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Microclimatic studies in rainfed sorghum raised in alleys of different vegetative barriers

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ABSTRACT

Microclimatic studies in rainfed sorghum planted as an intercrop in the alleys of different vegetative barriers were made during 1995 and 1996 *kharif* seasons at the research farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Different vegetative barriers, viz. *Sesbania sesban, Leucaena leucocephela. Cajanus cajan Vetiveria zizanoides and Cenchrus ciliaris* showed pronounced effect on the microclimate of the sorghum crop. Lowered surface evaporation, maintenance of higher soil moisture regime, increased RH, lowered VPD and canopy temperature during flowering and grain filling stages of sorghum was brought about by different vegetative barriers in general and Sesbania and Leucaena barriers in particular. An increase in productivity of sorghum to the extent of 4.9 q ha^{-1}(32%) and 4.3 ha^{-1} (28%) was recorded under Sesbania and Leucaena, respectively, over unbarriered (Control) crop.

Key worlds : Microclimate, Sorghum, Vegetative barriers, Canopy temperature

Crop production in dryland areas is determined, besides other factors by the degree of harshness of both above and underground environment prevailing during the crop growth period. Recent studies in India and abroad have shown that crops grown in the alleys of vegetative barriers experience better environment for growth and development (Gupta *et al.*, 1984; Ramakrishna *et al.*, 1982).

A vegetative barrier when planted at right interval across the slope of land and managed properly not only helps to capture rainfall at the site of occurrence better but also helps to reduce environmental harshness by way of regulating temperature, humidity etc. (Huxley, 1984; Corlett *et al.*,1989). The present study was conducted to understand how and to what extent different vegetative barriers influenced the microclimate and productivity of rainfed sorghum grown on light textured eroded soil under semi-arid condition of central Uttar Pradesh.

MATERIALS AND METHODS

A field study was carried out on rainfed sorghum sown in the alleys of different vegetative barriers viz., (1) *Sesbania sesban,* (II) *Leucaena leucocephala,* (III) *Cajanus cajan,* (IV) *Vetiveria zizanoides,* (V) *Venchrus ciliaris* and (VI) control (unbarriered) during two consecutive *kharif* seasons of 1995 and 1996 at the research farm of Chandra Shekhar Azad University of Agriculture and Technology

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Kanpur. Different vegetative barriers seeds were sown in to raise across the slope in paired rows 0.5 m apart on plot border at a distance of 5.4 m during July, 1993 in north-south direction. The average heights of barriers during 1995 and 1996 years were 2.6, 2.7, 1.6, 1.3, 1.1 m, respectively.

The sorghum crop (cultivars viz. Varsha, CSV-13 and CSV-15) was sown on 1st and 5th July during 1995 and 1996, respectively. The average heights of Varsha, CSV-13 and CSV-15 varieties were 214, 153, and 204cm, respectively during both the years of experiment. The experimental field was sandy loam in texture having 30 percent water holding capacity, 0.25 percent organic carbon, 0.24 percent total nitrogen, 11.7 kg ha^{-1} available phosphorus 165 kg ha^{-1} available K_2O and 8.2 pH. The crop received a total rainfall of 621.9 mm and 741.8 mm (Table 1) during 1995 and 1996 crop growing seasons, respectively. Metal cans of two kilograms capacity covered with wire mesh which were kept at a distance of 2 m from the vegetative barriers in E-W (down wind) direction were used to record the evaporation. These cans were calibrated against stadard USWB class A pan evaporimeter. Evaporation was recorded by bringing the water level to a fixed point by adding water to the can. Knowing the volume of water added and cross section area of the can, the depth of water evaporation was calculated. The observations were recorded at 0800h daily starting from 30 days after sowing to maturity of the crop. Observations were also taken on air temperature, canopy temperature, humidity and vapour pressure profile at sorghum crop canopy height and at barrier height. Air temperature was measured at crop canopy and barriered canopy heights with the help of a dry-bulb and wet-bulb shielded thermometers fitted in wooden (adjustable height) stand. Canopy temperature was measured using an infra-red thermometer. Observations were recorded at 830, 1030 and 1430 hrs. For calculating of vapour pressure and relative humidity the dry-bulb and wet-bulb thermometers readings recorded at these hour were used. The values of vapour pressure and relative humidity were obtained from psychrometric table. The microclimate studies, however, were done in one replication only. Calibration factor for the experimental season between can and pan evaporation was found to be 6.17.

RESULTS AND DISCUSSION

Evaporation

The evaporation (weekly total) was minimum in crop having *Sesbania* barrier followed by *Leucaena* while the maximum rate was recorded under control crop during both the years (Fig. 1). *Cajanus cajan, Vetiveria, Cenchrus* grass barriers also recorded lower evaporation rates than control. These results are in accordance with those of Konstaninov and Struzer (1969) and Thiruvenkataswami and Dhandapani (1994).

Air temperature

The temperature noted at 1230 hrs and 0830 hrs were 32.2 to 38.2°C and 30.0 to 32.5°C respectively. Air temperature in barriered crop was slightly lower than the (unbarriered) crop at 0830 hrs. But at other hours it was a little higher in barriered crop compared to unbarriered crop both at flowering and grain filling stages of sorghum crop canopy height (Fig. 2). The differences recorded in air temperature at 1030, 1230 and 1430 hrs between *Seshaina* barriered and the

Table 1 : Weekly weather during the crop period (1995-1996).

	1995						1996					
Std. week	Rainfall (mm)	Atmospheric temp. (°C)		Mean relative humidity (%)	Wind speed (km hr⁻¹)	Evaporation (mm day⁻¹)	Rainfall (mm)	Atmospheric temp. (°C)		Mean relative humidity (%)	Wind speed (km hr⁻¹)	Evaporation (mm day⁻¹)
		Max.	Min					Max.	Min			
1	2	3	4	5	6	7	2	3	4	5	6	7
27	2.3	37.8	25.7	61	7.6	6.4	6.2	35.2	25.9	69	8.0	7.7
28	18.9	35.4	26.0	77	7.2	3.8	15.0	35.6	25.3	76	7.3	6.4
29	28.7	34.6	25.9	71	9.5	3.6	52.0	34.3	26.9	77	9.5	3.6
30	4.0	35.3	26.2	71	10.1	3.9	39.6	35.0	35.5	74	7.7	4.5
31	36.2	33.9	26.0	76	7.2	4.9	60.0	33.0	25.3	84	7.1	4.2
32	70.7	32.7	25.1	86	7.8	5.1	105.0	32.3	26.4	90	5.8	4.7
33	76.2	32.9	24.6	81	6.8	4.5	237.0	30.8	21.6	87	4.0	3.9
34	86.0	31.9	25.1	83	4.0	3.6	47.8	32.0	24.4	82	7.7	3.8
35	52.8	33.3	25.4	81	4.9	4.1	63.4	33.4	25.1	82	5.0	4.0
36	221.2	32.3	23.4	87	7.7	3.9	30.4	32.7	24.1	78	6.1	4.3
37	11.8	33.1	23.6	79	4.2	4.6	17.4	34.2	24.7	78	6.1	4.3
38	13.1	33.8	23.8	70	4.6	3.8	2.0	35.0	25.2	80	6.8	4.5
39	–	34.6	23.7	72	4.8	5.2	–	35.3	23.3	78	2.2	4.5
40	–	34.6	23.5	70	3.7	4.6	66.0	33.7	23.0	82	2.3	3.7
41	–	35.0	22.4	58	2.4	5.3	–	32.7	20.0	75	2.0	3.9
42	–	34.7	19.2	58	1.1	4.4	–	32.6	18.0	54	1.7	4.2
43	–	33.1	14.6	57	2.8	4.2	–	32.4	14.6	58	1.5	3.9
44	–	32.1	12.9	56	2.6	4.2	–	31.4	12.5	48	1.5	4.0
45	–	31.2	11.9	50	2.2	4.2	–	31.4	12.5	48	1.5	4.0
46	–	30.0	13.0	60	3.5	4.1	–	31.1	10.9	54	1.7	4.4
Total	621.9	–	–	–	–	–	741.8	–	–	–	–	–
Mean	–	35.3	22.1	70	5.3	4.4	–	33.1	22.2	75	4.4	4.5

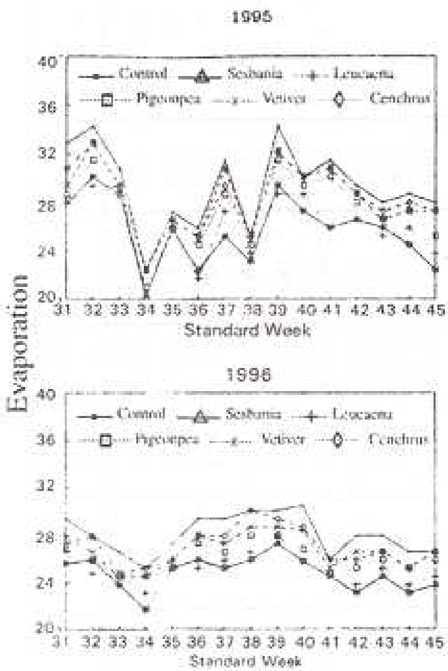

Fig.1 : Weekly evaporation in sorghum crop as influenced by various vegetative barriers.

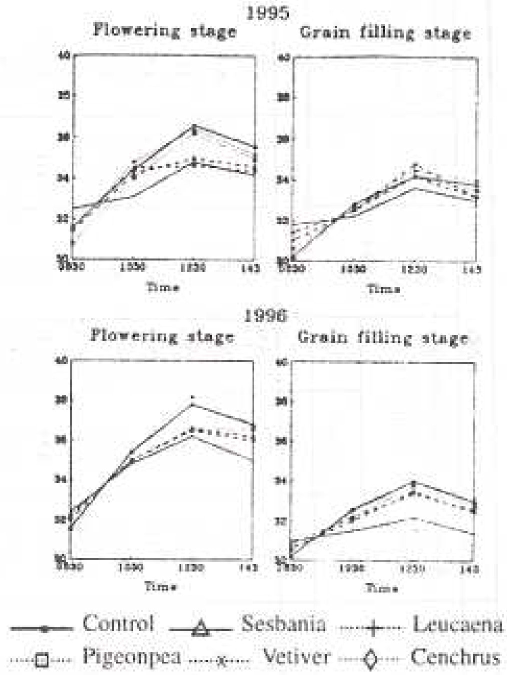

Fig.2 : Air temperature (°C) of sorghum canopy as influenced by various vegetative barriers.

control crop were 1.5, 1.7 and 1.6°C at flowering stage and 0.8, 1.2 and 1.2 °C at grain filling stage, respectively. Aase and Siddoway (1974) also reported a higher day time temperature ranging from 0.5 to 3°C in the leeward side of shelterbelt due to reduction in vertical diffusion and mixing of the air.

Canopy temperature

Wet and dry conditions prevailing at flowering and grain filling stages of sorghum, respectively, affected the changes in canopy temperature during the day. While the temperatures ranged from 29.8 to 35°C at flowering and 28.2 to 37.5 °C at grain filling stage in the barriered crop (Fig. 3), the crop under control (unbarriered) recorded slightly higher temperature at various heights in the crop canopy.

At flowering stage, the canopy temperature at top, middle and bottom of the unbarriered crop was higher by 2 °C at 0830 and 1030 hrs. as compared to barriered crop, but the trend was reversed at 1230 and 1430 hrs. Canopy temperature at grain filling stage was the lowest at 0830 hrs. at all heights of the barriered crops, but as the day advanced it gradually increased of maximum at 1230 hrs. and decreased slightly at 1430 hrs. The temperature differences may be attributed to

Table 2 : Grain and fodder yield (q ha^{-1}) as influenced by various vegetative barriers and varieties of sorghum.

Treatment	Grain (q ha^{-1})			Fodder (q ha^{-1})		
	1995	1996	Mean	1995	1996	Mean
Vegetative Barriers						
Control (unbarriered)	16.2	15.0	15.6	64.9	62.0	63.4
Sesbania sesban	20.2	20.9	20.5	80.0	84.9	82.4
Leucaena leucocephala	19.8	20.0	19.9	78.2	81.0	79.6
Cajanus cajan	19.1	19.5	19.3	74.7	76.0	75.3
Vetiveria zizanoides	18.8	17.6	18.2	71.9	67.7	69.8
Cenchrus ciliaris	17.6	16.5	17.1	68.9	64.3	66.6
C.D. at 5%	1.00	1.26	---	2.79	3.22	---
Sorghum Varieties						
CSV-13	18.7	18.3	18.5	70.9	67.5	69.2
CSV-15	16.0	15.9	16.0	63.3	65.9	64.6
Varsha	21.2	20.6	20.9	85.1	84.6	84.8
C.D. at 5%	0.86	1.23	---	2.46	3.22	---

differences in archetecture and height of different vegetative barriers.

The VPD was less than 14.3 mm of Hg at flowering stage compared to 33.4 mm at grain filling stage of sorghum (Fig. 4). All the vegetative barriers exhibited pronounced effect on VPD both at flowering and grain filling stages. During flowering stage VPD was higher in the barriered crop as compared to control (unbarriered) crop at 0830 hrs at all the heights of canopy but the trend was reversed at other times of the day.

Grain and stover yield

Grain and stover yield of sorghum as influenced by favourable micro-climatic conditions induced by different vegetative barriers is presented in Table 2. Sorghum crop yielded maximum with *Sesbania* barrier closely followed by *Leucaena* which gave significantly higher yield over grass barriers namely, *Vetiveria* and *Cenchrus*.

However, the barriers led to significantly higher yield over control. The differences in grain yield due to *Sesbania, Leucanea, Cajanus, Vetiveria* and *Cenchrus grass* over control were of the order of 4.0, 3.6, 2.9, 2.6, and 1.4 q ha^{-1} in the year 1995 and 5.9, 5.0, 4.6, 2.6 and 1.5 q ha^{-1} during 1996, respectively.

Higher yield of sorghum with vegetative barriers in general and *Sesbania* and *Leucaena* in particular over the control may be attributed to lower wind velocity, reduced air and canopy

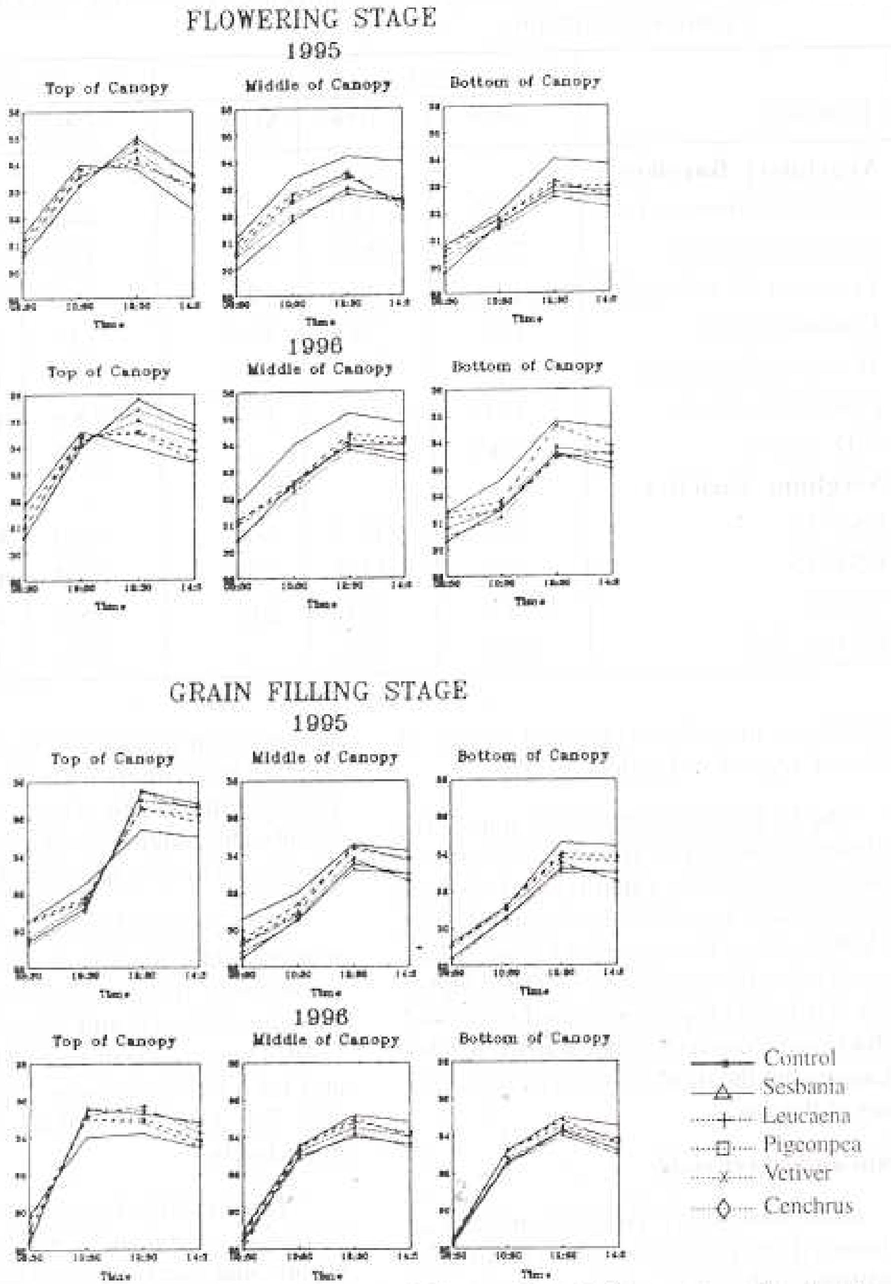

Fig.3 : Canopy temperature (°C) in sorghum as influenced by different vegetative barriers

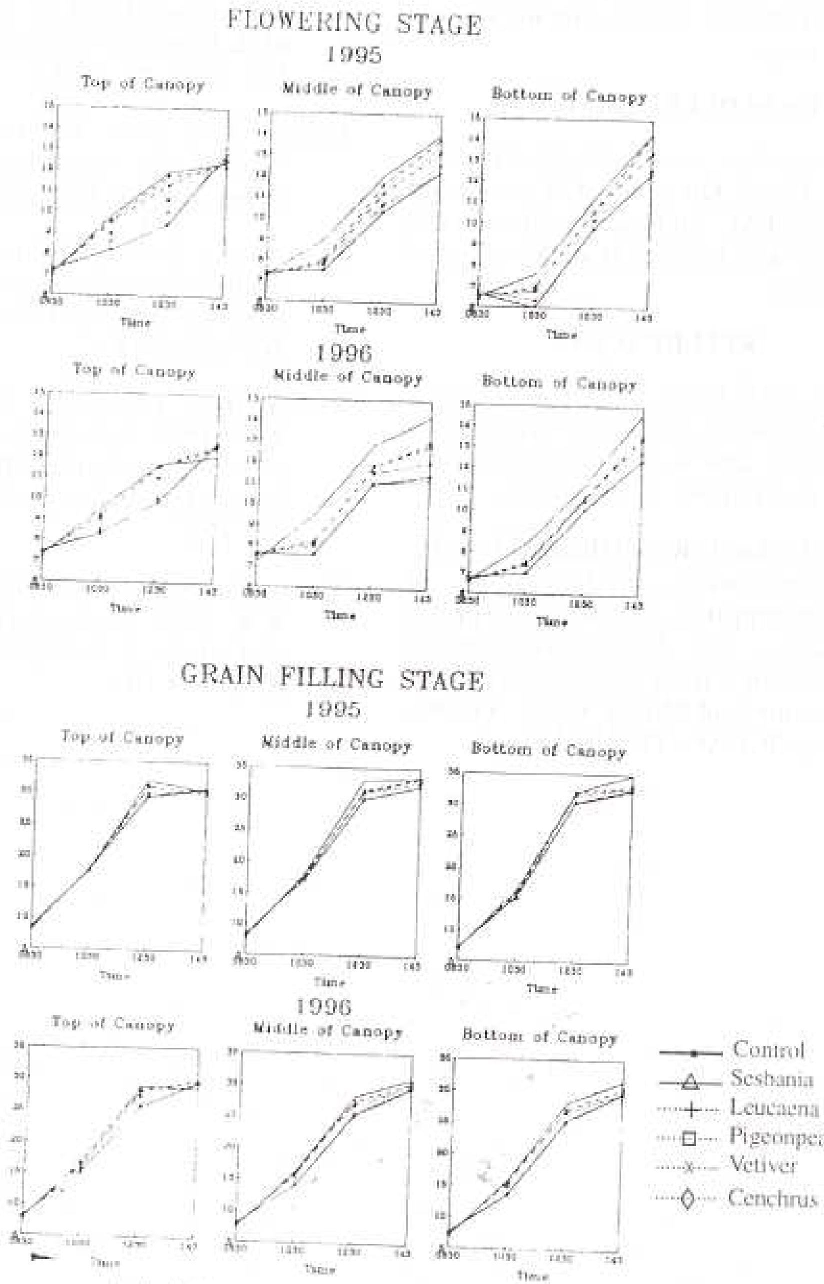

Fig.4 : Vapour pressure deficit (mm of Hg) as influenced by various vegetative barriers

temperature, lower evaporation which facilitated better micro-climate for the sorghum crop.

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