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Influence of Direction of Sowing on Radiation-use Efficiency of Pearl millet

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Abstract: Field experiments were conducted at the Indian Agricultural Research Institute, New Delhi, during *kharif* seasons of 1992 and 1993 to study the effect of direction of sowing on the radiation-use efficiency during different growth stages of three pearl millet cultivars (*Pennisetum glaucum* (L.) R.). Efficiency of radiation utilization in dry matter production was maximum in HHB-67 and minimum in variety HHB-60. Sowing the crop in a north-south direction improved the radiation-use efficiency by 0.21 g MJ^{-1} over an east-west sown crop.

Key words: Cultivars, row direction, radiation-use efficiency, season, pearl millet.

One of the most important aspects of crop development influencing dry matter production and economic yield is development of the leaf canopy and its effect on the efficiency of radiation interception. Radiation interception depends mainly on the leaf area index (LAI) and canopy architecture, whereas utilization efficiency depends on individual leaf photosynthetic characteristics, as well as architecture which determines the distribution of radiation within the canopy. The radiation attenuation is mainly determined by the leaf angle distribution, but other factors such as leaf surface properties (affecting reflection), leaf thickness (transmission), leaf size, shape and vertical distribution of leaf area (direct penetration) are also important. The elevation angle of sun and proportion of direct and diffuse solar radiation also affect the same, though to a smaller extent (Hay and Walker, 1989).

Steiner (1986) found that evapotranspiration was less for a given amount of light interception in the north-south row grain sorghum crop. It means that more light is utilized for biomass production. Dhingra *et al.* (1986) reported that higher yields in north-south row wheat crop were to be associated with greater light interception.

The present investigation was undertaken to study the effect of row direction on radiation-use efficiency of peal millet (*Pennisetum glaucum* (L.) R. Br.).

Material and Methods

Field experiments were conducted at the research farm of the Indian Agricultural Research Institute, New Delhi (28° 35′N, 77°10′E; 228.1 m above mean sea level)

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Table 1. Radiation-use efficiency (g MJ^{-1}) of pearl millet cultivars (average for both sowing directions)

Cultivars	Growth stages							
	1992				1993			
	GS1	GS2	GS3	Mean	GS1	GS2	GS3	Mean
Pusa-23	1.36	4.20	4.06	3.21	1.65	2.91	3.18	2.48
HHB-60	1.24	3.86	3.59	2.90	0.90	2.75	3.05	2.23
HHB-67	1.25	4.72	4.30	3.42	0.85	3.76	3.82	2.81
LSD	0.10	0.35	0.31	0.26	0.81	0.41	0.61	0.22

during *kharif* seasons 1992 and 1993. The soil was sandy loam belonging to the family of Typic Ustocrepts. Three varieties of pearl millet (Pusa-23, HHB-60 and HHB-67) were sown in east-west and north-south row directions. All recommended agronomic practices for the crop were adopted. Photosynthetically active radiation (PAR) was measured at 10-day interval with a line quantum sensor (LI-191B) from 20 days after sowing during 1130-1300 IST. PAR was measured at the ground level by keeping the sensor parallel and perpendicular to the rows and top of the crop canopy. The reflected PAR was measured by inverting the sensor over the crop canopy. The plants were uprooted from a sq. m area and leaves were separated for leaf area measurement with a leaf area meter (LICOR). Plant samples were weighed to determine the dry matter (g m^{-2}). These observations of LAI and dry matter production were taken on the same days when PAR was recorded.

Extinction coefficients (k) were calculated using the field data in the following formula:

$k = -\ln(I/Io)/F$ (Singh *et al.*, 1996) ...1

where,

I = PAR intensity at bottom of the canopy and,

Io =PAR at top of the canopy, and

F =leaf area index.

Daily solar radiation (Rs) over crop surface was computed by using the Penman's (1948) formula for the incoming radiation:

$Rs = RA\ (a+bn/N)$

$NRs = Rs\ (1-r)$

where,

RA = Solar constant,

Table 2. Effect of sowing on radiation-use efficiency (g MJ^{-1}) of pearl millet (average for three cultivars and whole season)

Seasons	T. mean (c)	Direction of sowing		
		E-W	N-S	L.S.D.
1992	27.8	3.03	3.33	0.23
1993	29.9	2.36	2.58	0.15
Mean		2.70	2.96	

T mean - mean air temperature of the whole season, E-W - sowing in east-west direction, N-S - sowing in north-south direction.

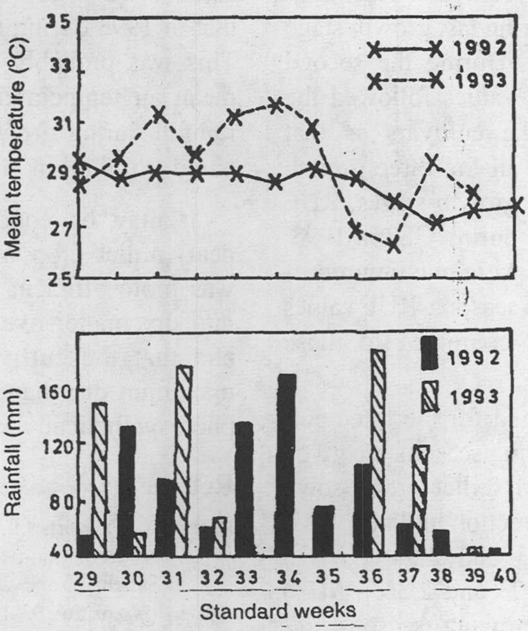

Fig. 1. Variation in mean temperature and rainfall during crop seasons.

r = albedo of the crop,

a = 0.32, b = 0.46,

n = actual sunshine hours,

N = maximum possible sunshine hours, and

NRs = net incoming solar radiation.

Incoming PAR was calculated by multiplying NRs by 0.45 (Rosenthal and Gerik, 1991). Daily radiation absorbed by the canopy was then determined form calculated extinction coefficient, incoming PAR and interpolated leaf area index measured between the radiation measurements.

Absorbed PAR = Incoming PAR $(1-e^{-kF})$ (Kiniry *et al.*, 1989) ...4

The radiation-use efficiency (RUE) was computed as:

RUE (g MJ^{-1}) = DM/absorbed PAR

where,

DM = Total dry matter produced in g m^{-2}

PAR = cumulated absorbed PAR from germination to the date of dry matter observation in MJ m^{-2}.

Results and Discussion

The RUE of three pearl millet cultivars, averaged for both direction of sowing during different growth stages, i.e., GS1 - seeding emergence to panicle initiation, GS2 - panicle initiation to anthesis, and GS3 - anthesis to maturity, is presented in Table 1. The cultivar Pusa-23 utilized PAR with maximum efficiency, followed by HHB-67 and HHB-60 during GS1 in the first season. During GS2, HHB-67 utilized PAR more efficiently by 0.52 and 0.86 g MJ^{-1} over

Pusa-23 and HHB-60 cultivars. A similar trend was observed during last growth stage of pearl millet (GS3). During the second growing season, RUE values followed the same trend among the cultivars as that of first season during all the three growth stages. But among the growth stages, RUE values were maximum during GS3 in 1993, whereas in 1992, they were maximum during GS2. Between both seasons, RUE values were higher in 1992 compared to those in 1993.

RUE values averaged for the three cultivars in both the growing seasons are given in Table 2. The pearl millet crops sown in the north-south direction utilized PAR more efficiently (3.33 and 2.58 g MJ^{-1}) over the east-west (3.03 and 2.36 g MJ^{-1}) in 1992 and 1993 growing seasons, respectively. The mean values of RUE for pearl millet in both seasons were 2.96 and 2.70 g MJ^{-1} of absorbed PAR in the north-south and east-west sown crops, respectively. Begue *et al.* (1991) reported that the maximum conversion efficiency of pearl millet was 2.9 g MJ^{-1} of absorbed PAR in the Sahelian zone.

RUE was higher in HHB-67, because it is a fast-growing and short duration variety. RUE of pearl millet was highest during GS2 in 1992, which might be attributed to the fact that the LAI was maximum during this stage. In 1993, however, RUE was highest during GS3 probably because no rainfall was received during GS2 and a good amount of rainfall was recorded during GS3. This resulted in regrowth as emergence of nodal tillers, accompanied by a steep fall in the mean temperature (Fig. 1), which would result in less respiratory losses. The efficiency of PAR utilization was higher in 1992 compared to that in 1993 during all three growth stages. This was probably due to lower seasonal mean air temperature and well distributed rainfall during growing season 1992 compared to that in 1993 (Table 3).

It may be concluded that sowing of pearl millet crop in north-south direction was more efficient in conversion of PAR into dry matter over east-west sown crop, and that the cultivar HHB-67 produced maximum dry matter per unit of absorbed photosynthetically active radiation.

References

Begue, A., Despart, J.F., Imbernon, J. and Baret, F. 1991. Radiation-use efficiency of pearl millet in Sahelian zone. *Agricultural and Forest Meteorology* 56: 93-100.

Dhingra, K.K., Dhillon, M.S., Grewal, D.S. and Sharma, K. 1986. Effect of row directions on growth, yield and yield attributes of wheat sown on three dates. *Journal of Agricultural Science* 107(2): 343-346.

Hay, R.K.M. and Walker, A.J. 1989. *An Introduction to the Physiology of Crop Yield*. Longman Scientific and Technical, U.K.

Kiniry, J.R., Jones, C.A., O'Toole, J.C., Blanchet, Cabelguenne and Spanel, D.A. 1989. Radiation-use efficiency in biomass accumulation prior to grain fillings for five grain-crop species. *Field Crops Research* 20: 51-64.

Penman, H.L. 1948. Natural evaporation from open water, bare soil and grass. *Proceeding of Royal Society*, London 193: 120-145.

Singh, R., Nehra, D.S., Singh, R., Ram Niwas and Bishnoi, O.P. 1996. Radiation interception and its efficiency for dry matter production in toria (*Brassica rapa* var. *napus*). *Indian Journal of Agricultural Sciences* 66(2): 95-100.

Rosenthal, W.D. and Gerik, T.J. 1991. Radiation-use efficiency among cotton cultivars. *Agronomy Journal* 83: 655-658.

Steiner, J.L. 1986. Dry land grain sorghum: water use, light interception and growth responses to planting geometry. *Agronomy Journal* 78(4): 720-726.