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Full Research Article

Diurnal Variation in Canopy Temperature and Stress Degree Day Index of Mungbean (*Vigna radiata*) Varieties under Different Dates of Sowing

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Abstract

A field experiment was conducted in the summer seasons of 2010 and 2011 on four mungbean varieties (V_1-Pant Mung-5, V_2-Bireswar, V_3-RMG-62 and V_4-Sukumar) sown on three different dates (D_1-15th February, D_2-1st March and D_3-15th March) at the university research farm under Sub-humid tropical environment. The experiment was laid out in a split plot design where the sowing dates and the varieties were considered as main plot and sub plot treatments respectively. The objective of this study was to identify the stress period in mungbean crop through canopy temperature measurement. The canopy temperatures were measured at 7:30, 11:30 and 15:30 hour during 25 to 46 days after emergence (DAE) at seven days interval. Canopy temperature increased from 7:30 to 11:30 hr, followed by a decline at 15:30 hr with a few aberrations. The mean canopy temperature under D_2 was lower than D_1 and D_3 in both the year which indicated no moisture stress suffered by the crop during that period. The SDDI was more at 11.30 hr which indicated moisture stress at that period. Overall, the moisture adequacy was better under D_2 sowing giving the probability of good yield under this sowing and was closely followed by D_3 sown crops. The variety V_1 suffered less moisture stress in comparison to the other varieties.

1. Introduction

Weather influences the growth, development and productivity of the crop. The mungbean is a highly remunerative pulse which is cultivated by the farmers under rainfed condition. Water stress affects various physiological processes associated with growth, development, and economic yield of a crop (Allahmoradi et al., 2011). Water deficit disturbs normal turgor pressure, and the loss of cell turgidity may stop cell enlargement that causes reduced plant growth (Srivalli et al., 2003). Further, water stress decreases leaf area index in Mungbean (Jordan and Ritichie, 2002). Water stress reduces photosynthesis; the most important physiological processes that regulate development and productivity of plants (Athar and Ashraf, 2005). Reduction in leaf area causes reduction in crop photosynthesis in plants leading to dry matter accumulation (Pandey et al., 1984). Under such situation, the yield is adversely affected if the crop does not receive one or two rainfall events in the lifecycle. The canopy temperature indicates the water status in the plant sap, thereby it points out whether a crop is in moisture stress or not (Idso et al., 1977; Ajayi and Olufayo, 2004). Canopy temperature shows diurnal variation also because of the variation in incident radiation due to solar elevation angle. The stress degree day index (SDDI) numerically expresses the degree of drought and the water status of the crops. The measurements of canopy temperature and stress degree day index (SDDI) may be greatly helpful for identifying the stress situation in the crop and minimize the wasteful use of irrigation water. However, no systematic study on mungbean is available in the Gangetic plains of Eastern India. To address this lacuna, the present experiment has been planned to identify the stress period in mungbean crop through the diurnal variation in canopy temperature measurement.

2. Materials and Methods

The experiment was undertaken during summer seasons of 2010 and 2011 at Jaguli Instructional Farm (New Alluvial zone), Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The farm was situated at 22°56′ N latitude, 88°32′ E longitude and at an altitude of 9.75 m above mean sea level.

The experiment was conducted in a sub-tropical humid climate having a short and mild winter. The average annual rainfall is 1457 mm mostly being precipitated during June to September and the mean monthly temperature ranges from 10 to 37 °C. The experiment was conducted under open field condition and the temperature variations during that period were completely monitored under the field condition. The experiment was laid out in a split plot design with three replications. The soil contained 0.58% organic carbon, 0.06% total nitrogen, 2.9 kg ha^{-1} available phosphorus, 136.66 kg ha^{-1} available potassium and a soil pH of 6.8. The main plot consisted of three dates of sowing (D_1: 15th February, D_2: 1st March and D_3: 15th March) and the sub plot comprised of four varieties (V_1: Pant Mung-5, V_2: Bireswar, V_3: RMG-62 and V_4: Sukumar). Seed treatment was done with *Rhizobium* culture @ 100 g ha^{-1} and sown @ 25 kg ha^{-1} at a spacing of 25×10cm^2. FYM @ 5 t ha^{-1} was applied at the time of final land preparation. A general dose of nitrogen @ 20 kg ha^{-1} through urea, P_2O_5 @ 40 kg ha^{-1} through Single Super Phosphate and K_2O @ 40 kg ha^{-1} through Murate of Potash were applied as basal.

The canopy temperature was recorded at an interval of seven days starting from 25 days after emergence (DAE) to the pod development stage at 7:30, 11:30 and 15:30 hours using a hand held Infrared thermometer (Model AG-42 Telatemp). The measurement was recorded on bright sunny days. The average bright sunshine hour during the observation period was 8 to 9 hours in two experimental years. The air temperature of each day was also collected from the adjacent Meteorological observatory and was used to calculate the Stress Degree Day Index (SDDI). The relationships between the canopy temperature, varieties and date of sowing were worked out to study the pattern of impact of each variable.

The Stress Degree Day Index (SDDI) was calculated using the following formula (Idso et al., 1977):SDDI=Canopy temperature–air temperature

3. Results and Discussion

3.1. Diurnal variation in canopy temperature

Canopy temperature increased from 7:30 to 11:30, followed by a decline at 15:30 with a few aberrations (Table 1). On 25th DAE, the lowest canopy temperature was observed in case of V_4 variety in the two experimental year; when the crop was sown on D_1. The mean canopy temperature for V_1 was 34.25 °C and it reduced to 30.83 °C for the variety V_4 in the first year experiment. The extent of reduction for the V_4 variety was 3.42 °C in 2010, whereas in 2011, the magnitude of reduction in canopy temperature was 1.25 °C when compared with the V_1 variety. It was observed that under D_1 sowing, V_4 recorded the lowest canopy temperature. On 32 DAE, the canopy temperatures under D_1 sowing for all varieties were almost similar, ranging from 28.67 to 29.42 °C. The canopy temperature on 32 DAE declined from 25 DAE under D_1 sowing. In the second year, the similar pattern was observed.

The mean canopy temperature for D_1 sowing showed that In case of the variety V_2, the mean canopy temperature reduced from 25 to 32 DAE with a further increase on 39 DAE in both the year; on 46 DAE, it declined in the first year but recorded an increase in the second year. The variety V_3 recorded a decline on 32nd DAE, thereafter showing an increasing trend. From the above table, it was observed the canopy temperature of V_1 and V_4 were almost similar on 46 DAE. In 2011, the canopy temperature for all four varieties did not change remarkably, ranging from 31.9 to 32.67 °C. In 2010, lower canopy temperature was observed than 2011. The overall mean canopy temperature in 2010 was higher than 2011 in all the varieties.

Under D_2 sowing, the canopy temperature of the variety V_1 ranged from 30.58 to 32.67 °C in 2010 and the same ranged from 28 to 31.75 °C in 2011 during 25 to 46 DAE. The canopy temperature was lower in 2011 than in 2010. The overall mean canopy temperature was almost similar in case of V_1 and V_4 in 2010; in 2011, it ranged from 29.1 to 29.79 °C for the different varieties.

The mean canopy temperature under D_3 sowing showed that the canopy temperature of V_1 was almost similar in two year of experimentation. However, the lower canopy temperature was observed in 2011 than in 2010. In 2010, canopy temperature for the four varieties ranged from 30.73 to 31.52 °C. The lowest was observed in V_1. In 2011, the overall canopy temperature ranged from 29.4 to 30.50 °C and the lowest was observed in case of V_4.

The mean canopy temperature under D_2 was lower than D_1 and D_3 for the variety V_1 in both the year. The varieties V_3 and V_4 recorded the lowest canopy temperature when sown on D_1. In general, the canopy temperature in D_2 sown crop was lower than D_1 or D_3 in 2011. The low canopy temperature under D_2 might have boosted the pod and seed yield in the mungbean varieties. Low canopy temperature indicates lower leaf temperature, stomatal diffusion resistance and higher transpiration rate which helps to absorb carbon dioxide for photosynthetic fixation (Pallash and Samish, 1974; Nayyar et al., 1990; Chakraborty, 1994). Moreover, lower canopy temperature indicates no moisture stress suffered by the crop. The second year crop received more rainfall than the first year. The D_2 sown crop received 29.8 mm of total rainfall within two days in 2010, whereas in 2011, it received 148.2 mm within eleven days distribution. Although the D_3 sown

Table 1: Diurnal variation in canopy temperature of mungbean varieties under different dates of sowing

2010																
25 DAE	V_1				V_2				V_3				V_4			
Date of sowing	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean
D_1	25.00	38.00	39.75	34.25	24.50	40.25	37.75	34.17	23.75	38.75	34.75	32.42	24.00	41.50	27.00	30.83
D_2	26.75	35.75	31.75	31.42	28.00	39.50	32.50	33.33	28.00	38.00	32.50	32.83	27.25	38.25	32.25	32.58
D_3	28.25	33.25	33.00	31.50	29.25	34.50	35.25	33.00	28.75	32.50	32.75	31.33	29.25	33.25	32.25	31.58
32 DAE	V_1				V_2				V_3				V_4			
D_1	26.00	33.75	28.50	29.42	26.00	34.50	28.25	29.58	26.00	33.00	27.00	28.67	26.00	33.50	27.25	28.92
D_2	27.75	31.50	32.50	30.58	27.25	32.25	32.75	30.75	28.00	32.50	31.75	30.75	28.25	31.00	31.75	30.33
D_3	28.50	34.25	31.25	31.33	29.00	34.25	32.25	31.83	29.25	34.25	32.50	32.00	29.50	33.75	32.25	31.83
39 DAE	V_1				V_2				V_3				V_4			
D_1	28.00	38.50	34.75	33.75	28.25	38.75	34.50	33.83	27.75	35.75	31.75	31.75	27.00	36.00	31.50	31.50
D_2	29.50	34.75	32.00	32.08	29.50	32.25	33.50	31.75	29.00	31.00	33.00	31.00	29.00	32.25	32.50	31.25
D_3	29.00	30.25	30.50	29.92	30.00	31.25	31.25	30.83	31.25	31.00	31.50	31.25	31.75	31.00	31.50	31.42
46 DAE	V_1				V_2				V_3				V_4			
D_1	28.50	34.25	33.50	32.08	28.75	34.50	24.00	29.08	28.00	32.75	31.75	30.83	28.00	32.75	32.50	31.08
D_2	30.00	34.25	33.75	32.67	30.50	34.00	33.50	32.67	30.25	34.00	32.50	32.25	30.25	34.50	32.50	32.42
D_3	29.75	31.50	29.25	30.17	30.50	31.50	29.25	30.42	29.50	31.25	29.00	29.92	29.75	32.00	29.00	30.25
2011																
25 DAE	V_1				V_2				V_3				V_4			
Date of sowing	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean
D_1	28.00	34.25	30.50	30.92	27.00	32.25	30.50	29.92	27.50	31.75	30.00	29.75	27.25	31.75	30.00	29.67
D_2	27.50	32.75	30.50	30.25	27.25	33.00	30.50	30.25	27.00	31.75	30.50	29.75	27.25	32.25	30.75	30.08
D_3	27.75	30.25	28.50	28.83	26.75	30.50	28.25	28.50	27.50	30.50	27.75	28.58	27.00	29.00	27.75	27.92
32 DAE	V_1				V_2				V_3				V_4			
D_1	27.50	29.25	27.75	28.17	27.00	26.25	28.00	27.08	26.75	28.00	27.75	27.50	27.00	27.25	27.25	27.17
D_2	27.00	29.25	27.75	28.00	27.50	28.25	28.00	27.92	27.00	29.00	27.50	27.83	26.25	28.00	27.00	27.08
D_3	24.00	39.25	26.00	29.75	23.50	34.00	32.25	29.92	23.00	32.00	29.50	28.17	23.00	32.00	29.00	28.00
39 DAE	V_1				V_2				V_3				V_4			
D_1	23.50	34.00	30.75	29.42	24.25	36.50	30.75	30.50	23.25	31.75	29.75	28.25	23.00	31.75	29.50	28.08
D_2	23.50	32.75	31.25	29.17	23.75	32.25	29.50	28.50	23.00	31.25	29.25	27.83	22.25	31.50	29.25	27.67
D_3	30.00	33.75	31.25	31.67	30.25	34.75	32.00	32.33	30.75	34.25	31.00	32.00	30.50	33.00	30.25	31.25
46 DAE	V_1				V_2				V_3				V_4			
D_1	30.25	35.00	32.00	32.42	30.25	35.50	32.25	32.67	30.00	34.50	31.25	31.92	30.00	34.50	32.25	32.25
D_2	29.75	33.50	32.00	31.75	30.25	34.25	32.25	32.25	30.50	34.25	31.50	32.08	30.00	33.75	31.00	31.58
D_3	28.00	35.50	29.50	31.00	29.25	34.75	29.75	31.25	28.50	34.50	29.75	30.92	28.25	33.75	29.50	30.50

crop received the highest amount of rainfall but this rainfall came during the later part of growth causing severe damaged to the flower flush as well as pod formation, that's why the yield was less under D_3 sowing (Tables 2 and 3). The low canopy temperature observed under D_3 sowing in 2010 was due to higher soil moisture content. Kiran and Bains (2008) also observed that the frequent rainfall might reduce the canopy temperature for mungbean crop. The average canopy temperatures they obtained in mungbean were 31.6, 36.1 and 29.3 °C when the crop was sown on 12th, 19th and 26th April

Table 2: Total rainfall (mm) received during different phenophases of mungbean under different dates of sowing													
	Days after emergence-2010							Days after emergence-2011					
	0-25	25-32	32-39	39-46	46-H	Total		0-25	25-32	32-39	39-46	46-H	Total
D_1	7.60	0.00	0.00	0.00	0.00	7.60	D_1	10.40	4.40	17.20	49.20	18.00	99.20
D_2	0.00	0.00	0.00	0.00	29.80	29.80	D_2	32.00	49.20	18.00	0.00	49.00	148.20
D_3	0.00	0.00	0.00	31.80	84.00	115.80	D_3	97.20	0.00	42.00	7.00	76.00	222.20

Table 3: Total number of rainy days during different phenophases of mungbean under different dates of sowing													
	Days after emergence-2010							Days after emergence-2011					
	0-25	25-32	32-39	39-46	46-H	Total		0-25	25-32	32-39	39-46	46-H	Total
D_1	2	0	0	0	0	2	D_1	2	1	1	3	1	8
D_2	0	0	0	0	2	2	D_2	4	3	2	0	2	11
D_3	0	0	0	3	2	5	D_3	7	0	1	1	6	15

under Punjab condition.

3.2. Diurnal variation in Stress Degree Day Index (SDDI)

The diurnal variation in SDDI is presented in Table 4. The result showed that the D_1 sown crop suffered moisture stress at 11: 30 hour in 2010. The mean SDDI values under D_1 sowing showed that the variety V_1 suffered moisture stress only during 25 DAE in 2010; this variety did not suffer any moisture stress. In 2011, the crop did not suffer any moisture stress upto 39 DAE, whereas in 2010, the early stage was subjected to moisture stress.

The D_2 sown crop did not suffer the moisture stress at any stage of growth in both the year. The moisture adequacy in crop leaf was more in 2010 than in 2011. In 2011, the moisture adequacy during 39 DAE was more than in 2010. This indicated a possibility of better flower and pod formation in 2011 sown crop.

The D_3 sown crop suffered the moisture stress during the later part of growth in 2011. Moreover, on both the early and later stage, all the varieties recorded lower moisture adequacy under D_3 sowing. If the overall mean for three dates of sowing and

Table 4: Diurnal variation in SDDI of mungbean varieties under different dates of sowing																
	2010															
25 DAE	V_1				V_2				V_3				V_4			
Date of sowing	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean
D_1	-1.50	3.00	8.25	3.25	-2.00	5.25	6.25	3.17	-2.75	3.75	3.25	1.42	-2.50	6.50	-4.50	-0.17
D_2	-2.75	-2.25	-7.75	-4.25	-1.50	1.50	-7.00	-2.33	-1.50	0.00	-7.00	-2.83	-2.25	0.25	-7.25	-3.08
D_3	-2.25	-1.25	-2.50	-2.00	-1.25	0.00	-0.25	-0.50	-1.75	-2.00	-2.75	-2.17	-1.25	-1.25	-3.25	-1.92
32 DAE	V_1				V_2				V_3				V_4			
D_1	-3.00	0.25	-5.00	-2.58	-3.00	1.00	-5.25	-2.42	-3.00	-0.50	-6.50	-3.33	-3.00	0.00	-6.25	-3.08
D_2	-2.25	-3.00	-3.50	-2.92	-2.75	-2.25	-3.25	-2.75	-2.00	-2.00	-4.25	-2.75	-1.75	-3.50	-4.25	-3.17
D_3	-3.00	-2.25	-6.75	-4.00	-2.50	-2.25	-5.75	-3.50	-2.25	-2.25	-5.50	-3.33	-2.00	-2.75	-5.75	-3.50
39 DAE	V_1				V_2				V_3				V_4			
D_1	-1.50	0.50	-4.75	-1.92	-1.25	0.75	-5.00	-1.83	-1.75	-2.25	-7.75	-3.92	-2.50	-2.00	-8.00	-4.17
D_2	-1.00	0.25	-3.50	-1.42	-1.00	-2.25	-2.00	-1.75	-1.50	-3.50	-2.50	-2.50	-1.50	-2.25	-3.00	-2.25
D_3	-1.00	-4.75	-5.00	-3.58	0.00	-3.75	-4.25	-2.67	1.25	-4.00	-4.00	-2.25	1.75	-4.00	-4.00	-2.08
46 DAE	V_1				V_2				V_3				V_4			
D_1	-1.50	-0.25	-2.50	-1.42	-1.25	0.00	-12.00	-4.42	-2.00	-1.75	-4.25	-2.67	-2.00	-1.75	-3.50	-2.42
D_2	-1.50	-2.25	-4.25	-2.67	-1.00	-2.50	-4.50	-2.67	-1.25	-2.50	-5.50	-3.08	-1.25	-2.00	-5.50	-2.92
D_3	-0.25	-1.50	-3.75	-1.83	0.50	-1.50	-3.75	-1.58	-0.50	-1.75	-4.00	-2.08	-0.25	-1.00	-4.00	-1.75

Continue...

2011																
25 DAE	V_1				V_2				V_3				V_4			
Date of sowing	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean	07:30	11:30	15:30	Mean
D_1	-0.50	1.75	-1.50	-0.08	-1.50	-0.25	-1.50	-1.08	-1.00	-0.75	-2.00	-1.25	-1.25	-0.75	-2.00	-1.33
D_2	-1.00	0.25	-1.50	-0.75	-1.25	0.50	-1.50	-0.75	-1.50	-0.75	-1.50	-1.25	-1.25	-0.25	-1.25	-0.92
D_3	-1.25	-1.25	-2.00	-1.50	-2.25	-1.00	-2.25	-1.83	-1.50	-1.00	-2.75	-1.75	-2.00	-2.50	-2.75	-2.42
32 DAE	V_1				V_2				V_3				V_4			
D_1	-1.50	-2.25	-2.75	-2.17	-2.00	-5.25	-2.50	-3.25	-2.25	-3.50	-2.75	-2.83	-2.00	-4.25	-3.25	-3.17
D_2	-2.00	-2.25	-2.75	-2.33	-1.50	-3.25	-2.50	-2.42	-2.00	-2.50	-3.00	-2.50	-2.75	-3.50	-3.50	-3.25
D_3	-3.00	5.75	-7.50	-1.58	-3.50	0.50	-1.25	-1.42	-4.00	-1.50	-4.00	-3.17	-4.00	-1.50	-4.50	-3.33
39 DAE	V_1				V_2				V_3				V_4			
D_1	-3.50	0.50	-2.75	-1.92	-2.75	3.00	-2.75	-0.83	-3.75	-1.75	-3.75	-3.08	-4.00	-1.75	-4.00	-3.25
D_2	-3.50	-0.75	-2.25	-2.17	-3.25	-1.25	-4.00	-2.83	-4.00	-2.25	-4.25	-3.50	-4.75	-2.00	-4.25	-3.67
D_3	-0.50	-0.75	0.25	-0.33	-0.25	0.25	1.00	0.33	0.25	-0.25	0.00	0.00	0.00	-1.50	-0.75	-0.75
46 DAE	V_1				V_2				V_3				V_4			
D_1	-0.25	0.50	1.00	0.42	-0.25	1.00	1.25	0.67	-0.50	0.00	0.25	-0.08	-0.50	0.00	1.25	0.25
D_2	-0.75	-1.00	1.00	-0.25	-0.25	-0.25	1.25	0.25	0.00	-0.25	0.50	0.08	-0.50	-0.75	0.00	-0.42
D_3	-0.50	5.50	-0.50	1.50	0.75	4.75	-0.25	1.75	0.00	4.50	-0.25	1.42	-0.25	3.75	-0.50	1.00

four varieties are presented it will be as follows –

	2010			2011		
	D_1	D_2	D_3	D_1	D_2	D_3
V_1	-0.67	-2.81	-2.85	-0.94	-1.38	-0.48
V_2	-1.38	-2.38	-2.06	-1.13	-1.44	-0.29
V_3	-2.67	-2.79	-2.46	-1.81	-1.79	-0.88
V_4	-2.46	-2.85	-2.31	-1.88	-2.06	-1.38

The above analysis showed that the crop did not suffer moisture stress at any stage. The moisture adequacy was better under D_2 sowing giving the probability of good yield under this sowing.

4. Conclusion

Canopy temperature for V_1 variety under D_2 sowing was found to be lower than other dates of sowing indicating the non stress situation. The SDDI values were more negative under D_2 sowing indicating higher moisture adequacy. The varieties V_1 and V_4 recorded lower canopy temperature and were found suitable for sowing under West Bengal situation preferably in the first week of March.

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