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Khilesh Kumar Sahu
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh, India

JL Chaudhary
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh, India

Priyanka Verma
Department of Vegetable Science, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Khilesh Kumar Sahu
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh, India

Deriving the different agro meteorological indices under different growing environments for chickpea crop

Khilesh Kumar Sahu, JL Chaudhary and Priyanka Verma

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Abstract
A field experiment entitled "to find out the different agro meteorological indices under different growing environments for chickpea crop" was conducted at the Research and Instructional farm of I.G.K.V., Raipur during *rabi* 2019-20. The treatments consisting of three Growing Environment (GEs) *viz*. 15th Nov., 30th Nov. and 15th Dec. and three chickpea varieties *viz*. Vaibhav, JG -14 and JG -16 were laid out in Factorial RBD with 3 replications. The results found that the agrometeorological indices Accumulated Growing Degree Day (GDDs) at maturity stage were highest (2086) for Vaibhav under 15th Nov. sowing maximum GDDs were observed in 15th Nov. as compared to normal sown crop 30th Nov. and late sown crop on 15th Dec. at maturity stage. The maximum HTUs of (13487) was recorded for variety JG-16 sown on 15th Nov. whereas second highest HTUs of (13189) was recorded for JG-14 in 30th Nov. growing environment and next for Vaibhav (13374) under 15th Dec. sown crop. Similar is trend for PTUs of chickpea varieties under different GEs. At maturity stage highest HUE and RUE is generally observed for normal growing environment. Vaibhav variety is found to be having highest HUE and RUE. It is followed by JG-14 and least value is being observed in JG-16 variety.

Keywords: Chickpea, agro meteorological indices**,** RUE, HUE and growing environment

Introduction
Pulses are member of the family of legumes but the word "pulse" also applies to the dry edible seed within pods, pulses grow and come in various sizes, shapes and colors. Major pulses cultivated in India include chickpea (gram), urd, moong beans, pigeon pea (tur or arhar), masur (lentil), peas and beans of various types. Pulses are important crops that provide high quality protein, which contains essential amino acid to meet the optimum protein supplementing cereal proteins for predominantly substantial vegetarian population of the country. They also provide a source of complex carbohydrates, essential vitamins and minerals such as folate and iron and antioxidants. Chickpea (*Cicer arietinum* L.) is an important pulse crop in India and south Asia, commonly referred to as Bengal Gram, Chana and Gram. It originated from South West Asia- probably from Afganisthan or Persia. Although, India is the world largest pulse growing country, pulses account for only 6-7 per cent of the total food grain production in the country. Chickpea (*Cicer arietinum* L.) is among the most important pulse crops grown in India and the world's second largest edible legume. It occupies around 15 percent of the total area of pulse globally and it is cultivated in almost 52 countries (FAO, 2014) [2]. In Chhattisgarh, the area of chickpea in the year 2017-18 is 349.81 thousand/ha and the productivity is 1116 kg ha^{-1} (Krishi diary, 2019) [4]. Chickpea is considered the third most important pulse in the world after bean and soybean (Soltani *et al.*, 2006) [8]. The crop is grown in above 50 countries/regions (in Asia 89.7%, Africa 4.3%, Oceania 2.6%, Americas 2.9% and 0.4% in Europe). (Gaur *et al*. 2010) [3]. Sub-optimal thermal requirement during crop growing season are known to have profound effect on crop productivity. The concept of thermal use efficiency has been used by several workers to compare the performance of different varieties or of several dates in different crops (Rao, *et al*., 1999, Aggarwal *et al*., 1999, Mrudula, *et al*., 2012) [7, 1].

Materials and Methods
The field experiment was carried out at the Research and Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya; Raipur located in the south-eastern central part of Chhattisgarh at

latitude, longitude and altitude of $21^0$16 ' N, $81^0$36 ' E and 289.5 meter above mean sea level respectively. The present study was conducted during the 2019-20 *rabi* season. Three chickpea cultivars, *viz*. Vaibhav (V_1), JG -14 (V_2) and JG -16 (V_3) were used and cultivated in a using factorial RBD with three sowing dates. The GDDs, HTUs, PTU,RUE and HUE were computed by using formula:

Accumulated Growing Degree Days (GDD)

Growing degree days at different phenological stages were calculated by summation of daily mean temperature above base (T_b= 5°C) temperature for a corresponding period from sowing, as suggested by Monteith (1984) [5] and expressed in degree Celsius (°C).

$$\textbf{GDD} = \left[\frac{(\sum T_{max} + T_{min})}{2} - Base\ temperature \right]$$

Where,
T_{max} = Daily maximum temperature
T_{min}= Daily minimum temperature

Accumulated Photo thermal Unit (PTU)

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

$$PTU = GDD \times N$$

Where,
N = maximum possible sunshine hour

Accumulated Heliothermal Unit (HTU)

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

$$HTU = GDD \times n$$

n = actual sunshine hours

Heat Use Efficiency (HUE)

Heat Use Efficiency (HUE) for total dry matter was obtained as under

$$HUE\ (G/m^2/^{\circ}day) = \frac{\text{Biomass (g/m2)}}{\text{GDD (°days)}}$$

Radiation Use Efficiency (RUE)

$$RUE\ (gMJ^{-1}) = \frac{\text{Biomass (g/m2)}}{\text{Radiation intercepted (M J/m2 /day)}}$$

Results and Discussion

Accumulated Growing degree days (GDD

In D_1 growing environment V_3 (JG-16) is requiring maximum GDDs to reach 50% flowering while lesser GDDs are required for V_1 (Vaibhav) and V_2 (JG-14). Further analysis leads to results that more number of GDDs are required at maturity stage in D_2 growing environment. V_1 (Vaibhav) and V_3 (JG-16) are requiring maximum GDDs to reach physiological maturity and these two varieties are almost equal in achieving this phenpohase while lesser GDDs are requiring for V_2 (JG-14) and D_3 growing environment. In D_1 growing environment V_3 (JG-16) is requiring maximum GDDs to reach pod formation while lesser GDDs are required for V_1 (Vaibhav) and V_2 (JG-14). In D_2 growing environment V_1 (Vaibhav) is requiring maximum GDDs to reach maturity stage while lesser GDDs are requiring for V_3 (JG-16) and V_2 (JG-14). In D_3 growing environment V_1 (Vaibhav) is requiring maximum GDDs while lesser GDDs are required for V_3 (JG-16) and V_2 (JG-14).

Helio Thermal Units (HTU)

In D_1 growing environment V_3 (JG-16) is requiring maximum HTUs to reach 50% flowering stage while lesser HTU are required for V_1 (Vaibhav) and V_2 (JG-14). Further analysis leads to results that in D_2 growing environment V_1 (Vaibhav) and V_3 (JG-16) are requiring maximum HTUs to reach maturity stage.

These two varieties are almost equal in achieving this phenpohase while lesser HTUs are requiring for V_2 (JG-14). In D_3 growing environment V_1 (Vaibhav) is requiring maximum HTUs while lesser HTUs are required for V_3 (JG-16) and V_2 (JG-14). In D_1 growing environment V_3 (JG-16) is requiring maximum HTUs to pod formation while lesser HTUs are required for V_1 (Vaibhav) and V_2 (JG-14). In D_2 growing environment V_2 (JG-14) is requiring maximum HTUs to reach maturity stage while lesser HTUs are requiring for V_3 (JG-16) and V_1 (Vaibhav).

Accumulated Photo thermal units (PTU)

Among the varieties also there are differences in PTUs and more degree days are required in D_1 growing environment for JG-16 while lesser PTUs are required in Vaibhav and JG-14. In D_2 growing environment more and same degree days are required for Vaibhav and JG-16 while lesser PTUs required in JG-14.In D_3 growing environment more degree days are required for Vaibhav while lesser PTUs are required for JG-16 and JG-14 varieties.

Heat Use Efficiency (HUE)

Highest HUE is generally observed for normal growing environment. Vaibhav variety is found to be having highest HUE and it is followed by JG-14. Least value is being observed in JG-16 variety.

Radiation Use Efficiency (RUE)

Highest RUE is generally observed for normal growing environment. Vaibhav variety is found to be having highest RUE and it is followed by JG-14. Least value is being observed in JG-16 variety.

Table 1: Growing degree days (GDD) at different growing stage of different Chickpea varieties under different growing environments

Treatments	Emergence	Branching	flower initiation	50% flowering	100% flowering	Pod formation	Maturity
	Days after Sowing						
	D_1- 15/11/2019						
Vaibhav	159	565	939	1054	1133	1199	2086
JG-14	141	565	893	954	1039	1084	2043
JG-16	159	580	1021	1084	1148	1217	2107
	D_2- 30/11/2019						
Vaibhav	131	530	864	947	992	1329	2008
JG-14	103	517	755	879	979	1216	2076
JG-16	131	517	879	947	992	1251	2054
	D_3-15/12/2019						
Vaibhav	126	534	752	950	1095	1224	2025
JG-14	91	560	666	725	1061	1163	1948
JG-16	108	551	698	739	1079	1203	1924

Table 2: Accumulated Helio thermal units (HTU) at different growing stage of different chickpea varieties under different growing environments

Treatments	Emergence	Branching	flower initiation	50% flowering	100% Flowering	Pod formation	Maturity
	Days after Sowing						
D_1- 15/11/2019							
Vaibhav	1352	3889	5738	6555	6946	7465	13309
JG-14	1227	3889	5439	5875	6547	6665	13007
JG-16	1352	3912	6421	6665	7087	7536	13487
D_2- 30/11/2019							
Vaibhav	827	2796	4780	5328	5479	7665	12808
JG-14	579	2794	4240	4922	5462	6995	13189
JG-16	827	2794	4922	5328	5479	7332	13089
D_3-15/12/2019							
Vaibhav	605	2724	4014	5303	6185	7280	13374
JG-14	352	2978	3634	3956	6127	6795	12720
JG-16	473	2834	3804	4014	6142	7124	12504

Table 3: Accumulated Photo Thermal Units (PTU) at different growing stage of different Chickpea varieties under different growing environments

Treatments	Emergence	Branching	flower initiation	50% flowering	100% flowering	Pod formation	Maturity
	Days after Sowing						
D_1- 15/11/2019							
Vaibhav	2111	7487	12352	13826	14835	15689	26380
JG-14	1873	7487	11771	12542	13634	14217	25873
JG-16	2111	7688	13404	14217	15034	15917	26626
	D_2- 30/11/2019						
Vaibhav	1716	6968	11248	12310	12644	17002	24999
JG-14	1347	6800	9848	11433	12476	15618	25795
JG-16	1716	6800	11433	12310	12644	16049	24731
D_3-15/12/2019							
Vaibhav	1659	6935	9698	12129	13913	15463	24731
JG-14	1200	7384	8617	9358	13495	14752	23873
JG-16	1424	7145	9024	9528	13716	15217	23603

Table 4: Effect of different growing environment on HUE (g / m^2 / ^{o} day) of different Chickpea varieties during *rabi* 2019-20

Treatments	Days after sowing					
	20	40	60	80	100	Maturity
D_1V_1	0.10	0.10	0.20	0.35	0.39	0.42
D_1V_2	0.08	0.09	0.19	0.41	0.29	0.32
D_1V_3	0.06	0.06	0.12	0.23	0.28	0.30
D_2V_1	0.08	0.09	0.23	0.30	0.52	0.58
D_2V_2	0.09	0.09	0.25	0.31	0.46	0.49
D_2V_3	0.06	0.06	0.15	0.26	0.39	0.42
D_3V_1	0.11	0.15	0.25	0.36	0.47	0.54
D_3V_2	0.09	0.13	0.25	0.34	0.37	0.43
D_3V_3	0.08	0.10	0.24	0.26	0.27	0.33

Table 5: Effect of different growing environment on RUE (gMJ-1) of different Chickpea varieties during rabi 2019-20

Treatments	Days after sowing					
	20	40	60	80	100	Maturity
D_1V_1	0.08	0.10	0.16	0.30	0.32	0.29
D_1V_2	0.07	0.09	0.16	0.35	0.24	0.22
D_1V_3	0.05	0.06	0.10	0.20	0.23	0.21
D_2V_1	0.08	0.08	0.19	0.24	0.43	0.41
D_2V_2	0.09	0.08	0.20	0.25	0.38	0.35
D_2V_3	0.06	0.05	0.12	0.21	0.32	0.30
D_3V_1	0.09	0.11	0.19	0.29	0.40	0.38
D_3V_2	0.07	0.10	0.19	0.27	0.31	0.31
D_3V_3	0.06	0.08	0.18	0.20	0.23	0.23

Varieties: V_1: Vaibhav V_2: JG-14 V_3: JG-16
Growing Environments: D_1-15/11/2019, D_2-30/011/2019, D_3-15/12/2019

Conclusion

Based on the above findings it was conducted that the agrometereological indices *viz*., accumulated growing degree days (GDDs),Photo Thermal Unit (PTU), Helio thermal unit (HTU) were recorded maximum in crop sown on 15th Nov as compared to on 30th Nov. and 15th Dec. sown. Radiation Use Efficiency (RUE) and Heat Use Efficiency (HUE) were recorded maximum in normal growing environments crop sown on 30 Nov. compared to early sown crop 15th Nov. and late sown crop on 15th Dec. With respect to varieties JG-16 recorded maximum accumulated growing degree days (GDDs), Photo Thermal Unit (PTU), Helio thermal unit (HTU). Radiation Use Efficiency (RUE) and Heat Use Efficiency (HUE) were recorded maximum in the variety Vaibhav as compared to variety JG-14 and JG-16.

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