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Original Research Article

To Study the Phenological Stages of Soybean Crop for Crop Weather Calendar

Vaishali Misal and Sujeet Deshmukh*

Department of Agricultural Meteorology, College of Agriculture Parbhani, Maharashtra, India

**Corresponding author*

Keywords

Soybean, Phenological stages, Weather parameters, Indices, Crop weather calendar

A B S T R A C T

An investigation was carried out during 2018-2019 at Department of Agricultural Meteorology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, as "Preparation of crop weather calendar of soybean crop under Parbhani Location". During the phenological observations, the crop weather calendar of soybean crop was found highest number of days for emergence to seedling stage (21-29 days). The lowest number of days taken for sowing to emergence (4-6 days). However, climatic normal of rainfall highest recorded in 30th MW (216.3mm). The mean highest T_{max} (38ºC) and T_{min} (24^0C) recorded in 23rd MW. Maximum RH-I and RH-II recorded in 37^{th} MW and 28thMW (86%) and (78%) respectively. Minimum RH-I (71%) and RH-II (34%) recorded in 23rd MW. In Agrometeorological indices, the recorded highest GDD, HTU and PTU for soybean crop was 2332.2^0C days, 14231.30C days hour and 24234.6^0C days hour in the year 2017 with meteorological week 23 MW-43MW respectively. The sowing dates D1 (27MW) accumulated maximum heat units. In case of phenological observations, the more days recorded in emergence to seedling stage (i.e. 21-29 days) and highest mean maximum and minimum temperature (i.e. 30.7^0C-35.5^0C and 22.5^0C-24^0C) in pod formation to grain formation

Introduction

Soybean (*Glycine max* (L.) Merrill) is a leguminous crop and belongs to family leguminosae. Soybean is also known as „wonder crop" and „gold of century" due to easy cultivation, high cost benefit ratio and low nitrogen requirement. Soybean is a native of Asia and the first known records, however, indicate that soybean emerged as a domesticated crop around the eleventh century BC in China. Soybean was introduced in India in 1970-80. It is an important pulse crop rich in food value. It is a cheapest, richest and easiest source of best quality protein and fat. Soybean was considered as pulse crop but due to high oil content and greater response to applied nitrogen, now it is placed in oil category. Soybean, being leguminous crop, improves soil fertility by fixing atmospheric nitrogen (AICRP on Agrometeorology, Parbhani. Centre). Germination is most critical stage in soybean it requires 8.0-10.0^0C temperature for germination. Excessive cold, moisture or prolonged drought causes injury and therefore the most optimum temperature for its growth is 24.0-30.0^0C while the range is 18.0-30.0^0C. The minimum temperature for most growth and development is about 10.00C. Soybean is a warm season (tropical)

crop but its cultivation now extends to subtropics and temperate climates. The major commercial production is between 250 and 450 N latitude at altitudes of less than 1000 m. It can be grown up to 2000 m.For most soybean varieties temperature between 26.5 to 30^0C appears to be optimal. Soil temperature of 15.5^0C or above favours rapid germination and vigorous seedling growth. The minimum temperature for effective growth is about 100C. Soybean is a basically a short day plant but response to day length varies with variety and temperature and developed varieties are adapted only to rather narrow latitude difference. Day length influences the rate of development of crop. In short day types, increased day length may result in the delay of flowering and taller plants with more nodes. Short day hasten flowering, particularly for late maturing varieties.

The critical photoperiod for bud initiation is around 14 hrs. Subsequent photoperiods influence blossoming. At 16 to 18 hrs, soybean flowers do not open but maximum floral blossoming occurs at 10-13 hrs photoperiod. Night temperatures also influence floral initiation.

Materials and Methods

The present research work on "Preparation of crop weather calendar of soybean crop under parbhani location" was conducted in the Department of Agricultural Meteorology, VNMKV, Parbhani.Weather Data for 1988-2017 i.e. 30 years collected from Department of Agricultural Meteorology, V.N.M.K.V. Parbhani etc. Weekly climatic normal for standard meteorological weeks for this location were computed. These normal meteorological data sets were arranged in a weekly format for cropping season from the month of sowing till the harvest of the crop.

Phenological data (As per available)

The study of the time pattern associated with the development of the different phenophases in the plant as affected by the plant environment is called phenology. The development of phenophases are the most essential component of soybean crop, which can be used to specify the most appropriate rate and time of the specific developmental phases for the maximization of crop yield during the crop life cycle of soybean in the field condition.

The phenological observations, i.e. no. of days required for different phenological stages, viz.

P1 : Sowing to emergence
P2 : Emergence to seedling
P3 : Seedling to branching
P4 : Branching to flowering
P5 : Flowering to pod formation
P6 : Pod formation to grain formatiom
P7 : Grain formation to pod development
P8 : Pod development to pod containing full size grain
P9 : Pod containing full size grain to dough stage
P10 : Dough stage to maturity

The collected soybean crop phenological data were arranged and evaluated according to its phenological stages and different dates of sowing D1 (27MW), D2 (28MW), D3 (29MW), and D4 (30MW) dates.

Results and Discussions

Soybean crop in Marathwada region is mainly cultivated as a rainfed crop and grown during kharif season. However, cultivation of irrigated soybean was also recorded. The climatic requirement of soybean varies in different phenological stages. The average temperature requirement of soybean ranges

between 26.5^{0}C to 30.0^{0}C. Any fluctuation in this range may result in stunted growth of crop finally lead to the reduction in yield.Soybean is the short day plant grown in subtropical and temperate regions in which weather play major role in crop production. Among the climatic factors, temperature plays a key role in determining the sowing time and consequently the duration of different phenophases, which affect the crop productivity. Hence, knowledge of the exact duration of all the developmental phases and their association with yield determinants is essential for achieving high yield. Growing degree days (GDD), Helio-thermal units (HTU) and Photo-thermal units (PTU) are estimators of soybean growth stages. Agrometeorological indices like Growing degree days (GDD), Helio-thermal units (HTU) and Photo-thermal units (PTU) show the temperature impact on the growth of crop.

Growing degree days (GDD) for soybean crop under different sowing dates from sowing to maturity are presented in table no.1 during 2003-2017. The data presented in table no.1 revealed that the highest mean heat load was reported during D1 (MW-27) 178.8^{0}C days and lowest D4 (MW-28) 158.7^{0}C days and D2 (MW-28) and to D3 (MW-29) i.e. 166.4 0C days and 162.6^{0}C days respectively. It may be due to dry spell occurred during crop life cycle. Whereas, D1 (MW-27) treatment indicated more heat load than other treatment of date of sowing i.e. 178.8^{0}C days. It may be due to maximum air temperature observed at the time of sowing (MW-27). It is cleared that when the temperature of air was maximum then it will definitely affect GDD of soybean crop.

The data presented in table no. 1 and fig.no. 1 revealed that the mean heat requirement variety during crop life cycle ranged from 163.9^{0}C day to 158.1^{0}C day. The mean heat load reported was 3 varieties V1 (MAUS-71), V2 (MAUS-81) and V3 (JS-335) i.e. 163.9 ^{0}C day, 161.05 ^{0}C day, and 158.13^{0}C day respectively. It may be occurs due to small crop duration, from emergence to maturity of such varieties.

The data presented in table no. 2 and fig. no. 2. Helio-thermal units for each phenophase were different required by different dates of sowing during 2003-2017. The mean helio-thermal units were observed, in date of sowing (D1 to D4) ranged from 858.8 to 1121.05^{0}C days hours. The HTU were higher in fourth date of sowing i.e. 1121.05^{0}C days hours and lowest HTU were in D1 (MW-27) i.e. 858^{0}C days hours than rest of the treatments due to variation of temperature, bright sunshine and dry spell occurred during the crop growing season. The helio-thermal units directly or indirectly affect the grain yield of soybean by delaying flowering, pod formation. Higher HTU are not conducive for better yield of soybean.

The requirement of mean helio-thermal units of different variety during crop life cycle was ranged from 946.2^{0}C days hours to 966.5^{0}C days hours. It may be due to same crop duration in above three varieties. Whereas, the HTU were lowest in V1 (MAUS-71) i.e. 946.2^{0}C days hours than rest of the treatments due to variation of temperature, growing period, bright sunshine and dry spell occurred during the crop growing season Chavan *et al.*, (2018).

The variation in PTU in different treatments at emerging and maturity has been presented in table no. 3 and fig no. 3. The varieties sown on 27 MW required maximum PTU (1964.9 ^{0}C days hour) till maturity which was superior over 28 MW, 29 MW and 30 MW sown crop at all stages. MAUS-71 requires maximum PTU (1958.7 ^{0}Cdays hour) at all stage which was significantly superior over rest of varieties.

Table.1 Growing Degree Day (GDD) at different phenological stages of soybean crop under Parbhani Location during 2003-2017

Treatments	Phenological stages 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(27MW)	90.5	425.3	80.5	92.5	102.7	195.3	215.5	178.7	175.5	231.5	1788	**178.8**
D_2(28MW)	95.5	378.5	71.5	92.8	98.7	105.5	198.5	212.5	175.5	234.5	1663.5	166.4
D_3(29MW)	88.9	385.5	70.8	93.6	90.5	103.5	180.7	215.5	175.5	221.5	1626	162.6
D_4(30MW)	89.6	355.6	67.9	95.6	81.9	117.6	180.5	205.6	196.7	195.5	1586.5	158.7
Variety												
MAUS-71	89.5	380.8	67.2	85	89.4	99	187.8	218.9	188.8	232.8	1639.2	**163.9**
MAUS-81	88.9	375.5	70.8	93.6	90.5	98	180.7	215.5	175.5	221.5	1610.5	161.05
JS-335	82.2	365.2	66.5	79.5	85.4	92.2	185.2	215.7	188.2	221.2	1581.3	158.13
MEAN	86.9	373.8	68.2	86	88.4	96.4	184.6	216.7	184.2	225.2	1610.3	161

P_1- sowing to emergence
P_2-emergence to seedling
P_3- seedling to branching
P_4- branching to flowering
P_5-flowering to pod formation
P_6- pod formation to grain formation
P_7- grain formation to pod development
P_8 -pod development to pod containing full grain size
P_9- pod containing full grain size to dough stage
P_{10}- dough stage to maturity

Table.2 Helio -Thermal Unit (HTU) at different phenological stages of soybean crop under Parbhani Location during 2003-2017

Treatment	Phenological stages 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(27MW)	289.6	1450.7	358.2	347.2	658.7	782.4	1439.9	590	850.9	1812.5	8588.83	858.83
D_2(28MW)	399.5	1451.5	227.3	570.3	656.9	789.8	685.5	609.4	1215.1	2324.1	8929.4	892.94
D_3(29MW)	366.8	1612.7	425.6	778.3	638.8	488.3	785	985.4	1788	1912.8	9781.7	978.17
D_4(30MW)	434.6	1510	320.5	705.3	338.5	988.8	1326.4	1883.2	1757.5	1945.7	11210.5	**1121.05**
Variety												
MAUS-71	220.8	1250.7	315.6	304	610.2	794.5	1127	1750	1399	1690.2	9462	946.2
MAUS-81	218.5	1456	285.6	332.2	670.2	795	1280	1754	1572	1857.5	10221	1022.1
JS-335	215.5	1326	329	345	703.6	774	1257	1753	1705	1257.6	9665.7	966.5
MEAN	218.26	1344.2	310	327	661.3	787.8	1221.3	1752.3	1558.6	1601.76	9782.9	978.26

P_1- sowing to emergence
P_2-emergence to seedling
P_3- seedling to branching
P_4- branching to flowering
P_5-flowering to pod formation
P_6- pod formation to grain formation
P_7- grain formation to pod development
P_8 -pod development to pod containing full grain size
P_9- pod containing full grain size to dough stage
P_{10}- dough stage to maturity

Table.3 Photo-Thermal Unit (PTU) at different phenological stages of soybean crop under Parbhani Location during 2003-2017

Treatment	Phenological stages 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(27MW)	1150.5	4896	959.1	1201.3	1203.3	1178.7	2116.7	2419.2	2001.2	2523.3	19649.3	**1964.9**
D_2(28MW)	1130.4	4202.9	802.5	1104.4	1450.3	1181	2105.8	2367.3	1939.6	2420.8	18705	1870.5
D_3(29MW)	1052.5	4510.5	886.8	1083.9	1003.1	1144.6	2015.4	2470.9	1998	2266.1	18431.8	1843.1
D_4(30MW)	1038.4	4304.1	789.4	1099.5	986.49	1256.2	1980.5	2196.7	2031.4	2050.2	17732.8	1773.2
Variety												
MAUS-71	1451.3	4510.7	798.2	998.4	1035.7	1317.2	2401	2404.1	2016.6	2654.2	19587.4	**1958.7**
MAUS-81	989.6	4536.8	785.8	1001.2	999.4	1167.4	2407.5	2234.1	2502.5	2098.5	18722.8	1872.2
JS-335	999.8	4483.5	781.9	999.3	987.8	1426.3	1879.4	2304.1	2004.7	2530.2	18397	1839.7
MEAN	1146.9	4510.3	788.6	999.6	1007.6	1303.6	2229.3	2314.1	2174.6	2427.6	18902.4	1890.2

P_1- sowing to emergence
P_2-emergence to seedling
P_3- seedling to branching
P_4- branching to flowering
P_5-flowering to pod formation
P_6- pod formation to grain formation
P_7- grain formation to pod development
P_8 -pod development to pod containing full grain size
P_9- pod containing full grain size to dough stage
P_{10}- dough stage to maturity

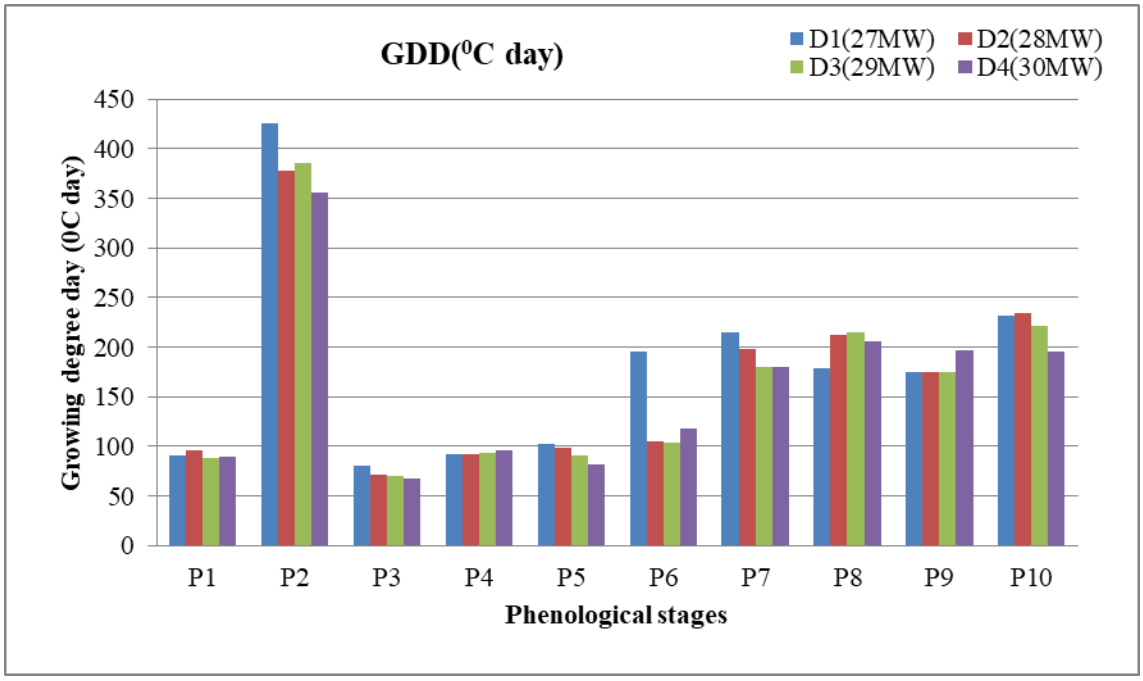

Fig.1 Growing Degree Day (GDD) at different phenophases of soybean crop under Parbhani location during 2003-2017

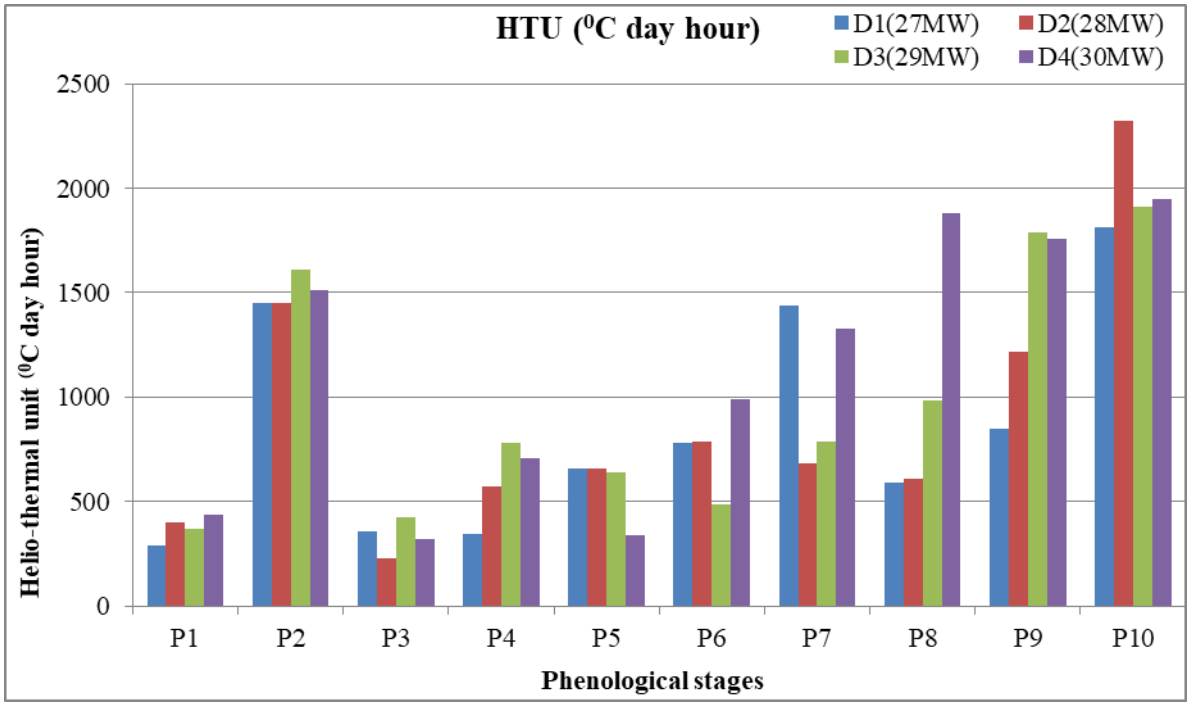

Fig.2 Helio-Thermal Units (HTU) at different phenophases of soybean crop under Parbhani location during 2003-2017

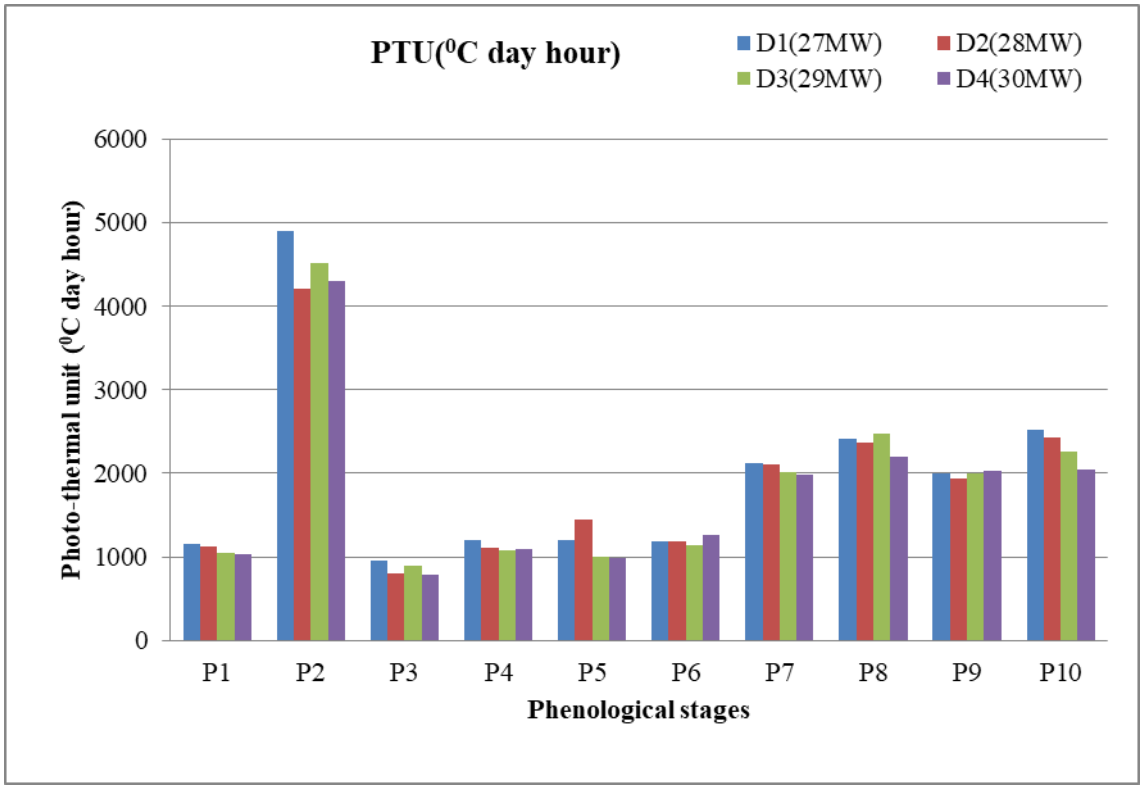

Fig.3 Photo-Thermal Units (PTU) at different phenophases of soybean crop at Parbhani location during 2003-2017

The higher PTU value in early sown crop may be due to fact that crop took longer duration to reach Phenological stage. The similar results were also indicating by the finding of Chavan *et al.,* (2018)

According to Chavan *et al.,* (2018) the crop was sown on 27th MW took maximum calendar days, growing degree days, photo thermal unit and helio-thermal unit to attain different phenological stages till maturity and reduced significantly with subsequent delay in sowing time. The grain yield recorded in 27thMW was significantly highest to rest of sowing dates. The significant reduction in grain yield of timely sown varieties was recorded when sowing was delayed from normal sowing dates.

The result showed that the range during 2003 to 2017 number of days required for maturity when crop was sown under D1 (MW27) were 92-112 days , D2(MW 28) 93-115 ,D3 (MW29) 94-114 days and D4(MW30) 93-112 during the crop growing season . Delay in the sowing induced the early flowering in the soybean crop, as the day length increase along with the increased temperature because of the crop is determinant type with short day length and thermo sensitive plant and its response to yield varies with variety temperature.

Further, the variation in the maturity period in all the treatment can be explained on the basis of the fact that the temperature was higher in D3 and D4 as compared to D1 and D2. The similar results were given by Khobragade *et al.,* (2016).

In conclusion, during 2003-2017 the highest GDD accumulated in D1 (8 July 27MW)

178.8^{0}C days as well as highest HTU accumulated D4 (29 July 30MW) i.e. 1121.05^{0}C days hour while highest PTU is accumulated D1 (8 July 27MW) i.e. 1964.9^{0}C days and also maximum GDD accumulated in MAUS-71 163.9^{0}C days while HTU in MAUS-81 i.e.1022.1^{0}C days hour and PTU in MAUS-71 i.e.1958.7^{0}C days hour according to their phenophases the maximum duration of crop accumulated highest heat units.

For Soybean crop ten phenological stages were required according to phenophases. The number of days required was highest from emergence to seedling stage 21-29 days. The lowest number of days required from branching to flowering 4-6 days. The various phenological stages were in relation to weather parameter likes rainfall, temperature, relative humidity, bright sunshine hour. Due to aberrant condition of weather these parameters affected the phenophases of soybean crop.

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