Thermal time approach under different sowing windows for Greengram

Abstract

Crop phenology and yield are highly influenced by prevailing weather condition during the crop growth phases. A research work was carried out at Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore during June to August 2022 to determine the suitable sowing window for greengram. The best time of sowing was established by using Growing Degree Days (GDD), Heliothermal Units (HTU), Photothermal Units (PTU) and Heat Use Efficiency (HUE). The study revealed that the24th Standard Meteorological week (SMW)recorded higher yield due to higher values of GDD, HTU, PTU and HUE at different crop growth stages.

Keywords: Greengram, sowing dates, GDD, HTU, PTU and HUE

Introduction

Greengram (*Vignaradiata*L.) commonly known as 'Mung bean' has become the third most important pulse crop next to the Bengal gram and Pigeon pea. It is native of India and Central Asia, a region where it has been grown since prehistoric times. The green gram seeds are extremely nutritious, which is almost 2.5–3.0 times higher in protein content than cereals [9]. In India, Mungbean was grown on an area of about 5.13 million hectares with the production of about 3 million tonnes and productivity of 601 kg/ha [6], Green gram was considered as "nutritional powerhouse" due to high protein content, among many pulses [17]. It is a leguminous crop and helps in enhancing the soil fertility by absorbing atmospheric nitrogen through root nodules. Rhizobium bacteria form nodules on the root of green gram and fix atmospheric nitrogen. Through nitrogen fixation, the green gram can increase soil fertility [15]. It supplies an excellent green fodder to the animals and also used as green manure crop.

Agriculture being backbone of economy in the country and mainly dependent on climatic factors that determines the success or failure of crop productivity. Crop Phenology and yield are highly influenced by prevailing weather condition during the crop growth phase. A change in climate had registered a deleterious effect on crop growth, development and productionduring the past [20]. Interception of photosynthetically active radiation, air and leaf temperature, relative humidity, prevailing wind speed, CO_2 concentration and soil moisture availability are all environmental factors which might have a major impact on crop growth during growing season [8] [10]

Temperature is a determinable weather parameter which plays a pivotal role, that directly have consequences on agro based ecosystem.Plants that grows above a temperature range are characterised either by lower and upper temperature thresholds as its growth thresholds. Under certain limits, temperature forms the linear relationships in crop development [18]. As temperature exceeds to the species optimum level, the growth rate of vegetative phase (leaf appearance) tends to increase. Most plant species have a higher optimum temperature for vegetative stage than for reproductive stage. The thermal environment seems to have an influence on the growth of all crop systems.Sowing window has been recognized as the most important non-monetary input factor because it ensures complete harmony between the vegetative and reproductive phases on the one side, and the climatic rhythm on the other [19]. It is precious and important for better and efficient utilization of available plant growth. Sowing time represents the most important factor that influences mung bean yield among numerous agronomic practises [4].

Many investigators used temperature based agrometeorological indices for evaluating plant growth and development viz., Growing Degree Days (GDD), PhotothermalUnits (PTU), Helio-thermal Units (HTU) and Heat Use Efficiency (HUE) [16][1][3]. GDDs is a model that converts raw climatic data into make crop management decisions [13]. The heat unit concept aids in explaining the direct and linear relationship between growth and temperature for evaluating crop yield potential under various weather scenarios.

Comment [SS1]: You should provide the meaning and utilization of HTU and HUE in order to complete

Present study was aimed to assess the growth and yield of green gram with heat units based agroclimatic models under various sowing windows.

Materials and Methods

The research trial was conducted during the *kharif* (June - August) season of 2022 at Wetland Farm,Tamil Nadu Agricultural University, Coimbatore and the study area was situated in Western Agro-climatic zone of Tamil Nadu at 11˚N latitude and 77˚E longitude with an altitude of 426.7 m above MSL. The soil of experimental field was clay in texture with a pH of 7.2. The field experiment was laid out in a Split Plot Design,replicated thricewith CO 8 variety of 55-60 days (short duration crop) by keeping two sowing windows of D_1 - 15 June 2022(24thSMW) andD_2 - 22 June 2022(25thSMW). The daily weather data like maximum, minimum temperature, bright sunshine hours required to compute the thermal time was obtained from Principal A Class Agro-meteorological Observatory, Coimbatore.

Thermal based Agrometeorological indices

Growing Degree Days (GDD):

It is calculated using the following formula proposed by [8].

$$GDD = \frac{T_{max} + T_{min}}{2} - T_{base}$$

where, T_{max} -daily maximum temperature (^{o}C)

T_{min}– daily minimum temperature (^{o}C) and

T_{base}- base temperature of $10^{o}C$was used.

Helio Thermal Unit (HTU):

It is determined using the formula indicated by [2].

$$HTU = GDD \times \text{Actual Bright Sunshine hours} \ (^{o}C\text{hr})$$

Photo Thermal Unit (PTU):

Adding the day length element and employing the GDD idea as a photo-thermal unit in climatic analogy studies, [11] aimed to improve the GDD concept. GDD multiplied by the number of bright sunlight hours that can possibly be obtained (N).

$$PTU = GDD \times \text{Day Length}$$

where day length refers to maximum possible sunshinehours.

Heat use efficiency (HUE)

Net amount of dry matter generated per thermal unit, or growing degree day, is known as heat use efficiency [5]. The efficiency with which the available heat is utilised for grain yields has been characterised as yield per growing degree day or thermal time.

$$\textbf{Heat use efficiency (HUE)} = \frac{\text{Seed Biomass / Yield (kg ha}^{-1}\text{)}}{GDD}$$

Comment [SS2]: What are the statistical analysis methods

Result and Discussion

Growing Degree Days (GDD) for Greengram

Data pertaining to thermal units of green gram at varied crop growth stages under different sowing window is presented in Table 1. It was observed that highest number of Growing Degree Days (GDD) were noticed on 24thSMWwhen compared to 25thSMW.

During flowering and pod initiation phase,highest thermal accumulation was obtained in 24thSMW(D_1–418^{o}C atflowering and 355^{o}C at pod initiation stage) followed by 25th SMW (D_2–411^{o}C at flowering and 333^{o}C at pod initiation stage. At physiological maturity phase, GDD accumulation recorded maximum (1745^{o}C)in 24thSMWfollowed by (162 ^{o}C)in 25thSMW. Similar result was reported by [14].Consistently, a decreasing trend in HTU and PTU for attaining all Phenological stages was observed in 25th SMW.

Table 1. Growing Degree days, Helio Thermal Unit and Photo Thermal Unit for various stages of Greengram under different sowing dates

	15th June			22nd June		
crop stages	**GDD**	**HTU**	**PTU**	**GDD**	**HTU**	**PTU**
Germination	108	794	1241	105	377	1206
Flower Initiation	418	1485	1252	411	1506	4765
Pod Initiation	355	1797	4186	333	1730	3926
Maturity	162	958	1916	175	1226	2063

Heat Use Efficiency (HUE) for Green gram

Data recorded on heat use efficiency for dry matter (kg ha^{-1}) as well as grain yield are presented in Table 2. The 24th SMW recorded the highest HUE for grain yield (0.8 kg ha-^{1o}C) followed by 25th SMW (0.81 kg ha-^{1o}C). The higher HUE for dry matter (2.81 kg ha-^{1o}C) was noticed on 24th SMW. This could be attributed by maximum consumption of heat units absorbed during vegetative growth phases. The lower HUE for dry matter (2.74 kg ha-^{1o}C) was found on 25th SMW. This was due to lower accumulation of thermal units. The findings are consistent with those found by [12].

Table 2. Heat use efficiency under different sowing dates of Greengram

Comment [SS3]: Provide legend for each abbreviation within Table 2

Crop stages	Yield	HUE	DMP	HUE
D1	890	0.85	2927	2.81
D2	824	0.81	2803	2.74

Sowing window significantly influenced the grain yield of green gram crop. Maximum grain yield was recorded in 24thSMWwith a yield of 890 kg/ha. It might be due to efficient utilization GDD, HTU and PTU. The crop grown on 25thSMW attained comparatively lesser yield of 824 kg/ha which is ascribed to continuousness of rains during ensuing weeks.Similar findings under late sowing alsonoticed by [7] and [12].

Conclusion

Study on heat units of green gram concluded that the sowing of greengram on 24th SMW showed better performance due to optimal thermal indices and higher use efficiency compared to sowing on25thSMW.

Comment [SS4]: What could be the application area of your finding

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