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Study of Microclimate of Soybean as Influenced by Planting Arrangement and Mulching

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Abstract: Planting arrangements showed significant influence on microclimate of a crop. Soil surface temperature between two rows was found higher over the mulched surface than that of open soil in all the treatments. With the decrease in row-spacing the soil surface temperature was found to decrease. The highest soil temperature was observed in 45 cm row spacing and lowest in 5 cm row spacing. The higher soil temperature (28°C) was observed in bare plots than that of mulched ones (23°C) at 1500 hr. Air near the soil surface (at 5 cm height) received sensible heat from the dry soil surface and showed high temperature than the mulched plots. In 5 cm row spacing, due to the higher canopy area relative humidity was found to increase through higher level of transpiration than that of wider row spacing. Canopy temperature was found to be increased with the decrease in row spacing. Penetration of solar radiation, net radiation and PAR were higher at wider row spacing. With the increase in canopy height, penetration of radiation increased. Maximum net radiation was obtained at midday and it was decreasing with the advancement of day. Data of 1500 hr show positive but small value of net radiation at 45 cm row spacing and negative at 25 cm and 5 cm row spacings. The negative trend of net radiation from small row spacings was due to higher out going long wave radiation from shade surface at late hours of the day.

Key words: Micro-environmental parameters, planting arrangement, mulching

Introduction

Crop yield is the interaction of crop growth and its microclimate. The radiation interception over the canopy or penetration below the canopy would influence the abortion of reproductive structures in soybean. Wiebold *et al*. (1981) reported that abscission is greatest within the shaded portion of the canopy. Temperature above 40°C causes severe pod abortion in soybean (Mann and Jaworski, 1970). Temperature extremes, low radiation intensities and moisture stress increase the flower and pod abortion (Saito *et al*., 1970). Therefore, greater light interception at different layers of the canopy during the vegetative and reproductive stages enhances yield in soybean through decreasing the rate of early abortion of reproductive structures (Schou *et al*., 1983). Flower production is also found to be linearly correlated with soil temperature (Robacker *et al*., 1983).

Soil temperature is an important influencing factor for crop production. Planting arrangement and mulching influence the soil and canopy temperature through modifying incoming solar radiation. Solar radiation is the primary energy source for crop production. Leaf number increases in narrow spacing than that of wide spacing. So, soil temperature is found to be high in wide spacing compared to narrow spacing due to larger penetrated solar radiation on it (Baten and Kon, 1997). The canopy temperature in narrow spacing is high due to maximum solar radiation interception. Radiation penetration is higher between spaced rows at partial canopy cover and produces high temperature. Wide spacing increases soil temperature due to low leaf area index and narrow spacing increases canopy temperature due to maximum solar radiation interception on a large leaf area index. On the other hand, optimum temperature decreases pod abortion which can be controlled by planting arrangement. This optimum soil temperature may also be maintained using black coloured mulch.

Scientists have also been tried soybean to adapt in our agro-climatic conditions and possibly, various works on soybean have already been done in our country without evaluating its microclimate. Past research reports clearly indicate that information regarding the effect of row arrangements of soybean on its micro environments are not reported in our country. Therefore, the present piece of work was undertaken with a view to evaluating the change in microclimates due to adoption of different planting patterns and mulches.

Materials and Methods

The experiment was carried out at the Agronomy Field Laboratory, under the Department of Agronomy, Bangladesh Agricultural University, Mymensingh during the period of December 1998 to April 1999. The soils of experimental field was sandy loam belonging to the Old Brahmaputra Floodplain-Agro-ecological Zone (UNDP. and FAO., 1988).

Application of fertilizers: The land was uniformly fertilized with TSP (150 kg/ha), MP (70 kg/ha) and well rotten cowdung (5 tons/hal at the time of final land preparation. The rate of urea was 60 kg/ha and one third of urea was applied during the final land preparation. The rest two thirds of urea were applied in two equal splits as top dressing, one at the vegetative phase before flowering (40 DAS) and the other at flowering stage (65 DAS).

The variety of soybean used in this experiment was Pb-1 (Shohag) and was collected from the Department of Genetics and Plant Breeding, BAU, Mymensingh.

The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. The whole area was divided into 3 blocks and each block into 10 unit plots. The size of the unit plot was 4 m × 3 m and the distance between plots and blocks were 0.5 m and 1.0 m, respectively. The experiment comprised two factors, one was arrangement of spacing and the other was use of mulches. The factors with levels are given below:

A. Spacings arrangement (5): a) 25 cm × 10 cm + 25 cm × 10 cm (S_1), b) 30 cm × 10 cm + 20 cm × 10 cm (S_2), c) 35 cm × 10 cm + 15 cm × 10 cm (S_3), d) 40 cm × 10 cm + 10 cm × 10 cm (S_i) and e) 45 cm × 10 cm + 5 cm × 10 cm (S_5).

B. Mulching (M): a) No mulch (M_0) and b) Water hyacinth mulch (M_1).

The distance between seeds was maintained by placing scale in the lines according to experimental design. Three seeds were sown at every 10 cm distance in the lines. In every plots the number of plants was equal. After sowing the seeds were covered with soil.

Application of Mulches: The indigenous mulch water hyacinth was uniformly spreaded over the plots for the mulch treatment. The mulch was applied at 8 t/ha (dry basis) immediately after sowing of seeds.

Microclimatic parameters: The following microclimatic parameters were recorded in a clean sunny day (March 03, 1999) at two hour intervals 700 h to 1700 h. Air temperature was recorded by Psychrometer (Testa 615, German): Psychrometer was placed between two rows at -5 cm height from the soil surface. Soil temperature was measured by ordinary thermometer at the depth of 5.0 cm. Thermometer was placed between two rows of the centre of the plot. Canopy temperature was measured by Infrared Radiation thermometer (TASCO THI-500, Japan). Infrared radiation thermometer was placed 25 cm above from the top of the canopy. Solar Radiation was recorded by Quantum sensor (SKP 2200, Skye Instruments, England). Data recorded with Quantum sensor were calibrated with the data of a Pyranometer and converted into solar radiation with unit W/m^2 (Baten, 1998). Per cent solar radiation penetration and interception was calculated following standard formula (Baten and Kon, 1997). Photosynthetically active radiation (PAR) measured by PAR sensor (SKP 2200, Skye Instruments, England). PAR sensor was placed between two rows in 25 cm row spacings at different plant height. Then per cent PAR penetration and interception was calculated. Relative humidity was recorded by Psychrometer (Testa 615, German). Psychrometer was placed between two rows at 5 cm height from the soil surface.

Calculation of net radiation: Net radiation at soil surface between two rows of soybean of spacing 5 cm × 10 cm, 25 cm × 10 cm and 45 cm × 10 cm was calculated for 1100 h, 1300 h and 1500 h with the following Equation (Rosenberg *et al.*, 1983):

$$Rn = (1\text{-}\alpha)Rs + LWRI - LWRI \quad \text{.....................(1)}$$
$$= (1\text{-}\alpha)Rs + \sigma T_s^4 - \sigma T_s^4 \quad \text{..........................(2)}$$

where, Rn = Net radiation,
Rs = Solar radiation between two rows of soybean
α = Soil albedo (assumed 0.1 between two rows of soybean (Baten, 1998)
σ = Stefan-Boltzmann constant (5.67×10^{-8} Wm^{-2} K^{-4}),
T_s = Surface temperature (° K) and
T_a = Air temperature (°K)
LWR = Long wave radiation

Results and Discussion

The results obtained from the present study entitled "Study of Micro-Environments of Soybean as Influenced by Planting Ariangement and Mulching" have been presented and discussed under the following heads.

Soil surface temperature: A remarkable variation of soil surface temperature was observed due to the effect of different planting arrangement (Table 1). Soil surface temperature between two rows was found higher over the mulched surface than that of open soil in all the treatments. With the decreases in row-spacing the soil surface temperature was decreased. The highest soil surface temperature was recorded at 1300 hr. in mulched with 45 cm row spacing and the lowest soil surface temperature was recorded in mulched plot with 5 cm row spacing at the same time. In 5 cm row spacing due to higher plant population, a shade was created by maximum number of leaves which resulted low temperature. Water hyacinth is a black body and a perfect light absorber and hence it produced higher temperature than the unmulched condition. Early in the morning mulch treated plots gave lower temperature than bare plots. Mulches decreased soil temperature at 0700 hr, increased from 0800 hr to 1500 hr and then decreased from 1700 hr compared to bare plots.

Soil temperature at 5 cm depth: Diurnal variation in soil temperature at 5 cm depth was recorded and shown in Table 2. The results showed that the temperature in different spacing was low at 0700 hr and highest at 1500 hr. The highest soil temperature was observed in 45 cm row spacing and lowest in 5 cm row spacing. In 5 cm row spacing, canopy created a shade through which light could not penetrate properly to soil surface and resulted decrease in soil temperature.

A variation of temperature was observed in 5 cm depth of soil due to the effect of mulch (Table 2). The higher soil temperature was observed in bare plots than mulched ones at 1500 hr. The result showed that mulches decreased the soil temperature at 5 cm depth. Mulches reduced the maximum soil temperature at day time (Awal and Khan, 1999). The maximum soil temperature under mulch reduced at day time as the mulches reflected a considerable part of incidental solar radiation and their lower thermal conductivity prevented and decreased the amount of downward transmission of heat (Giri and Singh, 1985). At 0700 hr mulched plots showed higher temperature over controlled plots. Soil heat flux showed negative trends (towards atmosphere) from 1600 hr to 0800 hr during winter (Baten *et al.*, 1996). The upward heat flux is trapped by any kind of mulch and produces higher minimum temperature at night. Thus, the soil temperature at morning below the mulch was higher than the open soil.

Air temperature above 5 cm of the soil surface: The highest air temperature was found in 45 cm row spacing and the lowest in 5 cm at 1300 hr (Table 3). Leaves often concentrate in the upper part of the canopy in 5 cm row

Table 1: Surface temperature (°C) below the canopy as influenced by different row spacing of soybean and mulching

Hour	0700		0900		1100		1300		1500		1700	
Spacing	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch
45 cm	18.4	17.8	22.8	24.8	28.8	30.7	29.0	31.5	26.8	29.8	22.5	22.4
40 cm	18.1	17.7	22.7	24.5	28.5	30.4	28.7	31.4	26.5	29.5	22.4	22.3
35 cm	18.0	17.5	22.5	24.3	26.2	30.1	28.5	31.2	26.3	29.1	22.2	22.2
30 cm	17.9	17.4	22.4	24.1	25.8	29.8	28.3	31.0	26.0	28.8	22.0	22.1
25 cm	17.8	17.2	22.3	23.8	25.6	29.6	28.0	30.7	25.7	28.6	21.9	22.0
20 cm	17.7	17.0	22.0	23.5	25.4	29.3	27.8	30.5	25.2	28.4	21.7	21.8
15 cm	17.3	16.8	21.8	23.2	25.2	29.1	27.5	30.3	24.8	28.2	21.4	21.7
10 cm	17.2	16.6	21.5	23.0	25.1	29.0	27.2	30.1	24.8	28.0	21.2	21.6
5 cm	17.0	16.4	21.3	22.7	24.8	27.8	26.9	28.9	24.1	27.8	21.0	21.5

Table 2: Soil temperature (°C) at 5 cm depth as influenced by different row spacing of soybean and mulching

Hour	0700		0900		1100		1300		1500		1700	
Spacing	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch
45 cm	19.0	20.5	22.0	20.0	26.0	23.0	27.3	22.9	28.0	23.0	25.0	22.0
40 cm	19.0	20.3	22.0	19.8	25.5	22.8	27.0	22.5	27.5	22.9	24.5	21.9
35 cm	19.0	20.0	21.8	19.7	25.1	22.5	27.0	22.3	27.0	22.8	24.0	21.8
30 cm	18.8	19.8	21.5	19.5	24.8	22.3	26.7	22.0	26.5	22.7	23.5	21.6
25 cm	18.7	19.6	21.3	19.2	24.6	22.1	26.4	21.8	26.1	22.8	23.0	21.5
20 cm	18.6	19.2	21.1	19.0	24.3	21.8	26.4	21.6	25.7	22.5	22.5	21.4
15 cm	18.5	19.0	20.9	18.7	24.0	21.4	26.3	21.4	25.4	22.3	22.0	21.3
10 cm	18.0	19.0	20.7	18.4	23.8	21.1	28.0	21.2	25.1	22.1	22.0	21.1
5 cm	17.2	18.5	20.4	18.1	23.3	20.8	25.0	21.0	24.9	20.5	21.8	19.0

Table 3: Air temperature (°C) above 5 cm of the soil surface as influenced by different row spacing of soybean and mulching

Hour	0700		0900		1100		1300		1500		1700	
Spacing	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch
45 cm	17.5	18.5	24.0	22.6	30.0	28.4	32.0	28.4	31.2	28.8	27.4	24.8
40 cm	17.4	18.5	23.9	22.6	30.0	28.4	32.0	28.4	31.1	28.4	27.4	24.6
35 cm	17.2	18.3	23.7	22.4	29.8	28.2	31.8	28.2	30.9	28.4	27.4	24.8
30 cm	17.2	18.3	23.7	22.0	29.6	26.1	31.8	28.2	30.7	28.2	27.1	24.4
25 cm	17.0	18.0	23.5	21.8	29.5	26.0	31.3	27.9	30.4	28.1	28.8	24.2
20 cm	18.7	18.0	23.4	21.5	29.3	25.8	31.3	27.7	30.2	28.1	26.5	23.9
15 cm	16.5	17.8	23.1	21.4	29.0	25.7	31.0	27.3	30.0	28.0	28.2	23.8
10 cm	16.5	17.6	22.9	21.3	28.9	25.3	31.0	27.2	29.8	27.8	26.2	23.8
5 cm	18.4	17.4	22.7	21.0	28.7	24.9	30.8	27.0	29.6	27.6	26.0	23.6

Table 4: Relative humidity (%RH) above 5 cm of the soil surface as influenced by different row spacing of soybean and mulchong

Hour	0700		0900		1100		1300		1500		1700	
Spacing	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch
45 cm	88.8	89.6	48.8	49.7	34.2	35.1	33.5	34.1	32.8	35.5	41.7	42.5
40 cm	89.6	90.2	49.2	50.1	34.7	35.8	33.9	34.4	33.3	34.1	42.1	43.1
35 cm	90.3	90.4	49.7	50.8	35.0	36.3	34.5	34.8	33.9	34.7	42.9	43.8
30 cm	91.2	91.3	50.1	51.3	35.4	37.1	35.0	35.3	34.3	35.3	43.5	44.3
25 cm	92.3	91.8	50.8	51.9	35.9	37,9	35.7	35.9	34.9	36.1	43.9	44.9
20 cm	92.8	92.3	50.9	52.5	38.4	38.5	38.1	36.3	35.3	36.8	44.7	45.3
15 cm	93.3	92.8	51.4	53.1	36.9	39.1	36.7	36.94	35.9	37.3	45.3	45.9
10 cm	94.1	93.2	51.9	53.9	37.5	39.8	37.1	37.3	36.3	38.0	45.9	46.6
5 cm	94.3	93.7	52.4	54.3	37.8	40.4	37.9	38.4	37.1	38.7	46.6	47.1

Table 5: Canopy temperature (°C) as influenced by different row spacing of soybean aned muichinp

Hour	0700		0900		1100		1300		1500		1700	
Spacing	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch
45 cm	16.0	15.7	23.1	23.3	25.4	25.0	26.3	25.0	24.4	24.2	19.9	19.0
40 cm	18.1	15.9	23.4	23.6	25.8	25.4	26.6	25.1	24.8	24.3	20.0	19.3
35 cm	16.3	18.3	23.7	24.0	25.8	25.5	26.9	25.2	24.9	24.5	20.2	19.5
30 cm	16.5	16.4	24.0	24.4	25.8	25.5	27.2	25.3	25.1	24.6	20.4	19.7
25 cm	18.7	16.5	24.4	24.7	25.9	25.7	27.6	25.5	25.3	24.8	20.5	19.9
20 cm	16.8	16.6	24.8	24.9	28.3	25.8	27.9	25.6	25.4	24.9	20.7	20.1
15 cm	17.0	16.7	25.2	25.4	26.7	26.0	28.1	25.9	25.5	25.3	20.9	20.2
10 cm	17.1	16.7	25.7	25.9	26.9	26.4	28.4	28.1	25.6	25.6	21.1	20.3
5 cm	17.3	16.8	28.1	26.5	27.0	26.6	28.6	28.3	25.8	25.9	21.4	20.4

spacing, restricting light penetration to the lower strata of the canopy. This is why 5 cm row spacing possessed lower temperature than the wider row spacing.

Application of mulches showed higher temperature over the controlled plots. At 0700 hr mulched plots showed higher temperature than the controlled. Irrespective of time of the day, black mulches conserved temperature and released it at late night which resulted higher temperature in the morning (at 0700 hr). The mulch reduced the maximum soil temperature at day time and increase the minimum soil temperature at late night (Awal and Khan, 1999). Air near the soil surface (at 5 cm height) received sensible heat from

Table 6: Solar radiation penetration (watt/m^2/hr) as influenced by different row spacing of soybean and mulching. (Light intensity is shown in appendix-II)

Hour	0700		0900		1100		1300		1500		1700	
Spacing	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch	Barc	Mulch
45 cm	1.35	1.35	39.0	36.0	75.0	73.5	81.5	77.0	52.5	49.5	1.15	1.15
40 cm	1.35	1.35	32.5	30.0	68.5	65.5	75.5	71.5	46.5	44.5	1.15	1.15
35 cm	1.35	1.35	26.0	22.5	81.5	57.5	68.0	64.5	41.5	37.5	1.15	1.15
30 cm	1.35	1.35	19.5	17.5	54.5	51.5	61.5	58.5	34.0	31.5	1.15	1.15
25 cm	1.35	1.35	14.5	12.0	49.0	46.0	56.5	52.5	27.5	24.5	1.15	1.15
20 cm	1.35	1.35	10.5	8.5	42.5	40.0	50.0	48.0	21.5	18.0	1.15	1.15
15 cm	1.35	1.35	7.0	6.0	37.5	34.5	46.0	42.5	16.0	15.5	1.15	1.15
10 cm	1.35	1.35	5.0	4.5	32.5	31.0	40.0	37.5	13.0	11.5	1.15	1.15
5 cm	1.35	1.35	4.0	3.5	30.0	28.5	35.0	33.5	9.5	7.0	1.15	1.15
Global ratiation	5.1		424.0		670.0		880.0		479.0		108.5	

Table 7: Solar radiation penetration (watt/m^2/hr.) as influenced by different plant height of soybean at 25 cm row spacing

Planting	10.00 hour		11.00 hour		12.00 hour		13.00		14.00 hour	
	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare .	Mulch	Bare	Mulch
10	40.5	37.0	107.5	92.5	250.5	230.5	275.5	250.0	210.5	170.5
20	44.0	40.5	146.5	120.5	287.5	260.5	308.0	280.0	235.5	200.0
30	49.0	45.5	192.5	167.5	309.5	290.5	370.5	340.5	295.5	255.5
40	53.0	49.5	240.5	200.5	350.5	320.5	440.0	400.5	340.5	300.5

Table 8: Percent solar radiation penetration and interception at various plant heights of the soybean canopy at mid day iin 25 cm row spacing

Plant height (cm)	Penetration (%)								Interception (%)							
	11.00 hour		12.00 hour		13.00 hour		14.00 hour		11.00 hour		12.00 hour		13.00 hour		14.00 hour	
	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch
10	16.00	13.8	32.12	29.55	31.31	28.41	29.83	24.00	84.00	86.20	67.88	70.45	88.89	71.59	70.37	76.00
20	21.87	17.98	36.86	33.40	35.00	31.82	33.15	28.15	78.13	82.02	63.14	66.60	65.00	88.18	88.85	71.75
30	28.73	25.00	39.88	37.27	42.10	38.69	41.80	35.96	71.27	75.00	60.32	82.73	57.90	61.31	58.40	64.04
40	35.89	29.93	44.94	41.00	50.00	4.00	47.92	42.29	84.11	70.07	55.06	59.00	50.00	54.50	52.08	57.71

Table 9: Percent PAR (Photosynthetically Active Radiation) penetrationand interception at various plant heights of the soybean at midday in 25 cm row spacing

Plant height (cm)	Penetration (%)								Interception (%)							
	11.00 hour		12.00 hour		13.00 hour		14.00 hour		11.00 hour		12.00 hour		13.00 hour		14.00 hour	
	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch	Bare	Mulch
10	35	31	37	34	44	41	38	36	65	69	63	66	56	59	62	64
20	48	45	51	48	58	55	47	45	52	55	49	52	42	45	53	55
30	61	58	62	59	67	62	61	58	39	42	38	41	33	38	39	42
40	77	72	81	78	84	82	78	74	23	28	19	22	16	18	22	26

Table 10: Net radiation (watt/m^2) at soil surface between three row spaces of soybean

Hour spacing	11:00	13:00	15:00
45	46.41	53.48	19.77
25	19.99	30.10	-4.34
5	3.18	7.17	-23.83

the dry soil surface and showed high temperature than the mulched plots. On the contrary black colored mulch absorbed heat from upper air and kept the above air cool and hence, resulted low air temperature than the open soil.

Relative humidity above 5 cm height above the soil surface: The highest relative humidity was obtained at 0700 hr and lowest was obtained at 1500 hr in different row spacings (Table 4). The 5 cm row spacing showed higher relative humidity than the others. In 5 cm row spacing, due to the higher canopy area increased relative humidity through higher level of transpiration than that of wider row spacing. Mulched plots showed higher value of % RH than the bare (Table 4) Different mulches conserved the soil moisture (Kapitany, 1971). Soil moisture conserved in mulches and increased the air moisture which resulted higher RH (%) in those region.

Canopy temperature: The highest value of canopy temperature (28.6°C) was observed at 1300 h in mulched plots with 5 cm row spacing as compared to other treatments (Table 5). The higher values of canopy temperature were observed at 1300 h and lowest values at 0700 hr. Canopy temperature was found to be increased with the decrease in row spacing. Decreased row spacing produced dense canopy where interception/absorption of solar radiation was higher (Baten, 1998) and it produced higher canopy temperature. The canopy temperature followed the air temperature (Khushu *et al.*, 1991). Higher air temperature may increase the canopy temperature and in dense populated plant communities canopy temperature was found to vary with row orientations of soybean (Baten and Kon, 1997). Mulched treated plants gave the higher canopy temperature over the bare. The canopy temperature of mulch treated plants increased up to 1100 hr and decreased from 1300 hr to 1700 hr.

Solar radiation penetration: The penetrated solar radiation varied with different row spacings. The higher penetrated solar radiation was obtained in 45 cm row spacing and lower values in 5 cm row spacing (Table 6). The leaves concentrated densely in 5 cm row spacing and intercepted major portion of radiation, so small quantity (5% about) light penetrated the lower layer of leaves and branches. In 45 cm row spacing maximum portion of radiation penetrated to the lower layer due to less crowding of leaves. Results showed that solar radiation penetration is co-related with time of the day. The radiation intensity is higher at noon and lower at evening and morning. This is why, solar radiation penetration is maximum around midday and minimum in evening and morning.

Mulch treated plants showed lower values of penetration of solar radiation than the non-mulched plants at different spacings. Mulches increased soil moisture and decreased the soil temperature. This is why the number of leaves increased in mulched plants as compared to non-mulched plants and resulted decrease in the solar radiation penetration. Because part of light was intercepted by leaves and branches. The solar radiation penetration was low at 0700 hr and it was started to increase to reach the peak at 1300 hr thereafter it started to decrease again until 17.00 hour (Table 6).

Solar radiation penetration at different plant height of 25 cm row spacing: It is evident from the results that penetration of solar radiation decreased with the increase in plant height (Table 7). Penetration of solar radiation was the lowest at 10 cm height above the soil surface and it was highest at 40 cm height above the soil surface. Penetration of solar radiation at 40 cm height at 13.00 hour was largest in control plants as compareid to mulched plants. Mulched plants gave a good canopy and reduced the penetration of solar radiation over it.

Percent penetration and interception of solar radiation: The results showed that with the increase in plant height the penetration of solar radiation also increased (Table 8). Interception of solar radiation was highest at 10 cm height of the canopy and it was started to decrease with the increase in canopy height i.e. it was lowest at 40 cm height of the canopy. interception of solar radiation was larger in mulched canopy than that of non-mulched. It was due to better growth of the crop under mulch.

Percent penetration and interception of photosynthetically active radiation (PAR): Table 9 clearly shows that the highest % of PAR penetration was obtained from 40 cm height of the canopy and the lowest was from 10 cm height i.e. % of PAR penetration decreased with decreasing canopy height. Data also show that % of PAR penetration was larger in controlled plants as compared to mulched plants. The table also shows that % of PAR penetration was found highest at 1300 h of the day at different heights of the canopy.

The % of PAR interception was highest at 10 cm height of the canopy and it was lowest at 40 cm height of the canopy. The Table 9 also shows that highest % of PAR interception was obtained at 1100 h. The % of PAR interception was inversely related with the penetration.

Net radiation at soil surface between three row spaces of soybean: Table 10 shows values of net radiation calculated at 1100 hr, 1300 hr and 1500 hr between three row spaces. Values of net radiation decreased with decreasing row spacing at every hour of interest. Penetration of solar radiation was higher between larger row spaces which was the cause of higher net radiation as compared to smaller row spacing. Maximum net radiation was obtained at midday and it was decreasing with the advancement of day. Data of 1500 hr show positive but small value of net radiation at 45 cm row spacing and negative at 25 cm and 5 cm row, spacings. The negative trend of net radiation from small row spacings was due to higher out going long wave radiation from shade surface at late hours of the day (Baten, 1998). The 45 cm row spacing received a part of solar radiation even at 1500 hr instead of producing full shade (as the row space was larger) and gave positive net radiation.

it could be concluded from this study that row arrangements and mulching influence the microclimatic conditions of soybean. Thus, yield of a crop could be increased manipulating or modifying or improving its microclimate through mulching and making row arrangements of a crop.

References

Awal, M.A. and M.A.H. Khan, 1999. Alteration of soil temperature and moisture through mulching on the morpho-physiological differentiation in maize. Pak. J. Biol. Sci., 2: 1164-1167.

Baten, M.A. and H. Kon, 1997. Comparisons of solar radiation interception, albedo and net radiation as influenced by row orientations of crops. J. Agric. Meteorol., 53: 29-39.

Baten, M.A., 1998. Studies on the effect of row orientations of crops on micrometeorology. Ph.D. Thesis, Graduate school Science and Technology, Chiba University, Japan.

Baten, M.A., H. Kon and N. Matsuoka, 1996. Spatial variability in micrometeorology at soil surface below a potato canopy with two orientations. J. Agric. Meteorol., 52: 301-310.

Giri, G. and R.R. Singh, 1985. Influence of straw mulch and transpiration suppressants on soil temperature dry matter and total biomass production and nutrient uptake by dry land wheat. Indian J. Agric. Sci., 55: 256-261.

Kapitany, J., 1971. Investigation on the effect of plastic mulching in capsicum. Zoldsegler Mestesi Kutato Intezet Bulletinje, 6: 97-106.

Khushu, M.K., H.S. Mavi and D. Kachroo, 1991. Canopy temperature in rice (*Oryze sativa*) under different transplanting dates. Indian J. Agron., 36: 243-245.

Mann, J.D. and E.G. Jaworski, 1970. Comparison of stresses which may limit soybean yields. Crop Sci., 10: 620-624.

Robacker, D.C., P.K. Flottum, D. Sammataro and E.H. Eriehson, 1983. Effect of climatic and adaphic factors of soybean flowers. Field Crops Res., 6: 267-278.

Rosenberg, N.J., B.L. Blad and S.B. Verma, 1983. Microclimate: The Biological Environment. 2nd Edn., Wiley Interscience, New York, pp: 209-287.

Saito, M., T. Yamamoto, K. Goto and K. Hashimoto, 1970. Influence of cool temperature before and after an thesis, on pod setting and nutrients in soybean plants. Proc. Crop Sci. Soc. Jap., 39: 511-519.

Schou, J.B., D.L. Jeffers and J.G. Streeter, 1983. Effect of reflectors, black boards or shader applied at different stages of plant development on yield of soybeans. Crop Sci., 18: 29-34.

UNDP. and FAO., 1988. Land resources appraisal of Bangladesh for agricultural development. Technical Reports Nos. 1-7, FAO/UNDP Project BGD/81/035.

Wiebold, W.J., D.A. Ashley and H.R. Boerma, 1981. Reproductive abscission levels and patterns for eleven determinate soybean cultivars. Agron. J., 73: 43-46.