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The effect of sowing windows on phenology and heat unit accumulation of summer soybean for seed production

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Abstract

A field experiment was conducted during summer 2022 at PGI-Research Farm, MPKV, Rahuri. The experiment was laid out in split plot design with four sowing dates (3rd January, 17th January, 31st January and 14th February) and four varieties (Js-9305, KDS-726, KDS-753 and KDS-992) replicated thrice. The results revealed that, the number of days required to emergence, 50 % flowering, physiological maturity and harvest stage were significantly higher in case of 3rd January sowing (11.5, 75.6,115 and 126.5 days, respectively) and the 14th February sown crop took minimum days to emergence (7.4 days), 50 % flowering (55.5 days) and physiological maturity (90.5 days) as well as at harvest (101.8 days) during the year of investigation. The cumulative GDD to attain emergence, physiological maturity and harvest stage (126.1, 1797.5 and 2068.1 °C days, respectively) was highest under 3rd January sowing while at 50% flowering highest GDD (982.1) was attained by 14th February sown crop. The cumulative GDD at critical growth stages was highest in Phule Durva at emergence, 50 % flowering, physiological maturity and harvest stage (110.8, 1019.8, 1829.0 and 2161.3 °C days, respectively).

Keywords: Critical growth stages, GDD, sowing date, summer

1. Introduction

Soybean (*Glycine max* L. Merrill) has become miracle crop of the 21st century and is often designated as 'Golden Bean', "Wonder crop" and 'Poor man's meat'. Soybean belongs to family Fabaceae (Leguminosae). It is the most important economic oilseed crop and recognized as the most popular pulse cum oilseed crop in the world (Mehetre *et al.*, 2022) [10]. Soybean is generally sown in the beginning of monsoon and harvested at the end of October. It can be also grown from February -June. Most soybean cultivars respond to photoperiod as quantitative short-day plants. Soybean being a thermosensitive, short-day plant, non-monetary crop management practice such as sowing time has direct effect on production scenario right from its adoption to time of maturity (Kumar, 2005) [7]. Hodges and French (1985) [4] reported that soybean has a juvenile stage after emergence when it is especially sensitive to temperature and insensitive to day length. Soybean cultivates well in warm and moist climate. Temperature of 26.5 to 30 °C is optimum for its good cultivation. Soil temperatures of 15.5 °C and above are favorable for rapid germination and vigorous vegetative growth. The minimum temperature for effective growth is about 10 °C. A lower temperature tends to delay the flowering. Temperature is the most crucial factor for achieving the optimum production, the temperature lower than 10 °C are not suitable for performance of soybean (Arshi *et al.*, 2010) [1]. Most of the varieties will flower and mature quickly if grown under condition where the day length is shorter than 14 hours as long as temperatures are favourable. Therefore, time of sowing may be a vital consideration in soybean.

2. Material and Methods

A field experiment was carried out during *summer* season of the 2022 at Post Graduate Institute Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, M.S. The investigation was carried out to assess the effect of sowing windows on days required to critical growth stages and GDD of *summer* soybean for seed production. The experiment was laid out in Split plot design consisting of four sowing windows *viz.*, 1st MW (1st Jan to 7th Jan), 3rd MW (15th Jan to 21st Jan), 5th MW (29th Jan to 4th Feb), and 7th MW (12th Feb to 18th Feb) as main plot and four varieties of soybean *viz.*, JS-9305, Phule Kimaya (KDS-753), Phule Sangam (KDS-

(KDS-726) and Phule Durva (KDS-992) as sub plot and was replicated thrice.

2.1 Critical growth stages (CGS)
The data pertaining to the number of days required to emergence, 50 % flowering, physiological maturity and harvest stage were recorded by observing plants from net plot at all respective stages.

2.2 Growing Degree Days (GDD)
A growing degree day (GDD) or heat unit (HU) is the departure from the mean daily temperature above the threshold temperature of the crop. The threshold or base temperature is the temperature below which no growth of that particular crop takes place. The base temperature varied with crop, generally the tropical crops have higher base temperature and temperate crop have lower base temperature.In the present investigation, the base temperature of soybean was taken as 10 °C. The growing degree day (GDD) or heat unit (HU) were computed at critical growth stages of the crop by using formula given by Nuttonson (1955) [12] as under.

$$GDD = \sum_{i=1}^{n} \frac{T_{max.} + T_{min}}{2} - T\ base$$

Where,

$\sum_{i=1}^{n}$ = Period in days from sowing date till the last date of harvesting

GDD = Growing degree days

T_{max} = Daily maximum temperature of day i (°C)

T_{min} = Daily minimum temperature of day i (°C)

T_b = Base temperature

Growing degree days (GDD) thus determined was expressed as °C day.

3. Results and Discussion
A perusal of data revealed that in case of sowing windows, days to achieve emergence, 50 % flowering and physiological maturity as well as at harvest were significantly affected as the sowing of *summer* soybean was delayed from 1st MW to 7th MW. The data presented in Table 1 shows that the 1st MW sown crop took significantly a greater number of days (11.5, 75.6, 115 and 126.5 days, respectively) to reach emergence, 50 % flowering stage and physiological maturity as well as harvest, respectively followed by 3rd and 5th MW sowing. The 7th MW sown crop took lesser days to attain emergence, 50 % flowering, physiological maturity and harvest stage (7.4, 55.5, 90.5 and 101.8 days, respectively). It is clear from the above findings that different sowing windows had profound effect on number of days taken to reach emergence, 50 % flowering and physiological maturity as well as harvest. Late sown crop took lesser number of days to attain emergence, 50 % flowering, physiological maturity and harvest as compared to early sown crop. This is because when crop was sown late, its period from emergence to harvest gets shortened considerably as it experiences the temperature which is significantly higher than optimum for flowering. Therefore, the late sown crop was forced to flower and mature early whereas early sown crop experienced minimum temperature during the growth phases which resulted in delayed phenological growth stages. Similar results were also reported by Gibson and Mullen (1996) [3], Ram *et al.* (2010) [13] and Reddy (2020) [14].

The soybean varieties significantly influenced the days to emergence, 50 % flowering and days to physiological maturity as well as harvest. The variety Phule Durva took significantly more days (10.0, 68.2, 104.5 and 118.7 days, respectively) to reach emergence, 50 % flowering, physiological maturity and harvest stage respectively

Table 1: Days required to attained critical growth stages of *summer* soybean as influenced periodically by different treatments

Treatments	Days required to attain Critical growth stages (DAS)			
	Emergence (VE)	50% flowering	Physiological maturity	At harvest
A. Main plot : Sowing windows (S)				
S_1 : 1st MW (1st Jan.- 7th Jan.)	11.5	75.6	115.0	126.5
S2 : 3rd MW (15th Jan.-21st Jan.)	9.8	69.0	105.2	116.9
S3 : 5th MW (29th Jan.-04th Feb.)	9.0	62.4	97.7	109.2
S4 : 7th MW (12th Feb-18th Feb.)	7.4	55.5	90.5	101.8
S.Em. ±	0.2	0.5	1.0	0.7
C.D. at 5%	0.7	1.8	3.6	2.5
B. Sub plot : Varieties (V)				
V_1 : JS-9305	8.5	59.5	95.7	100.3
V_2 : Phule Kimaya	9.5	67.0	104.0	117.4
V_3 : Phule Sangam	9.6	67.8	104.2	118.0
V_4 : Phule Durva	10.0	68.2	104.5	118.7
S.Em. ±	0.2	0.8	0.8	0.6
C.D. at 5%	0.8	2.4	2.4	1.7
C. Interaction (S × V)				
S.Em. ±	0.5	1.6	1.6	1.2
C.D. at 5%	NS	NS	NS	NS
CV %	9.4	65.6	102.1	113.6
General Mean	11.5	75.6	115.0	126.5

Table 2: Heat Unit (GDD) of *summer* soybean as influenced periodically by different treatments.

Treatments	Growing degree days at critical growth stages			
	Emergence (VE)	50% flowering	Physiological maturity	At harvest
A. Main plot : Sowing windows (S)				
S_1 : 1st MW (1st Jan.- 7th Jan.)	126.1	959.0	1797.5	2068.1
S2 : 3rd MW (15th Jan.-21st Jan.)	98.2	955.5	1747.5	2022.7
S3 : 5th MW (29th Jan.-04th Feb.)	96.4	976.7	1771.1	2038.1
S4 : 7th MW (12th Feb-18th Feb.)	98.0	982.1	1781.3	2040.2
S.Em. ±	-	-	-	-
C.D. at 5%	-	-	-	-
B. Sub plot : Varieties (V)				
V_1 : JS-9305	96.6	847.3	1624.6	1732.0
V_2 : Phule Kimaya	104.9	994.8	1820.4	2131.3
V_3 : Phule Sangam	106.6	1011.2	1823.3	2144.4
V_4 : Phule Durva	110.8	1019.8	1829.3	2161.3
S.Em. ±	-	-	-	-
C.D. at 5%	-	-	-	-
C. Interaction (S × V)				
S.Em. ±	-	-	-	-
C.D. at 5%	-	-	-	-
CV %	-	-	-	-
General Mean	104.7	968.3	1774	2042.3

Whereas, it was observed that lowest number of days to attain emergence, 50 % flowering and physiological maturity stage as well as harvest stage (8.5, 59.5, 95.7 and 100.3 days, respectively) were taken by variety JS-9305, because it is a short duration variety and it complet the life cycle within 90 to 95 days. The variety JS-9305 took minimum number of days to harvesting (100.3 days) during the field trial. Therefore, it was noted that the time to achieve maturity was reduced by around 18 days with JS-9305 variety. The results are in accordance with the earlier findings by Kitano *et al.* (2006) [6] and Ram *et al.* (2010) [13].

The data presented in the Table 19 revealed that the GDD requirement at critical growth stages of *summer* soybean was strongly influenced by the sowing windows and varieties. The cumulative GDD at critical growth stages was highest in 1st MW sowing to attain emergence, physiological maturity and harvest stage (126.1, 1797.5 and 2068.1 °C days, respectively) and at 50% flowering highest GDD (982.1 °C days) was attained by 7th MW sown crop and the cumulative GDD at critical growth stages was highest in Phule Durva to attain emergence, 50% flowering, physiological maturity and harvest stage (110.8, 1019.8, 1829.0 and 2161.3 °C days, respectively). It is known fact that every crop needs a specific amount of GDD to enter its reproductive phase from vegetative phase. Earlier sown crop took higher number of days to reach different growth stages which may be attributed to prevailing cool temperatures during early stages of the crop growth.Early sowing resulted in absorbing sufficient GDD in relatively more time. Therefore, early sown crop had consumed maximum GDD at all phenological stages as compared to the rest of sowing. In case of delayed sown conditions, the crop experienced the much higher temperature causing reduction in number of days taken to attain any phenological stage. This resulted in the lower consumption of heat units under delayed sowing condition. The differential behaviour of varieties with respect to days required to reach various phenophases and GDD requirement could be solely ascribed to their genetic makeup. These results are in conformity with Medida *et al.* (2006) [9], Kumar *et al.* (2008) [8], Nath *et al.* (2017) [11], Chavan *et al.* (2018) [2] and Kessler *et al.* (2020) [5].

4. Conclusion

The number of days required to emergence, 50 % flowering and physiological maturity as well as at harvest were significantly higher in case of 1st MW sowing window (11.5, 75.6, 115 and 126.5 days, respectively) over rest of the sowing windows. The 7th MW sowing window took minimum days to emergence (7.4 days), 50 % flowering (55.5 days), physiological maturity (90.5 days) and harvest stage (101.8 days) during the period investigation. The maximum growing degree days value was recorded in 1st MW sowing window at emergence, physiological maturity and harvest stage (126.1, 1797.5, and 2068.1 °C days, respectively) and at 50% flowering highest GDD (982.1) recoded by 7th MW sown crop.

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