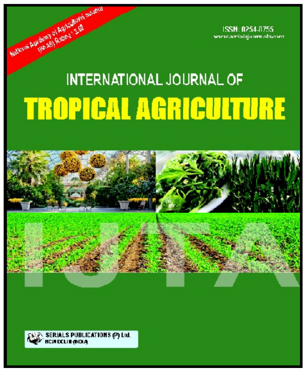

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Effect of Soil Texture on Phytotoxicity of an Invasive Weed, *Ageratum conyzoides* L.

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Abstract: A study was conducted to explore the influence of soil texture on the phytotoxic potential of *Ageratum conyzoides*. Effect of five different types of soils *i.e.* clay only, sand only, loam, sandy loam and clayey loam was studied using amendment of *A. conyzoides* leaf powder (1 and 2 g / 100 g soil) with separate control of each type against seedling length and dry weight of *Oryza sativa*. It was observed that greatest inhibition in seedling growth occurred in sandy soils, while it was minimum in clay soil. The amended soils were not poor in nutrients, rather these contained a significant amount of phenolics, water soluble allelochemicals. The inhibition in seedling growth was directly related to the amount of phenolics in the soils. The maximum content of phenolics was observed in sandy soils while minimum in clay. The study concludes that phytotoxicity of *A. conyzoides* is greatly influenced by soil texture and it enhances in sandy soils.

Key words: Billy goat weed, allelopathy, soil texture, allelochemicals, phenolics, seedling growth.

INTRODUCTION

Ageratum conyzoides L. (Billy goat weed; Asteraceae), native to tropical America, is now spread to various tropical and subtropical parts of the world including India. It is an annual, aromatic and invasive weed, primarily of agricultural fields, now thrives well in a variety of habitats such as agricultural fields, rangelands, pastures, wastelands, and along water channels [1]. In India, the weed proliferates rapidly owing to quick vegetative and sexual reproduction, and forms huge monospecific stands. The successful invasion of the weed is attributed to wide range of environmental adaptability, higher reproductive potential and allelopathy. Allelopathy is an interference mechanism that involves release of certain metabolites/chemicals from the plant into the environment that affect growth and establishment of associated plants [2]. It has even been proposed as a novel mechanism for the spread and establishment of invasive plants [3]. To describe an allelopathic potential of a plant, the use of soil is of great ecological significance [4, 5], since any change in the bioactive concentration of allelochemicals (chemicals involved in allelopathy) is well described in the soil. Singh *et al.* [6] and Batish *et al.* [7] reported the soil inhabited by *A. conyzoides* to be rich in non-volatile allelochemicals and phytotoxic towards growth of other plants. We hypothesized that soil texture may play an important role in determining the fate of allelochemicals as these upon release may either adsorb to soil particles or may undergo transformation depending upon environmental conditions. Therefore, a study was conducted to explore the influence of soil texture on the phytotoxicity of *A. conyzoides*.

MATERIALS AND METHODS

Fresh plants of *Ageratum conyzoides* were collected from the infested agricultural fields on the outskirts of Chandigarh, India. The leaves were harvested, shade dried, powdered and stored for bioassay. The different types of soils (upper 0–15 cm soil profile) were collected from an agricultural field and open lands (not infested by weed) of different sectors of Chandigarh. It was brought to laboratory, air-dried and sieved through a 2-mm sieve. On the basis of soil particle size, five types of soils *i.e.* sandy (S), clayey (C), loam (L), sandy loam (SL) and clayey loam (CL) soils were used for the present study. These were identified on the basis of soil particle size, *i.e.* sandy (with maximum % of fine sand with 0.2-0.02 mm particle size), clayey (with maximum % of clay with <0.002 mm particle size), loam (with ~equal % of coarse sand, fine sand, silt and clay particles), sandy loam (with more of coarse and fine sand) and clayey loam (with more of silt and clay particles).

For bioassay studies, certified seeds of rice (*Oryza sativa* L.) were purchased from the market. To these five types of soils, green leaf powder of *A. conyzoides* was incorporated in the ratio of 1 or 2 g/100 g soil. Likewise, for each type of soil, one set was kept as control where no amendment was done. Each type of soil, whether unamended or amended, was filled in plastic pots. For each treatment, five replicates were maintained. Ten healthy and fresh seeds of *O. sativa* were sown in each pot. After ten days, growth was measured in terms of seedling length and seedling dry weight. These soils (amended or unamended) were also analyzed for some physical and chemical properties. These included pH, conductivity, organic carbon (OC), organic matter (OM), amount of total phenolics [8] and some available macronutrients and micronutrients. The whole experiment was repeated and mean of data were analyzed by one-way and two-way ANOVA.

RESULTS AND DISCUSSION

Effect on Seedling Growth

A variable response of *O. sativa* sown in unamended different textured soil was observed. In control, maximum seedling length was measured in clayey soil followed by sandy, clayey loam, sandy loam and loam. In each type of soil amended with leaf powder of *A. conyzoides*, the seedling length of rice was reduced over respective controls. With increasing rate of amendment, inhibition in seedling length also increased. (Figure 1). At 1 and 2% concentration in clay, seedling lengths were reduced by nearly 17 and 54%, respectively. In sandy soil, more than 80% reduction was observed in both 1 and 2% leaf powder amended soils (Figure 1).

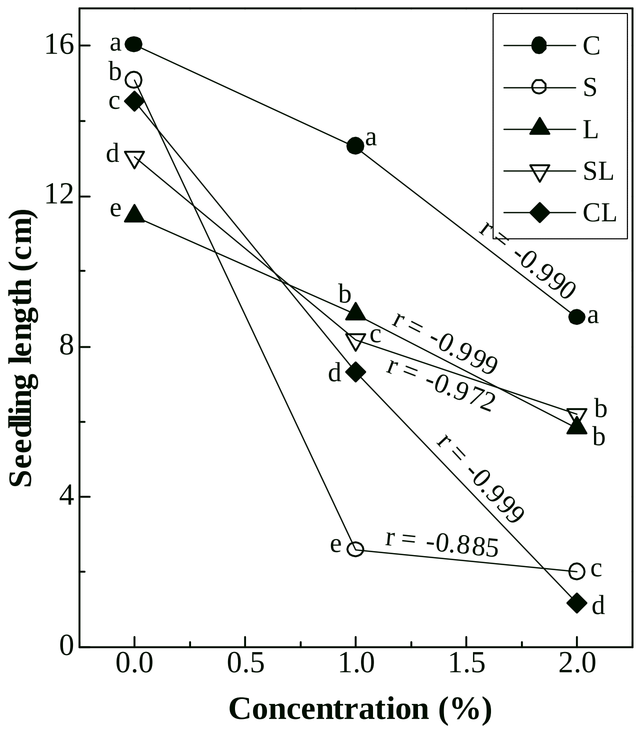

Figure 1: Seedling length of *O. sativa* in soils of different textures amended with leaf powder of *A. conyzoides*.
Different alphabets along a curve represent significant difference from control at $P<0.05$. *r* represents value of correlation coefficient.

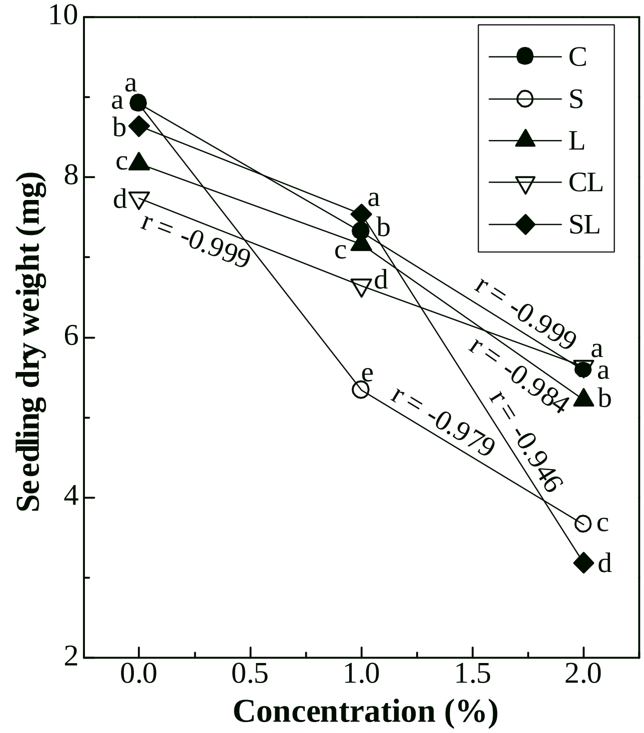

Figure 2: Seedling dry weight of *O. sativa* in soils of different textures amended with leaf powder of *A. conyzoides*.
Different alphabets along a curve represent significant difference from control at $P<0.05$. *r* represents value of correlation coefficient.

In loam soil amended with 1 and 2 g leaf powder, the seedling length exhibited a reduction of nearly 23 and 41%, respectively, whereas in sandy loam, it was inhibited by 50 and 92% (over control). In clayey loam, the seedling length was reduced by 37 and 53% at 1 and 2%, respectively (Figure 1).

Like seedling length, seedling dry weight of *O. sativa* seedlings decreased in amended soils and more inhibition was observed at 2% leaf powder amendment. Here also, maximum inhibition (63%) was observed in sandy loam followed by sandy soils (nearly 59%) when amended with 2% leaf powder. In case of clayey soil and loam amended with 2% leaf powder, reduction in dry weight of seedlings was nearly same (37 and 36%, respectively). In case of clayey loam, the dry weight was reduced only up to 27% and 14%, respectively at 2% or 1% concentration of leaf powder (Figure 2).

Effect on Soil Properties

Further, to explore whether the growth inhibitory effects are caused by amendment with leaf powder of *A. conyzoides* or involve some other factors, these soils were analyzed for some physio–chemical properties (Table 1). The pH of both sandy and sandy loam soils was significantly more than other soil types and minimum in clayey soil. However, soils amended with 2% leaf powder have significantly lesser pH compared to respective controls. In unamended soils, conductivity was the maximum in clayey loam and minimum in sandy soil. On the other hand, conductivity increased significantly in amended soils and the maximum values were observed in sandy loam, clayey loam and loam where it was more than 1000 µS. In contrast, in sandy and clayey soil, conductivity increased 4 to 5.5 times in amended soils compared to their respective controls (Table 1).

Table 1
Effect of amendment of green leaf powder (2 g/100 g) of *A. conyzoides* on pH and organic carbon and matter content in soils of different texture.

	Treatment	*Clayey*	*Sandy*	*Loam*	*Clayey loam*	*Sandy loam*
pH	Unamended	7.87e	8.28b	8.06d	8.12c	8.33a
	Amended	7.67b	8.10a	7.57c	7.50d	7.62b
EC (µS)	Unamended	149.1d	111.1e	169.6b	288.5a	158.1c
	Amended	827.4d	778.5e	1043.5c	1079.0b	1196.5a
OC (%)	Unamended	0.25a	0.04c	0.14b	0.17b	0.07c
	Amended	0.48b	0.45b	0.22d	0.57a	0.03c
OM (%)	Unamended	0.43a	0.16d	0.23c	0.28b	0.13d
	Amended	0.83b	0.78b	0.34d	0.98a	0.52c

EC: Electrical conductivity; OC: Organic carbon; OM: Organic matter

Similar superscripts in a row represent insignificant difference at $P<0.05$ applying DMRT.

Likewise, organic carbon and organic matter were also measured to be more when soils were amended with leaf powder of *A. conyzoides*. Increase in organic carbon was the maximum in sandy and sandy loam soil (5.0 and 4.3 times, respectively) and minimum in loam (1.6 times over control). Similar trend of changes was observed in organic matter also (Table 1).

The results show that the early growth of rice was relatively better in clay and sandy soils (unamended control conditions) with alkaline pH. Both clayey and sandy soils with pH values nearing 8 were suitable for *O. sativa* germination [9, 10] or otherwise rice can grow well both in sandy and clay soils, as observed in the present study. When such soils are amended, a direct effect of texture can be seen on the rice growth. The magnitude of inhibition of rice seedlings was less in loam, clayey loam as well as clay soil compared to sandy soils (sand only and sandy loam). The inhibition was more pronounced in sandy soil followed by sandy loam soil, showing 87 and 92% decline, respectively.

Appreciable changes were also observed with respect to various nutrients, *viz.* N, P, K, Na, Ca and Mg (Table 2). Available N was measured to be the maximum in clayey soil and minimum in sandy soil. In general, in all amended soils, content of available N increased than respective controls. Maximum increase was observed in loam while minimum in clayey soil. The content of P in the amended soils increased by nearly 1.5 to 3 times. Maximum increase of P was observed in sandy loam and minimum in clayey loam. In K, maximum increase was observed in sand and minimum in clay.

Likewise, the contents of Na, Ca and Mg were also more in the amended soils. Maximum amount of Na was observed in clayey loam while minimum in sandy soils. It significantly increased in amended soil and maximum increase was observed in sandy soils (1.6 times over control). Increase in Ca was the maximum in clayey loam, whereas in sand and sandy loam, increase in Ca was 2.4 and 2.6 times, respectively. Further, the amount of Mg in soil amended with leaf powder of *A. conyzoides*, increased significantly (11 times over control) in sandy loam and loam. However, in sand and clay soils, the increase in amount of Mg was 1.7 times only (Table 2).

The table 1 and 2 clearly suggests that different textured soils amended with leaf powder of *A. conyzoides* exhibit more organic contents and matter. Further, the nutrient contents in leaf powder amended soils were more compared to unamended

Table 2
Effect of amendment of green leaf powder (2g/ 100g) of *A. conyzoides* on available macronutrient content in the soils of different texture

	Treatment	*Clayey*	*Sandy*	*Loam*	*Clayey loam*	*Sandy loam*
N (kg/ha)	Unamended	71.43[a]	56.41[d]	65.83[b]	69.20[a]	60.27[c]
	Amended	89.54[b]	74.73[e]	92.50[a]	85.70[c]	78.10[d]
P(ppm)	Unamended	112.54[a]	48.24[e]	100.24[b]	78.24[c]	55.87[d]
	Amended	150.24[b]	129.03[d]	150.20[b]	142.38[c]	173.20[a]
K^+(ppm)	Unamended	193.33[a]	66.67[e]	106.67[c]	133.0[b]	86.67[d]
	Amended	473.33[c]	733.33[a]	473.33[c]	416.67[d]	580.0[b]
Na^+(ppm)	Unamended	50.23[b]	40.22[d]	55.67[a]	55.00[a]	46.24[c]
	Amended	69.24[b]	64.27[c]	68.40[b]	74.23[a]	65.00[c]
Ca^{++}(g/100g)	Unamended	1.57[a]	1.13[d]	1.27[b]	1.17[c]	1.10[e]
	Amended	4.70[a]	2.67[d]	4.10[b]	4.10[b]	2.85[c]
Mg^{++}(g/100g)	Unamended	4.63[a]	0.93[d]	1.37[c]	1.63[b]	0.87[e]
	Amended	8.03[d]	2.47[e]	2.10[c]	9.23[b]	9.95[a]

Similar superscripts in a row represent insignificant difference at $P<0.05$ applying DMRT.

soils (irrespective of texture) and hence were not limiting to the growth of rice seedlings. This points out that there must be some other factors / compounds responsible for growth retardatory effects of these amended soils. To investigate this, the amounts of total phenolics were also determined in amended and unamended soils (Figure 3). The phenolic contents increased by many folds in amended soils, especially sandy and sandy loam soil. Minimum content of phenolics was found in clay (0.69 µg/g soil) and in amended soil, amount was 5 times more. In sand, the increase in amount of total phenolics in amended soil was the maximum depicting 16.5 times increase over the control (unamended soil) (Figure 3).

Further, in sandy loam soil, the increase in amount of total phenolics was also high (8.7 times). In loam soil, the amount of phenolics in control was 7.13 and in contrast to amended soil, it was 16.78. In clayey loam soil, the amount of phenolics in amended soil exhibited 4.6 times increase over the control. Thus, maximum increase in amount of phenolics was observed in sandy soils whereas it was minimum in loam (Figure 3).

The different soil types amended with leaf powder had a variable reduction in rice growth. Since

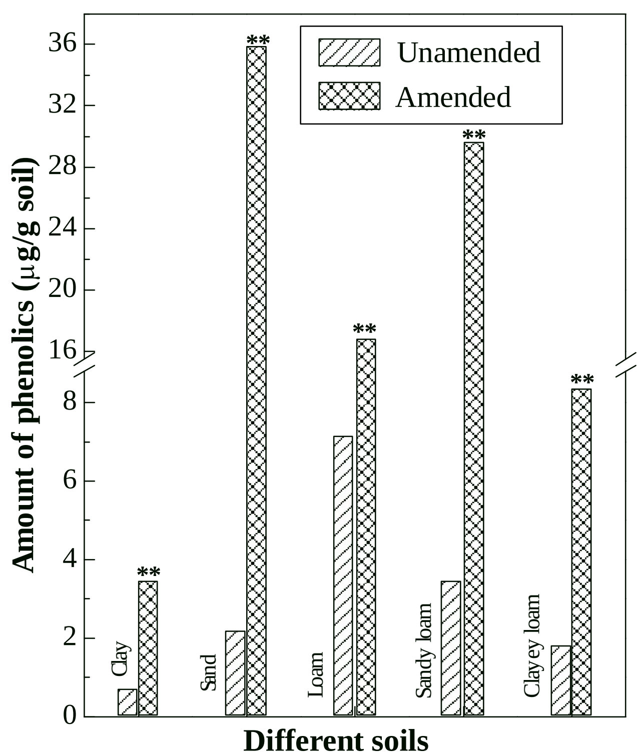

Figure 3: Changes in amount of total phenolics in soils of different texture upon amendment of leaf powder of *A. conyzoides*.

the amended soils were rich in nutrients, it suggests that some bioactive molecules, *i.e.* phenolics may interfere in the uptake of nutrients by the growing seedlings. These observations are supported by earlier reports indicating the interference of phenolics in the uptake of nutrients by the plants [11, 12, 7]. However, the direct evidence in this regard are largely unknown. The phytotoxic influence of amended soil was directly related with the amount of phenolics present. The maximum amount of phenolics were found in sandy soil where the greatest inhibitory effect was observed. In sandy soils, the greater amount of phenolics could be due to their non-adsorption to soil particles and thus, direct availablity for causing inhibition.

In other soils, however, due to adsorption to soil particles, the phenolics may not be directly available to plant system and thus caused lesser inhibition. Similar observations that phytotoxicity is influenced by the soil texture were also made by other workers [13, 14, 15]. Based on the results obtained in the present study, we conclude that phytotoxicity of *A. conyzoides* is significantly influenced by the soil texture due to the effect of various soil particles on the availability of phenolics.

REFERENCES

[1]Kohli RK, Batish DR, Singh HP, Dogra KS. (2006), Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Lantana camara* L.) in India. *Biol. Invasions* **8**: 1501–1510.

[2]Rice EL. (1984), *Allelopathy*. Academic Press, Orlando.

[3]Bais HP, Park S-W, Weir TL, Callaway RM,Vivanco JM. (2004), How plants communicate using the underground information superhighway. *Trends Plant Sci.* **9**: 26–32.

[4]Blum U, Shafer SR, Lehman ME. (1999), Evidence for inhibitory allelopathic interactions involving phenolic acids in field soils: concepts vs. an experimental model. *Crit. Rev. Plant Sci.* **18**: 673-693.

[5]Wardle DA, Nilsson M-C, Gallet C, Zackrisson O. (1998), An ecosystem-level perspective of allelopathy. *Biol. Res.* **73**: 305–319.

[6]Singh HP, Batish DR, Kaur S, Kohli RK. (2003), Phytotoxic interference of *Ageratum conyzoides* with wheat (*Triticum aestivum*). J. Agron. Crop Sci. **189**: 341–346.

[7]Batish DR, Kaur, S, Singh, HP, Kohli, RK. (2009), Nature of interference potential of leaf debris of *Ageratum conyzoides*. *Plant Growth Regul.* **57**: 137–144.

[8]Swain T, Hillis WE. (1959), The phenolic constituents of *Prunus domestica* I. The quantitative analysis of constituents. *J. Sci. Food Agric.* **10**: 63–68.

[9]Brady NC. (2003), *The Nature and Properties of Soils*. MacMillan Co., New York, USA.

[10]*Handbook of Agriculture*. (2003), Indian Council of Agricultural Research, New Delhi, India.

[11]Heisey RM. (1990), Evidence for allelopathy by tree-of-heaven (*Ailanthus altissima*). *J. Chem. Ecol.* **16**: 2039–2055.

[12]Baziramakenga R, Simard RR, Leroux GD. (1994), Effects of benzoic and cinnamic acids on growth, mineral composition, and chlorophyll content of soybean. *J. Chem. Ecol.* **20**: 2821–2833.

[13]El-Darier SM, Youssef RS. (2000), Effect of soil type, salinity and allelochemicals on germination and seedling growth of a medicinal plant *Lepidium satvum* L. *Ann. Appl. Biol.* **136**: 273–279.

[14]Einhellig FA. (1996), Interactions involving allelopathy in cropping systems. *Agron. J.* 88: 886–893.

[15]Tyler G, Olsson. (2001), Plant uptake of major and minor mineral elements as influenced by soil acidity and liming. *Plant Soil* **230**: 307–321.