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Studies on allelopathic effects of some agroforestry tree species on soybean

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ABSTRACT

The allelopathic effects of three agroforestry tree species viz mulberry, plum and pomegranate were tested by growing soybean crop for 30 days in pots containing field soil either mulched with leaves or irrigated with aqueous leaf extracts of the woody species. The maximum adverse effect on seed germination, germination relative index, vigor index, root length, shoot length and dry matter production of soybean was caused by leaf leachate after Hollis et al (1982) followed by leaf leachate obtained after Tukey and Mecklenberg (1964) and minimum by foliage mulched at the soil surface.

Keywords: Allelopathy; agroforestry; mulberry; plum; pomegranate; soybean

INTRODUCTION

Literature reveals that higher plants (tree crops) release some phytotoxins into soil which adversely affect the germination, growth and yield of crops. This type of tree-crop interaction was named phytochemical ecology/ecological biochemistry by Harborne (1977). Little attention has been paid to the tree-crop allelopathy but there are numerous reports in the literature indicating that the germination and biomass of herbaceous plants may decrease when grown under the influence of woody species (Rice 1979, Singh and Bawa 1982). The allelopathic effects are selective (Melkania 1983) and vary with different trees since these plants will vary in the amount of indigenous secondary metabolites and would release different amounts of the phytotoxins. Further the secondary compounds released from litter or formed by microbes decomposing the litter are influenced by the type of crop being leached or decomposed (Putnam and Duke 1978). In fact litter leaching and decay are the major pathways for the release of allelochems from plants (Tukey 1969). However there are several difficulties associated with rigorous research in allelopathy (Williamson 1990). Compared to forest trees, tree species found in farm land have been less investigated for allelopathic influences. There are many tree species grown around or in between cultivated fields in Himachal. These species are used as fuel, fodder or fruits by the local people. So there is a need to screen commonly grown tree species in agroforestry for their allelopathic influences. The present communication reports the results of experiment designed to determine the allelopathic effects of three agroforestry species namely mulberry, plum and pomegranate on soybean crop.

MATERIAL and METHODS

The study was conducted in the Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Solan, HP. The experimental site falls in the mid-hill zone of the state at an elevation of 1,250 m amsl representing 30°51' N latitude and 76°11'E longitude. The climate of the area is transitional between sub-humid, sub-tropical to sub-temperate. The average annual temperature ranges from 3°C to 34°C. The area receives an average annual rainfall of 800-1,300 mm. The field soil used for growing soybean crop was sandy loam, slightly basic in reaction and medium in OC, available N, P and K. The allelopathic influence of agroforestry tree crops viz mulberry (*Morus alba* L), plum (*Prunus salicina* L) and pomegranate (*Punica granatum* L) was investigated on soybean (*Glycine max* L).

The soybean crop was grown in shallow pots filled with five kg of field soil and replicated thrice. The pots were maintained under controlled conditions and watered regularly. 5, 10, 20 and 40 per cent aqueous wash of fresh leaves of the tree crops was obtained after Hollis et al (1982) and Tukey and Mecklenberg (1964) and 100 ml of this extract was added to each pot before seed sowing. Similarly 5, 10, 20 and 40 g of foliage was mulched in the upper soil layer of the pots followed by addition of 100 ml of water before seed sowing. Seed germination was recorded after 24 hours interval upto 7 days till no more seed germinated occured. Germination relative index (GRI) was recorded after Srivastava and Sareen (1972) and vigour index (VI) after Abdul-Baki and Anderson (1973). Other seedling attributes such as root length, shoot length and dry matter production (measured after Holm 1954) of soybean crop were recorded 30 days after sowing.

RESULTS and DISCUSSION

Per cent germination, germination relative index, vigour index, root length, shoot length and dry matter production of soybean was maximum in control (T_{13}) as compared to various mulberry leaf leachates (T_1-T_8) and mulch (T_9-T_{12}) treatments (Table 1). While comparing treatments (T_1-T_{12}) maximum inhibitory effect on soybean growth and yield characters was observed in T_4 showing 53.33 per cent germination, 33.15 germination relative index, 1,845 vigour index, 6.33 cm root length, 28.18 cm shoot length and 8.20 g/plant dry matter production. However minimum inhibitory effect for per cent germination (73.33), vigour index (3982), root length (13.95 cm) and shoot length (40.32 cm) was observed in T_{10} and for germination relative index (49.28) and dry matter production (16.20 g/plant) in T_9.

Plum leaf leachate (T_1-T_8) and mulch (T_9-T_{12}) treatments influenced germination, growth and yield attributes of soybean adversely as compared to control (T_{13}). Among different leaf leachates and mulch treatments (T_1-T_{12}) treatment T_4 affected per cent germination, germination relative index, vigour index, root length and dry matter production to the highest extent with their respective value of 46.66 per cent, 31.73, 1,592, 6.48 cm and 8.05 g/ plant respectively whereas shoot length (27.15 cm) was most negatively affected by T_3. However least adverse affect on per cent germination (73.33), germination relative index (46.08), vigour index (3,545) and root length (12.56 cm) was observed in T_9 and for shoot length (37.15 cm) and dry matter production (13.85 gm/plant) in T_{10} (Table 2).

The allelopathic effect of pomegranate leaf leachate and mulching on soybean germination, growth and yield attributes was also found significant (Table 3). Among various leaf leachates and mulch treatments (T_1-T_{12}) T_4 exercised its most adverse effect depicting 40 per cent germination, 27.80 germination relative index, 1,168 vigour index, 5.06 cm root length, 24.12 cm shoot length and 7.82 g/ plant dry matter production. Minimum negative influence for root length and dry matter production was noticed in T_9 with their respective values of 13.27 cm and 15.90 g/plant respectively whereas T_{10} affected germination relative index (48.40), vigour index (3,985) and shoot length (41.52 cm) to the minimum.

Allelopathic effect of mulberry, plum and pomegranate leaf leachates and mulch on germination, germination relative index, vigour index, root length, shoot length and dry matter production of soybean was statistically significant (Table 1, 2, 3). All the parameters under study were higher in the control as compared to treatments thereby indicating the adverse effect of tree components on soybean crop. In general all the three tree species namely mulberry, plum and pomegranate influenced the soybean growth and yield parameters most adversely by leaf leachate after Hollis et al (1982) followed by leaf leachate obtained after Tukey and Mecklenberg (1964) and minimum by foliage mulched at the soil surface. Maximum adverse effect was observed with 40 per cent leaf leachate obtained after Hollis et al (1982) and minimum with 5 g foliage/pot as surface mulch. This can be ascribed to release of more phytotoxic natural products from 40 per cent leachate and corresponding less through 5 g foliage as mulch. The toxicity

Table 1. Allelopathic effect of mulberry on germination, growth and dry matter production of soybean

Treatment	Germination (%)	Germination relative index (GRI)	Vigour index (VI)	Root length (cm)	Shoot length (cm)	Dry matter production (g/plant)
T_1 (5% leachate, Hollis et al1982)	66.66	41.48	3262	10.56	38.34	15.08
T_2 (10% leachate, Hollis et al1982)	60.00	42.66	2612	10.75	32.73	13.73
T_3 (20% leachate, Hollis et al1982)	53.33	38.20	2142	7.65	32.50	10.41
T_4 (40% leachate, Hollis et al1982)	53.33	33.15	1845	6.33	28.18	8.20
T_5 (5% leachate, Tukey and Mecklenberg 1964)	66.66	47.33	3322	11.50	38.26	15.42
T_6 (10% leachate, Tukey and Mecklenberg 1964)	66.66	45.75	2978	10.15	34.50	14.18
T_7 (20% leachate, Tukey and Mecklenberg 1964)	60.00	46.12	2422	10.05	30.26	12.19
T_8 (40% leachate, Tukey and Mecklenberg 1964)	60.00	41.90	2380	8.75	30.90	11.82
T_9 (5 g foliage as mulch)	66.66	49.28	3585	13.78	39.93	16.20
T_{10} (10 g foliage as mulch)	73.33	48.32	3982	13.95	40.32	16.00
T_{11} (20 g foliage as mulch)	66.66	46.78	3316	12.25	37.48	15.10
T_{12} (40 g foliage as mulch)	66.66	46.20	3265	11.85	37.10	14.85
T_{13} (control)	73.33	51.40	4432	14.85	45.60	18.20
SEd	2.27	1.69	257	0.64	1.06	1.54
$CD_{0.05}$	4.68	3.48	530	1.32	2.18	3.18

Table 2. Allelopathic effect of plum on germination, growth and dry matter production of soybean

Treatment	Germination (%)	Germination relative index (GRI)	Vigour index (VI)	Root length (cm)	Shoot length (cm)	Dry matter production (g/plant)
T_1 (5% leachate, Hollis et al 1982)	60.00	41.52	2680	9.20	35.42	12.10
T_2 (10% leachate, Hollis et al1982)	53.33	39.15	2170	8.80	31.90	11.74
T_3 (20% leachate, Hollis et al1982)	46.66	34.41	1645	8.02	27.15	9.45
T_4 (40% leachate, Hollis et al1982)	46.66	31.73	1592	6.48	27.60	8.05
T_5 (5% leachate, Tukey and Mecklenberg 1964)	60.00	43.15	2872	10.25	37.55	13.78
T_6 (10% leachate, Tukey and Mecklenberg 1964)	53.33	38.80	2399	9.85	35.10	12.24
T_7 (20% leachate, Tukey and Mecklenberg 1964)	53.33	36.34	2140	8.54	31.54	9.75
T_8 (40% leachate, Tukey and Mecklenberg 1964)	46.66	33.25	1618	6.34	28.32	9.10
T_9 (5 g foliage as mulch)	73.33	46.08	3545	12.36	35.78	13.74
T_{10} (10 g foliage as mulch)	66.66	42.76	3178	10.45	37.15	13.85
T_{11} (20 g foliage as mulch)	60.00	43.26	2763	10.80	35.25	11.98
T_{12} (40 g foliage as mulch)	66.66	40.46	2870	9.80	33.18	11.25
T_{13} (control)	80.00	50.10	4406	14.20	40.88	15.73
SEd	1.95	2.86	237	0.77	1.33	0.97
$CD_{0.05}$	4.02	5.90	490	1.59	2.75	2.01

Table 3. Allelopathic effect of pomegranate on germination, growth and dry matter production of soybean

Treatment	Germination (%)	Germination relative index (GRI)	Vigour index (VI)	Root length (cm)	Shoot length (cm)	Dry matter production (g/plant)
T_1 (5% leachate, Hollis et al 1982)	53.33	39.05	2358	9.85	34.36	11.73
T_2 (10% leachate, Hollis et al1982)	53.33	33.51	2114	8.40	31.39	9.16
T_3 (20% leachate, Hollis et al1982)	46.66	31.89	1778	6.24	31.75	9.82
T_4 (40% leachate, Hollis et al1982)	40.00	27.80	1168	5.06	24.12	7.82
T_5 (5% leachate, Tukey and Mecklenberg 1964)	60.00	42.16	2945	11.80	37.28	15.38
T_6 (10% leachate, Tukey and Mecklenberg 1964)	66.66	40.48	3164	9.72	37.75	13.44
T_7 (20% leachate, Tukey and Mecklenberg 1964)	53.33	36.33	2204	9.10	32.18	11.90
T_8 (40% leachate, Tukey and Mecklenberg 1964)	53.33	36.20	2082	8.60	30.45	10.75
T_9 (5 g foliage as mulch)	73.33	48.06	3953	13.27	40.64	15.90
T_{10} (10 g foliage as mulch)	73.33	48.40	3985	12.80	41.52	14.35
T_{11} (20 g foliage as mulch)	66.66	45.20	3506	12.94	39.65	15.38
T_{12} (40 g foliage as mulch)	66.66	43.32	3190	11.10	36.73	13.20
T_{13} (control)	80.00	50.75	4522	13.50	43.25	16.72
SEd	2.11	1.60	306	0.68	1.77	1.14
$CD_{0.05}$	4.36	3.30	631	1.40	3.66	2.3

effect varied from one woody species to another. Melkania (1984) also observed the different response of leachates of woody species on agricultural crops and concluded that leachates from *Celtis australis* were phytotoxic to *Glycine soja.* Bhatt and Todaria (1990) and Bhardwaj (1993) also observed decrease in germination, growth and yield parameters of agricultural crops with leaf leachates of different tree species. Rice (1979) and Singh and Bawa (1982) found reduced germination and biomass of herbaceous plants due to allelopathic influence of woody species.

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