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Research Article

Comparative field performance of some agricultural crops under the canopy of *Populus deltoids* and *Ulmus wallichiana*

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ABSTRACT : The performance of some agricultural crops *viz.,* maize, beans and sunflower was evaluated under the canopy of *Populus deltoids* and *Ulmus wallichiana* at FOA, Wadura. The germination, growth and yield of the three test crops was suppressed under both the tree species. The reduction; however, decreased when the cultivation of test crops was continued for a period of three years. The inhibition potential generally followed the order of *P. deltoids* < *U. wallichiana* for maize and sunflower and *Populus deltoids*> *Ulmus wallichiana* for beans. The soil variables exhibited an appreciable increase, which could be related to accelerated decomposition of organic matter due to continuous soil working under the canopy of selected tree species. The chromatographic investigation of extracts shows that the soils under *Populus deltoids* and *Ulmus wallichiana* differed in their composition of phenolic acids and phenolic glycocides. The results further reveal that except for caffic acid, all other allelochemicals disappeared and were no longer recovered in soil samples obtained after second or third year of cultivation. The tree crop compatibility reported in this paper could thus be explored more precisely for improved management of traditional agro-ecosystems of Kashmir to increase the overall productivity of the land.

KEY WORDS : Allelopathy, Agroforestry, Phenolic acids, Phenolic glycocides, Growth performance, Yield

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INTRODUCTION

Agroforestry is relatively younger area of research wherein the productivity is governed by a complex number of factors. Apart from physical factors, the naturally occurring phenomenon of allelopathy is being viewed to play a crucial role in determining the success of tree - crop associations (Inderjit and Weston, 2001). Reports on allelopathic phenomena most frequently focus on effects that are readily observed under controlled conditions. However, studies on soil ecology; which have not received the attention it deserved, not only help to understand a particular mechanism, but are of greater scope to argue the exact phenomena of allelopathy in nature. These allelopathic components play an important role by influencing the growth and establishment of plants and availability of soil inorganic ions (Bowen and Rovira, 1999). However; after entering soil, allelochemicals encounter millions of microbes, which generally degrade them to less toxic forms (Cheng, 1989). Thus the presence of allelochemicals per sea does not necessarily demonstrate similar qualitative status that actually existed in the plant debris (Blum, 1998). The fate of a chemical in the soil environment will as such depend upon the kinetics and interactions of many processes in the course of time at a particular site under a set of natural conditions. Analyzing allelochemicals in the soil medium over a period of time will thus provide useful information about the interaction of these compounds in explaining the observed growth responses of

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recipient crops.

EXPERIMENTAL METHODS

The main aim of this study was to assess the tree crop compatibility in agroforestry system involving maize, beans and sunflower as agricultural crops and *Populus deltoids* and *Ulmus wallichiana* as tree components. The experimental plantations (11 to 13 year old) of *Populus deltoids and Ulmus wallichiana* located at Faculty of Agriculture Wadura were used to evaluate the performance of selected agricultural crops grown under their canopies. The study site is situated between 34° 17' N latitude and 74° 33' E longitude with 1590 m altitude at MSL. The seed sowing was done during first week of May in 10 × 10 m plots laid under the canopy of each tree species planted at a distance of 3 x 4 m. The experiment was replicated four times within the tree stands and suitable control plots of similar size were also laid out side the canopy in the open sunlight. The plots were irrigated once in every week and all the cultural practices were carried out as per the recommended package of practices for these crops under the temperate conditions of Kashmir.

To quantify changes in soil fertility status, the soil samples were collected from ten randomly distributed places under the canopy of each tree species. The soil samples were passed through 10-mesh sieve and immediately subjected to the analysis of some chemical properties. The soil pH was determined electronically in 1:2.5 soil water suspension. The readings were taken directly on century digital portable kit (model ck 704) after appropriate calibration. The organic carbon content of soil was determined by Walkley and Blacks Chromic acid digestion and rapid titration method (Piper, 1966). Available nitrogen, phosphorus and potassium were, respectively determined by alkaline permanganate method (Subbiah and Asija, 1956), molybdate blue method (Vogel, 1961) and thiozole yellow method (Young and Gill, 1951).

The identification of allelopathic compounds was carried out by paper chromatographic procedure modified by Kil (1992) from that of Lodhi and Rice (1971). For preparation of extracts about 500 g of soil was dispersed in 800 ml of distilled water for 1 hour and the mixture was centrifuged at 4 x 103 rpm for 20 minutes. The wet soil was transferred to a conical flask. 300 ml of methanol was added to it and the contents were shaked for 48 h at 25^0 C. The mixture was again centrifuged at 4 x 103 rpm for 20 minutes. About 350 ml of acetone was now added and the mixture was shaked for 48 h at 25^0 C and again centrifuged at 4 x 103 rpm for 20 minutes. The mixture was filtered to discard the soil. The extract was evaporated to dryness in rotary evaporator and residue was dissolved in 10 ml of acetone. The chromatograms developed were inspected under ultra violet light and compounds were marked.

EXPERIMENTAL RESULTS AND ANALYSIS

The results pertaining to performance of maize under the canopy of selected tree species are presented in Table 1. The data show that inhibition of germination of maize seeds was 10 per cent under *Ulmus wallichiana* and 5 per cent under *Populus deltoids*. There was a concomitant decrease in plant height and dry weight, with respective inhibition of 3 and 6 per cent under *Populus deltoids* and *Ulmus wallichiana*. Compared to control the flowering was prolonged by 8 days under *Ulmus wallichiana* and 6 days under *Populus deltoids*. The mean number of lines per cob was in order of 11.7 under *Ulmus wallichiana* and 13.4 under *Populus deltoids* as compared to 14 .3 recorded under control.

The number of seeds per cob was reduced by 14 and 10 per cent under *Ulmus wallichiana* and *Populus deltoids*, respectively as compared to 203 seeds/ cob recorded in plants under control. The decrease in the test weight of seeds was 12 and 8 per cent under the canopy of *Ulmus wallichiana* and *Populus deltoids*, respectively. Consequently the yield was also reduced under both the tree species with reduction of 18 and 9 per cent under the canopies of *Ulmus wallichiana* and *Populus deltoids*, respectively as against the average yield of 44.89 q/ ha recorded under control.

The data recorded for beans (Table 2) show that the germination, growth and yield of this crop were also reduced when sown under the canopies of selected tree species. The extent of decrease in germination was 8 and 4 per cent under

Table 1 : Performance of maize under the canopy of *Populus deltoids* and *Ulmus wallichiana*

Parameters	Control	*Populus deltoids*	*Ulmus wallichiana*
Germination (%)	94.21	89.63	84.66
Plant height (cm)	172.39	166.87	158.92
Dry weight g/ plant	283.17	264.70	251.09
Initiation of flowering	47.33	53.33	55.66
Lines per cob	14.33	13.43	11.71
Seeds per cob	203.32	183.55	174.92
Seed Test weight (g/1000 seeds)	208.76	191.29	184.10
Yield (kg/ha)	4489.20	4063.40	3692.55

The data in table represents pooled mean for three years

Populus deltoids and *Ulmus wallichiana*, respectively. Height of bean plants was declined by 13 per cent under the canopy of *Populus deltoids* and 5 per cent under *Ulmus wallichiana*. The reduction in plant dry weight was in order of 21 and 12 per cent under the canopy of *Populus deltoids* and *Ulmus wallichiana*, respectively. The initiation of flowering was prolonged by 3 days under the canopy of *Populus deltoids* and 7 days under *Ulmus wallichiana.*

The reduction in the number of pods/ plant was 11 per cent under *Populus deltoids* and 6 per cent under *Ulmus wallichiana*. The minimum decrease in the number of seeds per pod was 15 per cent under *Ulmus wallichiana* as compared to 4.04 seeds per pod recorded under control. The test weight of seeds was also inhibited with respective reduction of 6 and 3 per cent under the canopy of *Populus deltoids* and *Ulmus wallichiana*. The total yield declined to the extent of 14 per cent in plants grown under the canopy of *Populus deltoids* and 10 per cent under *Ulmus wallichiana* as compared to average yield of 1902.54 kg/ha recorded for control.

The microhabitat under the canopy of both the tree species proved to be more hostile for sunflower as compared to maize and beans (Table 3). Contrary to control the respective inhibition of 15 and 11 per cent was recorded under the canopy of *Ulmus wallichiana* and *Populus deltoids*. The retardation of plant height was in order of 25 and 14 per cent in plants grown under *Ulmus wallichiana* and *Populus deltoids*, respectively. The plant dry weight was reduced by 21 and 9 per cent under the canopy of *Ulmus wallichiana* and *Populus deltoids*, respectively. The initiation of flowering was prolonged by 9 days under *Ulmus wallichiana* and 6 days under *Populus deltoids*.

The results on quantitative evaluation of yield parameters of sunflower show that diameter of capitulum, number of seeds per capitulum, test weight of seeds and total yield were conspicuously reduced under the canopy of selected tree species. The maximum reduction in diameter of capitulum (20%) was recorded under *Ulmus wallichiana* and least (17%) under *Populus deltoids.* The least reduction of 9 per cent with respect to number of seeds/ capitullum was recorded under *Populus deltoids*. The test weight of seeds was 10 and 7 per cent less under *Ulmus wallichiana* and *Populus deltoids*, respectively. The yield of this crop was also retarded under both the tree species. The average yield was 20 and 13 per cent lower under *Ulmus wallichiana* and *Populus deltoids*, respectively as compared to 9.69 q/ha recorded under control.

The remarkable observation recorded during the study period was that the reduction in germination, growth and yield of all the selected agricultural crops during the third year was less compared to that of preceding two years of study (Annexure I). These results are completely reverse to that observed when the selected crops were exposed directly to the aqueous extracts were in the inhibition potential of extracts increased with increase in the age of donor plants (Anonymous, 2006). These results suggest that continuous soil working under

Table 2 : Performance of beans under the canopy of *Populus deltoids* and *Ulmus wallichiana*

Parameters	Control	*Populus deltoids*	*Ulmus wallichiana*
Germination (%)	88.84	81.94	85.13
Plant height (cm)	51.25	44.71	48.65
Dry weight g/ plant	32.78	25.67	29.80
Initiation of flowering	24.00	27.33	31.00
Lines per cob	10.66	09.53	09.98
Seeds per cob	04.04	03.19	03.42
Seed Test weight (g/1000 seeds)	397.13	373.42	386.23
Yield (kg/ha)	1902.54	1640.10	1718.29

The data in table represents pooled mean for three years

Table 3 : Performance of sunflower under the canopy of *Populus deltoids* and *Ulmus wallichiana*

Parameters	Control	*Populus deltoids*	*Ulmus wallichiana*
Germination (%)	92.57	82.15	78.98
Plant height (cm)	130.63	112.41	97.92
Dry weight g/ plant	74.96	67.68	58.93
Initiation of flowering	31.00	37.66	40.00
Lines per cob	14.48	11.97	11.61
Seeds per cob	405.21	368.61	350.53
Seed test weight (g/1000 seeds)	68.58	63.93	61.41
Yield (kg/ha)	972.15	845.72	777.67

The data in table represents pooled mean for three years

Annexure I : Performance of maize, sunflower and bean under the canopy of *Populus deltoids* and *Ulmus wallichiana*

Parameters	Control			*Populus deltoids*			*Ulmus wallichiana*		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year	1st year	2nd year	3rd year
Maize									
Germination (%)	90.96	93.66	95.33	83.19	90.66	94.00	75.86	84.66	92.33
Plant height (cm)	181.69	174.50	178.50	167.53	163.60	168.40	154.48	158.40	162.40
Dry weight g/ plant	268.85	281.42	296.37	246.68	262.96	282.26	229.15	254.26	268.19
Initiation of flowering (days)	46	47	49	52	54	54	54	56	57
No of lines per cob	14.22	14.00	14.50	12.99	12.80	14.10	9.90	11.40	12.80
No of seeds per cob	202.9	204.0	200.5	158.37	188.00	187.00	151.17	176.00	180.30
Seed test weight (g/1000 seeds)	190.27	214.50	219.37	177.24	191.95	202.07	174.54	182.78	193.27
Yield (kg/ha)	4396.68	4575.85	4483.92	3878.62	4080.17	4216.36	3396.30	3737.54	3945.19
Beans									
Germination (%)	82.36	90.33	62.66	73.67	83.66	87.00	76.18	88.00	90.66
Plant height (cm)	46.00	52.20	54.30	33.82	45.90	49.20	38.30	49.50	51.70
Dry weight g/ plant	27.47	33.64	35.26	20.79	26.84	29.03	24.52	29.45	31.85
Initiation of flowering(days)	23	25	24	26	27	29	29	32	32
No of lines per cob	11.10	10.00	10.50	9.17	9.33	9.90	9.95	9.66	10.20
No of seeds per cob	3.79	4.20	4.00	2.76	3.33	3.40	2.88	3.66	3.60
Seed test weight (g/1000 seeds)	389.61	368.54	430.29	365.30	344.65	407.64	376.09	359.92	420.56
Yield (kg/ha)	1845.49	1896.47	1956.67	1511.28	1650.24	1752.76	1609.80	1729.52	1809.21
Sunflower									
Germination (%)	88.62	95.00	93.00	80.05	81.66	84.00	77.89	78.33	80.33
Plant height (cm)	125.33	135.30	129.40	96.00	122.00	118.60	80.58	105.60	107.30
Dry weight g/ plant	69.06	79.42	76.07	56.89	73.51	71.16	45.27	65.86	65.37
Initiation of flowering (days)	32	31	30	36	38	39	38	40	42
No of lines per cob	13.68	14.80	14.70	10.13	12.60	12.90	9.93	12.10	12.50
No of seeds per cob	426.39	401.94	384.50	367.68	374.62	362.30	346.19	352.10	350.90
Seed test weight (g/1000 seeds)	60.76	69.89	74.19	54.51	66.04	70.58	50.98	64.27	68.15
Yield (kg/ha)	945.49	969.37	998.29	796.66	839.85	897.58	702.38	770.54	856.79

the canopy of trees may be a positive factor to improve microhabitat conditions for soil microbes which consume allelochemicals as carbon sources and thus reduce their bio-availability and/or degrade them to less toxic form (Blum, 1998), These results are also in agreement to those reported by Chou *et al.* (1981) who found that allelochemicals produced by plants are readily degraded under aerobic conditions.

The data on soil reaction and changes in available nutrients under the canopy of *Populus deltoids* and *Ulmus wallichiana* are presented in Table 4. These data reveal that

Table 4 : Allelopathic compounds in soil under the canopy of *Populus deltoids* and *Ulmus wallichiana* by paper chromatography during the study period

Chemical component	*Populus deltoids*			*Ulmus wallichiana.*		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year
Benzoic acid	+	+	-	+	+	-
Caffic acid	+	+	+	+	+	+
p-hydroxybenzaldehyde	-	-	-	+	+	-
Salicylic acid	+	-	-	+	-	-
Hyroquinone	-	-	-	+	+	-
Vanilic acid	+	-	-	+	-	-
Populin	+	+	-	-	-	-
Betulin	-	-	-	-	+	-

Table 5 : Soil reaction and status of available nutrients in soil under the canopy of various selected tree species

Plant species	pH (1:2.5)			OC (%)			Available N (ppm)			Available P (ppm)			Available K (ppm)		
	1st year	2nd year	3rd year	1st year	2nd year	3rd year	1st year	2nd year	3rd year	1st year	2nd year	3rd year	1st year	2nd year	3rd year
Populus deltoids	6.20	6.57	6.90	0.62	0.53	0.50	155.0	183.0	185.0	13.0	17.0	17.0	66.74	70.24	72.96
Ulmus wallichiana	6.74	6.90	7.15	0.69	0.60	0.49	160.0	190.0	198.0	15.0	18.0	22.0	72.80	88.71	90.40
Control	6.97	7.12	7.17	0.51	0.50	0.48	107.0	108.9	106.7	9.0	12.0	11.0	44.18	47.07	48.12

the soil fertility was remarkably rejuvenated under the canopy of both the selected tree species. While soil pH increased from 6.20 to 6.90 under *Populus deltoids* and 6.74 to 7.15 under *Ulmus wallichiana*, the OC respectively decreased by 19 and 29 per cent under the canopy of two species, The data further show that available N increased by 6 and 19 per cent, available P by 24 and 32 per cent and available K by 8 and 19 per cent under the canopy of *Populus deltoids* and *Ulmus wallichiana*, respectively. From the proceeding results it is clear that continuous soil working not only enhances the rate of decomposition of organic carbon but also improves the soil absorptive power and with the result allelopathic compounds leached in the soil are rendered less toxic by the process of adsorption.

The chromatographic investigation of extracts reveals that the soils under *Populus deltoids* and *Ulmus wallichiana* were composed of four identical phenolic acids, identified as: benzoic acid, caffic acid, salicylic acid and vanilic acid (Table 5). The two additional phenolic acids identified in the soils under *Ulmus wallichiana* included p-hydroxybenzaldehyde and hydroquinone. Among the phenolic glycosides and aliphatic hydrocarbons, populin was identified in the soil samples collected under the canopies of *Populus deltoids* and betulin in samples collected under the canopy of *Ulmus wallichiana*.

The results (Table 5) show that soils developing under the different species differed in their composition of allelopathic components. This variation in allelochemical composition in soils supporting different plant species can be partially explained by differences in litter properties among the species. The critical examination of data (Table 5) further reveals that except for caffic acid, all other allelochemicals disappeared and were no longer recovered in samples obtained after second or third year of cultivation under the canopy of these two selected broadleaved species. Hepperly *et al.* (1992) and Cheng (1992) have also stated that under natural conditions, residues can remain on the surface of soil for extended period with out any significant precipitation and their degradation increases with soil tillage and increase in soil pH.

The results of this study thus show that although allelopathic interactions persist in the field under agroforestry systems, the accumulation and phyto-toxicity of plant chemicals is highly dependent on soil factors especially those governing their rate of production, adsorption, desorption and degradation in soil. These allelopathic interactions reported in this paper could thus be explored more precisely for improved management of traditional agro-ecosystems of Kashmir to increase the overall productivity of the land.

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