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ASSESSMENT OF AGROMETEOROLOGICAL OBSERVATIONS ON PEARL MILLET (*PENNISETUM GLACUM* L.) GENOTYPES GROWN UNDER DIFFERENT GROWING ENVIRONMENTS

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SUMMARY

Field experiment was conducted during kharif season of 2020 and 2021 at Research farm, Department of Agricultural Meteorology, CCS HAU, Hisar located at 29° 10′ N latitude, 75° 46′ E longitude and 215.2 m altitude for quantification of agro-meteorological observations of pearl millet genotypes under varying growing environments at rainfed conditions. The experiment was put in a factorial RBD design which comprised of three sowing dates *viz.* D_1 – second fortnight of June; D_2 – first fortnight of July and D_3 – second Fortnight of July and three different varieties *viz.*, V_1 – GHB558, V_2 – HHB67 improved, and V_3 – HHB272 at different phenological stages with four replications. Among varieties, GHB558 (national check) absorbed more PAR followed by HHB272 and HHB67 improved at all crop growth stages. Significantly higher intercepted solar radiation was gained in D1 followed by D_2 and D_3 sown crop at 35 DAS, LAI max and physiological maturity, respectively during both crop seasons. Among varieties, GHB 558 variety received higher intercepted solar radiation at 35 DAS, LAI max and physiological maturity. First date of sowing recorded significantly higher chlorophyll content as compare to other dates of sowing. During both crop seasons, the higher canopy temperature was observed at physiological maturity. The canopy temperature increased with delay in sowing. A comparison between two years of study, the highest chlorophyll content was observed during crop season 2020 as compare to crop season 2021.

Keywords : Pearl millet, PAR, LAI, Growing environment, Radiation

Pearl millet (*Pennisetum glacum* L.), which is grown on an area of 6.93 million ha with a productivity of 1243 kg/ha (Directorate of Millets Development, 2020) is an important kharif crop in Haryana. It is a short growing season crop and is most widely grown drought tolerant coarse grain cereal. It is used both as a feed and fodder for livestock. Being a C_4 crop, it produces high dry matter due to low photorespiration which leads to high photosynthetic efficiency. It is productive under most adverse environments than other cereals like maize and sorghum. In India, it is grown in dry regions of arid and semi-arid tropics. In crop production, radiation plays two roles, namely photosynthetically active radiation (PAR) photosynthesis for biological processes and thermal conditions for physiological processes. The microclimatic condition is responsible for the daily physical and physiological process i.e. actual evapotranspiration, photosynthesis rates, assimilation & transpiration rate of crop and finally influence the yield. Crop sown at appropriate time enables them to take full advantage of favourable weather conditions. In the process of photosynthesis, solar radiation trapped by chlorophyll provides the substances for better crop growth. Short wave radiation has an important role in biomass production which depends on solar radiation regime received by the crop at its different phenological stages. Crop growth and yield is the product of intercepted solar radiation in the crop canopy, conversion efficiency of radiation intercepted to dry matter partitioning (Jarwal and Singh, 1990). Canopy temperature is a useful indicator of water status of crop. Crop water status proves to be useful as it regulates the important physiological and morphological plant characteristic which determines the grain yield. Canopy temperature and solar radiation are closely related and it varies slowly when solar radiation varies with cloud cover. It gets increased in dense populated plant communities due to higher air temperature. There is a variation in micrometeorological aspects with variation in type of vegetation. The net radiation is the total energy available at the surface of earth to drive the climate processes of evaporation, air and soil heating, as well as biological process such as photosynthesis (Denmead *et. al.*, 1962). In cereals, maximum photosynthetically active radiation (PAR) interception is observed at reproductive phase. It is necessary to evaluate the pearl millet genotypes under different growing environments for sustainable crop production.

MATERIALS AND METHODS

The experiments were laid at Research farm of the Department of Agricultural Meteorology, CCS HAU, Hisar (Lat. 29^0 10' N; Long.75^0 46' E and 215.2 m above mean sea level) during kharif season of 2020 and 2021 with Pearl millet crop on a sandy loam soil, for assessment of agro-meteorological observations of pearl millet genotypes under varying growing environments at rainfed conditions. The main plot treatments consisted of three dates of sowing (D_1 – second fortnight of June; D_2 – first fortnight of July and D_3 – second fortnight of July) and subplot treatments consisted three varieties (V_1 – GHB 558, V_2 – HHB 67 improved, and V_3 – HHB 272) using factorial RBD design having gross plot size of 4.0 m × 3.6 m and net plot size of 3.0 m × 2.6 m with four replications. The recommended dose of nitrogen (40 kg N/ha) and phosphorus (20 kg P_2O_5/ha) along with gypsum were applied. Full dose of phosphorus and half dose of nitrogen were applied at sowing time and remaining half dose of nitrogen was applied at tillering stage of pearl millet crop. The sources of nitrogen and phosphorus were urea (46 % N) and single super phosphate (16 % P_2O_5), respectively. Sowing was done in rows spaced 45 cm and plant spaced 12 cm apart at a depth of 5 cm.

The agro-meteorological observations were recorded of PAR and canopy temperature at vegetative, anthesis and crop maturity stage and intercepted radiation, net radiation and at respective 35 days after sowing, maximum LAI stage and physiological maturity stage with clear sky at hourly interval from 0900 to 1700 hours in crop season kharif 2020 and 2021. The photosynthetically active radiation was measured using point quantum sensor (Model L1-190SB). Reflected PAR was measured by inverting the sensor over canopy. Canopy temperature was measured with the help of Infra-red thermometer (Model AG-45, Telatemp Corp.) during noon hours at different phenological stages. The amount of solar radiation received by crop was measured with the help of pyranometer connected to a digital multivoltmeter. This study was statistically analyzed by using the technique of analysis of variance (ANOVA) as applicable to factorial RBD design suggested by Fisher (1950). The significance of the treatment effects was determined using F-test at 5 per cent probability.

Net radiations were computed and tabulated using equation during different growth intervals under rainfed condition. The seven weather parameters *viz.* T_{max}, T_{min}, T_{mean}, RH_m, RH_e, BSS/n, WS (u_2), cloud condition and the latitude and altitude of field area was used to compute each parameter which is required for the radiation components.

a. Estimating downward solar (short wave) radiation (R_s)

This is the Hargreaves (1998) radiation formula.

R_s = 0.16 * R_a * sqrt[(T_{max} - T_{min})], Where R_s & R_a are in MJ m^{-2} day^{-1} ….(iv)

In equation daily observed maximum (T_{max}) and minimum temperature (T_{min}) were used

The PAR values were converted into MJm^{-2}, daily IPAR was calculated using expression.

PAR = Rs x 0.48 (Oleson *et al.*, 2000)

b. Estimating atmospheric emissivity (ε_a)

The original equation has been modified below to suit the units of the database

$$\varepsilon_a = (0.72+0.005T_{mean})\ (1–0.0084\ \text{Cloud}) + 0.0084\ \text{Cloud} \quad \dots (v)$$

T_{mean} is mean temperature and cloud cover used for the computation

c. Estimating net long wave radiation (R_L)

Assumed terrestrial emissivity=0.97

$$R_L = (4.903*10^{-9}) * (\varepsilon_a - 0.97) * [T_{mean}+273]^4 \quad ...(vi)$$

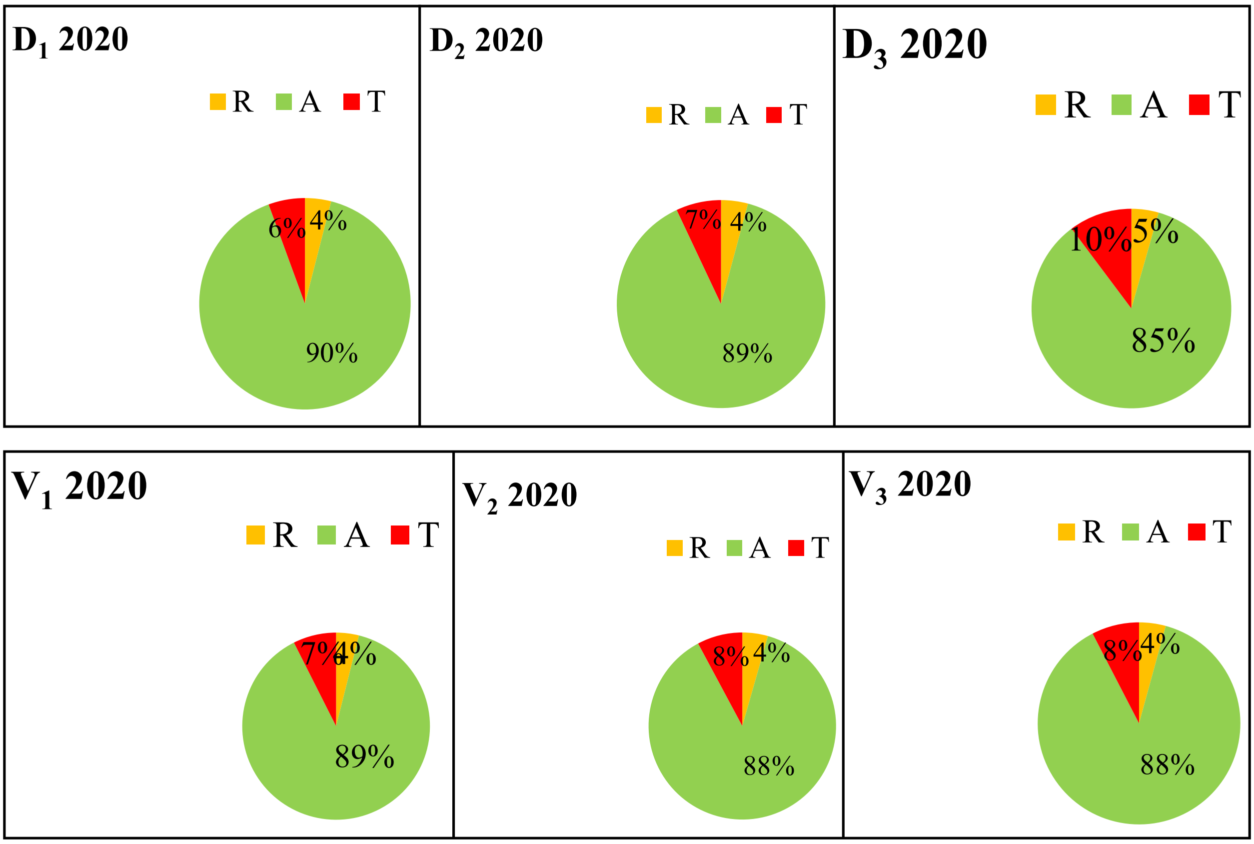

Fig. 1. Photosynthetically active radiation (%) on different growing environments and genotypes in pearl millet (*Kharif* 2020).

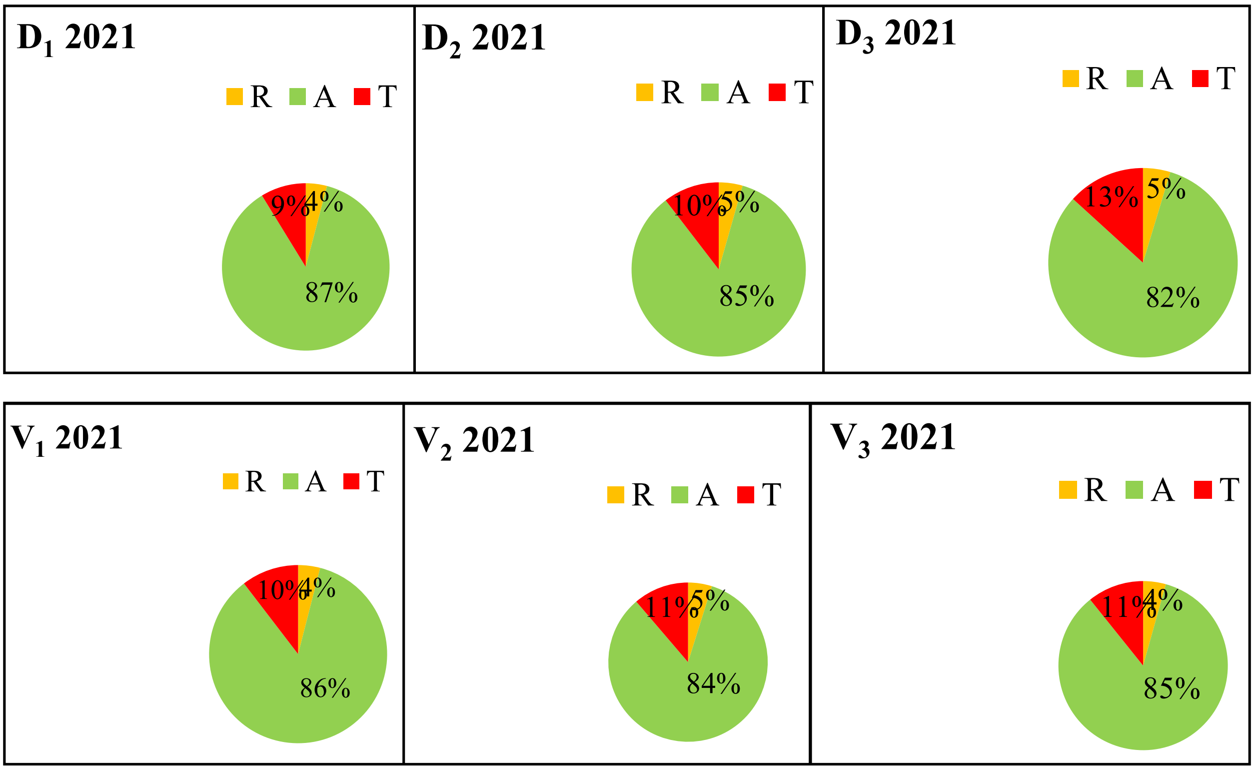

Fig. 2. Photosynthetically active radiation (%) on different growing environments and genotypes in pearl millet (*kharif* 2021).

Where, R_L is in MJ m^{-2} day^{-1}

d. Estimating net radiation (R_{net})

$R_{net} = (0.77 * R_s) - R_L$ Where R_L, R_{net}, R_L are in MJ m^{-2} day^{-1} ...(vii)

RESULTS AND DISCUSSION

Photosynthetically active radiation (PAR %)

Photosynthetically active radiation (PAR %) of solar radiation *viz.,* reflected (R), absorbed (A) and transmitted (T) of pearl millet crop recorded at vegetative, anthesis and physiological maturity stage are shown in Fig. 1 and 2. During both the crop seasons, absorbed radiation increased from tillering to anthesis till the crop attained maximum leaf area index and then decreased from milking stage up to physiological maturity phase among different growing environments and varieties. Early sown crop (D_1) had more absorption i.e. 90.4 % and 87.2 % among the growing environments, whereas, among varieties, V_1 variety had highest absorption *i.e.* 88.6.0 % and 85.7 % at anthesis stage during crop season 2020 and 2021 respectively (Fig. 1 and 2). The absorbed of radiation was higher in 2020 than 2021. The reflection of radiation due to senescence of leaves and decrease in chlorophyll content in foliage of crop and transmission of radiation due to less ground canopy cover by leaves which was highest at physiological maturity stage during both the crop seasons.

Intercepted Radiation

Comparative accounts of radiation intercepted for completion of different phenological stages of pearl millet under different growing environments during 35 DAS, maximum LAI (LAI_{max}) phase and at physiological maturity phase are presented in Table 1. In both the crop seasons 2020 and 2021, physiological maturity stage accumulated maximum intercepted PAR by the crop sown under D_1, (354.7 and 324.7 MJ/m^2/day) followed by D_2 (330.2 and 290.2 MJ/m^2/day) and D_3 (301.1 and 271.1 MJ/m^2/day) in crop seasons 2020 and 2021, respectively. Among pearl millet genotypes as shown in Table 2, V_1 (337.3 and 304.0 MJ/m^2/day) accumulated maximum intercepted PAR at physiological maturity stage followed by V_3 (327.9 and 294.6 MJ/m^2/day) and V_2 (226.8 and 266.1 MJ/m^2/day) in crop seasons 2020 and 2021, respectively.

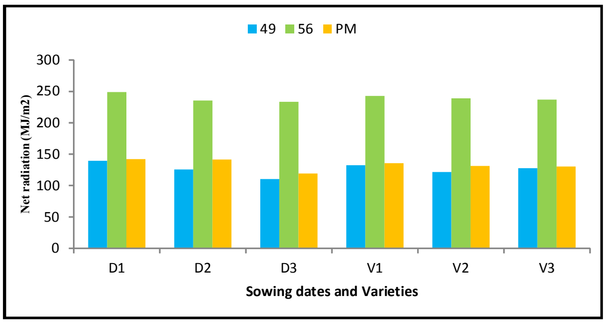

Fig. 3. Net Radiation influenced by different growing environments and varieties (*Kharif* 2020).

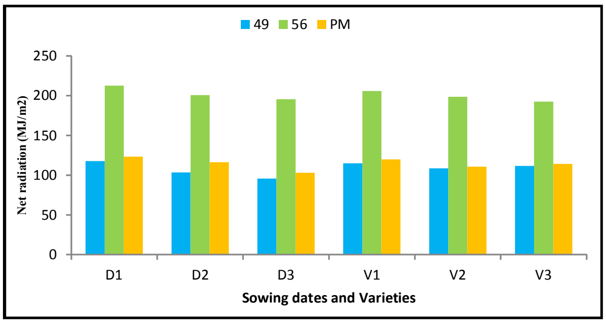

Fig. 4. Net Radiation influenced by different growing environments and varieties (*Kharif* 2021).

Among the growing environment, the highest accumulated intercepted radiation was received in D_1 followed by D_2 and D_3 at 35 DAS, LAI_{max} and physiological maturity during both the crop seasons. During the crop season 2021, the D_1 sown crop received 124.7 MJ/m^2/day and 229 MJ/m^2/day of accumulated intercepted radiation at 35 DAS and LAI_{max} phases. Among the varieties, the highest accumulated intercepted radiation was received in V_1 followed by V_3 and V_2 at 35 DAS, LAI_{max} and physiological maturity during both the crop seasons. In both the crop season 2020 and 2021 the accumulated intercepted PAR increased with advancement of crop phenological stages and was recorded maximum at physiological maturity. Jarwal *et. al.,* 1990 supported these results on intercepted PAR with reference to bajra cultivars research work.

Net Radiation

The net radiation over the pearl millet crop increased with time in all the treatments up to dough stage (Table 2). Then after at the physiological maturity, it decreased. D_1 (354.6 and 346.7MJ/m^2/day) recorded highest value for net radiation followed by D_2 (330.2 and 318.4 MJ/m^2/day) and D_3 (30.1.1 and 305.7 MJ/m^2/day) during 2020 and 2021 respectively.

TABLE 1

Accumulated Intercepted Radiation ($MJ/m^2/day$) of Pearl millet, under different growing environments at 35 DAS, maximum LAI phase and at physiological maturity phase of growth (2020 & 2021)

Treatments	2020			2021		
	35 DAS	LAI max	PM	42 DAS	LAI max	PM
2nd fortnight of June	147.7	240.0	354.7	124.7	229.0	324.7
1st fortnight of July	141.7	232.0	330.2	112.3	226.3	290.2
2nd fortnight of July	140.1	209.3	301.1	116.1	181.5	271.1
SEm ±	0.11	0.08	0.12	0.11	0.08	0.13
CD at 5%	0.32	0.25	0.34	0.33	0.25	0.38
GHB 558	147.2	230.6	337.3	124.5	217.5	304.0
HHB 67 improved	137.7	222.3	320.7	115.0	207.8	287.3
HHB 272	144.6	228.4	327.9	113.6	211.5	294.6
SEm ±	0.11	0.08	0.12	0.11	0.08	0.13
CD at 5%	0.32	0.25	0.34	0.33	0.25	0.38

DAS: Days after sowing, LAImax: Maximum LAI stage; PM: Physiological maturity; NS: Treatment difference not significant.

TABLE 2

Accumulated net radiation ($MJ/m^2/day$) of Pearl millet under different growing environments at 35 DAS, maximum LAI phase and at physiological maturity phase of growth (2020 & 2021)

Treatments	2020			2021		
	35 DAS	LAI max	PM	42 DAS	LAI max	PM
2nd fortnight of June	195.6	268.9	354.6	185.2	237.6	346.7
1st fortnight of July	194.1	253.5	330.2	172.8	232.6	318.4
2nd fortnight of July	181.2	239.8	301.1	160.8	223.8	305.7
SEm ±	0.09	0.09	0.09	0.09	0.15	0.11
CD at 5%	0.28	0.28	0.29	0.27	0.43	0.32
GHB 558	196.8	260.6	337.3	178.8	238.1	332.3
HHB 67 improved	185.0	248.4	320.7	167.8	223.5	315.6
HHB 272	189.0	253.1	327.9	172.2	232.5	322.9
SEm ±	0.09	0.09	0.09	0.09	0.15	0.11
CD at 5%	0.28	0.28	0.29	0.27	0.43	0.32

As shown in figure 3 and 4, among varieties V_1 (337.3 and 332.3 $MJ/m^2/day$) recorded highest value of net radiation followed by V_3 (327.9 and 322.9 $MJ/m^2/day$) during 2020 and 2021 respectively.

Canopy temperature

In pearl millet crop, growing environments and varieties significantly influenced the canopy temperature (Table 3). Highest canopy temperature observed in D_3 followed by D_2 and D_1. Maximum canopy temperature was observed in V_2 followed by V_3 and V_1 during both the crop seasons. Among different growing environments, the higher canopy temperature (Tc) was observed at D_3 followed by D_2 and D_1 during both the crop season at physiological maturity (Table 5) whereas; it was almost same at vegetative and anthesis stage during both the crop season.

CONCLUSION

As above micrometeorological research analysis of rainfed pearmillet crop sown under the semi-arid condition of Hisar, Haryana. The crops sown on second fortnight of June (D_1) were most efficient in thermal condition and radiation utilization which resulted in better crop growth and produced higher grain and stover yield as compared to other dates of sowing, due to less number of phenological days. This causes to decrease in yield. Among the varieties, the variety V_1 (GHB 558) resulted better crop growth and produced higher grain and straw yield in Comparision with other sown varieties under varying growing

TABLE 3

Effect of varying growing environments on canopy temperature from vegetative to physiological maturity stage over pearl millet crop (2020 & 2021)

Treatments	2020			2021		
	Vegetative	Anthesis	PM	Vegetative	Anthesis	PM
2nd fortnight of June	32.1	32.8	35.2	31.2	31.3	32.5
1st fortnight of July	32.8	34.0	36.8	32.4	32.6	33.3
2nd fortnight of July	37.0	34.3	36.8	36.5	32.9	34.2
SEm ±	0.13	0.16	0.13	0.15	0.11	0.13
CD at 5%	0.39	0.46	0.39	0.43	0.32	0.39
GHB 558	32.6	33.1	36.0	32.0	31.5	32.6
HHB 67 improved	35.3	34.0	36.5	34.6	32.7	34.0
HHB 272	34.1	34.0	36.3	33.5	32.6	33.4
SEm ±	0.13	0.16	0.13	0.15	0.11	0.13
CD at 5%	0.39	0.46	0.39	0.43	0.32	0.39

environments during 2020 and 2021. Canopy temperature increased with delay in sowing. Reflected radiation decreased from tillering to anthesis after that it increased upto physiological maturity. The absorbed radiation increased from tillering to anthesis till the crop attained maximum leaf area index and then it decreased upto physiological maturity due to senescence of leaf. Therefore the trend was reversed for transmission in PAR radiation component.

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