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Heat use Efficiency of Soybean (*Glycine max*) at Different Phenophases and Different Treatments of Varieties under Varied Environment at Parbhani Region, India

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A B S T R A C T

Soybean is important pulse crop substantial in food value. Maharashtra is accounting second place in production. The field experiment was conducted at department of agricultural meteorology, college of agriculture,Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani field entitled Study of Phenophagic thermal requirement of soybean(*Glycine max*) under varied environment at parbhani region. The experiment was laid in split plot design, gross plot size was 5.4 m x 3.6 m and 4.5 m x 2.7 m net plot size, replicated thrice in which four sowing dates were imposed as a main treatments and three varieties were tested as sub plot treatment. The crop was sown on 27 MW took maximum, heat use efficiency, to attend different phonological stages. Among the varieties (MAUS-158) took highest calendar days heat use efficiency to reach the maturity.

Introduction

Soybean is the third largest oil seed crop of India (Tiwari, 2003). Cultivation of soybean on large scale was started in selected state during the year 1971-1972 (Wasnik, 1986). Pulses and vegetable oils are the essential parts of Indian diet. The per capita availability of pulses and oils in India is 35 and 12 g/day as against recommended level of 85 and 45 g/day, respectively. The temperature is an important meteorological variables that affect plant growth and development (Londe and Woodward, 1988) [4]. Day light or bright sunshine hours play an important role in growth and development of soybean crop. Same varieties flower in less than 30 days after emergence if exposed to day light less than twelve hours (Beard and Knowles, 1973). Soybean is broadly cultivated in tropical, subtropical and warm temperate regions of the world. Soybean grows effectively in warm and moist climate. A temperature of 26°C to 30°C aspect to be the optimum for most of the varieties. Soil temperature of 15.5°C or above favour rapid germination and vigorous seedling growth. The minimum temperature for effective growth is about 10°C. Days length is the key factor in most of the soybean varieties as they are short day plant and are sensitive to photoperiods. Most of the varieties will

flower and mature quickly in grown under condition where the day length less than 14 hrs provided that temperatures are also favorable. In view of above, a field experiment was undertaken to find out the growing degree days (GDD) and Heat use efficiency (HUE) at different phenophases of soybean crop in different sowing windows of soybean crop.

Materials and Methods

The field experiment was conducted at the department of agricultural meteorology, college of agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani field entitled. Work out heat use efficiency of soybean (*Glycine max*) at different phenophases and different treatments of varieties under varied environment at parbhani region. The experiment was laid in split plot design, gross plot size was 5.4 m x 3.6 m and 4.5 m x 2.7 m net plot size, replicated thrice in which four sowing dates were imposed as a main treatments and four varieties were tested as sub plot treatment. The entire recommended package of practices were adopted. The crop was harvested at physiological maturity stage.

Computation of agro-meteorological indices

Growing degree days (GDD)

Growing degree days defined as the total amount of heat required between the lower and upper thresholds, for an organisms to develop from one point to another in it's life cycle is calculated in units. The growing degree days (GDD) were worked out by considering the base temperature of 10 ^{0}C. The total growing degree days (GDD) for different phenophases were calculated by using the following equation:

$$\text{Accumulated GDD} = \sum_{ds}^{dh} [(Tmax + Tmin)/2] - Tb$$

Where,

GDD = Growing degree day
Tmax = Daily maximum temperature (^{0}C)
Tmin = Daily minimum temperature (^{0}C)
Tb = Base temperature (10 ^{0}C)
Ds = Date of emergence
DH = Date of harvest.

Heat use efficiency (HUE) [(Kg/ha)/^{0}C day] OR (gm^{-2}/^{0}day)

$$HUE = \frac{\text{Grain yield OR Straw yield}}{\text{Accumulated GDD } (^0\text{C days})}$$

Where, GDD is growing degree days and calculated by the following formula

GDD=Σ [(Tx + Tn)/2 – Base temperature.

Where,

GDD = Growing degree day
Tmax = Daily maximum temperature (^{0}C)
Tmin = Daily minimum temperature (^{0}C)
Tb = Base temperature (10 ^{0}C)
(Base temperature is temperature which below plant cannot grow)

Results and Discussion

The data recorded on these aspects were not subjected to 'F' test of variances and results are interpreted on the basis of values.

Seed yield and straw yield (kg/ha)

The data regarding grain yield and seed yield are presented in Table 2.

The data on grain yield and straw yield indicated that the crop sown in D_2 MW-27 recorded higher grain yield (1655.2 Kg ha^{-1}) and (i.e. 2174.3 Kg ha^{-1}) found significantly superior over other treatments whereas the lowest yield was recorded in treatment D_4

Over all this year the crop recorded highest yield due to ample soil moisture during crop growing period. variety MAUS-158 (V_2) produced higher seed yield and straw yield (1683.8 kg/ha) (1887.2 Kg ha^{-1}) and found significantly superior over the remaining treatments.

It may be due to suitable weather conditions for the cultivar V_2 (MAUS 158). The interaction effect between date of sowing and different cultivars was found to be non-significant at all stages.

Biological yield (Kg ha^{-1})

The data regarding biological yield was significantly influenced by different treatments are presented in Table 2. The data presented in Table 2. indicated that crop sowed in D2 (MW 27) recorded highest biological yield (i.e. 3829.4 Kg ha-1) and found that the significantly superior over other sowing dates D1 (MW 26), D3 (MW 28) and D4 (MW 29). Statistical analysis of soybean cultivars showed significant results and presented in Table 2. Among the varietal treatments, cultivars V2 (MAUS 158) produced higher biological yield (i.e. 3571.0 kg ha-1) and found that the non-significantly superior over V3 (MAUS 162) i.e. (2884.1 Kg ha-1). The interaction effect between date of sowing and varieties was found to be non-significant.

Table.2 Mean seed yield (Kg ha^{-1}), straw yield (Kg ha^{-1}) and biological yield (Kg ha^{-1}), harvest index (%) and HUE for grain yield [(Kg/ha)/0C day and HUE for straw yield [(Kg/ha)/0C]of soybean as influenced by different treatments

Treatment	Seed yield (Kg ha^{-1})	Straw yield (Kg ha^{-1})	Biological yield (Kg ha$^{-1)}$	Harvest index %	HUE for grain yield [(Kg/ha)/^{0}C day]	HUE for straw yield) [(Kg/ha)/^{0}C day]
Date of sowing						
D_1 (MW 26)	1391.9	1626.6	3018.4	46.1	1829.1	0.50
D_2 (MW 27)	1655.2	2174.3	3829.4	43.4	1771.4	0.61
D_3 (MW 28)	1497.0	1728.4	3225.4	46.9	1739.4	0.60
D_4 (MW 29)	1287.6	1436.7	2724.3	47.6	1704.6	0.47
S.E. ±	46.5	57.9	62.3	1.38	-	-
C.D. at 5 %	182.7	227.4	244.8	5.42	-	-
Cultivar						
V_1 (MAUS 71)	1440.3	1702.8	3143.1	46.2	0.53	0.96
V_2 (MAUS 158)	1683.8	1887.2	3571.0	47.8	0.61	1.03
V_3 (MAUS 162)	1249.7	1634.5	2884.1	44.0	0.53	0.94
S.E. ±	18.3	27.6	27.2	0.5	-	-
C.D. at 5 %	54.3	82.1	80.8	1.73	-	-
Interaction(D×V)						
S.E. ±	73.1	110.5	10.8.8	2.32	-	-
C.D. at 5 %	NS	NS	NS	NS	-	-
G. Mean	1457.9	1741.5	3199.3	46	-	-

Table.3 Growing Degree Day (GDD) at different phenophases of soybean crop under different treatments

Treatment	Phenophases of soybean										Total	Mean
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}		
Date of sowing												
D_1 (MW 26)	84.4	170.4	180.9	197.6	113.2	187.7	186.2	254.6	244.4	209.7	**1829.1**	**182.9**
D_2 (MW 27)	80.9	165.8	170	191.2	110.9	186.9	183.9	246.2	234.5	201.1	**1771.4**	**177.1**
D_3 (MW 28)	79.9	164.9	169.2	190	110.2	185.2	182.6	234.1	223.4	199.9	**1739.4**	**173.9**
D_4 (MW 29)	72.4	155.9	169	182.8	109.9	179.9	180.9	234	221.9	197.9	**1704.6**	**170.5**
Cultivars												
V_1 (MAUS-71)	80.9	165.8	170	191.2	110.9	185.8	183.9	246.2	234.5	201.1	**1770.3**	**177.0**
V_2 (MAUS-158)	83.9	170.4	179.6	197.6	113.1	187.7	186.2	254.4	243.2	210.2	**1826.3**	**182.6**
V_3 (MAUS-162)	79.9	164.9	169.2	190	110.2	185.2	182.6	234.1	223.4	199.9	**1739.4**	**173.9**
Mean	283.2	373.6	556.5	472.7	665.4	1251.0	1071.5	2073.3	2078.8	1727.4	**73872.6**	**1055.3**

Table 4 Heat use efficiency (HUE) at different phenophases of soybean crop under different treatments

Treatment	Phenophases of soybean										Total	Mean
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}		
Date of sowing												
D_1 (MW 26)	0.13	0.25	0.48	0.62	0.72	0.81	0.84	1.00	0.84	0.69	**6.38**	**0.64**
D_2 (MW 27)	0.14	0.26	0.49	0.68	0.78	0.86	0.89	1.56	0.89	0.72	**7.27**	**0.73**
D_3 (MW 28)	0.14	0.28	0.49	0.69	0.77	0.82	0.85	1.21	0.85	0.71	**6.81**	**0.68**
D_4 (MW 29)	0.15	0.29	0.40	0.62	0.70	0.82	0.82	0.99	0.80	0.63	**6.22**	**0.62**
Cultivars												
V_1 (MAUS-71)	0.14	0.26	0.46	0.64	0.72	0.83	0.83	1.00	0.84	0.69	**6.41**	**0.64**
V_2 (MAUS-158)	0.13	0.28	0.49	0.68	0.76	0.84	0.85	1.46	0.86	0.72	**7.07**	**0.71**
V_3 (MAUS-162)	0.14	0.22	0.46	0.62	0.70	0.82	0.82	0.98	0.81	0.64	**6.21**	**0.62**
Mean	**0.14**	**0.26**	**0.47**	**0.65**	**0.74**	**0.83**	**0.84**	**1.17**	**0.84**	**0.69**	**44.7**	**0.66**

Harvest index

The data regarding harvest index is presented in Table 2 indicated that the mean harvest index was 46.0%.The sowing date D_4 (MW 29) recorded highest harvest index i.e.47.6 per cent and lowest harvest index i.e. 43.4 per cent was recorded in D_2 (MW 27). The cultivar V_2 (MAUS 158) recorded highest harvest index (i.e.47.8 per cent) and lowest harvest index was recorded by V_3 (MAUS162) (i.e. 44.0 per cent).The interaction effect between date of sowing and varieties was found to be non-significant.

Heat use efficiency for grain yield and straw yield of crop

The data regarding heat use efficiency for grain yield and straw yield presented in Table 1. The highest heat use efficiency for grain yield and straw yield of soybean is required to D_2 i,e 0.61 [(Kg/ha)/°C day], 1.23 [(Kg/ha)/°C day] the lowest heat use efficiency of soybean is required to D_4 i,e 0.47 [(Kg/ha)/°C day], 0.8 [(Kg/ha)/^{0}C day]The cultivar V_2 (MAUS 158) recorded highest heat use efficiency for grain yield and straw yield requirement i.e.0.61 [(Kg/ha)/ °C day], 1.03 [(Kg/ha)/°C day] and lowest heat use efficiency requirement was recorded by V_3 (MAUS 162) i.e.0.53 [(Kg/ha)/°C day], 1.03 [(Kg/ha)/^{0}C day].The interaction effect between date of sowing and different cultivars was found to be non-significant at all stages and the results to that effect are presented in Table 2.

Growing Degree days (GDD)

Growing Degree Days (GDD) for soybean crop under different sowing dates and variety from sowing to maturity are presented in Table 3.The data presented in Table 3 revealed that the mean heat unit requirement from the life cycle i.e. emergence to maturity stage (P_1 to P_{10}) in all dates of sowing and cultivars was 1055^{0}C day. The mean heat load reported during D_1 (MW 27) was 182.9°C day and it was followed by D_2 (MW 28), D_3 (MW 29) and D_4 (MW 30) i.e. 177.1°C day, 173.9°C day and 170.5°C day. It indicated that the mean heat load was decreased from D_1 to D_3 it may be due to delayed sowing. In case of varieties V_2 (MAUS-158) required highest total growing degree days i.e. 182.6°C day as compare to varieties V_1 and V_3. It may be due to different growth period.

Heat use efficiency (gm^{-2}/^{0}day)

Heat use effieciency (HUE) for soybean crop under different sowing dates and varieties from sowing to maturity. The data presented in Table 4, revealed that the mean heat use efficiency required for soybean crop from the life cycle i.e. emergence to maturity stage (P_1 to P_{10}) stage was 0.66 gm^{-2}/^{0}day. The total heat use effieiency was recorded during D_1 (SMW 26) was 6.38 gm^{-2}/^{0}day and it was followed by D_2 (SMW 27) i,e 7.27 gm^{-2}/^{0}day and D_3 (SMW 28) i,e 6.81gm^{-2}/^{0}day, D_4 (SMW 29) i,e 6.22 gm^{-2}/^{0}day. Date of sowing D_2 (SMW 27) indicated more heat load (i.e. 7.27 gm^{-2}/^{0}day) than rest of the treatments it may be due to maximum air temperature prevailed at sowing time. In case of varieties V_2 (MAUS-158) required highest total heat use efficiency i.e. 7.07 gm^{-2}/°day as compare to varieties V_1 and V_3. It may be due to different growth period.

In conclusion it is cleared that, when the temperature of air was maximum then it will definitely affect GDD of soybean crop. The total GDD was higher in D_1 (MW-26) *i.e.* 1829.1°C days than rest of the treatments, whereas the lowest total GDD was recorded in D_4 (MW-29) *i.e.* 1704.6 ^{0}C days. Varieties V_2 (MAUS-158) was highest mean GDD over the rest of varieties. Mean heat use efficiency required during total crop growth period was

highest in D_2 (MW 27) i.e. 0.73 $gm^{-2}/°$ day as compare to remaining treatments. In case of cultivars V_2 (MAUS-158) required highest mean heat use efficiency i.e.0.71 $gm^{-2}/^0$day as compare to remaining cultivars. Whereas lowest mean heat use efficiency was recorded in D_4 (MW 29) i.e. 0.62 $gm^{-2}/^0$day in case of cultivar V_3 (MAUS-162) i.e. 0.62 $gm^{-2}/^0$day. It may be due to different growth period.

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