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Thermal indices for prediction of mungbean phenology under varying irrigation schedules

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ABSTRACT

Phenology and thermal requirement of mungbean genotypes were studied under varying irrigation schedules. Crop irrigated twice (20 and 45 DAS) consumed more number of GDD, HTU and PTU to attain physiological maturity as compared to crop irrigated once either at 20 or 45 DAS. Mungbean genotype MH-85-111 resulted in higher HUE for both dry matter and seed yield as compared to other genotypes under study. A linear relationship obtained between occurrence of different phenophases and HTU and PTU can be used to predict mungbean phenology, DMA and seed yield.

Key words : Growing degree-days, helio-thermal units, photo-thermal units

Thermal and photoperiodic conditions experienced by the crop during its life cycle play an important role in deciding the initiation and completion of different phenophases, growth and final yield. The application of agro-climatic indices provides a base for determining the effect of temperature and photoperiod on phenological behaviour of the crop. An attempt has been made to study the phenology of summer sown mungbean genotypes in relation to energy summation indices such as growing degree days, heliothermal and photothermal units under variation in scheduling of irrigation.

MATERIALS AND METHODS

A field experiment comprising of three irrigation schedules -irrigation at 20 DAS (I_1), irrigation at 45 DAS (I_2) and two irrigations, one each at 20 and 45 DAS (I_3) in main-plots and four genotypes (Asha, MH 85-111, K 851 and T 44) in sub-plots was conducted in split plot design with four replications during summer season. The crop was sown after a pre-sowing irrigation of 7 cm depth at a row spacing of 30 cm using 25 kg seed per hectare. A basal dose of 20 kg N as urea and 40 kg P_2O_5 as SSP was applied per hectare. All other cultural practices were followed as per local recommendations. The phenological development of mungbean crop was recorded on the basis of visual observations. Meteorological data were recorded from Agro-Meteorological Observatory situated near the experimental site.

The accumulated heat units for each

day were calculated for different phenological stages as per the equation suggested by Nuttonson (1955), using base temperature of 10°C. Heliothermal units (HTU) are the product of growing degree days (GDD) and corresponding actual sunshine hours for that day. Photothermal units (PTU) are the product of growing degree days and corresponding day length hours for that day. GDD, HTU and PTU were accumulated from the date of sowing to each date of sampling relative to a particular phenophase upto physiological maturity.

Heat use efficiency (HUE) for seed yield was computed following Rajput (1980) as under:

HUE = Seed yield / Accumulated heat units

RESULTS AND DISCUSSION

The crop irrigated twice at 20 and 45 DAS (I_3) required more number of days for completion of all the phenological events as compared to crop irrigated once either at 20 DAS (I_1) or 45 DAS (I_2) (Table 1). Singh *et al.* (1994) also observed a delay of 3-4 days in frequently irrigated summer moong. Application of two irrigations resulted in accumulation of 1204 GDD, 11783 HTU and 15702 PTU to attain physiological maturity with a variability of 2.7 and 5.0% in GDD, 2.5 and 4.3% in HTU and 2.9 and 5.2% in PTU in comparison to one irrigation applied at 45 and 20 DAS, respectively (Table 1). The data further indicated that flower bud initiation, flower initiation and pod formation were slightly earlier in irrigation treatment I_2 than in I_1, however, the occurrence of later phenophases followed a reverse trend (Table 1). This could be due to resource induced competition for the earliness of phenological stages (Kaur *et al.*, 2001).

In general, crop irrigated twice accumulated significantly more dry matter and recorded higher seed yield irrespective of cultivar type leading to comparatively better HUE for dry matter (7.76 kg ha^{-1} $°C^{-1}$ day^{-1}) and seed yield (14.11 kg ha^{-1} $°C^{-1}$ day^{-1}) as compared to crop irrigated once either at 45 or 20 DAS (Table 1). There was a successive increase in HUE for dry matter at each periodical interval of observation upto maturity. At 40 DAS, comparatively better efficiency of utilization of heat in terms of dry matter accumulation was observed in case of irrigation treatments I_1 and I_3 in comparison to I_2. This might be due to application of irrigation water at 20 DAS in both these treatments.

Significant variation in days taken to reach different phenophases, GDD, HTU and PTU was also observed within the mungbean genotypes; MH-85-111 consumed lesser days and thermal time to attain physiological maturity and recorded higher DMA and seed yield as compared to other genotypes under study. This resulted in comparatively better HUE for dry matter (7.93 kg ha^{-1} $°C^{-1}$ day^{-1}) and seed yield (15.38 kg ha^{-1} $°C^{-1}$ day^{-1}) over other genotypes (Table 2).

Table 1: Accumulated growing degree-days for different phenophases and heat use efficiency as influenced by varying irrigation schedules

Parameters	I_1 – 20 DAS	I_2 – 45 DAS	I_3 – 20 & 45 DAS	CD (P=0.05)
Accumulated heat units (°C day)				
Flower bud appearance	600 (40)	579 (39)	609 (40)	4.4 (1.0)
Flower initiation	631 (41)	629 (41)	650 (42)	12.4 (NS)
Pod formation	704 (45)	698 (45)	733 (46)	10.2 (NS)
Completion of flowering	918 (54)	931 (55)	943 (55)	NS (NS)
Completion of pod formation	1036 (60)	1062 (61)	1093 (63)	23.6 (2.0)
Physiological maturity	1147 (65)	1172 (66)	1204 (67)	27.1 (NS)
Heat unit efficiency (kg $ha^{-1}°C^{-1}$ day^{-1}) at harvest				
Dry matter	6.67	7.14	7.76	-
Seed yield	11.62	12.47	14.11	-
Dry matter heat unit efficiency (g m^2 $°C^{-1}$ day^{-1})				
20 DAS	0.021	0.021	0.021	-
40 DAS	0.282	0.222	0.278	-
60 DAS	0.307	0.299	0.332	-
At harvest	0.375	0.400	0.436	-

DAS – days after sowing , Figures in parentheses indicate actual number of days taken to different phenophases

Table 2: Accumulated growing degree-days for different phenophases and heat use efficiency as influenced by mungbean genotypes

Parameters	Asha	MH-85-111	K 851	T 44	CD (P=0.05)
Accumulated heat units (°C day)					
Flower Bud appearance	613 (40)	575 (38)	597 (40)	599 (40)	18.3 (1.1)
Flower initiation	655 (42)	615 (40)	636 (42)	641 (42)	13.6 (NS)
Pod formation	723 (46)	697 (45)	721 (46)	699 (45)	17.7 (NS)
Completion of flowering	947 (56)	925 (54)	929 (55)	923 (55)	NS (NS)
Completion of pod formation	1093 (62)	1036 (60)	1061 (62)	1064 (61)	32.2 (1.7)
Physiological maturity	1206 (67)	1144 (65)	1171 (66)	1176 (66)	18.7 (1.5)
Heat unit efficiency (kg $ha^{-1}°C^{-1}$ day^{-1}) at harvest					
Dry matter	7.13	7.93	6.93	6.79	
Seed yield	13.12	15.38	11.76	10.76	
Dry matter heat unit efficiency (g m^2 $°C^{-1}$ day^{-1})					
20 DAS	0.021	0.022	0.021	0.021	
40 DAS	0.260	0.274	0.253	0.248	
60 DAS	0.318	0.339	0.300	0.294	
At harvest	0.401	0.446	0.389	0.381	-

DAS – days after sowing, Figures in parentheses indicate actual number of days taken to different phenophases

Table 3: Prediction equations for mungbean phenology

Phenophases	Heliothermal units		Photothermal units	
	Regression equation	R^2 value	Regression equation	R^2 value
Flower bud appearance	0.0049X + 9.4645	0.9996	0.0040X + 9.6862	0.9624
Flower initiation	0.0050X + 9.2246	0.9184	0.0039X + 9.8649	0.9745
Pod formation	0.0042X + 14.631	0.9504	0.0034X + 14.170	0.9126
Completion of flowering	0.0058X + 9.6635	0.9046	0.0033X + 14.828	0.8954
Completion of pod formation	0.0046X + 12.462	0.9123	0.0033X + 15.456	0.9852
Physiological maturity	0.0054X + 8.6666	0.9845	0.0033X + 16.006	0.9974

Y= Days of occurrence of phenophase; X= Thermal units; Significant at 5% level

Table 4: Correlation between growing degree days at different phenological stages and seed yield of mungbean

Characters	Flower bud appearance	Flower initiation	Pod formation	Completion of flowering	Completion of pod formation	Physiological maturity	Seed yield
Flower bud appearance	1.000	0.462**	0.428**	0.518**	0.454**	0.343**	0.110*
Flower initiation		1.000	0.410**	0.407**	0.371**	0.322**	0.131*
Pod formation			1.000	0.512**	0.387**	0.480**	0.200*
Completion of flowering				1.000	0.475**	0.538**	0.111*
Completion of pod formation					1.000	0.462**	0.234*
Physiological maturity						1.000	0.195*
Seed yield							1.000

* and ** significant at 1 and 5% level of significance, respectively

The occurrence of phenological growth showed a linear relationship with accumulated HTU and PTU (Table 3) and could be used for predicting the phenology of mungbean cultivars. A positive and significant but low correlation was observed between accumulated heat units and seed yield (Table 4). Thus, heat unit concept could be applied to predict different growth phases of the crop and can also be useful in the identification of thermo-tolerant genotypes.

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