Forage Res., **41** (4) : pp. 212-217 (2016) **http://forageresearch.in**

GROWTH, BIOMASS AND YIELD OF RAINFED PEARL MILLET IN RELATION TO AGROMETEOROLOGICAL INDICES

RISHU SHEKHAR SINGH, M. L. KHICHAR*, RAM NIWAS, ANIL KUMAR AND ANURAG

Department of Agricultural Meteorology
CCS Haryana Agricultural University,
Hisar-125 004 (Haryana), India
(e-mail : dr.mlkhichar@gmail.com)
(Received : 10 February 2016; Accepted : 25 March 2016)

SUMMARY

Field research was conducted at Research Farm of CCS Haryana Agricultural University, Hisar to evaluate the relationship of crop growth, fodder biomass and yield with agrometeorological indices in pear millet. Pearl millet crop was sown in randomized block design with 13 fertility levels of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) and in three replications. Agrometeorological indices : thermal, helio-thermal and photo-thermal units were computed for all the fertility treatments using weather data recorded at agricultural meteorological observatory. Efficiency of thermal and radiation energy conversion into dry biomass was computed using the thermal and radiation indices. Agrometeorological indices and crop parameters were correlated for developing regression models to predict the different plant biometrics as dry matter, yield and leaf area index in pear millet crop. Yield and yield traits (grain yield, stover yield and biological yield) were correlated with photothermal unit (PTU), thermal (TUE) and radiation use efficiency (RUE) showed higher correlation coefficient with RUE as compared to TUE. The multiple regression models developed for prediction of leaf area index (LAI) and dry matter (DM) based on agrometeorological indices are as under :

$$DM=0.658-.000056\times PTU+90.662\times HUE-0.117\times RUE \quad (R^2=0.98)$$

$$LAI=1.895+0.006\times 4HUE+0.726\times RUE \quad (R^2=0.74)$$

Agrometeorological indices were explained up to 74 and 92 per cent variability in leaf area and dry matter, respectively.

Key words : Fertilizer level, regression, pearl millet, correlation, weather parameters, rainfed

Pearl millet is an important dual purpose cereal crop in India which not only provides grains for human consumption but also fodder and grain for cattle. Besides providing food and fodder, pearl millet is grown in the tropics, hot and dry climate and also can be grown in areas like arid or semi-arid where rainfall is not sufficient as received erratic and variable amount and also have characteristics to drought tolerant warm season (Sharma *et al*., 2010). Rainfall, temperature and radiation are major meteorological parameters, which influence all aspects and stages of growth of the crop. Solar radiation is an important asset in crop production and it is seldom a limiting factor in the arid and semi-arid regions. Pearl millet is a photosensitive and thermo sensitive long day plant. Solar radiation interception and its efficiency play major role in dry matter production. The fraction of radiation energy intercepted during the growing period depends on total incident radiation that was intercepted due to canopy development during its various phenophases. Application of higher fertilizer level showed pronounced effect on yield attributes and finally higher grain yield of pearl millet crop. Grain yield in the 60 kg N+30 kg P_2O_5 +20 kg K_2O/ha was found to be maximum (2063.1 kg/ha) over the control (1256.5 kg/ ha) and reported higher level of fertilizer significant correlation with yield (Parihar *et al.*, 2005). Murtisankar *et al.* (2012) also found that fertilizer treatments were significantly influenced on grain yield of pearl millet. Agroclimatic indices are useful for assessing the impact of agrometeorological variables at different crop growth stages. Fertilizer deficiency affects crop growth by reducing the pearl millet leaf area and intercepted photosynthetically active radiation (IPAR) by Sharma *et al.* (2000) found the relationship between PAR interception and dry matter production in pearl millet. Rathore *et al.* (2008) reported that radiation absorption coefficient of photosynthetic active radiation was higher and radiation transmission coefficient was less in 90 kg N+45 kg P_2O_5/ha. Therefore, the present study was undertaken to evaluate the relationship of crop growth, biomass and yield with agrometeorological indices.

MATERIALS AND METHODS

The field experiment was conducted at the Research area of Dry Land Agriculture, CCSHAU, Hisar, which is situated at 29°10' N latitude, 75°46' E longitude and altitude of 215.2 metres. The experiment was laid out in randomized block design with 13 fertilizer levels in three replications as mentioned below :

S. No.	Treatments	Fertility levels
1.	T_1	Control
2.	T_2	40 kg N+20 kg P_2O_5 /ha
3.	T_3	40 kg N+20 kg P_2O_5 +10 kg K_2O/ha
4.	T_4	40 kg N+20 kg P_2O_5 +15 kg K_2O/ha
5.	T_5	40 kg N+20 kg P_2O_5 +20 kg K_2O/ha
6.	T_6	50 kg N+25 kg P_2O_5/ha
7.	T_7	50 kg N+25 kg P_2O_5 +10 kg K_2O/ha
8.	T_8	50 kg N+25 kg P_2O_5 +15 kg K_2O/ha
9.	T_9	50 kg N+25 kg P_2O_5 +20 kg K_2O/ha
10.	T_{10}	60 kg N+30 kg P_2O_5/ha
11.	T_{11}	60 kg N+30 kg P_2O_5 +10 kg K_2O/ha
12.	T_{12}	60 kg N+30 kg P_2O_5 +15 kg K_2O/ha
13.	T_{13}	60 kg N+30 kg P_2O_5 +20 kg K_2O/ha

Soil was analyzed to determine the physico-chemical properties of the experimental field. The soil texture was sandy loam, structureless and water holding capacity (WHC) of experimental field soil was 39.5 per cent. The exchangeable cation (EC) was 0.14 dS/m. The soil chemical properties like pH level of soil were 8.1, available nitrogen (N) 156 kg per hectare, P_2O_5 12 kg per hectare and K_2O 325 kg per hectare. The seed of pearl millet hybrid HHB 67 of pearl millet (*Pennisetum glaucum* (L) R. Br.) was sown at about 5 cm soil depth by hand ploughing in rows 45 cm apart and plant to plant distance of 15 (45 × 15 cm) cm.

Quantum sensor was used to measure the photosynthetically active radiation (PAR) at three levels of crop canopy at ground, middle and above to crop canopy surface. Daily weather data recorded at agrometeorological observatory were used to calculate the following agrometeorological indices :

1. Growing degree days (GDD)

$$GDD = \sum_a^b \left[\frac{Max.T + Min.T}{2} - T_b\right]$$

2. Helio thermal units (HTU)

$$HTU = \sum_a^b (TU \ x \ \text{Sunshine hours})$$

3. Photo thermal units (PTU)

$$PTU = \sum_a^b \{(TU \ x \ Day \ lengt(N)\}$$

4. Thermal use efficiency (TUE)

$$TUE = \frac{Dry \ matter \ (DM)}{\sum TU}$$

5. Radiation use efficiency (RUE)

$$RUE = \frac{\text{Dry matter (DM)}}{\text{PAR absorbed}}$$

Correlation and regression analysis was carried out for developing the relationship between agrophysiological and agrometeorological indices.

RESULTS AND DISCUSSION

Correlation of Agronomic and Biological Parameters

The correlation coefficients of agrometeorological parameters with agrophysiological parameters for different fertility levels of pearl millet crop are presented in Table 1. All the agrometeorological indices were positively correlated with agrophysiological parameters. Among the various agrometeorological indices, heat use efficiency was best correlated with dry matter (0.98) and radiation use efficiency with leaf area index. Dry matter production was best associated with agrometeorological parameters and 'r' values ranged between 0.81 and 0.98 in all the treatments. Leaf area index was better correlated with radiation use efficiency as compared to other agrometeorological indices HTU and PTU. Radiation used efficiency (RUE) showed maximum association with leaf area index because radiation interception was directly related with leaf area index.

TABLE 1

Correlation matrix of agrophysiological parameters with agrometeorological indices

Parameter	LAI	DM	Grain yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)
TU	0.78	0.86	0.59	0.61	0.61
HTU	0.77	0.86	0.58	0.61	0.61
PTU	0.78	0.86	0.59	0.62	0.61
HUE	0.71	0.98	0.51	0.50	0.51
RUE	0.86	0.81	0.75	0.79	0.79

Regression Equation and its Plotting

Simple relationship of biological parameters with agrometeorological indices and is depicted in Figs. 1, 2 and 3.

Leaf area index was linearly related with growing degree days, helio-thermal units, heat use efficiency and radiation use efficiency. Among the agrometeorological indices, radiation use efficiency explained the maximum variability in leaf area index i. e. up to 86 per cent. Thermal/heat use efficiency explained more variability (98%) in dry matter as compared to other agrometeorological indices.

The data in Fig. 2 reveal that the response of grain yield to agrometeorological indices in terms of coefficient of determination (R^2) varied with range of 0.51 to 0.61. The growing degree days alone explained 61 per cent variability in grain yield, and further more photothermal unit explained 57 per cent in pearl millet variability. This shows that was photo and thermo sensitive crop.

The simple regression equation developed and computed different parameters. Best fit regression equations were developed for estimation of leaf area index, dry matter and grain yield by clubbing one or more than one agrometeorological indices together using step-wise regression technique and are presented in Table 2. The multiple regression models were developed to predict the agrophysiological parameters of different biometric of rainfed pearl millet. The coefficient of determination of agrometeorological indices based biometric models ranged from 0.74 to 0.98. Photothermal units, heat and radiation use efficiency collectively explained the variability in leaf area index of pearl millet crop up to 86 per cent. The variability up to 79 per cent in dry matter accumulation was explained by heat use efficiency alone. Further its predictability was increased by 19 per cent with addition of photothermal units and radiation use efficiency. The radiation use efficiency explained the variability in grain yield up to 75 per cent. Heat use efficiency and photothermal units further increased the accuracy of above model by 13 and 12 per cent variability remained unaccounted. This might be taken care of by the management parameters. The above based models are location-specific and could be used for rainfed pear millet in Hisar agroclimatic conditions.

CONCLUSION

Based on the results, it was concluded that the variability in leaf area index, dry matter and grain yield was better explained by radiation use efficiency, thermal use efficiency and thermal units, respectively. It reflects that pearl millet is a photo-thermal sensitive crop.

TABLE 2

Regression equations for agrophysiological parameters on agrometeorological parameters

Regression equation	R_2
LAI= 1.895+0.006 × 4HUE+0.726 × RUE	0.74
LAI=1.714+.00005 × PTU-0.3777 × HUE+0.634 × RUE	0.86
DM=4.0949+1346.79 × HUE	0.79
DM=0.658-.000056 × PTU+90.662 × HUE-0.117 × RUE	0.98
Grain Yield= 2504.332 × RUE-5602.019	0.75
Grain yield= -5430.09+0.1579 × PTU-3758.16 × HUE+2839.09 × RUE	0.88

LAI : Leaf area index, DM : Dry matter, HUE : Heat use efficiency, PTU : Photo-thermal unit and RUE : Radiation use efficiency.

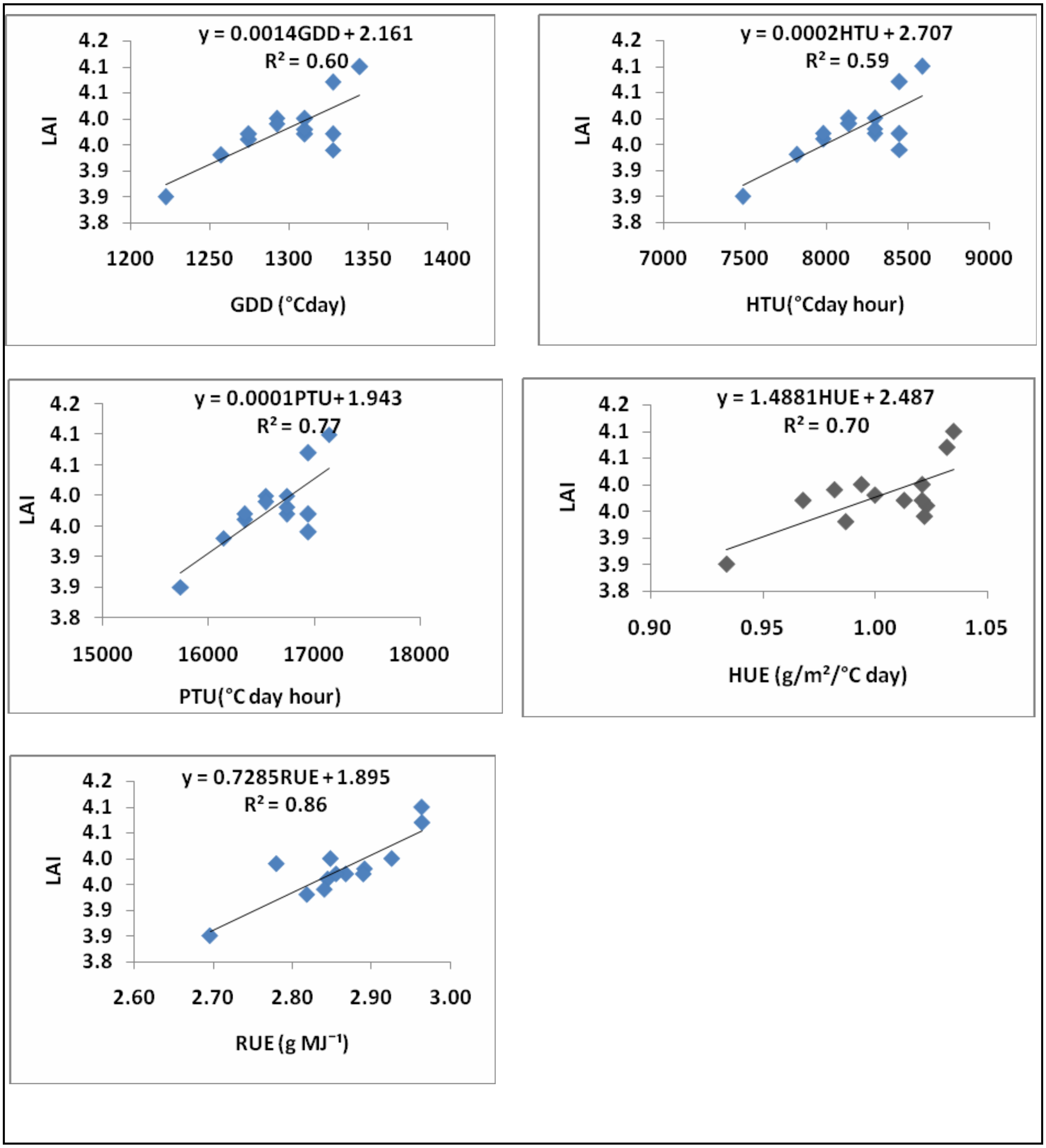

Fig. 1. Response of leaf area index (LAI) to agrometeorological indices.

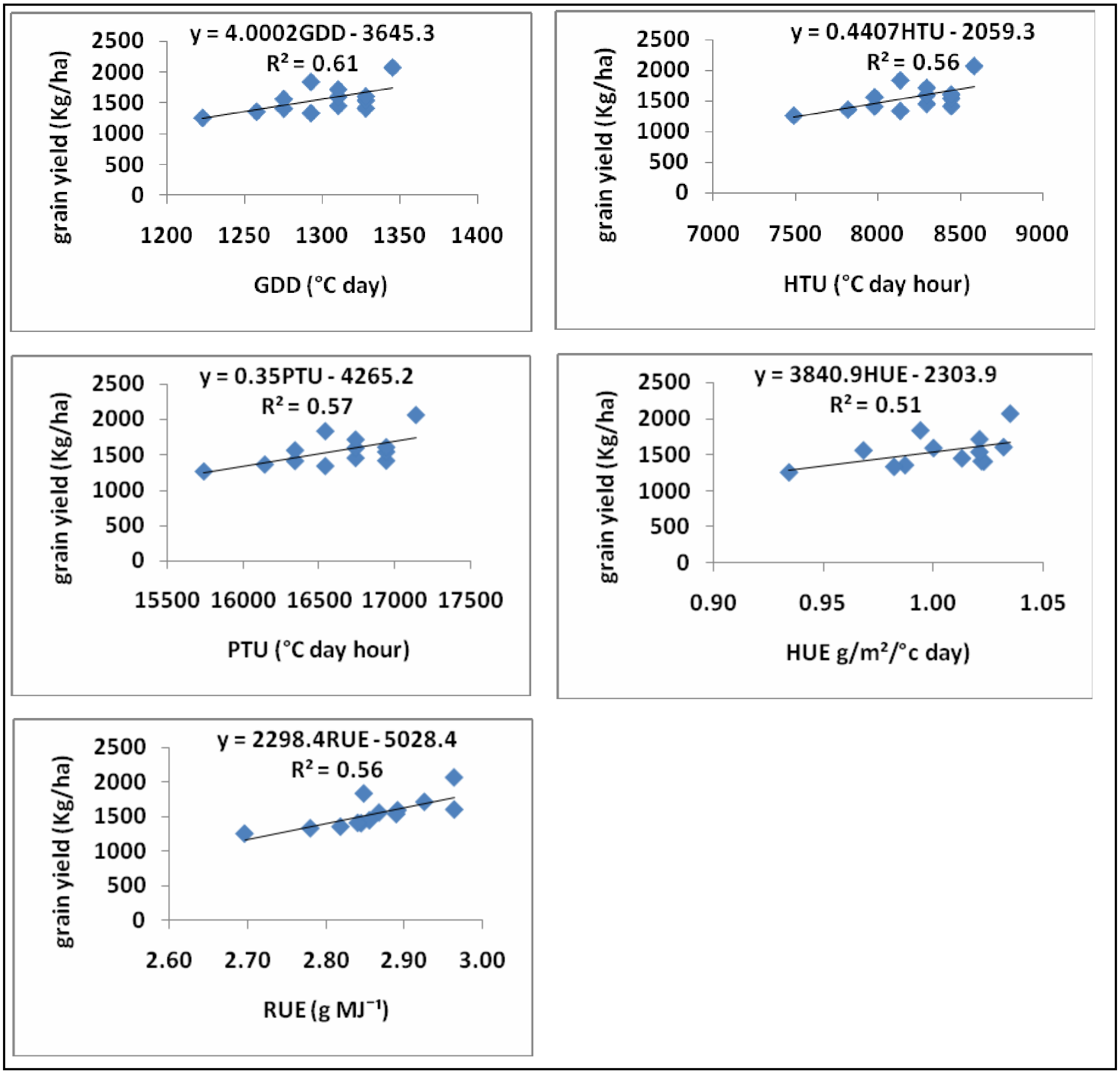

Fig. 2. Response of grain yield to agrometeorological and agrophysiological parametrs.

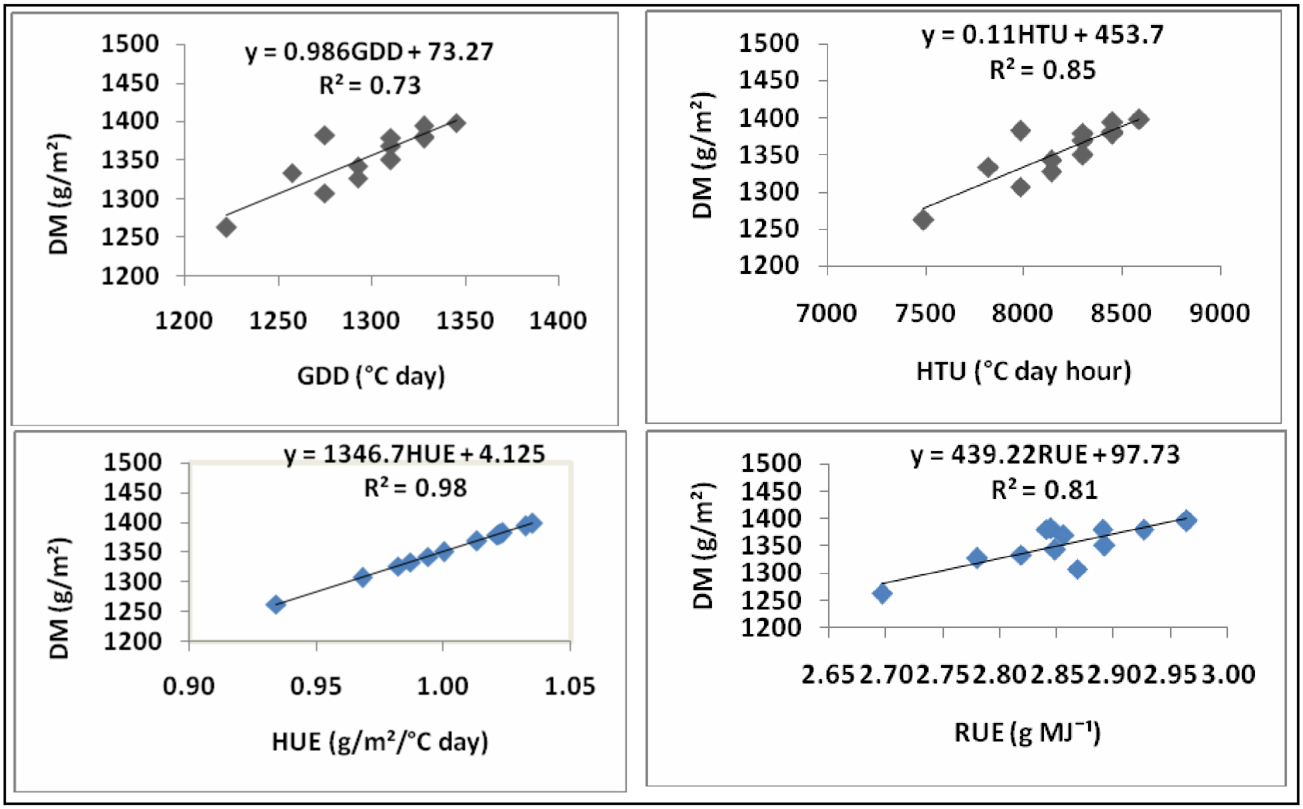

Fig. 3. Response of dry matter to agrometeorological indices.

ACKNOWLEDGEMENTS

The authors acknowledge Dr. S. B. Mittal, Chief Scientist-cum-Head and Dr. B. S. Jhorar, Sr. Scientist of Department of Dry Land, CCSHAU, Hisar for providing research inputs and guidance in this research. They also acknowledge the staffs who were involved in this research.

REFERENCES

Marutisankar, G. R., P. K. Mishra, K. L. Sharma, S. P. Singh, A. K. Nema, D. K. Kathmale, S. K. Upadhye, M. S. Sidhpuria, M. Osman, G. Ravindra Chary, J. Kusum Grace, B. Venkateswarlu, and A. K. Singh. 2012 : Efficient tillage and nutrient practices for sustainable pearl millet productivity in different soil and agro-climatic conditions. *Expl Agric.* **48** : 1-20.

Parihar, M. D., Harbir Singh, R. S. Hooda, V. P. Singh, and K. P. Singh. 2005 : Grain yield, water use, water use efficiency of pearl millet (*Pennisetum glaucum*) hybrids under varying nitrogen application. *Res. on Crops*, **6** : 209-210.

Rathore, B. S., V. S. Rana, and R. K. Nanwal. 2008 : Effect of plant density and fertility levels on growth and yield of pearl millet hybrids under limited irrigation conditions in semi-arid environments. *Ind. J. Agric. Sci.*, **78** : 667-670.

Sharma, B. R., K. V. Rao, K. P. R. Vittal, Y. S. Ramakrishna, and U. Amarasingh, 2010 : Estimating the potential of rainfed agriculture in India : Prospects for water productivity improvements. *Agric. Water Manage*, **97** : 23-30.

Sharma, K., R. Niwas, and M. Singh. 2000 : Effect of sowing time on radiation use efficiency of wheat cultivars. *J. Agrometeorol.*, **2** : 166-169.