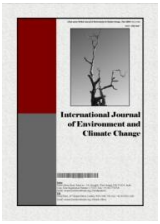

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Influence of Weather Parameters and Thermal Time Approach on Green Gram at Coimbatore, Tamil Nadu

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SAN, SK, SPR, GAD and SAF designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out at the Agro Climate Research Centre, Tamil Nadu Agricultural University, on the effect of weather parameters on the green gram yield sown at various sowing dates during the rabi season of 2019. At various sowing dates, two green gram cultivars, VBN 4 and ADT 3, were sown. For both cultivars, the phonological crop length decreased with delays in sowing dates beyond October 23rd. The yield of green gram sown on 23rd October was significantly higher than the crops sown on 30th October and 6th November. The weather parameters Maximum Temperature (T_{max}), Diurnal Range (T_{range}), Bright Sunshine Hours (BSS), Relative Humidity (RH I), Wind Speed (WS) were found to be negatively correlated with seed yield whereas Minimum Temperature (T_{min}), Relative Humidity (RH II), Vapour Pressure (VP) were found to be positively correlated with the yield of green gram. The accurate prediction of green gram yield could be done with the maximum temperature, bright sunshine hours, wind speed and with thermal indices especially hygrothermal unit II with 82 percent, accuracy level.

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Keywords: Sowing dates; crop duration; correlation; yield.

1. INTRODUCTION

Climate change is virtually certain that there will be more frequent hot and warm cold temperature extremes over most of land areas on daily and seasonal timescales, as global mean surface temperature increases. It is very likely that heat waves will occur with a higher frequency and longer duration. Occasional cold winter extremes will continue to occur [1].

Climate change and variability will directly and significantly affect the current and future agriculture [2]. The productivity of green gram was mostly influenced by weather parameters like wind velocity, relative humidity in the evening, rainfall and number of rainy days [3]. High temperature is implicated as a major limiting factor for yield decline in green gram [4]. When green gram crop was subjected to an elevated temperature of more than 2°C and 4°C from the ambient, showed significant changes in its physiology, biochemical and yield attributes [5]. Generally, the optimum period depends primarily on the prevailing agro-climatic conditions of an area, in addition to the variety grown. Planting thus ensures greater harmony between the plant and the environment at the optimum period, resulting in higher crop yields [6].

The seed yield of green gram have significant positive correlation with weather parameters during the different phenophases [7] and impact of temperature on phenology and crop yield can be evaluated under field conditions by means of an accumulated heat unit system [8]. The change in sowing dates directly impacts both thermal and photoperiod, and thus has a significant effect on the development phase and compartmentalization of dry matter [9]. Since the crop has to pass its life cycle within a particular atmospheric specification, to properly demarcate its growing season, it is important to examine the effect of weather parameters on the crop. Keeping the above facts in view, the present investigation was carried out to study the influence of weather parameters and thermal indices on green gram.

2. MATERIALS AND METHODS

The experiment was conducted at the Eastern Block Farm of Tamil Nadu Agricultural University Coimbatore during *rabi* season of 2019. The soil of experimental plot was clay loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and potassium status. Six treatment combinations with three dates of sowing (S_1:23rd October (43rdSMW), S_2:30th October (44th SMW) and S_3:6th November (45th SMW)) and two varieties (VBN 4 and ADT 3) were tried in split plot design with five replications with the date of sowing as main plot and varieties in sub plots. VBN 4 is a multi bloom variety, non-shattering type, moderately resistance to Mungbean Yellow Mosaic Virus (MYMV) and powdery mildew diseases and resistance to urdbean leaf crinkle virus disease with duration of 65-70 days and ADT 3 variety suitable for rice fallow condition with duration of 70 days. The crop was sown in lines with a spacing of 30 x 10 cm. The crop was kept free from major insect pests by taking suitable plant protection measures. Phenological observations were recorded from five selected plants from net plot. The crop growth stages from each date of sowing were recorded as date of emergence (P_1), branching (P_2), 50 per cent flowering (P_3), pod development (P_4) and pod maturity (P_5). Weather parameters viz., maximum temperature (T_{max}), minimum temperature (T_{min}), relative humidity (RH I & RH II), Vapour pressure (VP_1, VP_2), bright sunshine hours (BSS), evaporation (EP) and wind speed (WS) were recorded at the agrometeorological observatory located near the experimental field. The agrometeorological indices viz., growing degree days (GDD), photothermal units (PTU), heliothermal units (HTU) and hygrothermal units (HgTU I & II) were calculated with the base temperature of 10°C.

HgTU-I& II = GDD × Relative humidity at morning (I) and at afternoon (II)

The effective day temperature (T_{photo}) and night temperature (T_{nycto}) and Interdiurnal range of temperature (T_{IDR}) was calculated following [10] and [11]

$$T_{photo} = T_{max} - 1/4 \times (T_{max}-T_{min})$$

$$T_{nycto} = T_{max} + 1/4 \times (T_{max}-T_{min})$$

$$T_{IDR} = (T_{max})_i - (T_{min})_{i+1}$$

Where, T_{maxi} = maximum temperature of the ith day,

T_{min+1} = minimum temperature of the (i+1)th day

3. RESULTS AND DISCUSSION

The result on phenological observations indicated that the duration of green gram increased with delay in sowing dates (Table 1). Late sown crop took longer duration for maturity than the early sown crop to fulfil the thermal unit requirements. The results on seed yield revealed that sowing on 23rd October have significantly higher seed yield than other date of sowing in both varieties. The variety VBN 4 gave significantly higher seed yield (1091 kg ha^{-1}) than ADT 3 variety (698 kg ha^{-1}) (Table 2). This may be because the crop was being exposed to favourable climatic conditions. A research study in Coimbatore on sweet sorghum also reported similar results [12].

3.1 Statistical Analysis

The correlation analysis between weather parameters and yield of green gram for the entire crop growth period was done and reported (Table 3). The results revealed that most of the weather parameters had positive and highly significant correlation with the seed yield of green gram except T_{max}, T_{range}, RH I, WS and BSS which have negative correlations.

Similarly, the correlation analysis between thermal indices and yield revealed that there is significant relationship among HgTU-II, T_{photo}, T_{nycto}, and T_{IDR} except in case of GDD, HTU, PTU and HgTU I.

Using correlation analysis, the relationship between yield and phenophase-wise average weather parameters was analysed. Based on significant correlation, step wise regression was used to develop a regression model as given below

$$Y= -15437.38+115.672 (X_4\ T_{max}) - 543.00 (X_4\ BSS) + 654.23 (X_5\ WS) + 0.224 (X_5\ HgTUII)$$

$$R^2 = 0.817^{**}$$

(Where, Y= Seed yield, X_1= Germination phase, X_2= Branching phase, X_3= Flowering phase, X_4= Pod development phase, X_5= Pod maturity phase, ** Significant at 1% level of significance).

Table 1. Effect of date of sowing on duration of crop phenology in green gram

Variety	Date of sowing	Phenophases (Days)					Total (Days)
		P1	P2	P3	P4	P5	
VBN4	D1	3	26	15	8	12	64
	D2	3	28	16	9	13	69
	D3	3	28	17	9	14	71
ADT 3	D1	3	29	15	9	13	69
	D2	3	29	16	9	14	71
	D3	3	31	18	9	14	75

Where P_1-date of emergence, P_2- branching, P_3-50 per cent flowering, P_4- pod development and P_5 -pod maturity

Table 2. Effect of date of sowing on seed yield of green gram varieties

Treatments	Seed yield (Kg/ha)
Dates of sowing(D)	
23-Oct	672.3
30-Oct	563.9
06-Nov	554.0
SEM	5.8
CD at 5 %	22.7
Variety (V)	
VBN 4	1091.6
ADT 3	698.7
SEM	9.9
CD at 5 %	30.5

Table 3. Correlation coefficient of green gram yield with average weather parameters and agrometeorological indices

Weather parameters and agrometeorological indices	Mean value correlation coefficient
T_{MAX}	-0.97**
T_{MIN}	0.92**
T_{MEAN}	0.85**
T range	-0.94**
RH 1	-0.45*
RH2	0.93**
MRH	0.96**
VP1	0.98**
VP2	0.94**
MVP	0.95**
BSS	-0.96**
WS	0.65*
GDD	0.25
PTU	0.23
HTU	0.31
HgTU1	0.06
HgTU2	0.98**
T_{photo}	-0.91**
Tnycto	-0.96**
T_{IDR}	-0.93**

*Where, * Significant at 5% level of significance; ** Significant at 1% level of significance*

It may be seen that the Maximum Temperature (T_{max}), Bright Sunshine Hours (BSS) during pod development & Wind Speed (WS) and Hygrothermal unit (HgTU-II) during pod maturity were found to contribute significantly to predict the yield variation in green gram with R^2 = 0.817**. Parallel studies on summer green gram in 2015 also revealed the related findings [13].

4. CONCLUSION

The study results showed that no single weather parameter was responsible for changes in green gramme productivity, whereas the combined effect of different meteorological variables had an impact on yield, especially maximum temperature and sunshine hours during the stage of pod growth and wind speed and hygrothermal unit II during the stage of pod maturity. For estimating the green gram yield, this regression model can then be used.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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