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ORIGINAL ARTICLE

Agrometeorological Indices for Sunflower (*Helianthus Annuus L.*) Varieties under Different Sowing Windows

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ABSTRACT
The experiment was conducted in a split-split plot design with three replications having eighteen treatment combinations formed considering different protection, varieties and sowing windows. The cumulative GDD, cumulative HTU, LUE, PAR at the end of growth stages showed that higher requirement was at 30th MW (S_2:23rdJuly – 29th July) over rest of the sowing windows. Lower amount of heat unit was recorded at 26 MW (S_1: 26th June – 01st July). The cumulative GDD, cumulative HTU, LUE, PAR, at the end of growth stages showed that higher requirement were by Phule Raviraj over rest of the varieties. Lower amount of heat unit was recorded with variety MSFH-17.
Key words: *Agrometeorological indices, sunflower, LUE, SDD, GDD.*

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INTRODUCTION

Sunflower (*Helianthus annuus L.*) belongs to the family Compositae. It is a seasonal, erect and herbacious plant with leaves simple, alternate with stout petioles and lanceolate in shape. A single head produces 350 to 2000 seeds. In early 1970s, only about 0.1 million hectares were under sunflower cultivation, however, by 2012-13, it gone up to 5.5 million hectares. In India, it was used mainly as ornamental crop but in recent past it became an important source of edible and nutritious oil. Sunflower is a major source of vegetable oil in the world. It is used for a variety of cooking purposes. Sunflower seed contains about 48 – 53 % edible oil. The sunflower oil is considered premium compared to other vegetable oils as it is light yellow in color, high level of linoleic acid and absence of linolenic acid, possesses good flavour and high smoke point. Sunflower oil is a rich source (64 %) of linoleic acid which is good for heart patients. Linoleic acid helps in washing out cholesterol deposition in the coronary arteries of the heart. The oil is also used for manufacturing hydrogenated oil. Recent study confirms that varieties differ extensively in the physiological process determining the yield. It has been also shown that the total yield per plant and per unit area is determined by the number of head and seed weight per plant. These physiological factors also determined by environmental factors. Sunflower is photo and thermo-insensitive and day neutral plant. The sunflower oil has greater stability and quality under various climatic conditions. Now days, attentions also paid on global warming and due to global warming climatic change are oftenly observed in India. Growth, yield, oil percent is greatly affected. To overcome this problem, there is necessity to study the response of different varieties of sunflower to different sowing times.With this view, to identify suitable variety and influencing sowing date and yield of sunflower, present investigation has been undertaken.

MATERIALS AND METHODS

The field experiment was conducted during *kharif*, 2015 at Mulegaon Agricultural Farm, Zonal Agricultural Research Station, Solapur, Maharashtra State (India). Geographically the campus of Mulegaon Agricultural Farm is situated on 17º41' N latitude and 75º 56'E longitude. The altitude is about 483.6 M above mean sea level. The data revealed that during the crop growth period, the annual maximum and minimum temperature ranged between 25.0 to 43.2^{0}C and 7.3 to 27.1^{0}C, respectively. During the *kharif* season, the maximum temperature ranged between 29.0 to 40.8^{0}C with an average of 34.7^{0}C, whereas, the minimum temperature ranged between 18.0 to 26.2^{0}C.The pan evaporation ranged between 1.8 to 12.8 mm with an average of 7.4 mm. The wind speed ranged between 2.1 to 18.3 Kmph with an average of 9.7 Kmph. In case of BSS which was ranged between 0.0 to 12.1 hrs with an average of 5.2 hrs. The morning RH ranged between 60 to 90 per cent with an average of 75per cent and the afternoon RH ranged between 24 to 90 per cent during the crop growth period. Experiment Details and treatment details were given below.

The experiment was conducted in split plot design with 3 replication. 8-10 Kg seed ha^{-1} was used. The spacing adapted was 45 × 20 cm^2. Application of 50 kg N + 25 kg P_2O_5 ha^{-1} to the experiment. Gross and Net plot size were 6.0 x 4.5 m^2 and 4.2 x 3.6 m^2 respectively.

Table 1: Treatment Details

Treatment	Combinations
T_1 - S_1V_1	S_1 - 26MW (26 June-01 July), V_1 - Bhanu
T_2 - S_1V_2	S_1 - 26MW (26 June-01 July), V_2- MSFH-17
T_3 - S_1V_3	S_1 - 26MW (26 June-01 July), V_3 - PhuleRaviraj
T_4 - S_2V_1	S_2 - 30MW (23 July-29 July), V_1–Bhanu
T_5 - S_2V_2	S_2 - 30MW (23 July-29 July), V_2 - MSFH-17
T_6 - S_2V_3	S_2 - 30MW(23 July-29 July), V_3 - PhuleRaviraj
T_7 - S_3V_1	S_3 - 34MW(20 Aug.-26 Aug.), V_1 –Bhanu
T_8 - S_3V_2	S_3 - 34MW(20 Aug.-26 Aug.), V_2 - MSFH-17
T_9 - S_3V_3	S_3 - 34MW(20 Aug.-26 Aug.),V_3 - PhuleRaviraj

Dry matter plant^{-1}(g)

To determine the dry matter plant^{-1} one representative plant sample from each net plot was uprooted and observations were recorded at 28, 42, 56, 70, 84 DAS and at harvest. The material was chaffed and was first air drying later on and they were kept for oven drying at 60 ± 2^{0}C till constant weight were obtained. After weighing the material, the dry matter of plant was recorded.

Measurement of incident radiations (PAR)

For measurement of incoming PAR, Line Quantum Sensor was positioned facing up 1ft. above the top of the canopy and value was recorded for incoming PAR.

Measurement of reflected radiations

For measurement of reflected radiations, Line Quantum Sensor was positioned facing down towards the bed and value was recorded for reflected.

Measurement of transmitted radiations

Line Quantum sensor was placed above the ground across the rows and value was recorded for transmitted radiations.

Measurement of absorbed radiations

Absorbed radiation was calculated by formula given below.

$$APAR = (PAR + RPAR) - (TPAR + RPAR)$$

Estimation of light use efficiency (LUE/RUE)

$$LUE = \frac{\text{Amount of Green/dry matter produced (g /m}^2\text{)}}{\text{Amount of cumulutive light absorbed (MJ/m}^2\text{)}}$$

Growing degree days (GDD)

Temperature is a major environmental factor that determines the rate of plant development. The temperature requirement and range of optimum temperature varied with species and genotype. The thermal response of genotype can be quantified by using the heat unit or thermal time concept. There is high probability of successfully predicting the development of sunflower by heat unit.

Thermal time or growing degree days were calculated according to the equation.

$$G.D.D. = \sum_{i=1} [(T_{max.} + T_{min.})/2 - Tb]$$

Where,

G.D.D. = Growing degree days

$T_{max.}$ = Daily maximum temperature of day i (^{0}C)

$T_{min.}$ = Daily minimum temperature of day i (^{0}C)

Tb = Base temperature

In present study, the base temperature of sunflower was taken as 8^0C.

Heliothermal units

The helio thermal unit is product of GDD and the mean daily hours of bright sunshine. The sum of HTU for each phenophase was worked out by using the following formula.

Accumulated HTU = Σ [(T+ Tb.)/2 – Tb) D]

Where,

HTU = helio thermal unit

T = mean daily temperature

Tb = base temperature

Ts = date of sowing or starting date of the phenophase ofinterest

Th = date of harvesting or ending date of phenophase of interest

D = hours of bright sunshine

RESULTS AND DISCUSSION

Growing degree days (^0C days)

The accumulated growing degree days were reasonably higher during reproductive stage as compared to vegetative stage. The accumulated growing degree days to reach various growth stages differ among the different sowing widows. The middle sown crop at 30^{th} MW (S_2) accumulated the highest growing degree days (^0C days) to reach various phenophases which decreased with delayed sowing. Similar findings were reported by Anil Kumar *et al*. [1]. The sunflower registered the highest accumulated growing degree days for variety Phule Raviraj as compared to Bhanu and MSFH-17. These results are in conformity with the finding of Khushu *et al*. [2].

Helio thermal unit (^0CDays)

The accumulated helio thermal units to reach various growth stages differ among the different sowing windows. The middle sown crop at 30^{th} MW(S_2) accumulated the highest helio thermal units to reach various phenophases which decreased with delayed sowings. Similar findings were reported by Anil Kumar *et al*. [1]. The sunflower registered the highest accumulated helio thermal units for variety Phule Raviraj as compared to Bhanu and MSFH-17. These results are in conformity with the finding of Khushu *et al*. [2].

Cumulative light/radiation use efficiency (g/MJ)

The highest radiation use efficiency (RUE) recorded with 30^{th} MW followed by all other sowing windows across the total growing period of the sunflower crop. The lowest radiation use efficiency was recorded in 26^{th} MW. (Table 19) It was observed that the mean general radiation use efficiency was the highest at 70 DAS and thereafter decreased at the harvest stage. These results are in conformity with the findings of Kumar *et al.* [1].

The varieties (Phule Raviraj) recorded the highest amount of RUE at 70 DAS (3.49 g/MJ). Thereafter, decreased up to harvest and the variety Bhanu and MSFH-17 recorded 3.24 g/MJ and 2.84 g/MJ at the time of 70 DAS, respectively. The radiation use efficiency was generally depending upon weather condition of the day. The low RUE was observed when cloudy condition of the day and remained while recording the observations.

Table 2: Growing degree days (^0C days) across various phenophases of sunflower as influenced by different treatments

Treatment	Phenological stage					
	Germination	Leaf development	Stem elongation	Inflorescence emergence	Flowering	Ripening
Main plot treatments (3 sowing dates)						
S_1- 26 MW	37.4	254	245.9	119.8	125.6	152.9
S_2- 30 MW	56.2	429	362.6	266.3	225.5	239.1
S_3- 34 MW	45.6	332	277.1	233.4	187.2	175.3
Sub plot treatments (3 varieties)						
V_1 : Bhanu	49.7	334	288.4	209.2	179.6	189.7
V_2 : MSFH-17	39.4	297	275.0	185.3	156.5	173.4
V_3 : Phule Raviraj	50.1	385	322.1	225.1	202.1	204.1

Table 3: Helio thermal units (^{0}Days) across various phenophases of sunflower by different treatments

Treatment	Phenological stage					
	Germination	Leaf development	Stem elongation	Inflorescence emergence	Flowering	Ripening
Main plot treatments (3 sowing dates)						
S_1 - 26 MW	513	13226	2388	3181	8080	5012
S_2 - 30 MW	667	20285	3086	5459	11389	7363
S_3 - 34 MW	584	16221	2554	4134	8344	7076
Sub plot treatments (3 varieties)						
V_1 : Bhanu	599	16206	2782	4201	8941	6503
V_2 : MSFH-17	501	15981	2429	4110	8738	6005
V_3 : Phule Raviraj	664	17544	2817	4463	10134	6944

Table 4: Cumulative light/radiation use efficiency (g/MJ) as affected periodically by different treatments

Treatments	DAS					
	28	42	56	70	84	At harv.
Main plot treatments (3 sowing dates)						
S_1 - 26 MW	0.65	0.98	1.49	2.97	1.66	1.63
S_2 - 30 MW	0.98	1.41	1.81	3.40	2.44	1.83
S_3 - 34 MW	0.94	1.26	1.60	3.20	2.06	1.66
Sub plot treatments (3 varieties)						
V_1 : Bhanu	0.96	1.17	1.57	3.24	2.14	1.71
V_2 : MSFH-17	0.61	1.23	1.51	2.84	1.95	1.65
V_3 : Phule Raviraj	1.00	1.25	1.82	3.49	2.07	1.76

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