Physico-chemical interpretation of allelopathic interaction of vetiver with two non-edible oil yielding fence plants

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ABSTRACT:

Dry plant litter upon rainfall leaches out several allelochemicals which influence the growth of same or other plants in the vicinity. To test the allelopathic interactions of aqueous leachates on vetiver, plantlets of *Vetiveria zizanioides* were planted on pre-analysed sterilized sand treated with 1:10, 1:20 and 1:50 v/v pre-analysed leachates of *Jatropha curcas*, *Ricinus communis* and *Vetiveria zizanioides*, respectively, along with distilled water treated control. Analyses of changes in soil biochemical status and five-leaf plantlet at six-leaf stage were carried out to estimate losses or gains to the soil and allelopathic interactions of vetiver with other fence plants grown commonly in India for oil to biofuel purposes. Whereas vetiver leachates promoted total chlorophyll and root nitrogen content with lowering of shoot peroxidase activity after new leaf emergence in the plantlets, *Jatropha* leachates promoted root nitrogen only with increased shoot peroxidase activity. Further, vetiver plantlets enriched soil in terms of organic carbon, nitrogen and phosphorus maximally when the soil was treated with *Ricinus* leachates. With increasing dilution of vetiver leachates, cation exchange capacity (CEC) decreased indicating high density vetiver plantation to be autopromotory for vetiver growth. However, vetiver leachates promoted the growth of *Jatropha* seedlings and inhibited the growth of *Ricinus* seedlings suggesting vetiver-*Jatropha* to be a suitable fence plant option for plant-plant interaction.

Keywords: Allelopathic interaction, leachate, phenolics, phytotoxicity, vigour index

1. INTRODUCTION:

Monocultural practices of agricultural have been replaced by polycultural practices owing to the stress of nutrient demand, disease infestation, etc leading to poor yield. It was noticed that in polyculture, too, some crops give better yield, while others give lower yield. Plants have been found to produce and store various allelochemicals (intermediary metabolic products) viz., alkaloids, phenolics and others as preferably defense compounds (Putnam *et al*, 1989). Sorghum is known to produce bioherbicides eg. Sorgholeone, a gene for which is already identified (Yang, 2004). Thus, an understanding of plant- plant interactions termed as allelopathy evolved. Considering allelopathy to be an interaction between neighbouring plant or microbial species involving chemical control — either beneficial or detrimental — of one organism by another (Rice,1984), the present work has been carried out on the performance of vetiver plantlets as fence plant with newly popularized biofuel plants *Jatropha curcas* and *Ricinus communis* using fallen leaves (litter) of these plants as leachate.

2. MATERIALS AND METHODS:

The experiments were conducted at Department of Botany, C.C.S. University Campus, Meerut (Latitude 29^0 01'N; Longitude 77^0 43' E; 730' from sea level) situated in U.P. For the present study leachate was prepared by soaking 150 gm. of air dried senescent leaves each of *Jatropha curcas*, *Ricinus communis* and *Vetiveria zizanioides* in 1 liter of double distilled water for 48 hours at room temperature (25 ± 2^0C). The solution was filtered and made up to 1 liter by adding double distilled water (i.e.15%). The 15% leachates of *J. curcas, R. communis* and *V. zizanioides* were further diluted up to 10, 20 and 50 times with the double distilled water which is represented as J-1:10, J-1:20, J-1:50 for *J. curcas* leachate, R-1:10, R-1:20, R-1:50 for *R. communis* leachate and V-1:10, V-1:20 and V-1:50 for *V. zizanioides* leachate.

Healthy seeds of *J. curcas* and *R. communis* were disinfected with 0.1% $HgCl_2$ solution for 5 minutes and washed 5-6 times with distilled water to remove its traces. 30 healthy seeds (in three replicates) each for *J. curcas* and *R. communis* during June were allowed to germinate in different dilutions of *V. zizanioides* leachate (i.e. V-1:10, V-1:20 and V-1:50) in Petri plates filled with sterilized sand and saturated on alternate days with V-1:10, V-1:20 and V-1:50 leachates at room temperature under diffused light inside the laboratory. *V. zizanioides* plantlets of same size and age were grown in different dilutions of *J. curcas, R. communis* and *V. zizanioides* leachates (i.e. J-1:10, J-1:20, J-1:50, R-1:10, R-1:20, R-1:50, V-1:10, V-1:20 and V-1:50) in plastic glasses filled with sterilized sand and saturated at intervals of three days with the same solutions at room temperature inside the laboratory. Distilled water application was used as control.

Biochemical analyses of *V. zizanioides* plantlets with new leaf emerged (5-leaf stage to 6-leaf stage) were carried out for estimation of total chlorophyll (Arnon,1949), peroxidase activity (Maehly and Chance,1967), phenolics (Bray and Thorpe, 1954), total Sugars (Nelson,1944) and nitrogen (Snell and Snell,1967), for *J. curcas, R. communis* and *V. zizanioides* leachates pH, Organic Carbon (Datta, *et al,*1962), and Phosphorus (Olsen, 1954) were estimated in addition, and for the soil cat-ion exchange capacity was analyzed in addition.
Vigour index and Phytotoxicity percentage of seedlings and plantlets were estimated according to the following formula:

Vigour Index = % germination x total seedling length (Abdul-Baki and Anderson, 1973)
Phytotoxicity percentage:

$$\frac{\text{Root or Shoot length of control - Root or Shoot length of treatment}}{\text{Root or Shoot length of Control}} \times 100$$

3. RESULTS AND DISCUSSION:

The leachates were initially analysed for their biochemical status and *R. communis* leachates were recorded to be richest in % organic carbon, nitrogen and phenolics, whereas Vetiver leachates were richest in Phosphorus content and *J.curcas* leachates in sugar content.(Table 1.)

Table 1.Biochemical analyses of leachates

Leachates	pH	% O.C.	**Nitrogen** (mg/g D.wt.)	**Phosphorus** (mg/g D.wt.)	**Phenolics** (mg cinnamic acid eq./g D.wt.)	**R.S.** (mg/g D.wt.)	**NRS** (mg/g D.wt.)	**TS** (mg/g D.wt.)
Jatropha curcas	7.69	6.08×10^{-5} $\pm 8.76 \times 10^{-6}$	0.187 $\pm 9 \times 10^{-3}$	6.92×10^{-4} $\pm 3.27 \times 10^{-5}$	104.36 ±4.9	0.240 ±0.005	1.028	1.268 ±0.011
Ricinus communis	6.97	1.79×10^{-4} $\pm 1.63 \times 10^{-6}$	0.238 $\pm 2.8 \times 10^{-3}$	5.84×10^{-4} $\pm 1.31 \times 10^{-5}$	293.65 ±14.00	0.457 ±0.012	0.469	0.926 ±0.043
Vetiveria zizanioides	7.33	0.00	0.188 $\pm 1.4 \times 10^{-3}$	8.69×10^{-4} $\pm 6.78 \times 10^{-5}$	53.60 ±2.50	0.159 ±0.006	0.808	0.967 ±0.023

The initial biochemical status of the sterilized sand used as medium to grow *Jatropha* and *Ricinus* seedlings and vetiver plantlets, was also recorded (Table 2.).

Table 2. Biochemical analysis of sterilized sand

Sand	**pH**	**% O.C.**	**Nitrogen** (mg/g D.wt.)	**Phosphorus** (mg/g D.wt.)	**Phenolics** (mg cinnamic acid eq./g D.wt.)	**CEC** (m.eq./100g sample)
initial	7.82	1.073×10^{-5} $\pm 1.01 \times 10^{-6}$	0.059 ±0.009	3.075×10^{-4} $\pm 7.500 \times 10^{-6}$	13.48 ±8.83	33.58

The sand was saturated with the above leachates and distilled water imbibed seeds of *J.curcas*, *R.communis* and 5-leaf plantlets of *V. zizanioides* were sown in them. Increase in the length of 21 days old plantlets (with 6^{th} leaf emerged) was recorded for finding out the effect of different dilutions of these leachates. (Table 3.). Though overall, vetiver shoot length in all the leachates was less than distilled water controls and root length was more than distilled water controls. Interestingly, maximum increase in vetiver shoot length amongst all the treatments was attained in *J. curcas* leachates, though increasing dilution decreased the increase in shoot length. Minimum rise in shoot length occurred in *Ricinus* leachates. In root length maximum increase was recorded under vetiver leachates, which increased further by dilution of the leachate; *J. curcas* leachate was second in response, indicating supportive interaction of *J. curcas* with Vetiver (Plate-1).

Table 3.Increase in Shoot and Root length of *V. zizanioides* grown in different dilutions of *J. curcas*, *R. communis* and *V. zizanioides* leachates for 21 days

	***J. curcas* leachate**		***R. communis* leachate**		***V. zizanioides* leachate**	
Dilutions	Shoot	Root	Shoot	Root	Shoot	Root
Control	15	2.66	15	2.66	15	2.66
1:10	13.3	2.7	2.66	3.67	3.34	3.66
1:20	13	3	3.34	3.33	3.67	3.66
1:50	10.7	3.7	3.66	3.66	4.67	4.67

On the other hand, *J. curcas* seedlings also grew better than *R. communis* seedlings in vetiver leachates (Table 4., Plate-2). Dilution of the leachate increased the shoot length of J curcas seedlings upto V-1:50 dilution, though the vigour index decreased by 41.6% due to fall in germination percentage and root length. *R. communis* seedlings also grew better than controls upto V-1:20. This further indicates that Vetiver has moderate interaction with both the oil yielding fence plants.

Table 4. % Rise or fall in Shoot length, Root length and Vigour Index of *J. curcas* and *R.communis* seedlings in different dilutions of Vetiver leachate

	Shoot length		**Root length**		**Vigour Index**	
Dilutions	*J. curcas*	*R.communis*	*J. curcas*	*R.communis*	*J. curcas*	*R.communis*
Control	***	***	***	***	***	***
1:10	1.76	4.17	-0.86	-34.61	-39.4	-32.1
1:20	2.59	18.75	-14.26	-32.43	-41.6	-20.5
1:50	9.92	-3.13	-38.37	-31.99	-43.1	-26.2

Vetiver plantlets grown in *J. curcas* leachates accumulated phenolics in both root and shoot. However, nitrogen content of the roots too improved as compared to the controls (Fig 1.). In *R. communis* leachates only total chlorophylls were retained to some extent in the shoots but the roots accumulated phenolics only. In all other biochemical attributes vetiver plantlets declined as compared to the initial plantlets (Fig.2.). In its own leachates, *Vetiveria* plantlets exhibited increase in chlorophyll in the shoots with increasing dilutions of leachates, alongwith increase in phenolic content of the roots. Total nitrogen in the roots also increased as in case of vetiver root in *Jatropha* leachates (Fig.3.).

The soil (sand +leachate) in these sets also underwent certain changes during vetiver plantlet growth. In *J.curcas* leachate added soil organic carbon (O.C.) and phosphorus (P) increased and nitrogen (N) and phenolics decreased with dilution of leachate (Fig 4). In contrast, in *R.communis* leachate added soil, nitrogen too, increased, although increase in organic carbon and phosphorus was not as much (Fig 5). In vetiver leachate added soil, maximum increase in O.C., N and P occurred, although, with increasing dilution of leachates, nitrogen and phosphorus decreased (Fig 6.) CEC increased in J-1:50, V and R-1:10, 1:20 added soil. pH increased in R-1:10 and V-1:20 and 1:50 added soil.

So far, little information on allelopathic interactions of Vetiver is available. In Thailand, some allelopathic exploration of Vetiver as preventing invasion of weeds has been carried out (Techapinyawat, *et al*. pdf). Besides, Mao *et al* (2004 and 2006) have also reported vetiver to be insecticidal and weedicidal due to the presence of nootkatone1, a sesquiterpene, with minimum inhibition of growth of crop plants like *Pisum sativum* and Citrus. For water treatment vetiver is reported to be a cleanser due to absorption of most metal ions, phosphorus and bactericidal activity (Srivastava *et al*, 2007). For soil health maintenance vetiver grass strips (VGS) have been proposed by agricultural planners (Okon and Babalola, 2006) due to increase in soil pH, organic carbon and nitrogen, though phosphorus has been reported to reduce in VGS planted soil. In our study phosphorus availability also increased in the soil with addition of vetiver and J. curcas leachates (Fig.4 and 6). The increase in phenolic content in the plants along with decrease of phenolics in the soil indicates positive interaction of vetiver in general, with oil yielding plants, reducing the amount of growth inhibiting phenolics, added through leachates, from the soil. Putnam *et al.* (1989) have reported presence of phenolics to be growth inhibitory for several plants.

These results indicate soil health maintenance with sustainable growth of Vetiver to occur with *J.curcas*, rather than with *R. communis*. Besides, the growth of *R. communis* is reduced in vetiver leachates as compared to *J. curcas*.

However, interaction of vetiver needs to be studied with non-oil yielding plants (crop plants and trees) too, which are commonly grown in areas of thick vetiver plantation.

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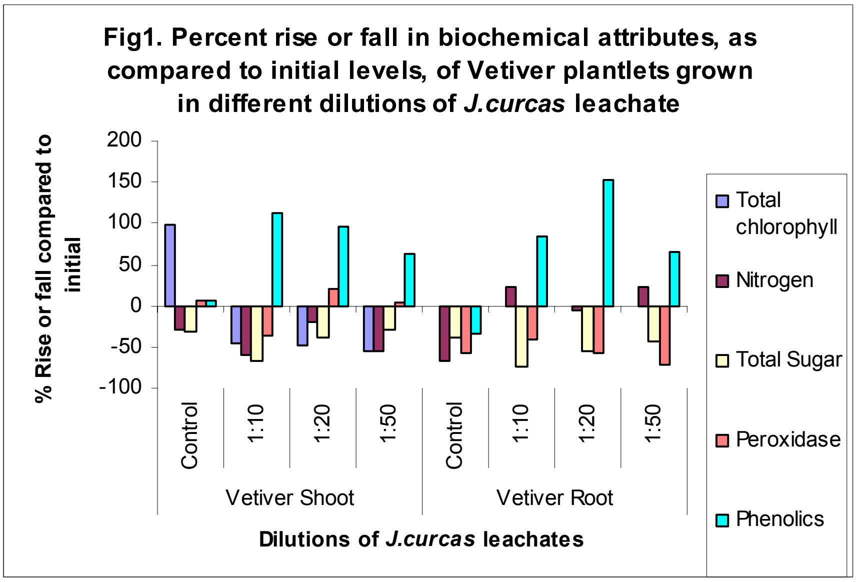

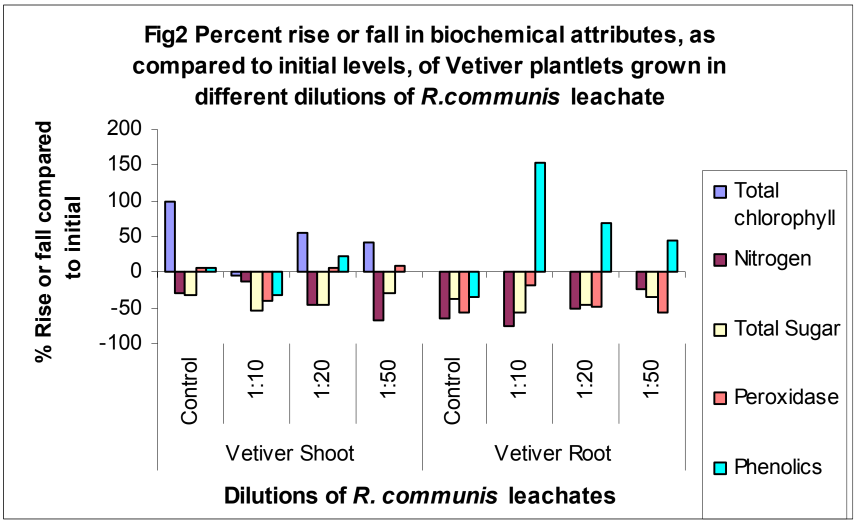

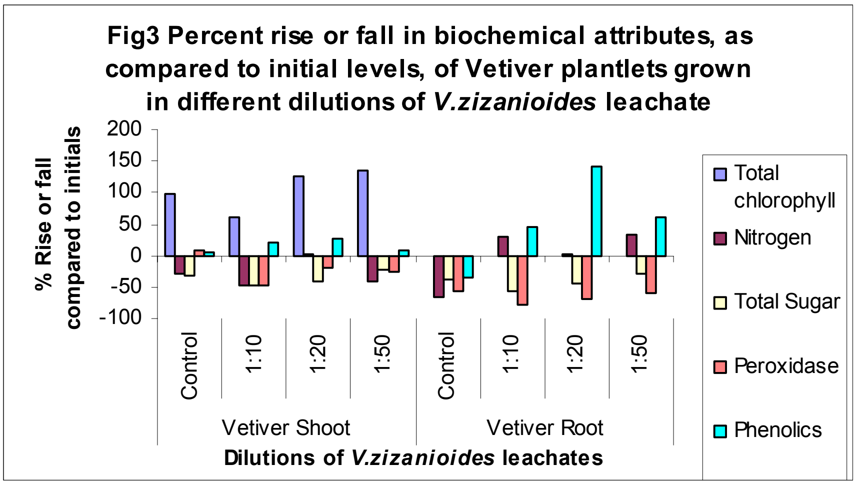
Fig3 Percent rise or fall in biochemical attributes, as compared to initial levels, of Vetiver plantlets grown in different dilutions of V.zizanioides leachate
% Rise or fall compared to initials
200
150
100
50
0
-50
-100
Control
1:10
1:20
1:50
Control
1:10
1:20
1:50
Vetiver Shoot
Vetiver Root
Dilutions of V.zizanioides leachates
Total chlorophyll
Nitrogen
Total Sugar
Peroxidase
Phenolics

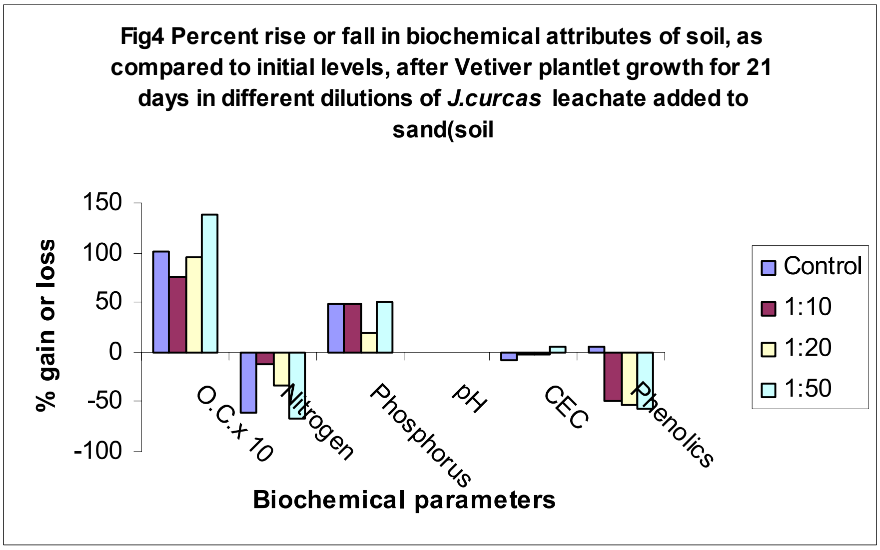
Fig4 Percent rise or fall in biochemical attributes of soil, as compared to initial levels, after Vetiver plantlet growth for 21 days in different dilutions of J.curcas leachate added to sand(soil
% gain or loss
150
100
50
0
-50
-100
O.C.x 10
Nitrogen
Phosphorus
pH
CEC
Phenolics
Biochemical parameters
Control
1:10
1:20
1:50

Fig5 Percent rise or fall in biochemical attributes of soil, as compared to initial levels, after Vetiver plantlet growth for 21 days in different dilutions of *R.communis* leachate added to sand(soil)

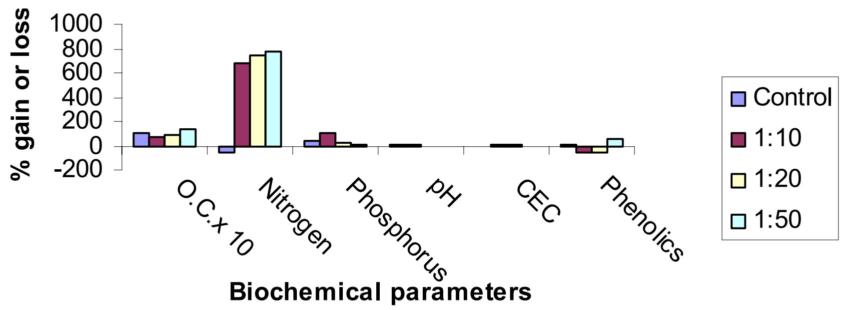

Fig6 Percent rise or fall in biochemical attributes of soil, as compared to initial levels, after Vetiver plantlet growth for 21 days in different dilutions of *V.zizanioides* leachate added to sand(soil)

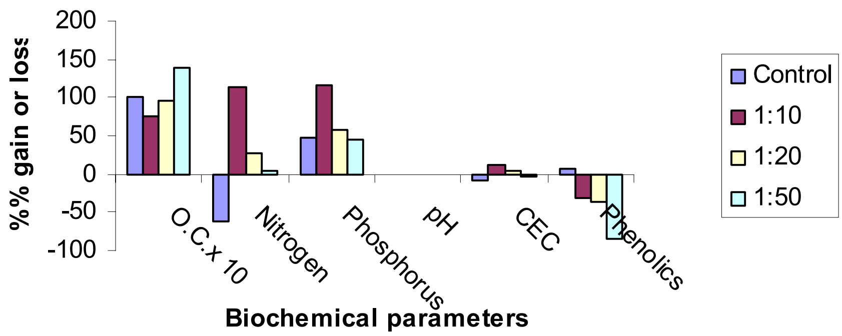

Plate-1. Growth of vetiver plantlets in *J.curcas*, *R.communis* and *V. zizanioides* leachates

Vetiver-Control

Vetiver in J-1:10, J-1:20, J-1:50

Vetiver in R-1:10, R-1:20,R-1:50

Vetiver in V-1:10, V-1:20, V-1:50

Plate-2. ***J. curcas* and *R. communis* Seedling growth in Vetiver leachates**

J. curcas -control

J. curcas in V-1:10,1:20,1:50

R. communis-

R. communis in V-1:10, 1:20, 1:50