

Effect of litter and leaf leachates of *Dendrocalamus strictus* on soybean and wheat crop under pot culture experimentation

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Abstract: The pot culture study was conducted to assess the effect of early age bamboo leaf litter and leachates/ aqueous extract of *Dendrocalamus strictus* on two popular agricultural crops of the Central India region i.e. *Glycine max* Linn. (Soybean) and *Triticum aestivum* Linn. (Wheat) to understand the suitability of intercrop under bamboo based agroforestry system in degraded agricultural lands in Jabalpur (Madhya Pradesh) India. Different applications of leaf litter quantity and leaf leachates concentration of i.e. 0.0, 1.0, 2.5, 5.0 and 10.0 per cent concentrations of *Dendrocalamus strictus* were used to study the effect on germination, number of tillers/ number of pods, plant height, root biomass, shoot biomass, grain yield and total biomass of both soybean and wheat crops. The results on pot culture of soybean in combination with *D. strictus* in sum revealed that in lower concentration had given a positive response on measured parameters and inhibitive response in higher concentration. Similar trend was also found in case of Wheat grown in combination with *D. strictus*, revealed that germination was inhibited significantly, however, the other measured parameters have shown a promoting response in the lower concentration and inhibitive in higher concentration equivalent of 200 g litter plus 10.0 per cent concentrations of bamboo leaf leachates per pot. The pot culture bioassays study of litter and leachates of *Dendrocalamus strictus* indicates that the inhibitory effect was pronounced for higher litter and leaf leachates concentrations, whereas the lower litter and leaf leachates concentration addition showed stimulatory effect in some cases.

Key words: Bamboo leaf litter, leaf leachates, allelopathy, pot culture, *Dendrocalamus strictus*.

INTRODUCTION

Allelopathy refers to all biochemical interactions (stimulatory or inhibitory) between the plants, including microorganisms (Molisch, 1937, Willis, 2010). These allelochemicals influence the plant growth through the processes of cell division and cell elongation, phytohormones induced growth, mineral uptake, availability of soil phosphorus and potash, stomata opening and photosynthesis, respiration, phytotoxicity and soil sickness, etc which results in delayed or complete inhibition of germination, reduction plant population, stunted and deformed roots and shoots (Rice, 1979; Eyini *et al.*, 1989; Krishna *et al.*, 2003; Solanki *et al.*, 1999). The reduction in crop yields in agroforestry system is also one of the reason of allelopathic effects. Therefore, it is imperative to assess the tree-crop compatibility before establishment

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of agroforestry system of suitable tree-crop combination. In India bamboo is known as “poor man's timber” and is one of the most important plants for soil reclamation, paper and pulp, constructional purposes apart from use by 'Basods' (bamboo craftsmen) for manufacturing of items of day to day use. Bamboo plays an important role in countries plagued by erosion, interlocked bamboo rhizomes keep saturated top soil firmly in place (Tewari, 1992) and ample of data showing that presence of bamboo and tree decreases soil erosion but no direct evidence from agroforestry systems (Varmah and Bahadur, 1980; Nair, 1989; Young, 1989). This bamboo species is very well popular amongst the farming community in central India and the farmers retained or maintained either in bunds or in fields (Tewari, 1988). The two agricultural crops namely soybean (*Glycine max* Linn.) and wheat (*Triticum aestivum* Linn.) were very common in farmers' field in the Central India. The most of the deciduous tree species shed their litter and accumulated on the ground and enriched soil nutrient and release some organic substances or allelochemicals into the soil inhibits seed germination (Rice, 1979). The development of bamboo based agroforestry models will give higher economic returns to the farmers (Ashutosh *et al.*, 1996), improve the degraded soil, reduce gap between demands and supply the raw materials to the nation & industry and use for rural domestic purposes. The field observations exhibit the effect of trees and the agricultural crops is either positive or negative, possibly a result of either competition or allelopathy. This pot culture experiment will provide an understanding on the tree–crop effects and are essential to nullify the effect of competition, that too, without compromising the many aspects of natural agroforestry systems. This experiment helped in estimation of the optimum range of concentrations of plant extracts and decomposed litter of *Dendrocalamus strictus* for the agricultural crops. Therefore, the agricultural crops namely soybean and wheat were selected and tested against the effect of litter and leachates of *D. strictus* under the study to know the allelopathic effects on soybean and wheat.

MATERIALS AND METHODS

The potculture study was conducted to evaluate the influence of bamboo with fully and partly decomposed litters and fresh leachates on growth and yield of agricultural crops at TFRI, Jabalpur (MP). To analyze the soil phytotoxicity, the litter consisting of leaves and small twigs were collected from the three years old bamboo based agroforestry experiment laid at farmers field near TFRI campus, Jabalpur (MP) which was established in the year 1996. The litter was collected during 1999 and the air dried litter weighed 20 kg for *D. strictus*. They were decomposed in pits of 75 cm³, by adding 20 kg of soil, in the month of April 1999. Eight months later, the litter was partly putrefied, depending on the species. This mixture of litter and soil was taken in 16 pots @ 500 g litter-soil mixture per pot per experiment in 4 treatments and 4 replications and 2 pots in control free from litter soil mixture. Each pot was filled with 15 kg of soil sterilised with formaline. These pots were again treated with 25 g, 50g, 75g and 100g of dried and powdered fresh litter of current season in soybean, whereas 50, 100, 150 and 200 g in case of wheat. Then twenty five seeds of these crops were sown per pot. The studies were conducted on the JS-335 variety of soybean and wheat Lokman. The control was not treated with any litter-soil mixture or current season litter. The

leachates of fresh samples (felled leaves and culm sheath) prepared by taking crushed bamboo leaf and sheath into powder and leachates of 0.0, 1.0, 2.5, 5.0 and 10.0 per cent concentration was prepared by taking 0.0g, 1.0g, 2.0g, 2.5g, 5.0g and 10.0g of powdered litter and prepared the leachates of respective concentration by dissolving each in 100 ml of distilled water separately to prepare the leachates of 0.0, 1.0, 2.5, 5.0 and 10.0 per cent concentrations respectively and kept each concentration separately for filter through Whattman Filter paper No. 1. and filtered extracts stored in the refrigerator. These extracted leachates were applied in the pot at the time of sowing. The size of the pots was 40 cm in diameter and 50 cm in height for soybean and 50 cm diameter and 50 cm height for wheat. The number of seeds germinating every day was recorded for 28 days and germination per cent was calculated. Average length of radicle and plumule was also calculated along with its dry weights. The growth parameters studied under pot culture experiments were germination (%), density, number of tillers/ number of pods, plant height, root biomass, shoot biomass, grain yield and total biomass

Statistical design

In the pot culture experiments, four treatments and control were employed with four replications. The data were recorded on all parameters by taking means of atleast five plant samples. The data were subjected to ANOVA in randomized complete block design as given by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The data obtained on addition of well decomposed litter, freshly dried powdered litter and whole plant aqueous leachates of *D. strictus* were tabulated in Tables 1 and 2 for soybean and wheat crop respectively. Since the data revealed no variation between the species exhibiting same trends as evident from bioassay studies, only *D. strictus* has been repeated in the second year and the same data has been presented for the sake of brevity.

Table 1: Potculture studies of soybean (*Glycine max* Linn.) in combination with fresh aqueous leachates of Bamboo (*Dendrocalamus strictus*) in various concentrations

Treatments Powdered litter + fresh aqueous leachates in %	Germination percent	Mean height (cm)	Number of pods per plant	Number of seeds per pod	Grain yield (g/pot)	Root biomass (g)	shoot biomass (g)	Root shoot ratio	Total biomass (g)
T1 (25.0 g + 1%)	90.00	33.00	6.53	2.25	6.82	3.29	15.59	0.211	18.88
T2 (50.0 g + 2.5%)	78.00	32.45	7.29	2.15	6.58	3.54	16.75	0.211	19.25
T3 (75.0 g + 5.0%)	69.00	26.85	5.85	2.01	4.69	2.63	13.50	0.195	16.13
T4 (100 g + 10.0%)	61.00	22.10	5.21	1.80	3.25	2.09	11.95	0.175	14.04
T0 (Control)	98.00	30.50	6.12	2.04	4.79	4.02	12.57	0.320	16.59
SE (m) ±	2.066	1.152	0.927	0.045	0.593	0.259	0.672	0.056	0.318
CD (0.05)	4.50	2.56	2.04	0.10	1.29	0.57	1.48	0.123	0.70

Table 2: Potculture studies of wheat (*Triticum aestivum* Linn.) in combination with fresh aqueous leachates of Bamboo (*Dendrocalamus strictus*) in various concentrations

Treatments Powdered litter + fresh aqueous leachates in %	Germination Per cent	Mean height (cm)	Number of Tillers per plant	Number of seeds/ spike	Grain yield (g/pot)	Root biomass (g)	Shoot biomass (g)	Root shoot ratio	Total biomas s (g)
T1 (50.0 g + 1%)	24.00	35.00	4.25	25	38.25	22.08	73.59	0.230	95.67
T2 (100.0 g + 2.5%)	23.50	40.50	5.00	26	46.47	23.38	80.55	0.225	103.93
T3 (150.0 g + 5.0%)	21.75	45.75	4.25	24	34.17	15.04	61.71	0.196	76.75
T4 (200 g + 10.0%)	18.75	34.45	4.00	20	21.96	10.22	47.18	0.178	57.40
T0 (Control)	25.00	28.25	2.00	12	10.80	10.77	29.12	0.275	39.89
SE (m) +	1.259	2.232	0.129	0.541	2.593	0.495	4.466	0.055	8.522
CD (0.05)	2.74	4.76	0.28	1.18	5.64	1.06	9.52	0.12	18.54

Root and shoot weights are recorded on oven dry weight basis, grain yield is the yield in grams at 12 percent moisture approximately

Pot culture study of Soybean

The following parameters have been studied on soybean crop treated with litters partly of well decomposed and partly of dried and powdered fresh litter and aqueous leachates of *D. strictus* in different concentrations such as 25 g powdered litter + 1.0 per cent concentration of fresh aqueous whole plant leachate (T1), 50 g powdered litter + 2.5 per cent concentration of fresh aqueous whole plant leachate (T2), 75 g powdered litter + 5.0 per cent concentration of fresh aqueous whole plant leachate (T3) and 100 g powdered litter + 10.0 per cent concentration of fresh aqueous whole plant leachate (T4) and Control (T0). The results are tabulated in Table 1 and presented in the following heads:-

Germination percent

The data on germination percent reveals that it was found maximum (98.00 %) in control and was significantly superior to all others and minimum of 61.00 per cent in highest treatment concentration. However, the germination per cent decreased gradually with an increase in the treatment concentration.

Plant height

The man height of soybean plants reached a maximum of 33.00 cm in T1 and was found to be at par with T2 and also control. As the concentration increased from control the height increased upto T2 (2.5% leachate+50 g litter) and T3 (5% leachate+75 g litter) afterwards the height had recorded a decline.

Number of pods per plant

The number of pods per plant was found to 6.12 in control. The pods per plant increased in lower concentration of treatments upto T1 (1.0% leachate+25 g litter) and T2 and (2.5% leachate+50 g litter) where 7.29 pods per plant were recorded. Whereas, further increase in treatment concentration has caused a decrease in the number of pods per plant significantly upto 5.21 pods in T4 (10.0% leachate+100 g litter).

Number of seeds per pod

The number of seeds per pod was 2.04 in control. The number of seeds per pod increased in lower concentration of treatment upto 2.25 seeds per pod in T1 (1.0% leachate+25 g litter) and as the concentration increased the number of seeds per pod decreased reaching a low of 1.08 seeds per pod in the highest concentration of T4 (10.0% leachate+100 g litter).

Grain yield

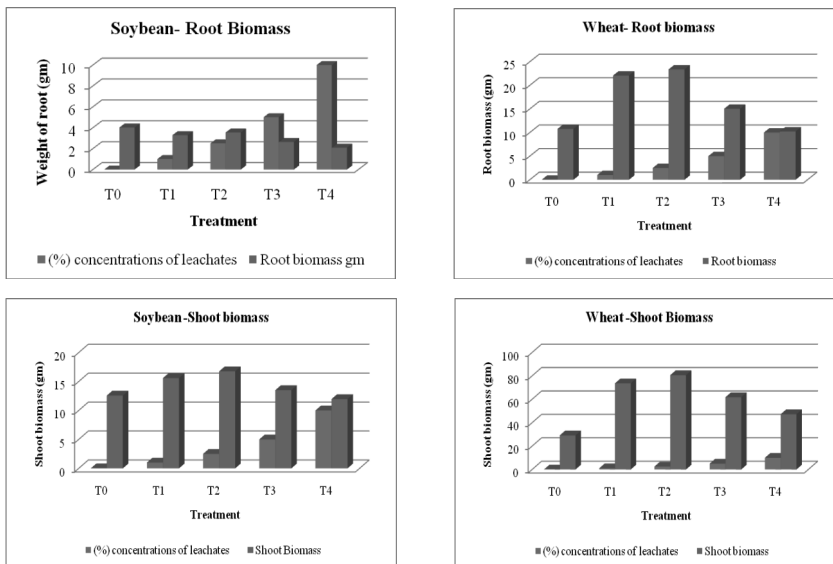
The grain yield per pot was observed to be maximum in T1 at 6.82 g/pot. With a further increase in concentration above this level, there was a decrease in the grain yield that was found to be statistically significant. The treatment T4 recorded the lowest yields of soybean at 3.25 g per pot.

Root biomass

The root biomass increased upto T2 (2.5% leachate+50 g litter). However, higher concentration suppressed the biomass. It is evident from the Fig. 1

Shoot biomass

The shoot biomass increased from control upto T2 concentration (2.5% leachate+50 g litter) exhibiting a maximum of 16.75 g biomass per pot. The Fig. 1 showed trends of shoot biomass performance in different treatments.



D. strictus in different concentrations of fresh aqueous whole plant leachate
 T1- 25 g powdered litter + 1.0 per cent concentration
 T2- 50 g powdered litter + 2.5 per cent concentration
 T3- 75 g powdered litter + 5.0 per cent concentration
 T4- 100 g powdered litter + 10.0 per cent concentration

D. strictus in different concentrations of fresh aqueous whole plant leachate
 T1- 50 g powdered litter + 1.0 per cent concentration
 T2- 75 g powdered litter + 2.5 per cent concentration
 T3- 100 g powdered litter + 5.0 per cent concentration
 T4- 150 g powdered litter + 10.0 per cent concentration

Figure 1: Performance of soybean and wheat influence by the bamboo leaf leachates

Root shoot ratio

The ratio gives directly the proportions of plant by composition into root and shoot. The ratio also reflects budgeting of biomass into root or shoot depending on crops' need. The more the value of the ratio the more is the biomass allocation into the root which also indicates the poor fertility condition. The bigger ratio is found in control where the root system may be spreading in search of nutrients more and more. Since the soil used in pots was free from humus and micro-organisms. The smallest ratio value was recorded in the highest concentration of litter and leachates.

Total biomass

The pattern of response in total biomass was quite similar to root and shoot biomass. The maximum observed in T2 at 19.25 g per pot where as the minimum 14.04 g per pot in T4. The greater concentrations have however, recorded a significant fall in total biomass over control.

Pot culture study of Wheat

The following parameters have been studied on Wheat (*Triticum aestivum* Linn.) crop treated with litters partly of well decomposed and partly of dried and powdered fresh litter and aqueous leachates of *D. strictus* in different concentrations such as 50 g powdered litter + 1.0 per cent concentration of fresh aqueous whole plant leachate (T1), 100 g powdered litter + 2.5 per cent concentration of fresh aqueous whole plant leachate (T2), 150 g powdered litter + 5.0 per cent concentration of fresh aqueous whole plant leachate (T3) and 200 g powdered litter + 10.0 per cent concentration of fresh aqueous whole plant leachate (T4). The results are tabulated in Table (2) and presented in the following heads:-

Germination percent

The data on germination percent reveals that it was found to be maximum (100 %) in control and was significantly superior to all others. However, the germination percent decreased gradually with an increase in the treatment concentration. The treatment means were significantly different from one another.

Mean plant height

The height of wheat plants reached a maximum of 45.75 cm in T3 and was found to be superior to all other treatment means. The lowest height was found in control. The plant height increased upto 5.0 per cent leachate + 150 g litter (T3) and decline in 10 % leachate + 200g litter (T4).

Tillers per plant

The tillers per plant were lowest of 2.00 per plant in control (T0) whereas they increased upto a maximum of 5.0 per plant (T2) but with a further increase in treatment concentrations the number of tillers per plant decreased significantly though the tillers were more than in control.

Number of seeds per spike

The number of seeds per spike were 12 in control (T0) whereas maximum of 26 in T2 and further increase in treatment concentration has caused a decrease in the number of seeds per spike significantly upto 20 seeds per spike.

Grain yield

The grain yield per pot was observed to be maximum in T2 at 46.47 g per pot. With a further increase in concentration above this level, there was a decrease in the grain yield, which was found to be significant. The control recorded in lowest yields of Wheat.

Root biomass

It is evident from the data that the root biomass increased from T0 (Control) to T2 (100 g powdered litter + 2.5 %). However, higher concentration suppressed the root biomass (Fig. 2).

Shoot biomass

The shoot weight increased from T0 (control) upto T2 (100 g powdered litter +2.5%) concentration exhibiting a maximum of 80.55 g biomass per pot. The treatment effects on shoot biomass is presented in Fig. 2.

Root shoot ratio

The ratio gives directly the proportions of plant by composition into root and shoot. The ratio also reflects budgeting of biomass into root or shoot depending on crops' need. The more the value of the ratio the more is the biomass allocation into the root which also indicates the poor fertility condition. The bigger ratio is found in control where the root system may be spreading in search of nutrients more and more. Since the soil used in pots was free from humus and micro-organisms. The smallest ratio value was recorded in the highest concentration of litter and leachates.

Total biomass

The pattern of response in total biomass is quite similar to shoot biomass. The maximum was observed in T2 at 103.93 g per pot where as the minimum 39.89 g per pot in control. The greater concentrations have however, recorded a significant fall in total biomass so much so that T4 was at par with control.

It is also evident from the Fig. 1 that the trends of root and shoot biomass in pot culture studies that effect from bamboo leachates on soybean and wheat are in the same direction and also of same degree (.1). The results on pot culture of soybean in combination with *D. strictus* in sum revealed that though germination (%) was inhibited significantly, the other measured parameters have given a positive response to the lower concentration and inhibitive response in higher concentration equivalent

of 100 g powdered litter per 1256 sq cm surface area i.e., equivalent of 800 g per sq m of air dried litter (Table 1). This becomes 8.0 t per ha of litter. Similarly 25 g per pot means 2.0 t per ha of litter. It is possible to achieve so much litter only in a mature bamboo plantation where twigs and leaves can contribute so much at only a closer spacing or when the ground is fully occupied by bamboo clumps. Therefore, it becomes amply clear that by the addition of litter and leachates, no losses to crop yields can be anticipated well into full maturity and harvest of the crop. Therefore, any reductions in agricultural crop yields may well be due to physical factors such as shade or even competition for nutrients and or even moisture but not due to the chemicals released by bas evident from the pot culture study. These results follow the same trends due to bamboo leachates as reported by Tripathi *et al.* (1998) but differ in magnitude. They have reported that higher concentration (20%) of bamboo extracts promoted radicle and plumule lengths and nodulation in soybean under potculture.

The results on pot culture of wheat in combination with *D. strictus*, in sum, revealed that though germination was inhibited significantly, the other measured parameters have shown a positive response in the lower concentration and inhibitive in higher concentration equivalent of 200 g powdered litter per 1963 sq cm of surface area i.e., equivalent of 1018.85 g/sq m of air-dried litter. This becomes 10.19 t/ha (Table 2). It is possible to achieve so much litter only in a mature bamboo plantation at a higher density. Therefore, it is quite apparent that by the addition of litter and leachates, the losses to crop cannot be anticipated well into full maturity and harvest of the crop under field trials atleast due to allelochemicals. The primary effect of allelopathy could be a result from an association with plant litter in or on the soil. Allelochemicals are reported to be present in almost all plant tissue, stems, roots, leaves and fruit (Rice, 1979). These allelochemicals are released from the plant residues by different processes such as root exudation, leaching, decomposition and volatilization. Therefore, reductions in agricultural crop yields in higher concentration may well be due to accumulation allelochemicals on growing media which create hindrance in germination and some other plant growth parameter.

The findings soybean wheat were in line with earlier reports by Sharma *et al.* (1967) who reported that the germination per cent declined significantly, which was due to the effect of leachates. Reddy *et al.* (2000) reported similar trends in result of pot culture studies with rice and *Acacia nilotica*. Rao *et al.* (1994) and Sahai *et al.* (1999) in *Cajanus cajan* in combination with *Dalbergia sissoo*. The inhibition might have been due to the presence of allelochemicals as reported by Chaturvedi and Jha (1992). Melkania (1984) observed the different response of leachates of woody species on agricultural crops. The study revealed that the effect of litter and leaf leachates of *D. strictus* to be inhibitory to wheat and soybean seed germination while grain yield of soybean and wheat were found to increased with increase in quantity of litter and leachates whereas the high quantity of litter and leachates were found to be inhibitory for yield and other yield parameters. Some field studies reported that *Bambusa nutans* planted in the farm, increased yield of ginger, turmeric etc. whereas rice, soybean, finger millet etc. was found satisfactory (Singh *et al.*, 1992). Similarly bamboo

agroforestry models with arhar on eroded area was found successful (Karnataka, 1994).

CONCLUSION

Allelopathic effect of leaf litter and extracts in different combination and concentrations of *D. strictus* was tested in a laboratory experiment on soybean and wheat agricultural crops to understand the phytotoxicity. Significantly the highest suppression of soybean and wheat crop in germination percentage, shoot length, root length, root biomass, shoot biomass were obtained in the higher litter and concentration *i.e* 100 g powdered litter + 10% aqueous in soybean and 200 g powdered litter +10% aqueous in wheat. The inhibitory effect in germination (38%) and grain yield (32%) in soybean and (25%) in wheat germination was noticed. However, stimulatory effect was observed in lower concentration on some soybean and wheat growth parameters.

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