese and zinc (using an atomic absorption spectrophotometer) was measured. At least four replicates were maintained for each analysis.

Growth studies

For growth studies, the seeds of *Chenopodium album, Chenopodium murale, Cassia tora,* and *Cassia sophera* were collected from the agriculture fields of the Aligarh Muslim University and the premises of the university campus. The seeds of the *C. tora* and *C. sophera* were rubbed with sand paper for breaking the dormancy and dipped in water for 12 h. *C. album* and *C. murale* seeds was also soaked in water for 12 h. They were subjected to growth studies in pots filled with soil samples (rhizosphere soil as well as control). For each tested plant species and treatment, five replicates were used. The whole set-up was maintained under green house conditions. After one month, seedlings were uprooted carefully, keeping the root system intact. Their root and shoot lengths were measured and biomass quantified after oven drying.

Statistical analysis

The data were subjected to ANOVA followed by Duncan's Multiple Range Test (DMRT) (Duncan, 1955) and 2 sample t-test, wherever applicable.

RESULTS

Elemental contents

The content of various elements in the mature *T. cordifolia* are presented in Table 1.

Soil characteristics

The pH and electrical conductivity was significantly higher in the rhizosphere soil of *T. cordifolia* than in the control soil (Table 2). The amount of phenolics in the rhizosphere soil of *T. cordifolia* was as about four times as in control. The differences were also statistically significant and similar differences in regards to organic carbon and organic matter were observed (Table 2). Thus, the amount of organic carbon was maximum in soil of *T. cordifolia* invaded site followed by control. Amount of macro and micro nutrient was also observed in the rhizosphere soil and control soil. In general, maximum amount of nutrients was calculated in the soil of *T. cordifolia* invaded soil followed by control. Exception, however, were observed in the content of Cl. it was found maximum in control soil (3.74 g/100 g) as compared to rhizosphere soil (2.19 g/100 g). In the case K, Ca, Mg and Na maximum amount of the respective element was found in rhizosphere soil. The differences in the amount of all macro- and micronutrients among the control and rhizosphere soil were found to be statistically significant (Table 2).

Growth studies in rhizosphere soil of *T. cordifolia*

Germination

Seeds of each weed plants were germinated in the

Table 2. General characteristics of control soil and rhizosphere soil of *T. cordifolia*.

Soil character	Control	Rhizosphere soil
pH	7.63^{a}	7.74^{a}
Conductivity	132.1^{b}	187.5^{a}
Phenolic content (mg/100 g soil)	0.21^{b}	0.81^{a}
OC (%)	1.08^{b}	1.58^{a}
OM (%)	1.86^{b}	2.72^{a}
N (kg/ha)	175^{b}	286^{a}
P (kg/ha)	162.4^{b}	197^{a}
K (ppm)	104^{b}	147^{a}
Na (ppm)	37.4^{b}	67.1^{a}
Ca (g/100 g)	2.31^{b}	4.18^{a}
Mg (g/100 g)	1.51^{b}	2.38^{a}
Cl (g/100 g)	3.74^{a}	2.19^{b}
HCO_3 (g/100 g)	13.74^{b}	24.12^{a}
Zn (ppm)	2.4^{b}	5.1^{a}
Fe (ppm)	5.4^{b}	9.11^{a}
Mn (ppm)	10.2^{b}	10.76^{a}
Cu (ppm)	0.24^{b}	0.76^{a}

rhizosphere soil of *T. cordifolia* as well as in the control. There was no change in germination. Data have not been presented.

Root length

Root length of tested plant species emerging from the seeds sown in rhizosphere soil of *T. cordifolia* was shorter than those of control. The root length of *C. tora* was 5.62 ± 0.17 cm in control. While those grown in rhizosphere soil of *T. cordifolia* was 2.46 ± 0.23 cm decreased by 56.23% as the control (Figure 1a). In case of *C. sophera,* its root length was 6.32 ± 0.54 cm in control and decreased by 48.10% (Figure 1a). Similarly, the root length of *C. album* and *C. murale* was reduced by *T. cordifolia* to 46.20 and 38.85% respectively (Figure 1a). The maximum reduction was observed in *C. tora* (56.23%) while the minimum was in *C. murale* (38.85%).

Shoot length

The shoot length of tested plant species grown in the rhizosphere soil of *T. cordifolia* was less than those grown in the soil collected from free *T. cordifolia* area or control. The shoot length of *C. tora* was estimated to be 8.32 ± 0.13 cm in the control while it was 4.17 ± 0.56 cm (Figure 1b), grown in the soil collected from *T. cordifolia* invaded area. For *C. sophera*, its shoot length was reduced by 39.75% in rhizosphere soil in comparison to 10.59 ± 0.28 cm in control soil (Figure 1b). While the shoot length of *C. album* and *C. murale* grown in the rhizosphere soil was reduced by 35.34% (7.32 ± 0.14 cm) and 37.43% (6.87 ± 0.15 cm), respectively (Figure1b).

Dry biomass

The dry biomass of seedlings grown in the rhizosphere soil of *T. cordifolia* was less than those grown without *T. cordifolia* (Figure 1c). The maximum reduction was observed for *C. album* (49.88%), *C. tora* (39.76%), *C. murale* (36.74%) and *C. sophera* (31.48%).

DISCUSSION

The bioassay studies conducted in *T. cordifolia* rhizosphere soil indicates a retardatory effect on growth, the magnitude of which varied from species to species. It is clear from the experiments that growth of the tested plant species that is, *C. album, C. murale, C. tora* , and *C. sophera* was significantly affected when grown in the soil collected from *T. cordifolia* invaded fields (rhizosphere soil) compared to control. Their height and biomass accumulations were significantly reduced in the rhizosphere soil. On the basis of root length of the tested plant species, the retardatory effect was in an order: *C. tora* > *C. sophera* > *C. album* > *C. murale*. On the basis of shoot length the decreasing order of test plants was shown *C. tora* > *C. sophera* > *C. murale* > *C. album.* In the case of dry weight, the decreasing order of the test plants *C. album* > *C. tora* > *C. murale* > *C sophera.* This study indicates that some inhibitors are present in the rhizosphere soil of *T. cordifolia* that adversely affects the

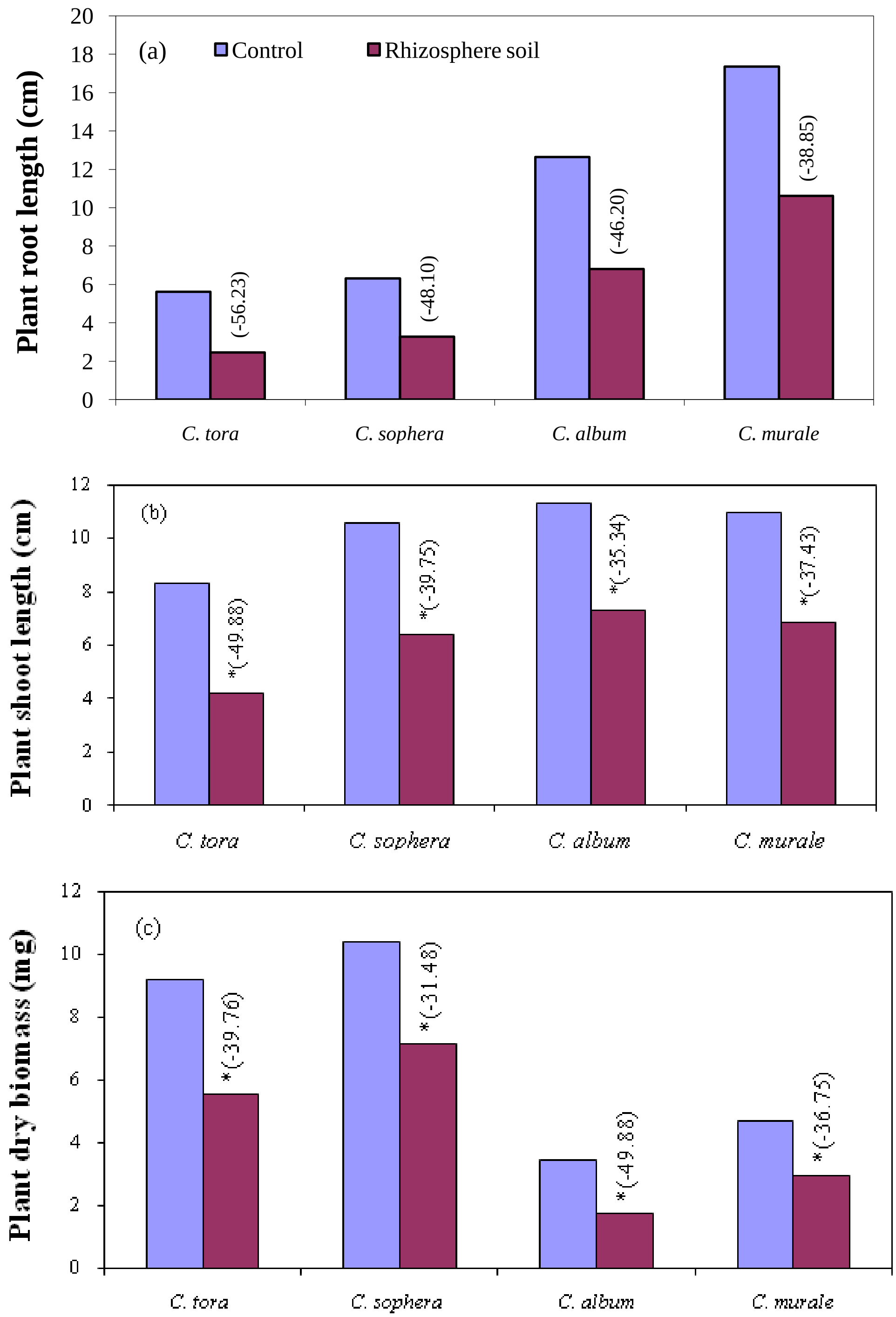

Figure 1. Root length (a), shoot length (b) and dry biomass (c) of test plants of one month after sowing in soil collected from *T. cordifolia* invaded area and control. *represent significant difference between data pertaining to growth of test plants in control and infested soil applying 2 sample t- test. Values in parenthesis represent the percent reduction of control.

early growth of tested plant species compared to the control. The phenolics- a well known group of secondary metabolites (Harborne, 1989; Seigler, 1996; Mizutani, 1999) were found in appreciable amount in the rhizosphere soil of *T. cordifolia* invade area compared to control. Several studies have indicated that these phenolics are responsible for growth retardatory effect on other plants including crops thus, causing appreciable injury in the growing plants (Rice, 1984, 1995; Qasem and Foy, 2001; Weston and Duke, 2003; Sisodia and Siddiqui, 2009). This indicates that phenolics could be the substances depressing the growth of the other plants grown in their rhizosphere soil.

Rhizosphere soil is an active root zone of soil densely populated and there are many biotic interactions among micro-organisms and roots (Walker et al., 2003). It is also an abundant source of organic material on which fauna and flora is dependant for food (Ryan and Delhaize, 2001). Most of the chemicals especially allelochemicals released from plants also accumulate in this zone. These may be released by roots as exudates or from above-ground parts through leachation or microbial degradation. Roots, however, are known to serve as one of the major source of organic chemicals released through root exudation. These exudates may contain a diversity of chemicals that regulate the biotic communities of soil besides its physical and chemical properties. These also inhibit growth of competing species (Rovira, 1969). Walker et al. (2003) and Verma and Rao (2006) have reported that plants release a number of low (phenolics) and high (polysaccharides, proteins) in this respect. The presence of phenolic allelochemicals in rhizosphere soil of *Tinospora* invaded fields indicates that these might have been release from the plants through any of the mode. Based on these observations, the growth retardatory effects of weeds may be attributed to allelochemicals in the rhizosphere soil of *Tinospora* invaded fields.

ACKNOWLEDGMENT

The authors wish to thank the UGC fellowship for the financial support rendered to ensuring that this research was a success.

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