Journal of Agrometeorology 4 (1) : 33 - 38 (June 2002)

Thermal requirement and growth of late sown summer mung (*Vigna radiata* L. Welczek) at various phenological stages

D. K. DAS,* S. K. BANDYOPADHYAY, K. K. NATHAN, T. K. DAS, A. K. SINHA AND S. KUSHWAHA

Water Technology Centre, Indian Agricultural Research Institute, New Delhi-110 012.

ABSTRACT

Crop phenology of summer mung (*Vigna radiata* L. Welczek) was expressed in terms of emergence, leaf initiation, branch initiation, flower initiation, 50% flowering, pod initiation, 50% podding, initiation of pod maturity and 50% pod maturity for irrigated, mulched and rainfed treatments. Corresponding requirement of days, growing degree days (GDD) and photo-thermal units (PTU) were worked out. The rainfed treatment matured 7 to 10 days later than other two treatments and accumulated more GDD and PTU. Irrigated and mulched treatments were comparable in accumulation of GDD/PTU. At maturity, the highest biomass was recorded by mulched (420 gm^{-2}) followed by irrigated (324gm^{-2}) and rainfed (166gm^{-2}) treatments. Heat use efficiency (HUE) also gave similar response as biomass accumulation. HUE, however, was improved during reproductive phase in all treatments. Relationships developed from the study can be used for simulation of phenology and growth of summer mung.

Key words : Mungbean, Phenology, Thermal requirement, Heat use efficiency

Summer mung (*Vigna radiata* L. Welczek) is one of the most important pulse crops in India. Although some research has been carried out on agronomic practices, fertilizer requirement and Rhizobium inoculation, but the research on agrometeorology which determines growth, development and yield of the crop in a particular region are yet to be studied in detail in this crop. Studies on phenology and water use efficiency was studied by Muchow (1985) in semiarid tropical environment. Fyfield and Gregory (1989) reported that the rate of germination was the fastest at 40°C at non limited water condition. Fernandez and Chen (1989) tried several models to predict the number of days to flowering and maturity using degree day concept. Simulation modelling of crops requires data on crop phenology, biomass production, heat use efficiency etc. Hence, the present study was conducted to generate data on thermal requirement and growth of different phenological stages of summer mung (cv. PS-16) for their use in developing growth models of summer mung.

MATERIALS AND METHODS

A field experiment was conducted on summer mung (*Vigna radiata* L.) cv. PS-16

*Present Address : National Centre for Integrated Pest Management, IARI Campus, New Delhi - 110012

Table 1 : Phenology of summer mung influenced by treatments.

Phenological events	Time requirement (days after sowing)		
	Irrigated	Mulched	Rainfed
1. Emergence	8 ± 0.5	8 ± 0.5	8 ± 0.5
2. Leaf initiation	10 ± 0.7	10 ± 0.7	10 ± 0.7
3. Branch initiation	35 ± 2.3	36 ± 2.2	46 ± 2.4
4. Flower initiation	38 ± 2.3	41 ± 2.2	51 ± 2.6
5. Flowering (50%)	42 ± 2.4	46 ± 2.3	62 ± 2.6
6. Pod initiation	42 ± 2.4	46 ± 2.3	63 ± 2.7
7. Podding (50%)	52 ± 2.5	55 ± 2.4	72 ± 2.9
8. Pod maturity (initiation)	63 ± 2.6	65 ± 2.5	78 ± 2.9
9. Pod maturity (50%)	79 ± 2.8	82 ± 2.6	89 ± 3.0

during the pre-*kharif* period (April to July 1994) at Indian Agricultural Research Institute Farm, New Delhi (28°35' N, 77°1' E and 228 m altitude). The soil was sandy loam, typic Ustocrept with pH 6.8. The season was characterized with high air temperature with an average around 30 to 32°C and the extreme air temperature reached above 46°C for two days in the month of June with considerable advection energy. A good amount of rainfall, 521 mm, was received during June and July due to south-west monsoon. A pre-monsoon shower of 12.6 mm was also received during second week of June. The treatments irrigated, mulched and rainfed crops were laid in a randomized block design with five replications. Two irrigations were given to irrigate crop at 33 and 55 days after sowing (DAS) when 25% of available soil moisture in root zone (60 cm) got depleted. Thin, and transparent (100 m thickness), polyethylene sheets as mulch were used to cover the inter row space in mulched treatment after the first irrigation at 33 DAS and no further irrigation was given. No irrigation was provided to rainfed crop. However, all the treatments received 12.6 mm and 57 mm rainfall at 46 DAS and 64 DAS respectively. The crop was sown on April 25, 1994 and the recommended agronomic practices were followed to maintain a good crop growth. The plot size was 2m x 2m and a uniform plant density of 50 plants m^{-2} was maintained.

Daily maximum (Tmax) and minimum (Tmin) temperatures were collected from nearby meteorological observatory and the maximum possible day length (MDL) was obtained from Smithsonian Meteorological Table (List, 1964). Heat indices, viz., growing degree day (GDD) and photothermal (PTU) were computed using the following formulae over a period of time.

$$GDD = \sum [(Tmax + Tmin)/2 - Tb]$$

$$PTU = \sum [(Tmax + Tmin)/2 - Tb] \times MDL$$

Table 2 : Growing degree day (GDD) and photo-thermal unit (PTU) requirement of different phenological events in summer mung.

Phenological events	Treatment		
	Irrigated	Mulched	Rainfed
Cummulative GDD			
1. Emergence	154 ± 5.4	154 ± 5.4	154 ± 5.4
2. Leaf initiation	198 ± 6.2	198 ± 6.2	198 ± 6.2
3. Branch initiation	7511 ± 4.6	776 ± 14.3	1027 ± 15.2
4. Flower initiation	829 ± 14.2	094 ± 14.4	1130 ± 16.5
5. Flowering (50%)	927 ± 15.1	1027 ± 14.9	1404 ± 16.3
6. Pod initiation	927 ± 15.1	1027 ± 14.9	1421 ± 16.9
7. Podding (50%)	1152 ± 15.8	1224 ± 15.6	1601 ± 17.4
8. Pod maturity (initiation)	1421 ± 16.3	1460 ± 15.6	1722 ± 17.3
9. Pod maturity (50%)	1742 ± 17.4	1803 ± 16.8	1938 ± 17.8
Cummulative PTU			
1. Emergence	2033 ± 13.3	2033 ± 13.3	2033 ± 13.3
2. Leaf initiation	2611 ± 16.1	2611 ± 16.1	2611 ± 16.1
3. Branch initiation	10130 ± 49.6	10484 ± 49.5	13969 ± 52.9
4. Flower initiation	11216 ± 47.1	12258 ± 46.5	15401 ± 53.9
5. Flowering (50%)	12578 ± 50.4	13969 ± 61.2	19232 ± 73.3
6. Pod initiation	12578 ± 50.4	13969 ± 61.2	19465 ± 73.7
7. Podding (50%)	15711 ± 54.8	16712 ± 62.8	21976 ± 72.9
8. Pod maturity (initiation)	19465 ± 72.3	20008 ± 75.7	23641 ± 76.4
9. Pod maturity (50%)	23927 ± 76.8	24768 ± 85.9	26597 ± 91.6

The base temperature (Tb) was taken to be 10°C for summer crops like different beans (Ghadekar and Sethi, 1986). Observations on different phenological events viz., emergence, leaf, branch and flower appearence, 50% flowering, pod initiation and 50% pod maturity were taken frequently following standard methods. Increase of dry biomass was also measured throughout the crop growth period at 10 days interval. The mean of the biomass data obtained from five replications were taken for calculation of heat use efficiency (HUE).

RESULTS AND DISCUSSION

The emergence and leaf initiation took 8 to 10 days in all the treatments (Table 1).

Table 3 : Biomass production and seed yield of summer mung during *pre-kharif* 1994.

Days after sowing	Biomass production (g m^{-2})		
	Rainfed	Irrigated	Mulched
10	2.5 ± 0.1	2.5 ± 0.1	2.5 ± 0.1
20	5 ± 0.2	6 ± 0.2	10 ± 0.4
30	20 ± 1.1	22 ± 1.3	29 ± 2.4
40	35 ± 2.2	45 ± 2.3	72 ± 4.1
50	61 ± 2.4	86 ± 2.7	121 ± 4.5
60	83 ± 2.7	145 ± 2.8	175 ± 4.2
70	110 ± 3.9	232 ± 3.2	262 ± 4.2
80	156 ± 3.6	330 ± 3.8	428 ± 4.8
90	181 ± 5.7	333 ± 3.7	430 ± 5.6
100	166 ± 6.8	324 ± 3.9	420 ± 5.8
	Seed yield (kg ha^{-1})		
Final	576 ± 154.1	785 ± 86.3	821 ± 75.8

Branch initiation took 35 and 36 days in irrigated and mulched plots respectively, but it was delayed by another 10 days in rainfed treatment. In all treatments, flower initiation stage came 3 to 5 days after branch initiation. Irrigated and mulched treatments reached 50% flowering stage within 4 to 5 days after flower initiation, but rainfed crop took 11days. Therefore, the growth periods from leaf appearence to branch appearence and flower initiation to 50% flowering may be soil moisture sensitive. Pod appearence occurred almost with 50% flowering in all treatments. Generally, this mung cultivar matures within 65 to 70 days after sowing (Chakravarty, 1980). But, the monsoon rain which started around 60 days after sowing, might have delayed the maturity by providing low air temperature.

Growing degree days (GDD) and photothermal unit (PTU) requirement of different phenological stages are presented in Table 2. For emergence and leaf initiation, there was no difference in GDD and PTU requirement. Branch initiation started after accumulating 751, 776 and 1027 GDD and 10130, 10484 and 13969 PTU in irrigated, mulched and rainfed treatments respectively. It revealed that irrigated and mulched treatments were almost similar, and varied widely with rainfed treatment. From branch initiation to flower initiation 78, 128 and 103 GDD and 1086, 1774 and 1432 PTU were accumulated respectively. Fifty per cent flowering stage, which was supposed to indicate the end of vegetative and starting of reproductive phase, accumulated 927, 1027 and 1404 GDD and 12578, 13969 and 19232 PTU, respectively. The rainfed

Table 4 : Heat use efficiency of summer mung.

Grouwth period	Heat use Efficiency (x10^{-2} g °C^{-1} day^{-1})		
	Irrigated	Mulched	Rainfed
Vegetative	5.4	7.5	2.8
Reproductive	33.6	44.2	23.6

Table 5 : Correlation between GDD and biomass production in summer mung (n = No. of observations).

Treatment	Intercept	Slope	R^2	n
Irrigated	-88.20	0.198	0.86	10
Mulched	-106.34	0.244	0.92	10
Rainfed	-37.51	0.098	0.95	10

treatment accumulated significantly more GDD and PTU compared to other two treatments.

The crop growth was evaluated in terms of dry biomass production (Table 3) at 10 day interval. Maximum biomass at harvest (420 g m^{-2}) was produced by the mulched, followed by irrigated (324 g m^{-2}) and rainfed (166 g m^{-2}) treatments. The differences in biomass production between mulched and non-mulched crops started at 20 days after sowing. The loss of moisture in the form of soil evaporation was checked by white transparent plastic mulch and that moisture could be utilized by the crop for transpiration and metabolic processes. The difference in biomass production between irrigated and rainfed treatment started around 40 days after sowing indicating the effect of first irrigation given 33 days after sowing. It was also observed that 15, 18 and 24 per cent of total harvest biomass was accemulated during vegetative phase (upto 50% flowering) and mulched treatment recorded the highest biomass at this phenological stage. Seed yield at harvest also followed the similar trend. The lowest seed yield was obtained from rainfed (576 kg ha^{-1}) treatment and there were substantial increases in seed yield in irrigated (36%) and mulched (42%) treatments. Variability (standard deviation) of seed yield was more in rainfed treatment followed by irrigated and mulched treatments. Therefore, maximum and consistent yield could be obtained from mulched treatment due to better utilization of soil moisture than other two treatments.

Heat use efficiency (HUE) i.e. biomass production per GDD is given in Table 4. During vegetative period HUE was low for all the treatments. At that period, highest HUE was obtained from mulched treatments

(7.5 x10^{-2} g °C^{-1} day^{-1}) followed by irrigated (5.4 x10^{-2} g °C^{-1} day^{-1}) and rainfed (2.8 x10^{-2} g °C^{-1} day^{-1}) treatments. During reproductive phase the same trend was maintained although marked enhancement in HUE was observed in all the treatments. Irrigated, mulched and rainfed treatments recorded 33.6, 44.2 and 23.6 x10^{-2} g °C^{-1} day^{-1}) HUE respectively during reproductive phase. This result revealed greater HUE by mulched crops which agreed with the earlier findings (Sastry *et al.*, 1985). A correlation between GDD and biomass production was worked out for all three treatments. The intercept, slope and R^2 values are given in Table 5. Highly significant postive correlations were obtained in all the treatments. However, variability in biomass production to the tune of 86, 92 and 95 per cent in irrigated, mulched and rainfed treatments respectively, was attributable to GDD. The relationships developed can be used for developing simulation models on phenology.

REFERENCES

Chakravarty, N.V.K. 1980. Crop-weather interactions in wheat (*Triticum aestivum* L.) and mung bean (*Vigna radiata* L. Welczek) with reference to crop phenology. Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi.

Fernandez, G.C.J and Chen, H.K. 1989. Temperature and photoperiod influence reproductive development of reduced photoperiod-sensitive mungbean genotypes. *J. Amer. Soc. Horti. Sci.* 114 (2):204-209.

Fyfield, T.P. and Gregory, P.J. 1989. Effect of temperature and water potential on germination, radicle elongation and emergence of mungbean. *J. Experi. Botany.* 40:667-674.

Ghadekar, S.R. and Sethi, H.N. 1986. Crops need heat to grow. *Sci Reporter,* September: 554-557.

List, R.J. 1964. Smithsonian Meteorological Table. Smithsonian Institute, Washington D.C., USA.

Muchow, R.C.1985. Phenology, seed yield and water use of grain legumes grown under different soil water regimes in a semiarid tropical environment. *Field Crops Res.* 11(1):81-97.

Sastry, P.S.N., Chaktravarty, N.V.K. and Rajput, R.P. 1985. A suggested index for characterization of crop response to thermal environment. *Int. J. Ecology Env. Sci.*, 11: 25-30.