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Phenology and Heat Unit Requirement of Summer Green Gram Varieties under Different Sowing Windows

Bharti Tijare, Anita Chorey*, Vilas Bhale and Sanjay Kakde

Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola-444104 (M.S.), India
**Corresponding author*

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A B S T R A C T

A field experiment was conducted at the Agronomy Department farm, Dr. PDKV, Akola during summer season 2011 to study the phenology and heat unit requirement of summer green gram varieties grown under different sowing dates. As early sowing faces low temperature while late sowing faces high temperature during initial stage in Akola. The crop sown early (1st march) took 73 days from sowing to maturity. While late sown green gram (30th March) took 67 days for physiological maturity. Sowing on 30th March accumulated significantly higher GDD, HTU and PTU at harvest (1549.61 ^{O}C day, 12109.40 ^{O}C day hour and 20609.8 ^{O}C day hour, respectively) as compared to rest of sowing dates from anthesis to physiological maturity. In case of varieties, PKV-Green gold accumulated significantly higher GDD, HTU and PTU at harvest (1593.91^{O}C day, 12457.62 ^{O}C day hour and 20960.9 ^{O}C day hour, respectively) followed by variety PKV-AKM-04, whereas Pusa Vaishakhi recorded lowest values at all growth stages of crop. Sowing on 20th March recorded significantly higher HUE and PUE for grain and biomass due to optimum temperature throughout the growth period. In respect of varieties HUE and PUE were higher in Pusa Vaishakhi viz; 0.738 kg ha^{-1} ^{O}C day^{-1} and 0.056 kg ha^{-1} ^{O}C day^{-1} for grain and 2.15 kg ha^{-1} ^{O}C day^{-1} and 0.164 kg ha^{-1} ^{O}C day^{-1} for biomass.

Introduction

Green gram (*Vigna radiata* L.) is third most important pulse crops in India. Being a leguminious, it is capable of meeting its nitrogen requirements from the atmospheric nitrogen through root nodules bacteria and also used as green manuring crop thus build up the soil fertility. The cultivation of Green gram during summer is becoming popular with the advent of high yielding, short duration and photo insensitive genotypes. These genotypes can express their full potential only when grown under optimum weather conditions. The time of sowing is an important non-monetary input to achieve synchronous maturity and higher productivity of summer green gram. As early sowing faces low temperature while late sowing faces high temperature during initial stage in Akola, these adversely affect the crop growth and yield. Therefore, determination of date of sowing and variety is important.

Plant has a definite temperature requirement before they attain certain phonological stages. A change in optimum temperature during different phonological stages of a crop

adversely affects the initiation and duration of different phenophases and finally economic yield of the crop. It is therefore indispensable to haves knowledge of exact duration of phenophases in a particular environment and their association with yield attributes for achieving high yields (Kumari *et al*., 2009). Influence of temperature on phenology and yield of crop plan can be studied under field condition through accumulated heat unit system (Haider *et al*., 2003 and Pandey *et al.*, 2010). Shift in sowing dates directly influence both thermo and photoperiod and consequently a great bearing on the phasic development and partitioning of dry matter (Leela Rani *et al*., 2012).

Materials and Methods

Field experiment was conducted during summer season 2011 at Agronomy Department farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, having 22.42^0 N latitude, 77.02^0 E longitude and 307.4 M above mean sea level. The soil of the experimental site was clay loam in texture, having pH 7.96, Electrical conductivity 0.37 dsm^{-1}, medium in Organic carbon, low in available nitrogen, medium in available phosphorus, and rich in available potassium. The treatment consisted of four sowing dates viz., 1st March, 10th March, 20th March and 30th March and three varieties viz., PKV-AKM-04, PKV- Green gold and Pusa vaishakhi. The experiment was laid out in spilt plot design with three replications. The crop was fertilized with uniform dose of 20 kg ha^{-1} N and 40 kg ha^{-1} P_2O_5 through urea and single super phosphate, respectively at sowing time.

During the crop period mean maximum temperature varied from 33.5^0 C to 43.4^0 C and mean minimum temperature varied from 15.3^0 C to 28.7^0C. It indicated that mean minimum temperature ranges did not cross extreme high and extreme low temperature. The relative humidity at morning (RHI) varied from 34 to 68 percent, where it was 14 to 29 percent in evening (RHII). The bright sunshine hours (BHS) varied from 6.3 to 8.7. The wind velocity ranges from 1.9 to 12.9 km/hrs during the growing season. The pan evaporation ranges from 6.7 to 17.3 mm.

Accumulated agrometerological indices *viz.*, GDD, HTU, PTU, HUE and PUE were computed by using daily meteorological data the date of occurrence of different phonological events *viz.*, vegetative, anthesis, first pod and maturity were recorded when 75 percentage of the plants in each replicated reached the respective stages. GDD determine using base temperature of 10^0C for summer green gram.

Growing degree days (^{O}C day)

$$GDD = \frac{Tmax + Tmin}{2} - Tbase$$

Where,
T max = Daily maximum temperature (^{o}C)
T min = Daily minimum temperature (^{o}C)
T base = Base temperature of 10^oC

Heliothermal unit (HTU) = *GDD X Actual sunshine hou*

Photothermal unit (PTU) = *GDD X Day length*

HUE (kg/ha/^{o}C day) =

$$\frac{\text{Seed yield / Total dry matter (kg/ha)}}{\text{Accumulated heat units } (^o\text{C day})}$$

PUE (kg/ha/^{o}C day)=

$$\frac{\text{Seed yield / Total dry matter (kg/ha)}}{\text{Accumulated photothermal units } (^o\text{C day})}$$

Results and Discussion

Day's requirement for phenophases development

The day's requirement of phenophases development of summer green gram is presented in table 1. The number of days required to attain different phonological stages decreased with delay in sowing from 1st March to 30th March. The crop sown early (1st march) took 73 days from sowing to maturity. While late sown green gram (30th March) took 67 days for physiological maturity. For emergence, crop sown on 1st March took significantly higher number of days as compared to other date of sowing (Table 1) due to low temperature during early growth period. The number of days taken from sowing to maturity was highest in early sown crop and decreased consistently with subsequent sowing, similar results was recorded by Kumar *et al*., (2012). In case of varieties PKV-Greengold took 73 days to attained maturity followed by variety PKV-AKM-04 (69.50 days), whereas Pusa Vaishakhi required 67.50 days.

Growing degree days (GDD)

Accumulated thermal units presented in table 1 and revealed that GDD required for different phenophases varied with date of sowing. GDD were found to be significant at all the growth stages in different sowing dates and varieties. Significantly higher GDD from emergence to vegetative were recorded with 10th March sowing.

Thereafter, from anthesis to physiological maturity sowing on 30th March accumulated significantly higher GDD as compared to rest of the sowing dates. The accumulated GDD from sowing to physiological maturity ranged from 380.57 to 1496.13 degree days. Sowing on 30th March accumulated significantly higher GDD at harvest (1549.61 OC day) as compared to 10th March sowing (1502.12OC day), whereas lowest were accumulated in 1st March sowing (1496.13 OC day) and significantly at par with 20th March sowing (1535.61 OC day). GDD required from anthesis to maturity increases with delayed sowing. The requirement of GDD was higher for normal growing condition than early growing condition.

This was due to fluctuated unfavourable low temperature during growing period so, the requirement of heat units decreased for different phonological stages with early sowing. Air temperature based agromet indice GDD has been used to describe changes in phonological behavior and growth parameters (Dhaliwal *et al*., 2007; Singh *et al*., 2007 and Kumar *et al*., 2008).

Amongst all varieties, PKV-Green gold observed statistically higher GDD from emergence to maturity. Variety PKV-Green gold accumulated significantly higher GDD at harvest (1593.91OC day) followed by variety PKV-AKM-04 (1508.94OC day), whereas lowest accumulated GDD (1459.45 OC day) was recorded for variety Pusa Vaishakhi. Early development of phonological stages might be the reason for less consumption of heat unit (Pandey *et al*., 2010).

Heliothermal units (HTU)

The heliothermal unit requirements for entire growth phases were found to decrease with delay sown crop and showed higher consumption of HTU as compared to early sown crop (Table 1). Late sown crop absorbed sufficient GDD in relative less time due to prevalence of higher temperature and longer sunshine hour during post sowing period (Pandey *et al*., 2010).

Table.1 Agrometeorological indices during different growth stages of summer green gram varieties under different sowing windows

Treatments	Emergence to vegetative				Emergence to Anthesis				Emergence to First pod				Emergence to Physiological maturity			
	Days taken	GDD	HTU	PTU	Days taken	GDD	HTU	PTU	Days taken	GDD	HTU	PTU	Days taken	GDD	HTU	PTU
Sowing dates																
S_1- 1st March	22.33	391.32	2919.56	4695.87	33.66	613.60	4719.20	7731.36	41.00	757.61	5734.37	9545.97	73.00	1496.13	11545.80	19599.3
S_2- 10th March	21.00	380.87	3109.26	4568.13	32.66	611.55	4840.87	7705.53	40.33	783.51	6128.46	9872.24	70.66	1502.12	11933.50	19677.8
S_3- 20th March	19.66	389.20	3054.92	4903.99	31.33	619.51	4745.57	7805.84	38.66	779.95	5984.37	9827.44	69.33	1535.21	12065.20	20111.3
S_4- 30th March	18.66	384.55	2902.83	4845.40	30.33	643.10	4893.97	8143.68	37.66	819.76	6259.72	10738.9	67.00	1549.61	12109.40	20609.8
SE (m) ±	0.34	6.83	58.00	82.12	0.60	13.07	104.02	170.47	0.44	10.18	87.51	132.13	0.24	6.17	52.32	80.78
CD at 5%	1.20	24.10	204.70	284.19	2.10	46.12	367.01	589.94	1.55	35.23	302.86	457.25	0.83	21.35	181.06	279.56
Varieties																
V_1- PKV-AKM-04	20.50	388.11	3012.57	4775.47	32.50	632.70	4892.33	7972.07	39.50	786.11	6026.60	10005.5	69.50	1508.94	11834.50	19843.5
V_2-PKV-Green gold	21.75	413.89	3200.16	5091.22	33.50	655.03	5060.50	8283.88	41.25	826.45	6362.61	10522.9	73.00	1593.91	12464.40	20960.9
V_3-Pusa Vaishakhi	19.00	357.30	2777.20	4393.36	30.00	578.08	4448.11	7283.85	37.50	743.06	5690.98	9460.02	67.50	1459.45	11441.60	19194.1
SE (m) ±	0.45	9.19	68.71	113.02	0.36	8.20	61.43	112.10	0.44	9.88	77.38	124.74	0.37	9.24	72.71	121.41
CD at 5%	1.35	27.55	206.01	338.86	1.08	24.61	184.18	336.10	1.33	29.62	232.02	374.00	1.11	27.71	218.01	364.00

Table.2 Efficiency indices at physiological maturity in summer green gram varieties under different sowing windows

Treatments	Biomass (kg ha^{-1})	Grain yield (kg ha^{-1})	Heat use efficiency (kg ha^{-1} ^{O}C day^{-1})		Photothermal use efficiency (kg ha^{-1} ^{O}C day^{-1})	
			Biomass	Grain	Biomass	Grain
Sowing dates						
S_1- 1st March	2746.53	829.11	1.84	0.557	0.140	0.042
S_2- 10th March	2865.11	906.16	1.91	0.607	0.146	0.046
S_3- 20th March	3139.42	1086.5	2.05	0.710	0.156	0.054
S_4- 30th March	2989.18	992.87	1.93	0.643	0.145	0.048
SE (m) ±	78.21	28.76	0.03	0.02	0.002	0.001
CD at 5%	270.60	99.55	0.13	0.07	0.010	0.005
Varieties						
V_1- PKV-AKM-04	2887.53	941.30	1.91	0.623	0.145	0.047
V_2-PKV-Green gold	2766.08	841.08	1.73	0.527	0.131	0.040
V_3-Pusa Vaishakhi	3151.57	1078.6	2.15	0.738	0.164	0.056
SE (m) ±	72.06	23.50	0.02	0.02	0.002	0.001
CD at 5%	215.85	70.46	0.08	0.06	0.006	0.003

At emergence to vegetative stage 10th March sowing accumulated significantly higher HTU (3109.26 OC day hour) and was comparable with 20th March (3054.92 OC day hour) and 1st March (2919.87 OC day hour) whereas significantly lower with 30th March sowing (2902.83OC day hour). However, from anthesis to maturity crop sown on 30th March accumulated significantly higher HTU (12109.40 OC day hour) and was comparable with crop sown on 20th March (12065.20 OC day hour) and10th March (11933.50 OC day hour) whereas, sowing on 1st March recorded lowest HTU (11545.80 OC day hour).

In respect of varieties, statistically higher HTU were accumulated with PKV- green gold at all the growth stages of crop. Similarly, at physiological maturity stage, among varieties pusa vaishakhi (11441.60 OC day hour) and PKV- AKM-04 (11834.50 OC day hour) acquired significantly less HTU than PKV- green gold (12464.40 OC day hour). It might be due to their longer life cycle than other varieties (Ram *et al*., 2012).

Photothermal unit (PTU)

The photothermal unit for different phenophases presented in table 1 indicated that PTU requirement for entire growth phase increase as the sowing was delayed up to 30th March and thereafter it decreases up to 1st March. This may be due to shorter day length, low temperature during early vegetative phase and longer day length, high temperature during late development phase (Kumar *et al*., 2010). The crop sown on 30th March required more PTU due to longer day length, PTU during 100 percent anthesis to first pod thereafter decreases with short day length.

Accumulation of photothernal unit (PTU) at emergence to vegetative growth stage found significantly higher in 20th March sowing (4903.99OC day hour). However, from

anthesis to physiological maturity accumulation PTU among 30th March sowing (20609.8OC day hour) which was significantly higher than 20th March (20111.3OC day hour), 10th March (19677.8OC day hour) and 1st March (19599.3OC day hour) sown crop.

Amongst all varieties, from sowing to maturity PKV- green gold accumulated significantly higher PTU at harvest (20960.9 OC day hour) while lowest values were recorded with PKV-AKM-04 (19843.5OC day hour) and Pusa Vaishakhi (19194.1OC day hour)

Heat and photothermal use efficiency (HUE and PUE)

Sowing on 20th March showed higher HUE of 0. 710 kg ha^{-1} OC day^{-1} for grain and 2.05 kg ha^{-1} OC day^{-1} for biomass and was statistically at par with 30th March with 0. 643 kg ha^{-1} OC day^{-1} for grain and 1.93 kg ha^{-1} OC day^{-1} for biomass (Table 2), whereas, it was significantly lowest with 1st March sowing (0. 557 kg ha^{-1} OC day^{-1} for grain and 1.84 kg ha^{-1} OC day^{-1} for biomass). Similar trend was observed for PUE. Sowing on 20th March acquired higher PUE of 0.042 kg ha^{-1} OC day^{-1} for grain and 0.140 kg ha^{-1} OC day^{-1}for biomass whereas lowest PUE recorded with sowing on 1st March (0.054 kg ha^{-1} OC day^{-1} for grain and 0.156 kg ha^{-1} OC day^{-1}for biomass). The heat and photothermal use efficiency were decreased with early sowing. Higher HUE and PUE with 20th March sown crop could be attributed to higher grain and biomass yield. As temperature was optimum throughout the growing period the crop utilized heat efficiently and increased biological activity that confirms higher yield. Similar relationship was also expressed by, Thavaprakash *et al*., (2007). In case of varieties, HUE and PUE were significantly higher in Pusa Vaishakhi 0.738 kg ha^{-1} OC day$_{-1}$ and 0.056 kg ha^{-1} OC day^{-1} for grain and 2.15 kg ha^{-1} OC day^{-1} and 0.164 kg ha^{-1} OC day^{-1} for biomass, respectively, as compared to that in PKV-AKM-04 with 0.623 kg ha^{-1} OC day^{-1} and 0.047 kg ha^{-1} OC day^{-1} for grain and 1.91 kg ha^{-1} OC day^{-1} and 0.145kg ha^{-1} OC day^{-1} for biomass and lowest in PKV-green gold (0.527kg ha^{-1} OC day^{-1} and 0.040 kg ha^{-1} OC day^{-1} for grain and 1.73 kg ha^{-1} OC day^{-1} and 0.131 kg ha^{-1} OC day^{-1} for biomass). Higher HUE and PUE in Pusa Vaishakhi variety could be attributed to higher grain and biomass yield.

In conclusion the crop sown on 1st March took maximum calendar days. Growing degree days, heliothermal units and photothermal units form emergence to physiological maturity which got increase with subsequent delay in sowing time recorded highest value on 30th March sown crop. Sowing on 20th March recorded significantly highest grain yield, biomass yield, heat use efficiency and photothermal use efficiency as compared to rest of sowing dates. Among varieties PKV- green gold took the highest calendar days, growing degree days, heliothermal units and photothermal units from emergence to physiological maturity. In case of grain yield, biomass yield, heat use efficiency and photothermal use efficiency, pusa vaishakhi recored significantly higher values as compared to other varieties.

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