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Diurnal variation in temperature and humidity profile within sesamum canopy and its impact on growth process under different dates of sowing*

P.K. CHAKRABORTY, ASIS MUKHERJEE and MRINAL BISWAS
Department of Agricultural Meteorology & Physics
Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur-741 252 (W. B.), India

ABSTRACT

An experiment laid out in simple RBD combined over dates of sowing (22nd Feb–D_1, 7th March–D_2 and 22nd March–D_3) and varieties (V_1–BT-894-3, V_2–Rama and V_3–BT-893-1) was carried out in three successive years (2004, 2005 and 2006) at BCKV, W. B. to find out temperature and humidity profile within sesamum canopy and their impact on various growth processes. Results revealed that different dates of sowing exposed the crop to different ranges of temperature and RH (above and below the crop). From PCR analysis it is evident that temperature and RH on all data points significantly affected the biometric parameters. This crop could not be sown after 7th March under West Bengal condition; both the flowering and capsule-setting would be adversely affected by higher temperature below the sesamum canopy.

Key words : Air temperature, relative humidity, sesame

To augment the production, agriculturists always use the climate as zero input which leads to grow the crop in varying climatic condition to identify the best growing season for a particular crop. This approach is culminated in the date of sowing experiment in agricultural research where a crop is sown on different dates of sowing with the aim of characterizing the climate for best growth and productivity. When weather acts as a source of variation, lot of changes occur in the physical environment of plant as the environment is a source of radiant energy, water, major and minor nutrient elements. The weather elements viz., radiation (total and photosynthetically active), temperature, rainfall, relative humidity, vapour pressure, wind speed and evaporation exert remarkable influences on growth processes of plants or crops. This gives the birth of a new dimension to climate within the crop, and a crop interacts with its environment, the physical processes involved are rarely simple (Monteith and Unsworth, 2001). Temperature and humidity profile within a crop canopy greatly affect the growth process and yield of a crop (Nath *et al*., 2000; Prasad *et al*., 2000; Nath *et al*., 2001). Diurnal pattern of variation in air temperature and humidity profile has also a profound impact on growth processes which have not received due attention. The present paper, emanated from a three year field study on sesamum crop, sown on three dates, will discuss this aspect.

MATERIALS AND METHODS

An experiment laid out in simple RBD, combined over three dates of sowing (22nd Feb.–D_1, 7th March–D_2 and 22nd March–D_3) and three varieties (V_1–BT-894-3, V_2–Rama and V_3–BT-893-1) was carried out in three successive years (2004, 2005 and 2006) at BCKV, W.B. There were nine treatment combinations and the plot size was 20 m^2. Air temperature and relative humidity 25 cm above the crop and ground surface (within crop canopy) were measured at 8.00, 10.00, 12.00, 14.00 and 16.00 h on 30^{th}, 45^{th} and 60^{th} days after emergence (DAE) with the help of Assman Psychrometer. Principal component regression analysis was done to find out the impact of air temperature and relative humidity on different growth processes. The data bases presented in this paper are averaged over different varieties and experimental years.

RESULTS AND DISCUSSION

Diurnal variation in temperature

On 30^{th} days after emergence (DAE), air temperature above the seasamum canopy increased gradually from 8.00 to 14.00 h, the extent of increase was to the tune of 7.4 ^{0}C and then followed a decline by 3°C (Fig. 1, A1). The temperature below the crop canopy also followed a similar trend, however, temperature below the sesamum canopy was always lower than that of the above; the difference ranged from 0.1 to 0.9 ^{0}C. On 45th DAE, the pattern of diurnal variation was very similar; however, the air temperatures above and below canopy were always higher than the temperatures recorded on 30th DAE (Fig. 1, B1). On 60th DAE, the trend was similar (Fig. 1, C1); however, the air temperature above and below the canopy was higher when compared with 45th DAE.

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When the crop was sown on 7th March, the temperature above the sesamum canopy ranged from 31.9 to 38.2°C during a diurnal period from 8.00 to 16.00 h on 30th DAE; the temperature below the crop canopy also ranged from 31.1 to 36.7°C during the same period (Fig. 1, A2). On 45th DAE, the temperature above the crop rose to a maximum of 39.6^0C at 14.00 h and then followed a decline at 16.00 h. On 60th DAE also, the sesamum crop experienced a very high temperature during its diurnal course of variation (Fig. 1, C2).

Sesamum sown on 22nd March recorded almost similar trend in respect to diurnal trend of temperature variation above and below crop canopy (Fig. 1, A3-C3). If the trend of variation in temperature above and below crop canopy would be inspected carefully, the following salient features would be evident :

If the crop sowing was delayed, the sesamum will be subjected to higher temperature both above and below the crop canopy.

Diurnal increase of temperature was such that maximum unit increase was recorded during 8.00 to 10.00 h; this high rise in temperature definitely affected the growth processes. Higher temperature below the sesamum canopy had adversely affected the capsule production in 1st and 2nd primary branches (Nath *et al.*, 2000).

This crop could not be sown after 7th March under West Bengal condition; both the flowering and capsule-setting would be adversely affected by higher temperature below the sesamum canopy.

Effect of temperature on growth process

The principal component regression analysis results showed that the air temperature above the crop canopy significantly explained the variation in LAI and dry matter of sesamum on different dates after emergence (Table 1). On 30th DAE, the principal component-2 (PC-2) significantly explained the variation in LAI due to variation in air temperature above the crop. About 26.4, 69.3 and 48.2% variation in LAI on 30th, 45th and 60th DAE were explained by the variation in temperature above the sesamum canopy (Table 1, A). Similarly, about 48.8, 81.1 and 66.7% variation in dry matter production had been explained by the variation in air temperature above the crop canopy (Table 1, B).

The PCR results due to air temperature below the crop canopy significantly affected the LAI as well as dry matter production of sesamum on all dates of observations; however, the effect was spectacular on 45th DAE (Table 2).

Diurnal variation in relative humidity

The diurnal variation in relative humidity (RH) showed that the RH was dipped at 14.00 h on all dates of observations (Fig. 1, A1-C1). The RH below the canopy was always higher than above, which might be due to higher temperature above the crop. The RH below the canopy at all time points was higher on 45th DAE in comparison to 30th and 60th DAE. As LAI increased from 30th DAE and reached maximum during 45th DAE, it might help in increasing the RH by reducing airflow within the crop canopy.

On the second date of sowing the basic trend was similar (Fig. 1, A2-C2). On all dates of observations, the RH above and below the sesamum canopy started to fall from 8.00 h, recorded a minimum value at 14.00 h and then again recorded an increasing trend; the RH below the crop canopy was always higher than the value observed above the canopy.

The pattern of diurnal variation in RH was very similar to 1st and 2nd dates of sowing (Fig. 1, A3-C3).

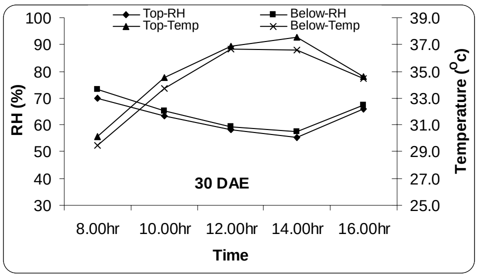
Effect of relative humidity on growth processes

From regression results, it was observed that the PC-2 significantly affected plant height ($R^2 = 0.31$); however, leaf number on 30th DAE could not be explained through PC-1 and PC-2. It indicated that the height of sesamum might be affected by the RH above the canopy. Both the plant height and leaf number of sesamum could be significantly explained by the variation in RH above crop; the R^2 value gradually increased with the progress of growth. The RH during the latter phase of growth might be more important in regulating growth processes (Table 3, A and B).

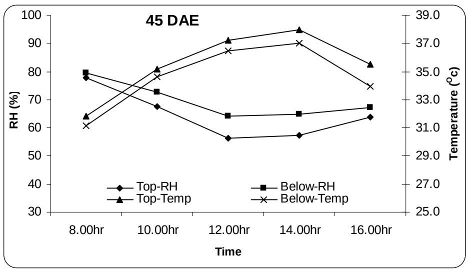
The RH below the canopy of sesamum significantly explained the variation in plant height and leaf number per plant (Table 4, A and B). The R^2 value increased gradually from 30th to 60th DAE, indicating the increasing importance of RH below the crop canopy of sesamum.

CONCLUSION

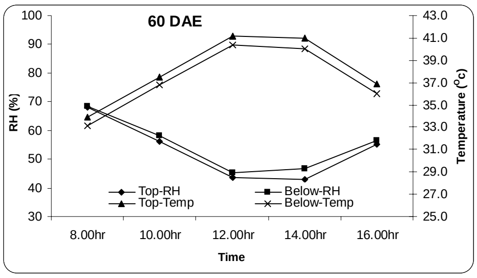
The 3-year study clearly indicated the role of temperature and humidity profile in regulating growth processes of sesamum. Delayed sown sesamum crop was subjected to higher temperature both above and below the crop canopy. Different dates of sowing exposed the crop to different ranges of RH (above and below the crop). From PCR analysis, it is evident that temperature and RH on all data points significantly affected the biometric parameters. This crop could not be sown after 7th March under West Bengal condition; both the flowering and capsule-setting would be adversely affected by higher temperature below



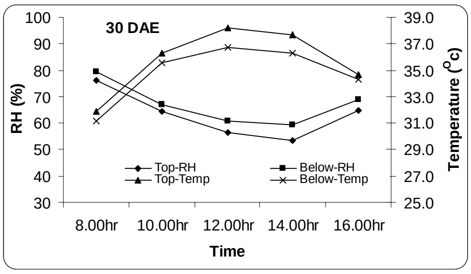
A1



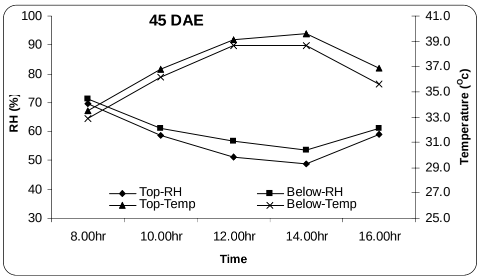
B1



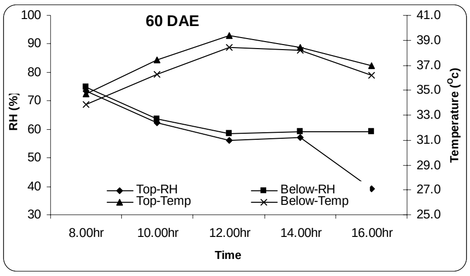
C1



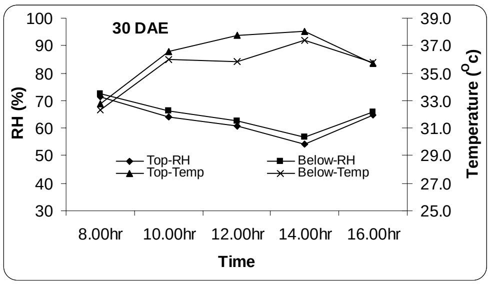
A2



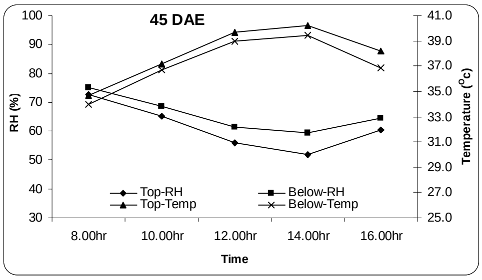
B2



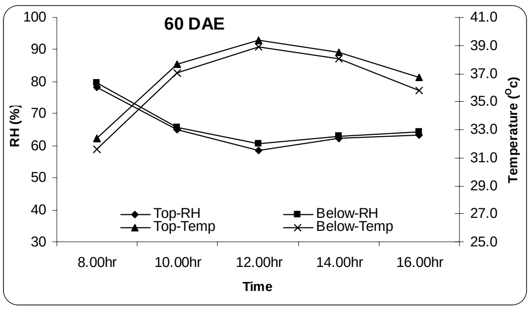
C2



A3



B3



C3

Fig. 1: Diurnal variation of temperature and relative humidity under different DOS (1st : A1-C1, 2nd : A2-C2 and 3rd : A3-C3).

Table 1: Principal component regression (PCR) analysis (stepwise) results keeping principal component score of air temperature above the crop canopy as predictors and LAI (A) and dry matter (B) dependent variables

Variable	Leaf area index				Variable	Dry matter			
	Stand. coefficient	SE	Sig.	R^2		Stand. coefficient	SE	Sig.	R^2
		30 DAE					**30 DAE**		
Pc2_30	0.26	0.04	0.02	0.264	Pc2_30	0.49	1.74	0.00	0.488
		45 DAE					**45 DAE**		
Pc1_45	0.69	0.05	0.00	0.693	Pc1_45	0.74	2.58	0.00	0.811
		60 DAE			Pc1_30	-0.31	5.05	0.00	
Pc2_60	-0.37	0.07	0.00	0.482	Pc2_30	0.24	5.07	0.00	
Pc2_30	0.25	0.07	0.00				**60 DAE**		
					Pc1_45	0.96	8.34	0.00	0.667
					Pc1_30	-0.47	7.53	0.00	
					Pc1_60	0.33	7.75	0.01	

Table 2: Principal component regression (PCR) analysis (stepwise) results keeping principal component score of air temperature below the crop canopy as predictors and LAI (A) and dry matter (B) dependent variables

Variable	Leaf area index				Variable	Dry matter			
	Stand. coefficient	SE	Sig.	R^2		Stand. coefficient	SE	Sig.	R^2
		30 DAE					**30 DAE**		
Pc2_30	-0.16	0.04	0.14	0.027	Pc2_30	0.46	1.64	0.00	0.326
		45 DAE			Pcl_30	-0.34	1.64	0.02	
Pc1_45	0.69	0.05	0.00	0.300			**45 DAE**		
		60 DAE			Pc1_45	0.74	5.68	0.00	0.622
Pc2_60	-0.41	0.06	0.00	0.274	Pc2_30	-0.17	5.02	0.03	
Pc2_30	0.02	0.06	0.05		Pc2_30	0.43	5.81	0.00	
Pc1_60	-0.23	0.06	0.02				**60 DAE**		
					Pc2_30	0.60	5.20	0.00	0434
					Pc1_60	-0.22	5.20	0.01	

Table 3: Principal component regression (PCR) analysis (stepwise) results keeping principal component score of relative humidity above the crop canopy as predictors and plant height (A) and leaf number (B) dependent variables

Variable	Plant height				Variable	Leaf number			
	Stand. coefficient	SE	Sig.	R^2		Stand. coefficient	SE	Sig.	R^2
		30 DAE					**30 DAE**		
Pc2_30	0.31	0.85	0.01	0.311	Pc1_30	-0.11	0.80	0.32	0.244
		45 DAE			Pc2_30	0.22	0.80	0.05	
Pc1_45	-0.54	1.86	0.00	0.498			**45 DAE**		
Pc1_45	-0.27	1.86	0.02		Pc2_30	-0.42	1.24	0.00	0.441
		60 DAE			Pc1_45	-0.37	1.24	0.00	
Pc1_60	0.87	0.57	0.00	0.886			**60 DAE**		
Pc1_30	0.14	0.57	0.01		Pc1_60	0.76	0.96	0.00	0.835
					Pc2_30	-0.35	0.96	0.00	
					Pc1_30	0.21	0.95	0.00	

Table 4: Principal component regression (PCR) analysis (stepwise) results keeping principal component score of relative humidity above the crop canopy as predictors and plant height and leaf number dependent variables

Variable	Plant height				Variable	Leaf number			
	Stand. coefficient	SE	Sig.	R^2		Stand. coefficient	SE	Sig.	R^2
	30 DAE					**30 DAE**			
Pc1_30	0.49	0.78	0.00	0.490	Pc1_30	0.25	0.79	0.03	0.248
	45 DAE					**45 DAE**			
Pc1_45	-0.70	1.79	0.00	0.628	Pc2_30	-0.45	1.19	0.00	0.485
Pc2_30	-0.39	1.65	0.00		Pc1_45	-0.42	1.29	0.00	
Pc1_30	-0.26	1.71	0.01		Pc1_30	-0.23	1.23	0.04	
	60 DAE					**60 DAE**			
Pc1_60	0.90	0.55	0.00	0.895	Pc1_60	0.76	0.90	0.00	0.852
					Pc2_30	-0.36	0.90	0.00	

the sesamum canopy.

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