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Thermal indices and thermal use efficiencies for suitable sowing time of chickpea under coastal agro-ecosystem of Andhra Pradesh

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Abstract
A field experiment was conducted during *rabi* 2018 on vertisols of Agriculture college, Bapatla to work out the thermal indices and thermal use efficiencies and to study the performance of chickpea varieties grown under different Standard Meteorological Weeks. Higher values of all agroclimatic/weather health indices *viz.,* GDD, HTU, PTU, PTI, TPR, HUE, HtUE and PtUE were recorded with 2nd fortnight of October (44th SMW) sowing irrespective of the varieties. Among the varieties NBeG-119 (V_3) took maximum days to attain different phenophases and recorded the optimum values of all agroclimatic/weather health indices. These weather health indices were found to be optimum for all the varieties to produce maximum potential yields.

Keywords: chickpea, weather health indices/ climatic normals, yield

Introduction

Chickpea (*Cicer arietinum* L.) is the premium pulse crop of India cultivated mainly on remnant monsoon preserved moisture under rainfed conditions on marginal lands and semi arid regions. Chickpea occupies an area of 83.99 lakh hectares with a production of 70.6 lakh tonnes and productivity of 840 kg ha^{-1} (Ministry of Agriculture, Government of India, 2015-16) in India. Among the various agronomic practices, planting time is the most important non-monetary input having profound influence on crop growth, phenological development, occurrence of pests and crop productivity (Yadav *et al*., 2016). Optimum time of sowing has a crucial role in fully utilizing the genetic potentiality as it provides the best possible growing conditions such as light, temperature, rainfall and humidity (Vennela and Shnde, 2016). The optimum sowing time and selection of improved cultivars play a remarkable role in exploiting the yield potential of a crop under particular agroclimatic condition (Tyagi, 2014) [14].

Appropriate time of sowing enables the crop to take full advantage of favourable weather condition during the *Rabi* season. Determination of sowing time depends upon the thermal time and thermal use efficiency of the crop (Agrawal and Upadhyay, 2009) [1]. Several workers (Torkaman *et al.,* 2018; Tiwari and Meena, 2014; Sahu *et al.,* 2007; Agrawal *et al.,* 2002) [12, 11, 10, 2] studied the response of chickpea varieties under different sowing windows in different regions of the country. Hence, the present investigation was undertaken to study the impact of thermal environment on the performance chickpea varieties under different sowing dates and to find out the optimum sowing time for chickpea crop under changing weather conditions at coastal agro-ecosystem of Andhra Pradesh.

Material and Methods

The investigation was carried out during *rabi* season (2018) at the Research Farm of Agriculture College, Bapatla, Acharya NG Ranga Agricultural University (15° 53' N and 80° 27' E and 6 m above MSL). The field experiments was laid out Randomized Block Design with factorial concept with five dates of sowing (Standard Meteorological Weeks 44,46,48,50,52 as D_1, D_2, D_3, D_4 and D_5) three chickpea varieties (NBeG-47, NBeG-49 and NBeG-119 as V_1, V_2 and V_3) and and replicated thrice. Recommended agronomic practices and plant protection measures were followed to raise the crop. Daily weather data (Maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, Bright sunshine hours, rainfall and day length) was taken from the agrometeorological observatory situated near the experimental site (Fig.1). The date of occurrence of different phenophases was recorded when 50% of the plants in each replication reached the respective stage. Various weather health indices were calculated as follows.

Growing Degree Days (GDD)

A degree day or a heat unit is the departure from the mean daily temperature above the threshold temperature of the crop. Growing degree days (GDD) concept assumes that there is a direct and linear relationship between growth of plants and temperatures (Murthy, 2016) [6]. This was expressed as ºC day. The GDD were calculated by the following equation (Iwata, 1984) [4].

GDD= $(T_{max} + T_{min})/2 - T_b$ (T_{max} + T_{min} are daily maximum and minimum temperatures and temperature T_b is the base temperature taken as 5^0C for rabi crops).

Heliothermal units (HTU) = GDD × bright sunshine hours. Rajput (1980) [8].

Photo thermal units (PTU) = GDD × day length. Nuttonson (1956) [7].

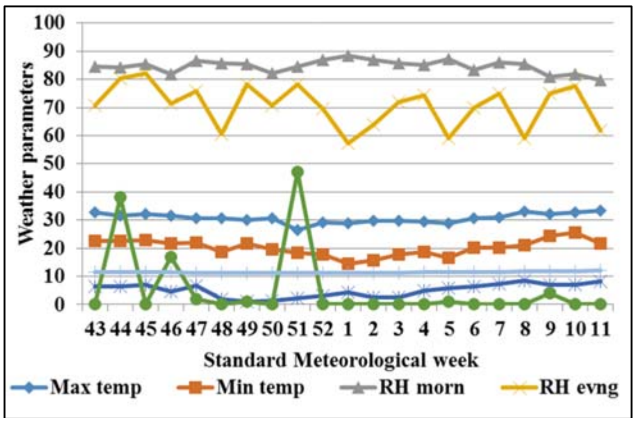

Fig 1: Average data of weather parameters at Bapatla Agriculture college farm, Guntur district (2018-2019)

Heat use efficiency defined as yield per day ºC on growing day concept or per unit of day ºC hours on heliothermal units indicating the efficiency with the available heat utilized for seed yields. This is expressed as kg ha^{-1} $^oC^{-1}$ day^{-1}. This was calculated using the following formula (Haider *et al.,* 2003) [3].

$$HUE = \frac{\text{Total drymatter / seed yield (kg ha}^{-1})}{\text{Accumulated heat units (}^oC\text{ day) (GDD)}}$$

Heliothermal use efficiency is defined as total drymatter yield per hours ºC on growing day concept or per unit of ºC day hours on heliothermal units indicating the efficiency with the available sunshine hours utilized for drymatter yields. This was expressed as kg ha^{-1} $^oC^{-1}$ day^{-1} hour. This was calculated by using the formula (Rajput, 1980) [8].

$$\text{Heliothermal use efficiency (HtUE)} = \frac{\text{Total drymatter/ seed yield (kg ha}^{-1})}{\text{Heliothermal units (HTU)}}$$

Photothermal use efficiency is defined as total drymatter yield per hour ºC on growing day concept or per unit of ºC day hours on photothermal units indicating the efficiency with the available day length utilized for drymatter yields. This was expressed as kg ha^{-1} $^oC^{-1}$ day^{-1} hour. This was calculated using the formula as suggested by Rajput (1980) [8].

$$\text{Photothermal use efficiency (PtUE)} = \frac{\text{Total drymatter/ seed yield (kg ha}^{-1})}{\text{Photothermal units (PTU)}}$$

Results and Discussion

The number of days taken to attain different phenophases from vegetative to maturity stage ranged from 38 to 110 days for different dates of sowing and varieties. Among the dates of sowing 2nd fortnight of October (44th SMW) took maximum days to attain maturity followed by 1st fortnight of November (46thSMW) Among the varieties, the mean maximum number of days to attain vegetative, reproductive and maturity phase were recorded with NBeG-119 followed by NBeG-49 and NBeG-47 varieties. Number of days taken to attain different phenophases was decreased with delay in sowing due to increase in temperature at reproductive phase and flowering is delayed as day length becomes shorter than base photoperiod with successive delay in sowings (Venkatachalapathi and Reddy,2013; Tyagi, 2014) [15, 14].

Thermal indices

The GDD, HTU and PTU varied with different crop growth stages under different sowing times for all the 3 chickpea varieties (Table 1). The thermal units required for attaining all the phases decreased consistently with delay in sowing in all the 3 varieties. It might be due to longer crop duration recorded with early sowing in October, bright sunshine hours, higher temperatures**,** higher day length and photoperiod during 44th SMW that favoured crop growth for accumulating higher GDD, HTU and PTU (Kiran and Chimmad, 2018; Rathod and Chimmad, 2016, Agarwal and Upadhyay, 2009; Tripathi *et al*., 2008; Sahu *et al.,* 2007) [5, 9, 1, 13, 10]. Among the different types of chickpea cultivars the cumulative Growing degree days (heat units) ranges from 2,085 to 2,167 ºC day, Heliothermal units ranges from 8,706 to 9,176 ºC day hours and Photothermal units ranges from 23,623 to 24,580 ºC day hours.

Table 1: Cumulative Accumulated GDD, HTU and PTU of chickpea varieties under different sowing dates

Growth stages	Sowing dates																			
	44th SMW				46th SMW				48th SMW				50th SMW				52nd SMW			
	DP	GDD	HTU	PTU	DP	GDD	HTU	PTU	DP	GDD	HTU	PTU	DP	GDD	HTU	PTU	DP	GDD	HTU	PTU
NBeG-47																				
G1	46	982	4549	11175	45	917	3046	10348	42	791	1718	8867	40	731	1852	8194	38	685	2575	7738
G2	68	1382	5644	15642	65	1272	4323	14323	61	1143	2938	12840	57	1047	3272	11787	54	1010	4740	11494
G3	106	2085	8706	23623	91	1756	7477	18326	85	1619	7027	17630	81	1550	6988	15794	70	1375	5877	15614
NBeG-49																				
G1	48	1023	4670	11628	46	937	3105	10567	43	809	1815	9064	42	788	1945	8833	39	704	2631	7954
G2	71	1435	5819	16230	68	1327	4368	14935	63	1182	3014	13286	60	1124	3762	12669	54	1010	4739	11494
G3	107	2106	8847	23855	98	1920	8373	20186	91	1749	7512	19852	85	1643	7424	18732	72	1424	7000	17245
NBeG-119																				

G1	50	1062	4710	12067	48	975	3195	10994	45	845	1980	9466	43	769	1871	8623	41	742	2924	8389
G2	72	1451	5846	16423	69	1345	4404	12339	65	1215	3243	13658	61	1104	3622	12439	57	1078	5302	12293
G3	110	2167	9176	24580	99	2029	8576	21718	92	1772	8211	20130	86	1666	7725	19000	76	1520	7235	17533

G1- vegetative, G2- flowering and G3- physiological maturity stages.
DP – duration of different phenophases viz., G1, G2 and G3 in days
GDD - Growing Degree Days (°C day), HTU - Heliothermal Units (°C day hour), PTU - Photo Thermal Units (°C day hour).

Thermal use efficiencies

Thermal use efficiencies (HUE, PtUE and HtUE) of chickpea cultivars for biological and seed yield under five dates of sowing are given in Figures 1, 2 and 3. The results indicated that the thermal use efficiencies were highest in first sowing date (44th SMW) followed by second (46th SMW) and third sowing dates (48th SMW). Poorest efficiencies were noted under fourth (50th SMW) and fifth (52rd SMW) sowing windows. This indicates that the chickpea crop sown under delayed sowing time got exposed to the suboptimal thermal regime thereby in delayed sowing all the varieties were less efficient in heat use (Agrawal and Upadhyay, 2009) [1]. Similar results have been reported by Sahu *et al*., 2007 [10].

Among the three chickpea varieties, NBeG-119 has recorded higher thermal use efficiency (Fig. 1) compared to other two varieties NBeG-47 and NBeG-49 (Fig.2 and Fig.3). This indicates that among the three chickpea varieties, NBeG- 119 is the best variety as it has responded well to change in heat units under different sowing windows.

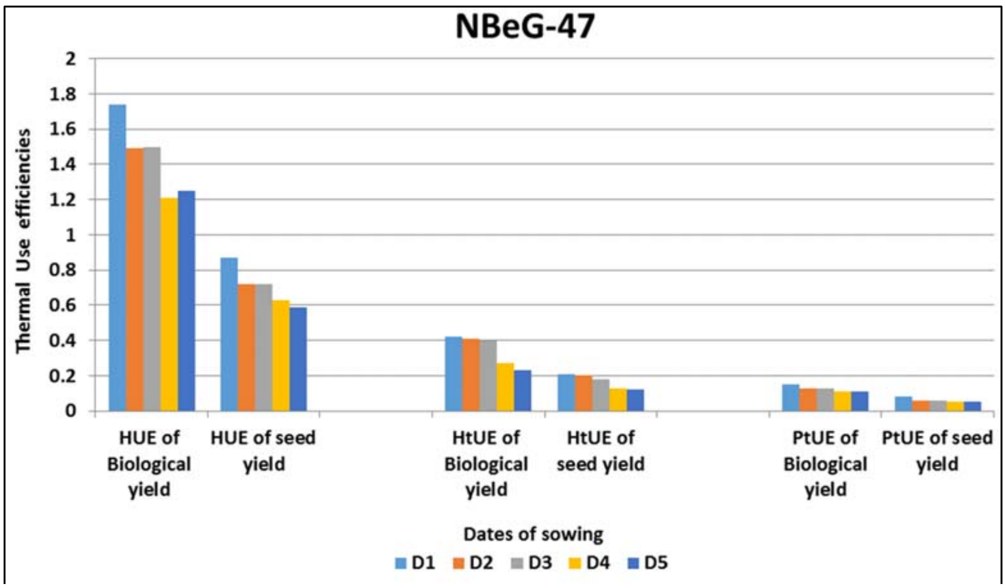

Fig 2: Thermal use efficiencies (HUE, HtUE and PtUE) of chickpea variety NBeG-47 as influenced by different dates of sowing.

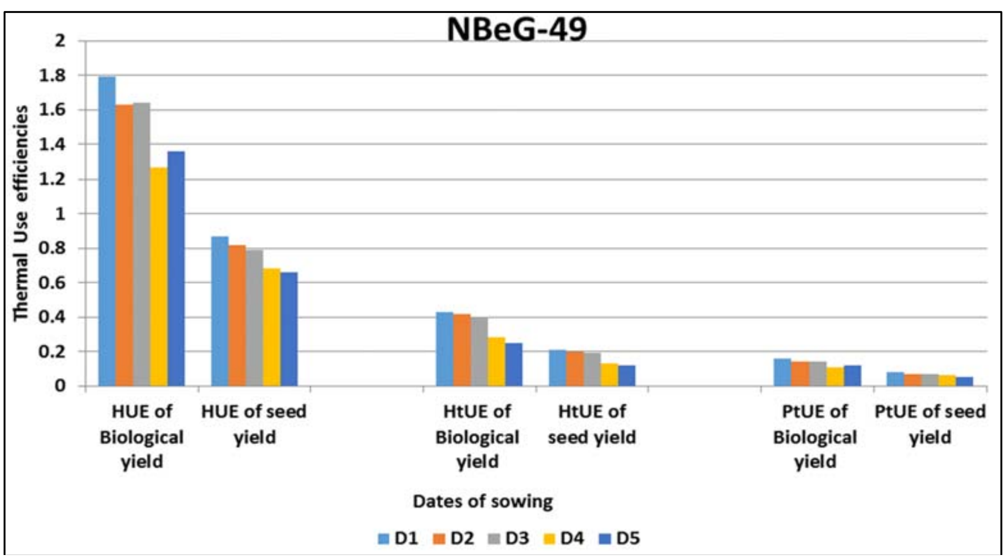

Fig 3: Thermal use efficiencies (HUE, HtUE and PtUE) of chickpea variety NBeG-49 as influenced by different dates of sowing.

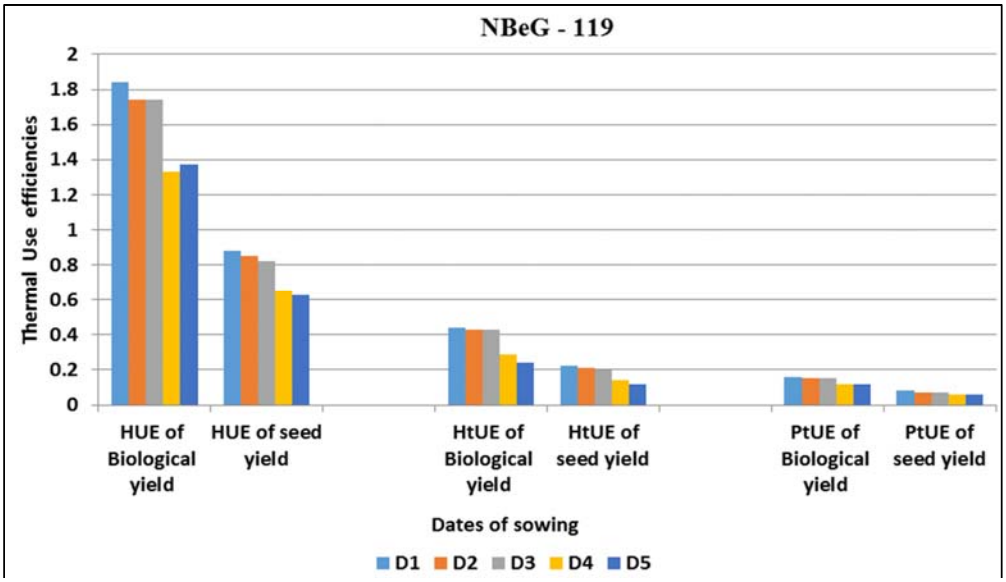

Fig 4: Thermal use efficiencies (HUE, HtUE and PtUE) of chickpea variety NBeG-119 as influenced by different dates of sowing.

Conclusion

From the present investigation, it can be concluded that chickpea varieties can be sown on 2nd fortnight of October (44th SMW) and first fortnight of November (46th SMW) in Bapatla region of Guntur district, Andhra Pradesh based on thermal indices and thermal use efficiencies to achieve stabilized yields and maximum productivity.

References

1. Agrawal KK, Upadhyay AP. Thermal indices for suitable sowing time of chickpea in Jabalpur region of Madhya Pradesh. Journal of Agrometeorology 2009;11(1):89-91.
2. Agrawal KK, Upadhyay AP, Shanker U, Gupta VK. Photothermal effect on growth development and yield of gram genotypes. Indian Journal of Agricultural Sciences 2002;72(3):169-176.
3. Haider SA, Alam MZ, Alam MF, Paul NK. Influence of different sowing dates on the phenology and accumulated heat units in wheat. Journal of Biological Sciences 2003;3:932-939.
4. Iwata F. Heat unit concept of crop maturity. Physiological aspects of dryland farming. (Gupta, U.S. ed). Oxford and IBH 1984, pp. 351-370.
5. Kiran BA, Chimmad VP. Climatic impact on phenology, growing degree days and seed yield in chickpea cultivars. Environment and Ecology 2018;36(1):38-42.
6. Murthy VRK. Principles and Practices of Agricultural Disaster Management, B.S.Publishers, Hyderabad 2016, Pp 111-127.
7. Nuttonson MY. A comparative study of lower and upper limits of temperature in measuring variability of day-degree summation of wheat, barley and rye. American Institute of Crop Ecology. Washington D.C 1956.
8. Rajput RP. Response of soybean crop to climatic and soil environments. Ph.D. Thesis. Indian Agricultural Research Institute, New Delhi, India 1980.
9. Rathod MK, Chimmad VP. Influence of temperature regime on heat unit accumulation in relation to phenology and yield of chickpea. Journal of Farm Science 2016;29(1):28-31.
10. Sahu DD, Chopada MC, Patoliya BM. Determination of sowing time for chickpea varieties in South Saurashtra, India. Journal of Agrometeorology 2007;9(1):68-73.
11. Tiwari D, Meena VD. Effect of sowing dates and weed management on growth and yield of chickpea in Indo-gangetic plains. Proceedings of National Academic Science, India, Section B, Biological Science 2014, Pg 1-6.
12. Torkaman M, Mirshekari B, Farahvash F, Yarnia M, Jafari AA. Effect of sowing date and different intercropping patterns on yield and yield components of rapeseed and chickpea (*Cicer arietinum* L.). Legume Research 2018;41(4):578-583.
13. Tripathi P, Singh AK, Sheobardan, Adhar S. Growth and thermal unit of chickpea genotypes under variable weather conditions of Eastern Uttar Pradesh. *Asian* Journal of Environmental Science 2008;3(2):164-168.
14. Tyagi PK. Thermal requirements, heat use efficiency and plant responses of chickpea cultivars under different environment. Journal of Agrometeorology. 2014;16(2):195-198.
15. Venkatachalapathi V, Reddy MVS. Phenophase prediction model for chickpea growth using agrometeorological indices sown under different dates of sowing and number of irrigations in anantapur district. Progressive Research 2013;8(2):221-224.
16. Yadav AK, Patel A, Singh RK, Mishra AN, Sharma AK. Effect of Changing Environment on Growth and Yield of Chickpea (*Cicer arietinum* L.). Advances in Life Sciences 2016;5(24):11157-11162.
17. Vennela PR, Shnde SR. Identification of promising chickpea genotypes suitable for different sowing times. Environment and Ecology 2016;34(3A):1118-1123.