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Impact of Multipurpose Trees on Productivity of Barley in Arid Ecosystem

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Abstract: In the arid region of Haryana, the effect of *Prosopis cineraria, Tecomella undulata, Acacia albida* and *Azadirachta indica* on the productivity of *Hordeum vulgare* (barley) was assessed. The yield and yield attributing parameters of barley increased under these tree species compared to those from areas devoid of trees. *P. cineraria* enhanced the grain yield by 86.0%, *T. undulata* by 48.8%, *A. albida* by 57.9% and *A. indica* by 16.8% over the control. Biological yield was also higher under the trees than that in the open area. The soils under different tree canopies were rich in organic carbon content, moisture availability and nutrient status (N, P and K). These trees improved the productivity of barley due to enhanced moisture and nutrients.

Key words: Arid, agroecosystem, barley, productivity, sand dune, vegetation.

The hot deserts of India cover about 12% of the total geographical area of the country. Crops often experience drought at some stage of growth and as a result, yields are generally low. The adverse effects of drought on crop yield are further accentuated due to the poor fertility status of the soils. To increase the productivity of such areas, the only course left is to plant trees along with crops/grasses. The plantation of multipurpose trees in arid regions helps to reduce wind erosion hazards, and makes crop production possible where cropping would otherwise be extremely difficult (Tejwani and Lai, 1992; Puri *et al.*, 1994). As information on tree-crop combinations in arid regions is scanty, the present study was carried out in the arid region of Haryana to see the effect of existing multipurpose tree species on the productivity of barley crop.

Materials and Methods

The study was carried out at a farmer's field in the village Balawas, Hisar district, bordering the Thar desert, (221 m altitude; 29°10′N latitude and 75°46′E longitude). The area is characterized by low annual precipitation (46.6 and 102.2 mm during the crop growing seasons of 1993-94 and 1994-95, respectively), high evaporation and extreme diurnal variation in temperature. Over 90% of the total annual rainfall is received between June and September. The landscape is gently undulating and the sand dunes are the dominant formation. The soil is loamy sand in texture having coarse sand (20.2%), fine sand (66.8%), silt (2.5%) and clay (10.5%), and is saline in reaction.

A 5 ha farm with scattered trees of *P. cineraria* (10 trees ha^{-1}), *T. undulata* (6 trees ha^{-1}), *A. albida* (3 trees ha^{-1}), and *A. indica* (3 trees ha^{-1}) was selected. Five trees of each species were selected in November, 1993, and their height, basal diameter, crown diameter and approximate age are presented in Table 1. Barley (*Hordeum vulgare*) variety C-138 was sown

Table 1. Mean height, basal diameter, crown diameter and age of different multipurpose tree species

Tree species	Height (m)	Basal diameter (cm)	Crown diameter (m)	Approximate age (years)
Prosopis cineraria	9.40	77.16	6.70	16
Tecomella undulata	5.50	43.33	4.13	10
Acacia albida	5.31	32.46	2.58	5
Azadirachta indica	8.22	50.17	4.41	8

in the first week of November in 1993 and 1994 under the tree species and in control under rainfed condition. The directions (east, west, north and south) were treated as four replications, and the samples of barley crop under the canopy of each tree were collected during second week of April by using 1 x 1 m quadrant. Since the results obtained during 1993-94 and 1994-95 were consistent within the tree species, only the mean values for the two years are reported here.

Random soil samples were collected at a depth of 0-50 cm (effective root zone) from midway between the main stem and the canopy edge (for under-canopy samples) and from open non-vegetated area. The samples were analyzed for their physicochemical characteristics following Kalra and Maynard (1991).

Results and Discussion

The available water content was maximum beneath the *P. cineraria* trees and minimum in the open field devoid of trees. Except *P. cineraria* and *A. albida*, the soil moisture content under all the systems varied significantly (Table 2). The results are in conformity with those of Aggarwal *et al.* (1976), Gupta and Saxena (1978) and Kumar *et al.* (1996). The organic carbon content of soil was 3 to 5-fold higher beneath the tree canopies than in the adjacent open field. Similarly, the available nutrients (N, P and K) were also higher in the vicinity of trees. The major source of addition of organic matter and nutrients to the soil was litter fall and decomposition of under storey vegetation. Among the tree species, the effect on soil properties was maximum under *P. cineraria*, followed by *A. albida* and *T. undulata*, and it was minimum under *A. indica*. Similar observations were also made by Skujins (1981), Marmillon (1986), Palm (1995) and Sanchez (1995).

All the crop parameters (plant density, number of culms, plant height, 1000-grain weight, grain yield and biological yield) were found to be maximum under the canopies of multipurpose trees as compared to those in the adjacent open area (Table 3). Plant density was more (100.35 m^{-2}) under *P. cineraria*, and the least (78.75 m^{-2}) in control plot. The number of plants per sq. m under *P. cineraria*, *T. undulata* and *A. indica* was significantly higher than that under *A. albida* and in open area. Similarly, the number of culms per sq. m was comparable under *P. cineraria*, *T. undulata* and *A. albida* but was significantly higher than that recorded under *A. indica* and in the area devoid of trees. 1000-grain weight recorded in all the agroforestry systems differed significantly with each other except

Table 2. Initial physico-chemical characteristics of the soil of study site in 1993

Soil property	Tree species				
	P. cineraria	*T. undulata*	*A. albida*	*A. indica*	Control
Available water (%)	5.11 b*	3.43 c	4.77 b	2.92 d	1.81 a
Organic carbon (%)	0.31 b	0.30 b	0.29 b	0.20 c	0.06 a
Available nitrogen (kg ha^{-1})	104.52 b	100.90 b	102.13 b	91.32 c	58.84 a
Available phosphorus (kg ha^{-1})	9.37 b	8.46 bc	9.12 b	7.75 c	5.62 a
Available potassium (kg ha^{-1})	220.08 b	216.41 b	218.38 b	210.77 b	190.44 a

*Values having the same letters within a line are not significantly different at 5% level.

those in *P. cineraria* and *A. albida* (Table 3). Higher test weight under *P. cineraria* resulted in higher grain yield beneath this tree (999 kg ha^{-1}), followed by *A. albida* (848 kg ha^{-1}), *T. undulata* (799 kg ha^{-1}) and *A. indica* (627 kg ha^{-1}). Significant variation was noticed in grain yield of barley under different systems except in *A. indica* and in the area without trees. Although biological yield was statistically equal under *P. cineraria*, *T. undulata* and *A. albida*, it varied significantly with that recorded beneath *A. indica* trees and in the area devoid of trees, which were statistically at par with each other.

The percentage performance of the crop for the six parameters studied revealed that the per cent increase in all the crop parameters was more under *P. cineraria,* followed by *A. albida* (except plant density) and *T. undulata*, and it was less under *A. indica*. The least increase in plant density under *A. albida* may be due to less seed

Table 3. Yield and yield attributing parameters of barley under the canopy of four multipurpose trees and in open area (mean of both years)

Soil property	Tree species				
	P. cineraria	*T. undulata*	*A. albida*	*A. indica*	Control
Plant density (m^{-2})	100.35 b*	99.00 b	87.75 a	97.65 b	78.75 a
	(27.43)**	(25.71)	(11.43)	(24.00)	
Number of culms (m^{-2})	321.75 b	276.75 b	292.50 b	222.75 c	149.85 a
	(114.71)	(84.68)	(95.19)	(48.65)	
Plant height (cm)	46.00 a	42.40 a	42.70 a	38.70 a	38.00 a
	(21.05)	(11.58)	(12.37)	(1.84)	
100 grain weight (g)	49.86 b	45.23 c	48.59 b	41.76 d	38.79 a
	(28.54)	(16.60)	(25.26)	(7.66)	
Grain yield (kg ha^{-1})	999.00 c	799.00 d	848.00 b	627.00 a	537.00 a
	(86.03)	(48.79)	(57.91)	(16.76)	
Biological yield (kg ha^{-1})	1918.00 b	1745.00 b	1806.00 b	1155.00 a	959.00 a
	(100.00)	(81.96)	(88.32)	(20.44)	

* Mean values having the same superscript horizontally are not significantly different at 5% level.

**Values in parenthesis are percentage increase in different parameters of barley over that of open area.

rate or proper seeding depth, because in this region the farmers generally broadcast the seed by hand. Seed drill is not used due to undulating topography and sandy soil. Maximum increase in yield and yield contributing parameters of barley beneath the *P. cineraria* trees may be due to its deep root system, higher availability of moisture and nutrients, and symbiotic relationship with adjoining crops. However, the low productivity of barley under *A. indica* was due to higher evapotranspiration, surface roots, tree-crop competition for moisture and nutrients, whereas in open area the low yield may be attributed to higher evaporation from soil surface.

These results clearly present evidence that the crop productivity is greater in the vicinity of trees compared to adjacent open areas. Aggarwal (1980) attributed the increased yield of pearl millet under *P. cineraria* and Singh (1987) of mung bean and clusterbean under *A. albida* and *P. cineraria* in arid conditions. Similarly Puri *et al.* (1994) reported increase in the productivity parameters of chickpea when grown with *P. cineraria* trees in desert ecosystem. Likewise, Palm (1995) and Sanchez (1995) reported higher yield of maize crop under *A. albida* trees in the desertic conditions of South Africa. The beneficial effects of trees assume greater significance from the fact that farmers holding small land can grow agricultural crops in association with multipurpose indigenous and exotic trees in arid regions. Thus, the maintenance of favorable soil moisture and improved soil physical and chemical conditions by the trees studied suggests that agroforestry is a viable system in arid areas to solve land management problems.

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