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Effect of planting methods and mulching on the thermal environment and biological productivity of groundnut*

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ABSTRACT

To estimate the altered thermal environmental effect due to adoption of planting methods and different mulches, a field experiment was conducted on groundnut at the CR Farm, BCKV, W. B., India in the summer seasons of 2003, 2004 and 2005. The experiment was laid out in a split-plot design, where the planting methods (flat and ridge) were the main plot treatments and the mulches (banana leaf with dry grass, water hyacinth, transparent polythene sheet, rice straw, jute stick and non-mulch control) were considered as the sub-plot treatments. The results showed that ridge planting method with use of water hyacinth or banana leaf with dry grass greatly altered the thermal environment by reducing air temperature, canopy temperature and SDDI in groundnut; both the dry matter production and yield of the crop were increased due to adoption of ridge planting and bio mulches due to conducive thermal environment. There existed a significant negative correlation between yield and air temperature, dry matter and air temperature, yield and canopy temperature, dry matter and canopy temperature yield and SDDI, dry matter and SDDI.

Key words : Air temperature, canopy temperature, dry matter, groundnut, stress degree day index (SDDI), thermal environment, yield

The growth and productivity of crop depend on the abiotic environment to which the crop is exposed. Among the abiotic factors, radiation and thermal environments largely regulate all the physical and physiological processes relating to the growth and development of crop. In the sub humid tropical climate, thermal environment takes the lead role in the process. Use of mulch alters the abiotic environment within the crop canopy; the groundnut and rice husks regulate the air temperature within the crop canopy. However, detailed study in this aspect is lacking. The present investigation was carried out for consecutive three years (2003, 2004 and 2005) on groundnut crop using various low cost biomulches to investigate the thermal environment and its effect on dry matter production and yield of the groundnut crop.

MATERIALS AND METHODS

The cultivar AK-12-24 of groundnut was grown at the Central Research Farm, Bidhan Chandra Krishi Viswavidyalaya (23^0N and 89^0E) during summer seasons of 2003, 2004 and 2005. The experimental soil was sandy loam. The crops were sown on 26 February in all the years

The experiment was laid out in a split-plot design, where the planting methods (flat and ridge) were the main plot treatments and the mulches viz., banana leaf with dry grass (BG), water hyacinth (WH), transparent polythene sheet (PS), rice straw (RS), jute sticks (JS) and a control i. e. without mulch (CO) were considered as the sub-plot treatments. The size of each sub-plot was 4 x 3 m where the seeds were sown in rows 30 cm apart having a plant to plant spacing of 15 cm. Such treatment combinations were replicated thrice. Each plot received 20 kg N, 50 kg each of P and K/ha through urea, single super phosphate and muriate of potash, respectively. The air temperature at the ground level and canopy temperature (AG-42, Telatemp) were measured at 08.00, 12.00 and 16.00 h on the 30th, 45th, 60th, 75th and 90th days after emergence (DAE). The stress degree day index (SDDI) was calculated by subtracting the mid-day air temperature from mid-day canopy temperature (Idso *et al.*, 1977). The dry matter production on the above mentioned dates and yield of the crop were also estimated. The correlation coefficients were computed for finding out the relationship between the components of thermal environment and biological production i. e. dry matter production and yield. For brevity, 3-year pooled mean was presented.

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Table 1: Effect of planting methods and mulch management on the diurnal variation of ambient temperature within the canopy of groaundnut (Pooled mean of 2003, 2004 and 2005)

Treatment	8.00 h					12.00 h					16.00 h				
	Days after emergence														
	30	45	60	75	90	30	45	60	75	90	30	45	60	75	90
Planting (P)															
Flat	31.8	31.7	30.8	30.6	33.6	36.3	37.7	36.2	34.6	36.5	34..1	35.4	32.4	32.4	35.6
Ridge	33.1	31.6	30.6	30.2	32.9	36.3	37.6	35.9	34.2	35.6	34.1	35.2	32.0	31.7	34.5
LSD	0.10	0.04	0.05	0.03	0.04	NS	0.01	0.04	0.04	0.11	NS	0.02	0.07	0.04	0.06
Mulches (M)															
BG	32.8	31.4	30.7	30.3	33.1	36.2	37.5	36.0	34.2	35.6	34.0	35.1	32.2	31.9	34.8
WH	32.4	31.3	30.4	29.9	32.5	35.8	37.0	35.6	33.6	34.9	34.0	34.9	31.2	31.1	33.9
PS	32.7	31.8	30.8	30.6	33.5	36.4	38.0	36.2	34.7	36.5	34.1	35.4	32.4	32.5	35.4
RS	32.6	31.7	30.7	30.4	33.3	36.3	37.6	36.1	34.4	36.1	34.1	35.3	32.2	32.2	35.2
CO	31.7	31.9	30.9	30.8	33.8	36.0	37.9	36.3	35.0	36.9	34.1	.5.6	32.6	32.6	35.8
JS	32.4	31.7	30.8	30.5	33.4	36.4	37.8	36.1	34.5	36.2	34.1	35.3	32.3	32.2	35.3
LSD	0.12	0.11	0.08	0.06	0.10	0.11	0.08	0.06	0.07	0.11	0.04	0.05	0.07	0.11	0.08
P x M	0.16	NS	NS	0.08	NS	NS	NS	0.09	0.09	0.16	NS	0.08	NS	0.16	0.11

NS : Not Significant.

RESULTS AND DISCUSSION

Diurnal variation in air temperature

Diurnal variation of temperature within the groundnut canopy showed that the ridge planting method reduced the air temperature within the crop canopy significantly at all hours and on all dates of observations (Table 1). A continuous temperature reduction was observed from 30 days after emergence (DAE) to 75 DAE; however, on 90 DAE air temperature within the crop canopy was increased. Mulching greatly influenced the air temperature within the crop canopy. Use of water hyacinth (WH) or banana leaf with grass (BG) caused a significant reduction in air temperature within the canopy as compared to other mulches or to the no mulch control. The interaction effects of planting methods and mulches were non-significant. The continuous temperature decrease within the crop canopy was the result of canopy development with the progress of time; however, at 90 DAE the observed reverse trend was due to senility and shedding of leaves which facilitated the penetration of radiation within the canopy. Use of mulch reduced the soil temperature as well as conserved the soil moisture (Sharma, 1991; Ghosh *et al.*, 2003) and this might also reduce the air temperature within the canopy. From the present study, it was observed that the soil moisture conservation was better in WH or BG-mulched crop (Chakravarti, 2006) that had caused the reduction in soil as well as ambient temperatures.

Diurnal variation in canopy temperature

The canopy temperature was always lower in ridge planting method in comparison to the flat planting method (Table 2). Maximum canopy temperature was recorded at 12.00 h; canopy temperature at 08.00 h did not show much variation. With the progress of time, however, it showed a continuous increase from 30 to 90 DAE at 12.00 h or at 16.00 h. Among the mulches, the WH recorded a significant reduction in canopy temperature. Since the canopy temperature is a function of soil moisture as well as plant water status, the use of mulch conserved soil moisture and provided more water to the plant for transpiration, it reduced the canopy temperature as a concomitant effect. The WH provided more soil moisture for which a greater reduction in canopy temperature was observed. Increment in canopy temperature with the progress of growth was due to the aging of leaves of the canopy whose ability of transpiration was less than the young leaves.

Variation in stress degree day index (SDDI) in groundnut

The SDDI is an index, which shows the soil moisture as well as plant water status in unison. As it is the difference between canopy temperature and air temperature estimated at 12.00 h, higher degree of negativity will indicate the low canopy temperature with a low water stress. The results (Table 3) showed that the ridge planting recorded minimum

Table 2 : Effect of planting methods and mulch management on the diurnal variation of canopy temperature of groundnut (Pooled mean of 2003, 2004 and 2005)

Treatment	8.00 h					12.00 h					16.00 h				
	Days after emergence														
	30	45	60	75	90	30	45	60	75	90	30	45	60	75	90
Planting (P)															
Flat	29.1	29.4	29.0	29.2	31.5	34.6	32.8	33.7	35.8	37.2	30.1	29.0	29.5	31.0	34.6
Ridge	28.7	28.9	28.6	28.8	31.2	33.8	32.0	33.5	34.5	37.1	30.2	28.8	29.1	30.4	34.4
LSD	0.26	0.09	0.11	0.06	0.09	0.21	0.23	0.05	NS	0.06	NS	0.09	0.07	0.19	0.07
Mulches (M)															
BG	29.2	28.7	28.8	28.8	31.2	33.8	31.8	33.3	37.3	37.1	29.4	28.6	29.1	30.5	34.3
WH	28.3	28.6	28.0	28.3	31.0	33.5	31.8	32.9	33.4	36.5	29.8	28.3	28.6	30.0	34.1
PS	29.3	29.5	29.3	29.4	31.4	33.9	32.8	34.1	35.1	37.3	30.6	29.3	29.8	31.1	34.6
RS	29.4	28.7	28.7	28.9	31.2	34.8	32.1	33.4	34.6	37.1	29.9	28.8	29.0	30.5	34.5
CO	28.5	29.9	29.3	29.6	31.8	35.2	33.6	34.4	35.5	37.9	31.3	29.7	30.3	31.4	35.0
JS	28.9	39.4	28.7	28.9	31.4	34.0	32.3	33.5	35.0	37.2	30.0	28.8	29.0	30.5	34.7
LSD	0.31	0.19	0.17	0.10	0.07	0.34	0.28	0.12	NS	0.10	0.27	0.21	0.15	0.17	0.09
P x M	NS	0.27	0.24	0.14	NS	NS	0.39	NS	NS	NS	NS	NS	NS	NS	NS

NS : Not Significant.

Table 3: Effect of planting methods and mulch management on the variation in stress degree day index in groundnut (Pooled mean of 2003, 2004 and 2005)

Treatment	Stress degree day index (SDDI)				
	Days after emergence				
	30	45	60	75	90
Planting (P)					
Flat	-2.22	-5.54	-3.29	-1.57	-1.94
Ridge	-3.30	-6.38	-3.55	-1.96	-2.15
LSD	0.23	0.21	0.06	0.13	0.09
Mulching (M)					
BG	-3.14	-6.57	-3.67	-1.96	-2.19
WH	-3.37	-6.57	-4.11	-3.05	-2.71
PS	-3.07	-5.60	-2.89	-1.34	-1.94
RS	-2.21	-6.29	-3.62	-1.79	-2.10
CO	-1.76	-4.71	-2.63	-0.99	-1.29
JS	-3.01	-6.04	-3.58	-1.45	-2.03
LSD	0.34	0.28	0.13	0.24	0.12
P x M	NS	NS	NS	NS	NS

NS : Not Significant.

SDDI value; use of BG or WH as mulch also recorded the minimum SDDI values. It indicated that the adoption of ridge planting method with the BG or WH as mulch proved to be beneficial regarding the soil moisture and plant water status for groundnut. The SDDI values showed a continuous decrease (except on 45 DAE due to rainfall) due to low availability of soil moisture with the progress of growth.

Dry matter production and yield of groundnut

Dry matter production and yield of groundnut are presented in Table 4. Results showed that the ridge planting method recorded higher dry matter production and yield in comparison to flat method. Among the mulches, WH was proved to be the best regarding the dry matter and yield of groundnut. The order of groundnut yield as affected by mulching can be expressed as WH>BG>PS>RS>JS>CO.

Thermal environment on dry matter production and yield of groundnut

Effect of thermal environment on dry matter production and yield of groundnut has been presented in Table 5. Results showed that the air temperature within the crop canopy, canopy temperature and SDDI had a significant negative correlation with the dry matter production as well as yield of groundnut. Higher temperature caused accelerated respiratory activities of leaf on the one hand and higher canopy temperature indicated low water status i. e. water stress on the other hand. Samuel and Paliwal (1994), Mouromicale *et al.* (2002) and Dey and Hundal (2003) had a similar observation in their studies.

Table 4: Effect of planting methods and mulch management on the variation in dry matter accumulation and yield of groundnut (Pooled mean of 2003, 2004 and 2005)

Treatment	Dry matter accumulation (I/plant)					Yield ($t\ ha^{-1}$)
	Days after emergence					
	30	45	60	75	90	
Planting (P)						
Flat	5.22	16.68	28.10	41.47	59.91	1.67
Ridge	6.07	18.20	31.34	47.66	73.81	1.88
LSD	0.16	0.15	0.31	0.30	1.43	0.03
Mulching (M)						
BG	6.70	18.43	32.67	50.73	74.26	1.93
WH	8.39	20.32	37.06	54.91	91.11	2.20
PS	5.52	18.06	31.46	46.92	68.90	1.82
RS	5.21	17.44	28.72	43.37	62.33	1.75
CO	3.14	13.73	22.68	33.24	45.60	1.29
JS	4.89	16.66	25.74	38.23	58.97	1.67
LSD	0.17	0.16	0.31	0.42	1.80	0.04
P x M	0.24	0.23	0.44	0.59	2.55	0.06

Table 5: Effect of thermal environment on dry matter production and yield of groundnut

Days after emergence	Correlation coefficient					
	Ambient temperature within the canopy		Canopy temperature		Stress degree day index (SDDI)	
	Dry matter	Yield	Dry matter	Yield	Dry matter	Yield
30	-0.95**	-0.93**	-0.79**	-0.84**	-0.74**	-0.82**
45	-0.74**	-0.79**	-0.87**	-0.87**	-0.86**	-0.86**
60	-0.84**	-0.88**	-0.71**	-0.82**	-0.70**	-0.82**
75	-0.86**	-0.93**	-0.22	-0.32	-0.85**	-0.89**
90	-0.92**	-0.90**	-0.88**	-0.95**	-0.90**	-0.96**

**Significant at P=0.01 level.

CONCLUSION

Thermal environment of the groundnut crop greatly affected the biomass production and yield of the crop. Adoption of ridge planting method with the use of low cost biomulch (viz., BG or WH) greatly altered the thermal environment of the crop, which had favourable effect on the yield of the crop.

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