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Allelopathic Effect of *Dendrocalamus stocksii* (Munro.) on Growth and Yield of Paddy

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ABSTRACT

Present investigation was carried out to study the allelopathic effect of solid bamboo *Dendrocalamus stocksii* on growth and yield of paddy. Bamboo leaf leachate was prepared by soaking the dry leaves in tap water for 24 hours in a ratio of 1:10 weight by volume. The prepared leachate was diluted to three different concentrations *i.e.* 25, 50 and 75 per cent by adding tap water accordingly, thus there were five treatments of leachates (control, 25, 50, 75 and 100% concentration).In lab experiment, results revealed that the increasing concentration of the leaf leachates had inhibitory effect on growth parameters (germination, plumule and radicle length) of paddy *(Oriza sativa),* except the leachates of lower concentration (25 per cent concentration), which had stimulatory effect on plumule length, the effect was concentration dependent. In pot culture experiment the leaf leachates had both stimulatory and inhibitory effect on yield parameters. Stimulatory effect was observed for number of tillers per plant, number of seeds per panicle, test seed weight (except 100 per cent concentration), and straw yield per hectare as compared to control. While inhibitory effect was observed for number of panicles per plant, seed yield per plant (except 50 per cent concentration) and grain yield per hectare (except 50 per cent concentration).

Key words:

Agricultural crops, allelopathy, Dendrocalamus stocksii, leaf leachates, pot culture, paddy

INTRODUCTION

Agroforestry is a collective name for land-use systems and technologies, where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components (Nair 1993). In natural and man managed ecosystems, neighboring plants may interact with the growth and development of other species (Narwal and Tauro 1994). The interaction may be either positive or negative (Nair 1993). Plants are known to synthesize allelochemicals that affect germination, growth, metabolism, development, distribution, behavior, and reproduction of other organisms (Narwal et al. 1997). These allelochemicals impose a kind of environmental stress on other plants growing on vicinity, a phenomenon known as allelopathy.

Under the traditional agro-forestry system in Western Ghat bamboos are commonly grown with different Agricultural crops. *Dendrocalamus stocksii* (Munro.) solid bamboo is endemic to the Western Ghat of India and is mainly distributed between 12° to 17.5° North latitudes (Rane et al. 2013), and is an extremely manageable bamboo species with a great economic and ecological importance (Singhal and Gangopadhyay 1999) finding large scale utilization in scaffolding, pulp and paper, crafts, construction, making baskets, umbrella handles and poles. The non-prominent node and good culm wall thickness to culm diameter ratio (cw/cd) makes it the most suitable species for furniture and construction industry below 2 inch category. Owing to its solid thorn less nature of culms, it is maintained in field bunds/farm boundaries and in homesteads (Viswanath et al. 2012).

MATERIAL AND METHODS

The research was carried out at the Research Laboratory and Poly house of College of Forestry, Dr. B.S.K.K.V., Dapoli, Ratanagiri district of Maharashtra having Geo coordinates of 17°45' N latitude and 73°12' E longitude with an elevation of 250 m MSL during the year 2014-15. The climate of the study area is warm and humid with an annual rainfall ranging from 3000 to 3500 mm, minimum and maximum mean temperature was 17.81°C and 31.29 °C respectively. The average relative humidity (RH) was 74.21 per cent during the study period.

Dry leaves of Solid Bamboo *(Dendrocalamus stocksii)* were collected from Forestry Research farm of College of Forestry at Wakavali. Bamboo leaf leachate was prepared by soaking the dry leaves in tap water for 24 hours in a ratio of 1:10 weight by volume. The leaf leachates were filtered with the help of cheese cloth, and the leachates of different concentrations25, 50 and 75 per cent were prepared by adding tap water accordingly, thus there were five treatments of leachates (control, 25, 50, 75 and 100% concentration) with three replications in each treatment. Freshly prepared leachates were used on paddy. The seeds were surface sterilize with (0.1 % mercuric chloride) for one minute to remove the fungal spores then washing of seeds several times to remove the mercuric chloride. Germination trial was conducted on sterilize plastic trays; hundred seeds of paddy were placed in each tray containing single blotting paper. The required leachates were added as per the requirement of treatment.

To observe the effect the solid bamboo leaf leachates of different concentration on the yield of these test crops, seedlings of each crop was transplanted in poly pots, and the leachates of different concentration was allocated as per the requirement of treatments. The germination and yield trials were laid out in Complete Randomized Design (CRD) with five treatments;whereT_1 = Control treatment,T_2, T_3, T_4 and T_5,are the leachate of 25, 50, 75, 100 per cent concentration of bamboo leaves respectively, with three replications in each treatment. The data pertaining to growth and yield were analysed subjected to CRD and t-test, statistically using the Microsoft excel and SAS 9.3 (TS1MO) software program on computer (IASRI-11601386).

RESULTS AND DISCUSSION

Germination

The different treatments of leaf leachates significantly affected the germination percentage of paddy in various stages of germination. The germination percentage was progressively decreased with increase in the concentration of leachates (Table 1).At final day (15 DAS) maximum germination percentage was observed in control *i.e.* treatment T_1 treatment (98 per cent), while minimum in treatment T_5 (92 per cent)(Table 1).Maximum inhibitory effect leaf leachate on germination was observed 3 days after sowing (DAS) in all the treatments as compared to control; in general the effect of leachates was inversely related with increasing the DAS. After 11th DAS no effect of any treatment was observed on germination of paddy (Table 1).Present study revealed the leaf leachates of *D. stocksii* significantly hampered the germination (6.12 per cent), as compared to control. The effect of leaf leachates was concentration dependent.

Reduction in germination could be due to the allelochemicals present in leaf leachates of *D. stocksii.* Eyiniv et al. (1989) also reported six phenolic acids (chlorogenic, ferulic, coumaric, protocatechuic, vanillic and caffeic) in the fallen leaf extract of *Bambusa arundinacea* and suggested it responsible for the allelopathic effectson growth of seedlings of Arachis hypogaea. Tripathi et al. (1998) also reported the *Dendrocalamus strictus* extracts were rich in phenols, glycosides and flavonoids and free of sterols, amino acids, alkaloids, sugars and cyanogens. High performance liquidchromatography revealed the presence of 4 phenolic acids in bamboo leaves. The results are also supported by the findings of (Gynar 1991; Chou 1981; Kaletha et al.1996; Kaushal et al. 2003 and Jayakumar and Manikandan 2005).

Table 1. Effect of *D. stocksii* on germination percentage of paddy

Treatments	Days after sowing (DAS)							Mean
	3	5	7	9	11	13	15	
T_1Control	85.00	96.66	97.33	96.50	98.00	98.00	98.00	95.78
T_2(25 %)	77.00	95.66	97.00	97.33	97.33	97.33	97.33	94.14
T_3(50 %)	77.33	94.66	96.25	96.33	96.66	96.66	96.66	93.51
T_4(75%)	75.66	93.00	94.00	95.00	94.33	94.33	94.33	91.52
T_5(100%)	72.00	87.33	91.00	92.00	92.00	92.00	92.00	88.42
Mean	77.40	93.46	95.11	95.43	95.66	95.73	95.73	92.65
	SE m ±				CD 0.05			
Treatments	5.99				1.51			
DAS	5.99				1.78			

Plumule and Radicle length

Plumule and radicle length was significantly affected by leaf leachates of solid bamboo. It decreased with increase in the concentration of leaf leachates except in treatment T_2 (25 per cent concentration) where stimulatory effect of leaf leachates was observed on plumule length. Maximum plumule length was observed in treatment T_2 (10.97 cm) as compared to control treatment T_1 (9.90 cm), while minimum in treatment T_5 (7.04 cm) whereas concentration dependent decreasing effect on radicle length with increase in leachate concentration was observed. Control treatment was significantly superior in radicle length (8.55 cm) while minimum radicle length was recorded in treatment T_5 (2.68cm). The decreasing effect on plumule and radicle length might be due to allelochemicals present in bamboo leaf leachates. Stimulatory effect of lower concentrations of leaf aqueous extract of *Anogeissus latifolia* (1 per cent) on plumule length of *Vigna unguiculata* was also reported by Bhat et al. (2011); Kaushal et al. (2003) and Kaushal et al. (2011).

Plumule and radicle length progressively increased with advancement in the days after sowing (DAS) in all the treatments. At 3 DAS maximum plumule (0.42 cm) and radicle length (0.73 cm) were observed in treatment T_3, followed by plumule length (0.38 cm) and radicle length (0.60 cm) in control treatment, while minimum plumule length (0.23 cm) and radicle length (0.40 cm) were recorded in treatment T_5. At 5 DAS concentration dependent decreasing effect of various leachates was observed on plumule and radicle length of paddy, maximum plumule (1.95 cm) and radicle length (2.60 cm) were observed in treatment T_1, while minimum plumule length (0.78

cm) in treatment T_5 (Table 2) and radicle length (0.85 cm) was recorded in treatment T_4 (Table 3). The same order for both plumule and radicle length was observed for 7 DAS. From 9 DAS stimulatory effect of leaf leachates of mild concentration (25 % concentration) was observed on plumule length and continued up to for 15 DAS, while concentration dependent decreasing effect of bamboo leaf leachate on radicle length with increase in leachate concentration was observed up to 15 DAS. Present study is also agreed with Chou (1981), Gynar (1991), Kaletha et al. (1996), Jayakumar and Manikandan (2005), Bhatt and Todaria (1990), Tripathi et al. (1998), John et al. (1999), Kumar et al. (2006), Kaushal et al. (2006), and Lawan et al. (2011).

Table 2. Effect of *D. stocksii* leaf leachates on plumule length of paddy

Treatments	Days after sowing (DAS) (cm)							Mean
	3	5	7	9	11	13	15	
T_1Control	0.38	1.95	4.03	6.24	7.63	8.28	9.90	5.22
T_2(25 %)	0.33	1.69	3.81	6.53	8.55	9.33	10.97	5.99
T_3(50 %)	0.42	1.49	3.37	5.72	7.29	8.29	8.95	5.00
T_4(75%)	0.30	0.84	2.65	4.41	6.38	6.99	8.05	4.22
T_5(100%)	0.23	0.78	2.15	4.06	5.46	6.41	7.04	3.73
Mean	0.33	1.35	3.17	5.51	7.06	7.86	8.86	4.83
	SE m ±				CD 0.05			
Treatments	0.2				0.27			
DAS	0.2				0.32			

Table 3. Effect of *D. stocksii* leaf leachates on radicle length of paddy

Treatments	Days after sowing (DAS) (cm)							Mean
	3	5	7	9	11	13	15	
T_1Control	0.60	2.60	4.22	5.34	7.12	7.56	8.55	5.15
T_2(25 %)	0.58	1.51	3.55	3.76	5.12	5.73	6.57	3.85
T_3(50 %)	0.73	1.23	2.44	3.44	4.1	5.06	5.54	3.18
T_4(75%)	0.49	0.85	1.70	3.04	3.71	4.49	4.95	2.73
T_5(100%)	0.40	1.16	2.02	2.07	2.43	2.66	2.68	1.92
Mean	0.56	1.47	2.71	3.68	4.5	5.1	5.66	3.366
	SE m ±				CD 0.05			
Treatments	0.34				0.36			
DAS	0.34				0.43			

POT CULTURE

Number of tillers per plant

Maximum number of tillers per plant was recorded in treatment T_4 (5.33) while minimum in treatment T_1 (3.16). Statistically at par number of tillers per plant were recorded in T_4 (5.33), T_3 (5.08) and T_5 (4.91) which were significantly more than the treatment T_1 (3.16) and T_2 (4). Treatment T_1 and T_2 are at par with each other while treatment T_2 and T_5 were at par with each other. Stimulatory effect of leaf leachates on number of tillers per plant were observed in paddy as compared to control treatment. Bari et al. (2010) also reported

that the tiller number per plant of ginger considerably stimulated by the soil mulched with dry leaf of *sissoo* tree (+34.78%).

Number of panicles / plant

Different treatments of leaf leachates had no significant effect on the number of panicle per plant, maximum number of panicles per plant was recorded in treatment T_1 (7.13) while minimum in treatment T_3 (5.97), intermediate values was recorded in treatment T_5 (6.49), T_4 (6.36), T_2 (6.35).Number of panicles per plant was recorded more in control treatments as compared to all the pots treated with leaf leachates, maximum reduction was proposed by treatment T_3 (16.8 per cent), although proportionate inhibitory effect of leaf leachates was observed by (Jayakumar and Manikandan 2005; and Dongre et al. 2010).

Number seed per panicle

No significant effect of bamboo leaf leachates of different concentration was observed on number of seed per panicle, maximum number of seed per panicle was recorded in T_2 (50.80), followed by T_3 (46.87), T_5 (46.80), and T_4 (42.80) respectively, while minimum number of seed per plant was recorded in control *i.e.* T_1 (42.67). Numbers of seeds per panicle were observed more in all the pots treated with bamboo leachates as compared to control treatment.

Test Seed Weight

The data presented in Table 4 revealed that different treatments of leaf leachates have no significant effect on the weight of 1000 seeds (Test seed weight), maximum test seed weight was recorded in treatment T_2 (23.33 gm) while minimum in treatment T_5 (20.87 gm). Present study corroborate with Ebrahimand Deokule (2013) who reported that 1000 grain weight of Neda variety of rice was not significantly hampered due to different leachates of leaves, stem and root of paddy weeds viz. *Cyperus difformis, Echinochloa crusgalli, Paspalum paspaloides and Sagitaria trifolia.*

Seed yield per plant

Maximum seed yield per plant was recorded in T_3 (3.13 gm), while minimum in T_5 (0.44 gm), statistically at par seed yield per plant was recorded in treatment T_3 (3.13 gm), T_1 (2.23 gm), T_2 (2.18 gm) and T_4 (1.94 gm), which were significantly higher than treatment T_5. Present study is more or less similar to the findings of Gantayet et al. (2014) who had reported that the plants of control set yielded the maximum quantity of seeds and minimum seed yield per plant of green gram grown in 16% concentration of leaf-litter dust of *Lantana camara.* Jayakumarand Manikandan (2005) also reported minimum seed

Table 4 Effect of *Dendrocalamus stocksii* leaf leachates on yield of paddy in pot culture

Treatments	No. of tillers/ plant	No. of panicle/ plant	No. of seeds/ panicle	Test Seed Weight (g)	Seed yield/ plant (g)	Grain Yield (kg/ha)	Straw yield (Kg/ha)
T_1Control	3.16	7.13	42.67	21.00	2.23	743.10	900.60
T_2 (25 %)	4.00	6.35	50.80	23.33	2.18	723.90	939.40
T_3 (50 %)	5.08	5.97	46.87	22.90	3.13	1044.70	988.60
T_4(75%)	5.33	6.36	42.80	22.17	1.94	647.50	1211.10
T_5 (100%)	4.91	6.49	46.80	20.86	0.44	148.10	1088.6
Mean	4.50	6.46	45.99	22.05	1.98	661.46	1025.66
SE m±	0.24	0.25	2.07	0.59	0.27	89.16	64.82
CD @ 5%	1.03	1.06	8.89	2.52	1.15	382.45	278.04

weight per plant was recordedin20 per cent leaf extract of *Acacia leucopholea* as compared to control in groundnut and sorghum respectively.

Grain and straw Yield

Maximum grain yield per hectare was recorded in T_3 1044.7 kg/ha) while minimum in T_5 (148.1 kg/ha) statistically at par grain yield per ha was recorded in treatment T_4 (647.5 kg/ha), T_2 (723.9 kg/ha) and T_1 (743.1 kg/ha) which was significantly more than treatment T_5. The leaf leachates had both stimulatory and inhibitory effect on paddy yield per hectare. The bamboo leaf leachates had no significant effect on straw yield per hectare, maximum straw yield per hectare was recorded in T_4 (1211.1 kg/ha), followed by T_5 (1088.6 kg/ha), T_3 (988.6 kg/ha), T_2 (939.4 kg/ha), respectively, while minimum straw yield per hectare was recorded in control i.e.T^1 (900.6 kg/ha) which were statistically at par to each other.

CONCLUSION

From the results obtained, it is concluded that solid bamboo leaf leachates have maximum inhibitory effect on all the test crops in earlier growth stage (germination, radicle length and plumule length) rather than the final yield stage (after transplanting). The allelochemicals present in bamboo leaves works differently on various growth and yield parameters within the same crop. Higher concentrations (100 per cent) have inhibitory effect on various parameters rather than the low concentrations. Finally it is suggested that further study is needed to identify the responsible allelochemicals and to understand the combine effect of bamboo leaf leachates along with various environmental factors. In general early growth stage of paddy, bamboo leaf leachates had inhibitory effect rather than after transplanting the new seedlings in poly pots, it acts differently on different parameters of study.

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