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Study about different agro meteorological indices under different growing environmental conditions of Raipur District of Chhattisgarh

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Abstract
The values of HTU are lower than PTU because of the fact that here in formula n value is taken into account while in PTU value of N is taken. There are more values of HTU in D_1 to reach germination while in D_2 least HTU are required. To reach flower initiation stage, highest number of HTUs are required while least HTUs are required in normal sowing or second growing environment. It can be very well observed that the highest HTUs are required in Vaibhav while equal number of HTUs are required in JG-14 and JG-16. Similarly in 50% flowering, 100% flowering, pod formation least HTUs are required in second growing environment and JG-14/ JG-16 alike. PTU for different growing environments and varieties are shown in Table no. It can be seen from the table that there are more PTUs generally in first growing environment to reach germination, flower initiation, 50% flowering and 100% flowering. Among the varieties also there are differences and more degree days are required for Vaibhav while lesser PTUs are required in JG-14 and JG-16. The GDDs affected by the growing environment and varieties. It can be seen that GDDs to reach germination stage are higher in D1 and go on decreasing with the delay in sowing. In general GDDs for first growing environment are 183 but with delay in growing environment, the GDDs values reach 170 in second growing environment and reach 159 by the third growing environment. To reach flower initiation stage, lesser GDDs are required for D_3 i.e. third growing environment while maximum, GDDs are required in first growing environment.

Keywords: GDD, HTU, PTU

Introduction
Crop heat unit (CHU) or thermal time or growing degree days is a temperature response of development that differs between day and night. Growing degree days is a way of assigning a heat value to each day. Heat units are involved in several physiological processes like specific amount of heat units required for the plant at each stage from its germination to harvest of the crop would vary and the important processes are growth and development, growth parameters, metabolism, biomass, physiological maturity and yield. Growing degree days are used to assess the suitability of a region for production of a particular crop, determine the growth stages of crops, assess the best timing of fertilizer, herbicide and plant growth regulators application, estimate heat stress accumulation on crops, predict physiological maturity and harvest dates and ideal weather unit in constructing crop weather models. (Parthasarathi *et al.*, 2013) [4].

Temperature is an important weather parameter that affects plant growth, development and yield. Winter crops are vulnerable to high temperature during reproductive stages and differential response of temperature change (rise) to various crops has been noticed under different production environments (Kalra, 2008) [2]. Various forms of temperature summations, commonly referred to as heat units and expressed in 'growing degree-days' (GDD) or in 'thermal time' (Tt), have been widely used in studies to predict phonological events for crops. The thermal time concept is based on the assumption that a fixed amount of heat units above a base temperature (Tb) or threshold temperature, below which no development takes place, is required to complete a specific development phase. Temperature based indices like growing degree days (GDD), heliothermal units (HTU), Pheno-thermal index (PTI), and Heat use efficiency (HUE) can successfully be used for describing phonological behaviour and other growth parameters like leaf area development, biomass production and yield (Singh *et al.*, 2007) [6].

In the view of recent climate change situation, the weather parameters are highly influencing the crop productivity simultaneously due to global warming wherein there is an increase in day temperature and drastic reduction in the night temperature. Among pulses, chickpea is more sensitive to temperature (Kiran and Chimmad, 2015) [3].

To find an impact of the thermal environment on growth and seed yield of chickpea, thermal indices viz., growing degree day (GDD), photothermal unit (PTU) and helio-thermal units (HTU) for two popular chickpea cultivars were calculated under varying sowing dates. The progress to flowering in chickpea is significantly influenced by temperature and can be described by accumulation of thermal time (Roberts *et al.*, 1985) [5].

Materials and Methods

The Study about different agro meteorological indices under different growing environmental Conditions of Raipur District of Chhattisgarh was conducted during the *rabi* season of 2017-18. The details of experimental soil, prevailing weather conditions, materials used and techniques adopted during the course of the investigation are briefly presented here.

1. Experimental Site

The field experiment was conducted at the research farm, Indira Gandhi Krishi Vishwavidyalaya; Raipur situated in South Eastern Central part of Chhattisgarh at latitude, longitude and altitude of $21^0$16' N, longitude $81^0$36' E and 289.5 m above mean sea level respectively.

2. Climate

The climate of Chhattisgarh state is dry sub humid. Nearly 90 % of the annual average rainfall occurs from June to September during south west monsoon. During the growth period the maximum temperature ranged between 22^0 C to 36.3^0 C while minimum temperature ranged between (8 to 20.7^0 C). The morning relative humidity varied from 59 to 100% whereas. The afternoon humidity varied from 20 to 83 % (47 SMW and 12 SMW).

3. Agro Meteorological Indices

3.1 Accumulated Growing Degree Days (GDD)

Growing degree days at different phenological stages were calculated by summation of daily mean temperature above base (Tb=10° C) temperature for a corresponding period from sowing, as suggested by Monteith (1984) and expressed in degree celcius (°C).

$$\mathbf{GDD = \Sigma [(Tx + Tn)/2 - Base\ temperature]}$$

Where,

Tx = Daily maximum temperature

Tn = Daily minimum temperature

3.2 Accumulated Photo thermal Unit (PTU)

PTU is calculated by multiplying GDD with maximum possible sunshine hours (N).

$$\mathbf{PTU = GDD\ X\ N}$$

Where,

N = maximum possible sunshine hour.

3.3 Accumulated Heliothermal Unit (HTU)

Helio thermal unit is calculated by multiplying GDD with actual sunshine hours (n).

$$HTU = GDD\ X\ n$$

Where,

n = actual sunshine hours

Results and Discussion

Accumulated Growing Degree Days (GDD)

The GDDs affected by the growing environment and varieties are shown in Table 1. It can be seen that GDDs to reach germination stage are higher in D1 and go on decreasing with the delay in sowing. In general GDDs for first growing environment are 183 but with delay in growing environment, the GDDs values reach 170 in second growing environment and reach 159 by the third growing environment. To reach flower initiation stage, lesser GDD_S are required for D_3 i.e. third growing environment while maximum, GDDs are required in first growing environment. It means that crop has started facing thermal stress condition in later part of growth cycle and duration to reach a particular phenophase has started decreasing. V_1 is requiring maximum GDDs while lesser GDDs are required for V_2 and V_3. There is third phase in chickpea which is called as 50% flowering and that is being achieved very early in the second growing environment, More quantity of GDD_S are required to reach this phase in first growing environment while in the third growing environment mediocre type of GDD_S are required. Further analysis leads to results that more number of GDDs are required for V1 while lesser GDDs are required for V2 and V3, these two varieties are almost equal in achieving this phenpohase. For 100% flowering, the least number of GDDs are required for second growing environment while mediocre type of GDDs are required in second growing environment while the third growing environment is achieving somewhat higher GDDs. It can be very well seen that V2 and V3 are almost at par in achieving this phenophase. Stage of pod formation will be immediately coming after this. It can be very well seen that V_1 variety is taking the maximum GDDs to reach the pod formation stage while the varieties V_2 and V_3 are needing somewhat lesser growing environment as compared to V_1. Again there is second growing environment which is needings the lesser number of GDDs to reach this phenophase while the first and third growing environments are needing less GDDs to reach this phenophase.

Interesting result which has come out from the study is that physiological maturity GDDs are achieved least in the third growing environment. The possible explanation for this is that third growing environment is subjected to thermal stress condition and physiological maturity will be achieved early in the crop which is sown last.

Accumulated Heliothermal Units (HTU)

Values of HTU are lower than PTU because of the fact that here in formula n value is taken into account while in PTU value of N is taken. There are more values of HTU in D_1 to reach germination while in D_2 least HTU are required. To reach flower initiation stage, highest number of HTUs are required while least HTUs are required in normal sowing or second growing environment. It can be very well observed that the highest HTUs are required in Vaibhav while equal number of HTUs are required in JG-14 and JG-16. Similarly in 50% flowering, 100% flowering, pod formation least HTUs are required in second growing environment and JG-14/ JG-16 alike. However it has been observed that to reach physiological maturity stage, highest HTUs are required in first growing environment and these go on decreasing with the delay in sowing. That is due to the fact that there is

thermal stress condition developing in the later part of growth cycle of chickpea and other *rabi* crops. (Table 2).

Accumulated Photo Thermal Units (PTU)

PTU for different growing environments and varieties are shown in (Table no. 3). It can be seen from the table that there are more PTUs generally in first growing environment to reach germination, flower initiation, 50% flowering and 100% flowering. Among the varieties also there are differences and more degree days are required for Vaibhav while lesser PTUs are required in JG-14 and JG-16. One thing that can be interpreted very clearly that lesser PTUs are required in the third growing environment because of the fact that the duration of chickpea variety is considerably shortened for last sown crop and that's way PTU required to reach physiological maturity are considerably reduced. This kind of situation is called thermal stress which is arising in late sown condition.

Table 1: Growing degree days (GDD) of Chick Pea (Rabi 2017-18)

Treatments	Germination	Flower initiation	50% Flowering	100% Flowering	Pod formation	Physiological Maturity	Harvesting Maturity	Total
	Days after Sowing							
D_1-10/11/2017								
V1- Vaibhav	183	889.3	1085.1	1189.7	1231.3	1780.4	1954.3	8313.1
V2- JG-14	183	859.7	1056.8	1158.2	1204.4	1738.8	1911.7	8112.6
V3- JG-16	183	859.7	1056.8	1158.2	1204.4	1738.8	1911.7	8112.6
D_2-25/11/2017								
V1- Vaibhav	170	821	1024	1149	1206	1810	1942.3	8122.3
V2- JG-14	170	791	993	1113	1169	1739	1882.7	7857.7
V3- JG-16	170	791	993	1113	1169	1739	1882.7	7857.7
D_3-10/12/2017								
V1- Vaibhav	159	804	1051	1200	1244	1662	1849.6	7969.6
V2- JG-14	159	771	1022	1160	1200	1646	1824.6	7782.6
V3- JG-16	159	771	1022	1160	1200	1646	1824.6	7782.6

Table 2: Heliothermal unit (HTU) of Chick Pea (*Rabi* 2017-18)

Treatments	Germination	Flower initiation	50% Flowering	100% Flowering	pod formation	Physiological maturity	Harvesting Maturity	Total
	Days after Sowing							
D_1-10/11/2017								
V1- Vaibhav	1505.4	6916.4	8381.8	9200.5	9597.8	14547.7	15738.2	65887.8
V2- JG-14	1505.4	6787.7	8164.4	8935.1	9349.5	14189.5	15464.7	64396.3
V3- JG-16	1505.4	6787.7	8164.4	8935.1	9349.5	14189.5	15464.7	64396.3
D_2-25/11/2017								
V1- Vaibhav	1274.9	6143.7	7909.8	8862	9253.9	14587.3	15807.0	63838.6
V2- JG-14	1274.9	5885.5	7605.8	8726.6	8991.9	13957.4	15251.0	61693.1
V3- JG-16	1274.9	5885.5	7605.8	8726.6	8991.9	13957.4	15251.0	61693.1
D_3-10/12/2017								
V1- Vaibhav	1351.6	6232.4	8254.9	9775.8	10177.9	13565.8	15250.1	64608.5
V2- JG-14	1351.6	5920.2	7954.3	9358.4	9775.8	13420.1	15027.6	62808
V3- JG-16	1351.6	5920.2	7954.3	9358.4	9775.8	13420.1	15027.6	62808

Table 3: Photo thermal unit (PTU) of Chick Pea (*rabi* 2017-18)

Treatments	Germination	Flower initiation	50% Flowering	100% Flowering	pod formation	Physiological maturity	Harvesting Maturity	Total
	Days after Sowing							
D_1-10/11/2017								
V1- Vaibhav	2026	9751	11912	13115	13593	20036	22124	92557
V2- JG-14	2026	9426	11594	12753	13284	19538	21612	90233
V3- JG-16	2026	9426	11594	12753	13284	19538	21612	90233
D_2-25/11/2017								
V1- Vaibhav	1885	9036	11380	12817	13473	20697	22320	91608
V2- JG-14	1885	8694	11016	12400	13040	19849	21569	88453
V3- JG-16	1885	8694	11016	12400	13040	19849	21569	88453
D_3-10/12/2017								
V1- Vaibhav	1742	8955	11824	13612	14139	19156	21525	90953
V2- JG-14	1742	8583	11467	13123	13612	18961	21210	88698
V3- JG-16	1742	8583	11467	13123	13612	18961	21210	88698

Conclusion

Growing degree days (GDD) value are found to be highest in 1st growing environments and go on decreasing with 2nd and 3rd growing environments that why the phonological stages are shorter with delay in sowing after 10th November. Similarly photo thermal unit (PTU) and helio thermal unit (HTU) value are found to be highest in 1st growing environments and go on decreasing with 2nd and 3rd growing environments that why the phonological stages are shorter with delay in sowing after 10th November.

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