

## Micro-climate in different planting systems of pearl millet under rainfed conditions

G. G. S. N. RAO and N. L. JOSHI

Central Arid Zone Research Institute, Jodhpur

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**सारा —** सूक्ष्म मौसम विज्ञान प्रेक्षणों जैसे नेट विकिरण फ्लक्स घनत्वों, वायु तापमान और बाजरे की फसल की परम्परागत रोपण प्रणालियों में वाष्प दाब प्रोफाइलों की जन्म प्रक्रियाओं के समय स्किपड और युग्म पंक्ति रोपण प्रणालियों के साथ तुलना की गई है। सूक्ष्म मौसम वैज्ञानिक प्राचलों के द्वारा विभिन्न रोपण प्रणालियों से प्राप्त फसल में विभिन्नताओं की व्याख्या की गई है।

**ABSTRACT.** Micrometeorological observations, viz., net radiation flux densities, air temperature and vapour pressure profiles in conventional planting system of pearl millet crop were compared to skipped and paired row planting systems at the time of reproductive stage. The variations in the yield obtained under different planting systems have been explained through micrometeorological parameters.

### 1. Introduction

Pearlmillet (*Pennisetum americanum*) is extensively grown in Rajasthan State under rainfed conditions and contributes nearly 26 per cent to the total production in the country (Mann and Singh 1975). Major area under this crop lies in the western arid districts of the State as its life cycle matches with the rainfall pattern. However, the average production rates in this region are the lowest in the country due to high probability of moisture stress experienced at maturity stage. Rao and Vyas (1983) reported that satisfactory yield in case of pearl millet could be possible only in 3 out of 10-year period in the arid districts. Rama Krishna *et al.* (1982) have studied the influence of systems of planting pearl millet on crop microclimate under arid condition and reported that tripple row and paired row systems maintained favourable micro-climatic conditions compared to conventional planting systems. However, they have not quantified the partitioning of net radiant energy into various components under the different systems. In the present work, the authors have attempted to explain the variations obtained in the yield of pearl millet crop under different planting systems through micro-climatological observations and the partitioning of net radiant energy in different planting systems with respect to their water use.

### 2. Material and methods

The studies described in this paper were conducted at the Central Research Farm of CAZRI, Jodhpur during kharif season of 1983. Pearl millet (CV. BJ 104) in different planting systems, viz., (1) uniform rows (50 cm between rows), (2) skipped rows (missing the

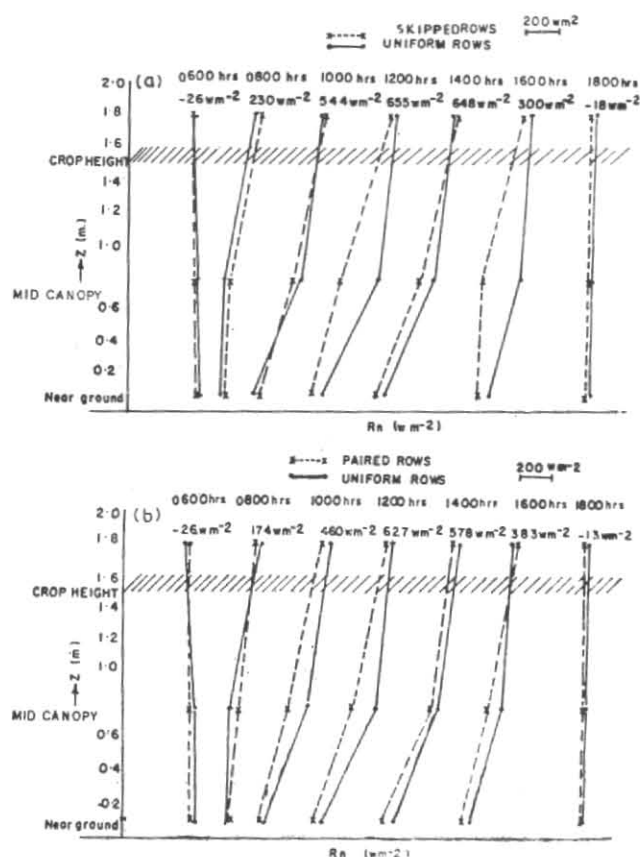
every 4th row in the uniform rows), (3) paired rows (30 cm between two rows and 70 cm between two pairs) were sown on 5 July 1983. The above planting systems were maintained at different doses of N-fertilizer, viz., 30, 60, 90 and 120 kg/ha with three replications in randomised block design. During the growing season an amount of 375.8 mm rainfall was recorded and it was fairly distributed throughout the season. Micro-meteorological observations were recorded during the reproductive phase of the crop. In view of the complexity of number of fertiliser treatments in different planting systems, observations were restricted only to the plots with 60 kg N, as this being the near optimum dose under rainfed conditions in arid areas (Joshi 1984).

Micro-meteorological observations were recorded during day time between 6 AM to 6 PM for a period of two days (15 and 16 September 1983) in the above mentioned planting systems. Net radiation profiles at bottom canopy, mid canopy and 50 cm above the canopy were recorded with Funk type net radiometers manually at hourly intervals. Air temperature and vapour pressure profiles were measured within and over the crop by Assman's psychrometer (accuracy  $\pm 0.1^\circ\text{C}$ ) at different levels, viz., near the surface, 50, 100 and 200 cm above the ground. Heat flux measurements were made with soil heat flux plates buried at 1 cm deep in the soil.

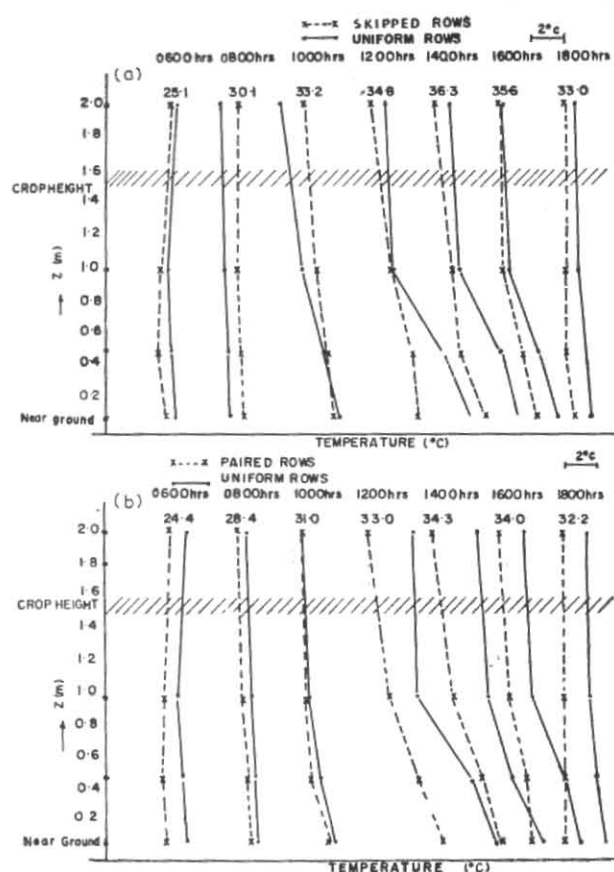
Energy balance computation for different planting systems were calculated as follows. Energy balance at any surface can be written as

$$R_n = G + H + LE + P + M \quad (1)$$

Where,  $R_n$  is the net radiation flux,  $G$  is the soil heat flux,  $LE$  is the latent heat flux. The terms  $P$  and  $M$



Figs. 1 (a & b). Diurnal variations in the profiles of net radiation in (a) Skipped rows and uniform rows and (b) Paired rows and uniform rows in pearl millet crop



Figs. 2(a & b). Diurnal variations in the profiles of temperature in (a) Skipped and uniform rows and (b) Paired and uniform rows in pearl millet crop

represent photosynthesis and miscellaneous exchanges due to plant metabolic activity. The terms  $P$  and  $M$  are usually ignored because the energy utilised is very small.  $R_n$  and  $G$  are directly measured with net radiometer and soil heat flux plates while  $LE$  is estimated by making use of the following equation :

$$LE = (R_n - G) \left[ 1 - \frac{1}{\left( \frac{\Delta}{\gamma} + 1 \right)} \times \frac{\Delta T}{\Delta T_w} \right] \quad (2)$$

where,

- $\Delta$  Slope of the saturation vapour pressure curve
- $\gamma$  Psychrometric constant
- $T$  Dry bulb temperature differences between two heights above the canopy
- $T_w$  Wet bulb temperature differences corresponding to the dry bulb temperature

From the temperature profile measurements and from the values of  $R_n$  and  $G$ , latent heat flux ( $LE$ ) values were worked out. Sensible heat flux ( $H$ ) values were indi-

rectly obtained by substituting the  $R_n$ ,  $G$  and  $LE$  values in Eqn. (1).

### 3. Results and discussion

The yield and yield attributes of pearl millet crop grown under conventional (uniform row planting) system and under skipped row and paired row system of planting are presented in Table 1.

The skipped row and paired row systems gave higher yield compared to uniform planting (Table 1). Skipped row system recorded 13.81 per cent higher yields over uniform planting inspite of the fact that this system had 25 per cent less nitrogen input owing to skipping of every fourth row. The higher per plant yield (14.3%) owing to higher number of heads/plant and weight/head under skipped row system seem to have contributed to this increased yield. The better performance of both paired and skipped row systems may be attributed to favourable micro-climatological conditions which are discussed in detail.

(A) Net radiation ( $R_n$ ) profiles — Profiles of net radiation in skipped rows and paired rows with respect

TABLE 1

Yield and yield attributes as influenced by planting systems

Planting system	Yield (kg/ha)	Yield/ plant (g)	Wt./head (g)	No. of heads/ plant	No. of tillers/ plant
Uniform rows	3164	203	30.12	1.42	4.64
Skipped rows	3601	237	43.97	2.30	5.98
Paired rows	3218	221	32.05	1.46	4.74

TABLE 2

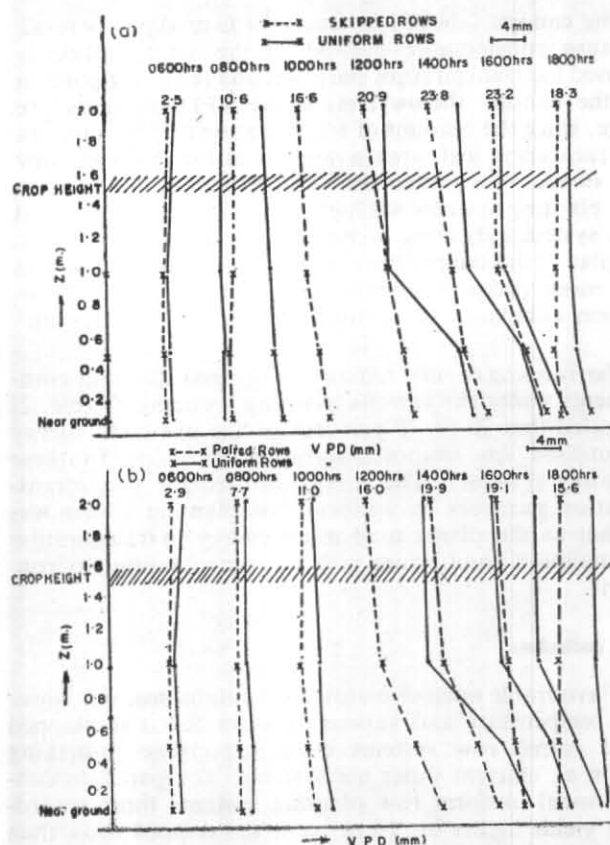
Energy balance components in different systems of planting in pearl millet crop during day hours ( $Wm^{-2}$ )

Systems	Net radiation ( $R_n$ )	Soil heat flux ( $G$ )	Latent heat flux ( $LE$ )	Sensible heat flux ( $H$ )
Skipped rows	4648	350	3259	1039
		(8)*	(70)	(22)
Paired rows	4607	230	3440	932
		(5)	(75)	(20)
Uniform rows	4736	423	3673	640
		(9)	(78)	(13)

\*Figures in brackets indicate the percentage values to that of  $R_n$ .

to uniform row planting system are presented in Fig. 1. In all the planting systems net radiation decreased with the depth during day light hours. Net radiation flux densities between the planting systems were almost equal during morning and evening, when the flux densities of  $R_n$  were small. As the day advances, differences in flux densities were observed between the systems. Higher  $R_n$  flux densities were recorded in uniform row planting systems at all levels compared to skipped row and paired row systems, suggesting that more radiation was absorbed in skipped rows and paired rows system while uniform row system allows higher amount of  $R_n$  to penetrate into the canopy. Rama Krishna *et al.* (1982) also reported that energy absorption was more under tripled and paired row system compared to uniform row planting system under rainfed conditions in arid areas. These differences in  $R_n$  attenuation were probably due to better canopy growth and increased leaf area in skipped and paired row systems.

(B) *Air temperature profiles* — In general air temperature profiles (Fig. 2) were lapse in all the three planting systems during day hours. However, during morning hours, lapse or near isothermal conditions were observed upto mid canopy level. This is due to the erectophile nature of the crop, facilitating the penetration of radiation into the canopy which is mainly consumed in



Figs. 3 (a & b). Diurnal variations in the profiles of VPD (mm) in (a) Skipped and uniform rows and (b) Paired and uniform rows in pearl millet crop

heating the soil and adjacent air layers. The air temperature profiles were similar in shape to those reported by Begg *et al.* (1964), Sauger (1970) and Baldocchi *et al.* (1983) for water stressed erectophile canopy. The profiles of temperature and  $R_n$  were almost similar during morning and late afternoon hours in all the systems as it being transitional phase. The energy available for heating the canopy is almost constant at each depth which has resulted in obtaining temperature profiles similar to  $R_n$  profiles. Uniform row system recorded higher air temperature at all the levels compared to other two systems except during morning hours. This is due to quick radiation losses from uniform row system to atmosphere due to more openings compared to skipped and paired row systems, where the energy is trapped within the canopy. It is observed that temperature differences were more significant between the paired and uniform row systems, because the paired row planting systems maintained low temperature and vapour pressure deficit values, due to more transpiration from the intercropped greengram crop between two pearl millet paired rows.

(C) *Vapour pressure deficit profiles (VPD)* — VPD profiles [Figs. 3 (a & b)] could be classified into two different segments during mid day hours, (a) upper portion

of the canopy (above 1 m) where VPD gradient is small because considerable portion of the net radiation is utilised for transpiration purposes and (b) lower portion of the canopy (below 1 m) where VPD gradients are large, since the amount of transpiration and the amount of transpiring leaf area available in the lower canopy are small. As expected the VPD profiles in the uniform row planting systems are higher than skipped and paired row system indicating higher evapotranspiration losses. Similar to air temperature differences VPD differences are more prominent between uniform and paired row system compared to uniform and skipped row system.

Partitioning of net radiant energy into different components under the various planting systems (Table 2) revealed that 70 to 78 per cent of the available energy is utilised for evapotranspiration purposes by these planting systems. The energy utilised for evapotranspiration purposes by uniform row planting system was higher as the plants used more energy in transpiration to maintain equilibrium with the surrounding environment.

#### 4. Conclusions

Favourable microclimatological conditions, viz., lower air temperature and vapour pressure deficit in skipped and paired row systems were responsible in making them as efficient water use systems, compared to conventional uniform row planting system thus recording yields higher by 14 per cent in skipped rows than in the conventional systems in spite of lesser inputs. Increase in yield in paired row is only marginal even though favourable microclimatological conditions were prevailing because of intercropping with green gram which has given additional yields. The net radiant energy partitioned for evapotranspiration is actually utilised for productivity purposes in skipped and paired row systems. Much of the net radiant energy in uniform row planting system on the other hand is utilised in the evapotranspiration process for maintaining equilibrium conditions with the surround-

ing environment which is being heated by increased radiation penetration into canopy due to variations in leaf area and its distribution.

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