Original Research Article

Evaluation of the agrometeorological indices impact on Cowpea crop at Khurdha District of Odisha

Abstract

Study was conducted in *rabi* season at research farm of ICAR-IIWM, Odisha to evaluate the impact of meteorological indices on cowpea cv. Kashi uttam under two (2018-19 & 2019-20) growing seasons. The duration of phenological stages and accumulation of agro-climatic indices (GDD, PTU and HTU) were greatly influenced with different growing season and delay in sowing. The results revealed that the higher GDD, PTU and HTU were accounted on different growth stages at second growing season. Among the seasons and sowing dates, the meteorological indices accretion was perceived in 2nd growing season as compared to 1st growing season crop. Second season crop had sown earlier and get highest heat use efficiency.

Keywords: meteorological indices, cowpea, impact, growing season, GDD.

Introduction

Weather variability and climate change greatly influence the agricultural productivity at all hemisphere. Production and productivity of every crop has its own definite requirements for particular weather condition for its proper growth, development and gaining optimum yield (Razzaq *et. al.,* 1986; Zinn *et. al.,* 2010). Temperature is one of the most important weather parameters for regulating and controlling the crop growth and development and plays the role in disease and pest infection. The concept of heat units based on the concept that real time required to achieve the phenological stage is linearly related to temperature in the range between base temperature & optimal temperature. Heat units are considered as the fundamental units used to examine the phenology of crops over climatic variations (Leith,1974; Sreenivas *et. al.,* 2010). Efficiency, utilization of heat in terms of dry matter accretion, depends on crop type, genetic factors & sowing time and it has great practical application on crop production and productivity (Rao *et. al.,*1999). Growth and yield performance varied with different growing season due to day-to-day changing weather conditions. Temperature based agro-meteorological indices such as growing degree days (GDD) and Heat Use Efficiency (HUE) are quite useful in predicting growth and yield of different crops. Influences on weather situations as well as temperature on phenology and yield of crop plant can be studied under two growing seasons through the accumulated heat unit system (Shankar *et. al.,* 1996). The aim of the present study was to predict pant stages and yield of cowpea crop using agrometeorological indices in tropical region of Khurdha district of Odisa.

Materials and method

Study area

The farm experiment was carried out during rabi season (2018-19 and 2019-20) at ICAR-IIWM, Deras, Mendhasal, Khurdha District of Odisha state. Which lies between Latitude 20°17' N and, Longitude 85°41' E; 23 m above sea level. The average annual rainfall of study area is 1428 mm. The rainfall receives mainly through south-west monsoon, which is started from end of June to lasts till October. The weather remains little dry from November to June. Summer season is hot humid and sometimes feel mercury crosses 45.5^0C in the May-June while winter is cool and dry. In this reason the warmest average temperature is 31.3^0C and lowest average temperature is 21.8^0C.

Observations

The cowpea crop (cv. Kashi uttam) was sown on December 2018-19 and 2019-20, respectively on 40 cm spaced ridges keeping plant-to-plant distance of 15 cm, with a seed rate of 12 kg ha^{-1} and N:P:K fertilizer dose of 25:50:25. Dates of major phenological stages viz., emergence, branching, beginning bloom, full flowering early pod development full pod development stage, full seed development and full maturity stages were recorded from the experimental plots. Weather data were recorded from the Agro-meteorological Observatory, situated near the experimental farm and weather variables namely Tmax, Tmin, SSH, wind speed (km/hrs), Rainfall and RH (%) are recorded daily during growing season 2018-19 and 2019-20.

Agro-meteorological Indices

The different agro-meteorological indices, viz. growing degree days (GDD), helio-thermal units (HTU), photo thermal units (PTU), pheno-thermal index (PTI), radiation use efficiency (RUE) and heat use efficiency (HUE) were computed by adopting procedure laid out by Singh *et al.*, 2015.

Growing degree days (GDD)

The sum of the degree days for the completion of each phenophases were obtained by using the following formula:

$$\textbf{GDD} = \Sigma\ [(Tx + Tn)/2 - T_{base}]$$

Where,

Tmax= Daily maximum temperature (^oC)

Tmin= Daily minimum temperature (^oC)

Tbase= Minimum threshold/Base temperature (^oC)

The growing degree days were computed by considering the base temperature of 10^0C.

Photo thermal Unit (PTU)

The day and night period is one of the basic factors controlling the period of vegetative growth for photosensitive cultivars. In case of long day plants, the length of night is critical for determining, whether plants will enter into reproductive phase or not. Photo-thermal units are the cumulative value of growing degree days, multiplied by bright sunshine hours. This can be mathematically represented by the following formula:

PTU (day °C hour)= GDD X N

Where, N = maximum possible sunshine hour.

Heliothermal Unit (HTU)

The heliothermal units for a day represent the product of GDD and the hours of bright sunshine for that particular day. The sum of HTU for particular phenophases of interest was determined according to the equation:

HTU (day °C hour)= GDD X n

Where, n = actual bright sunshine hours (n).

Phenothermal index (PTI)

Phenothermal index the ratio of degree days to the number of days between two phonological stages was calculated was determined according to the equation:

PTI (°C) =GDD/Number of days between two phenological stages.

Radiation use efficiency (RUE)

The radiation use efficiency is a ratio of biological yield and the radiation intercepted. It can be represented by using the following formula:

RUE (gMJ^{-1}) = Biomass (g/m^2) / PAR (MJ/m^2/day)

Where, PAR is cumulative intercepted photo synthetically active radiation.

Line Quantum sensor was used to measure the amount of intercepted radiant energy (PAR in the range of 380-700 nm) above the crop surface and ground surface keeping the sensor 5 cm above the surface. The observations were record at different growth stages. The intercepted PAR (IPAR) was measured following relationship:

$$I_i = I_0 - I_{re} - I_t + I_{rg}$$

$$I_i\ (\%)\ \text{by the canopy} = (I_i/I_0) * 100$$

where,

I_i = Intercepted photosynthetic active radiation (PAR) by the canopy
I0 = Incident PAR on the canopy
Ire = Reflected PAR by the canopy
It = Transmitted PAR through the canopy
Irg = Reflected PAR from the ground.

Heat use efficiency (HUE)

Heat use efficiency is also represented by thermal time use efficiency (TTUE), which indicates the amount of dry matter produced per unit of growing degree days or thermal time. This was computed by using the following formula:

$$\text{HUE } (g/m^2\ {}^0C\ day^{-1}) = \frac{\text{Biomass } (g/m^2)}{\text{GDD } ({}^0C \text{ days})}$$

Where, GDD is growing degree days.

Results and Discussion

Accumulated Growing Degree Days (AGDD)

Rabi cowpea in 2^{nd} season crop accumulated higher growing degree days to various phenophases (5485^0C day) then 1^{st} growing season (5069^0C day). The mean accumulated GDD was calculated 5277^0C day. These results were due to the availability of longer growth period and temperature variability for both the crop growing season. The favourable photoperiodic conditions in 2^{nd} season sown crop that high degree days induced at crop reproductive phases and maturity duration (Table 1).

Table 1: AGDD, AHTU, APTU and PTI to attain various phenophases in cowpea crop under two growing seasons.

Crop season	Sowing	Emergence	Branching	Beginning bloom/Early bloom	Full flowering	Early pod formation stage	Full Pod development stage	Full seed development stage	Full Maturity stage
AGDD									
2018	11	66	191	431	711	783	885	954	1037
2019	13	83	272	517	761	820	917	1005	1097
Mean	12	75	232	474	736	802	901	980	1067
AHTU									
2018	66	471	859	3789	5900	5480	5400	6965	8089
2019	55	753	585	2763	4147	6933	8573	6434	8010
Mean	61	612	722	3276	5024	6207	6987	6700	8050
APTU									
2018	120	664	1908	4952	8174	9003	10622	11449	12445
2019	137	907	2723	5165	8750	9435	10545	12063	13167
Mean	129	786	2316	5059	8462	9219	10584	11756	12806
PTI									
2018	0	8	10	11	12	12	13	13	13
2019	0	12	12	12	12	13	13	13	14
Mean	0	10	11	12	12	13	13	13	14

Accumulated Helio-thermal Units (AHTU)

Rabi cowpea the accumulated HTU at 2nd growing season highest accumulated (38254^{0}C day) whereas, 1st growing season crop less accumulated (37019^{0}C day) and mean accumulated HTU was calculated 37637^{0}C day. Reduction in HTU under late growing season from the normal sowing time indicated that the crop used more heat units under crop sown early rather than later crop growth stages. Similar results were reported by Solanki *et al.,* 2015.

Accumulated Photo-thermal Units (APTU)

Rabi cowpea showed the 2nd growing season crop accumulated highest APTU (62893^{0}C day) whereas, 1st growing season crop less accumulated (59338^{0}C day). And the mean accumulated PTU was calculated 61116^{0}C day of both crops growing season. In the 2nd season transplanted crop, higher values of agrometeorological indices (GDD, HTU and PTU) were accumulated to attain physiological maturity as compared to 1st season crop sown.

Phenothermal Index (PTI)

Similar in *rabi* cowpea the phenothermal index (PTI) showed significant variation under two growing seasons where, 2nd growing season crop Index was highest PTI (101) whereas, 1st growing season crop was obtained less PTI (92) index. And the mean PTI was calculated 97 Index of both crops growing season.

Table 2: Radiation use efficiency (RUE) and Heat use efficiency (HUE) to obtained various growth interval in cowpea under two growing seasons.

Crop season	30	45	60	Maturity	Mean
RUE (g/MJ)					
2018	0.25	0.21	0.24	0.29	0.25
2019	0.23	0.25	0.32	0.30	0.28
Mean	0.24	0.23	0.28	0.30	0.26
HUE (g/m^2/^{0}C day)					
2018	0.15	0.13	0.13	0.10	0.13
2019	0.15	0.13	0.14	0.12	0.14
Mean	0.15	0.13	0.14	0.11	0.13

Radiation Use Efficiency (RUE)

The most important aspect of crop development affecting the dry matter production that is concerned with the development of leaf canopy and its effect on the efficiency of radiation interception. In cowpea significant variation under two growing seasons depicted in Table 2. Whereas, highest mean RUE in 2^{nd} growing season (0.28 g/MJ) and lowest at 1^{st} growing season (0.25 $g/m^2/^0C$ day). During 2^{nd} growing seasons of rice-cowpea cropping system was obtained highest RUE in both the crop. RUE arose variation due to the differential in dry matter production in two seasons while intercepting different amount of radiation because of variation in canopy surface and the LAI. RUE mainly depends on three factors, viz., angle of radiation interception, photosynthetic efficiency of the plant canopy in utilizing the intercepted radiation used in dry matter production and loss of dry matter due to the physiological processes like respiration.

Heat Use Efficiency (HUE)

HUE of cowpea crop was resulted and relatively highest (0.14 $g/m^2/^0C$ day) in 2^{nd} growing season and lowest (0.13$g/m^2/^0C$ day) in 1^{st} growing season. It means that the early sown crop used heat, more deficiency as compare to late sown crop. The early sown crop has highest heat use efficiency and it decreased with delay in sowing (Keerthi *et al.*, 2016).

The present study indicated that the timely sowing played important role in determining the arrival of different phenological stages and grain yield. The timely crop sowing took higher thermal times as compared to delayed sowing. The heat units viz. accumulated growing degree days, photo thermal unit, helio-thermal unit, radiation use efficiency and heat use efficiency were recorded highest in crop sown on second season as compared to first season.

Conclusion

It can be concluded that variability on weather parameter occurs from one season to another season which affect the vegetative growth, production and productivity of crop.

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