Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 1425-1428
Received: 16-01-2020
Accepted: 18-02-2020

BS Bhalerao
Senior Research Fellow, AICRP on Agricultural Meteorology VNMKV, Parbhani, Maharashtra, India

DC Lokhande
Associate Professor, Department of Agronomy, VNMKV, Parbhani, Maharashtra, India

BR Bobade
Senior Research Fellow, FASAL Project, Agricultural Meteorology VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
BS Bhalerao
Senior Research Fellow, AICRP on Agricultural Meteorology VNMKV, Parbhani, Maharashtra, India

Thermal requirement of pigeon pea varieties at different phenological stages under varied weather conditions

BS Bhalerao, DC Lokhande and BR Bobade

Abstract
An experiment was conducted on the farm of Department of Agricultural Meteorology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S)., during *kharif* 2017 entitled "Assessment of pigeon pea (*Cajanus cajan* L.) cultivars under varied weather conditions" to study the GDD, HTU and PTU requirement for different phenological stages of pigeon pea cultivars. The experiment was laid out in split plot design with three replications. The layout consisted of total 36 experimental units i.e. four dates of sowing in different Meteorological Weeks (MW) *viz.*, D_1-25 MW, D_2-27 MW, D_3-29 MW and D_4-31 MW and three varieties (V) *viz.*, V_1- BDN-711, V_2- BDN-716 and V_3- BSMR-736 with gross plot size 5.4 m x 5.0 m and net plot size 4.5 m x 4.0 m. The results revealed that among all the phenophases of pigeon pea, floral bud initiation to 50 per cent flowering (P_3) stage recorded higher values of GDD, HTU and PTU. Among the three varieties, BDN-711 performed better as compared to the remaining phenophases. The total GDD required during crop growth period was highest in D_1 (4188.8 ^{0}Cd day^{-1}), followed by D_2 (3966.5^{0}Cd day^{-1}), D_3 (3814.2 ^{0}Cd day^{-1}) and D_4 (3620.7 ^{0}Cd day^{-1}), respectively.
In case of varieties, GDD requirement of all the varieties during crop phenophases *viz.*, BSMR-736 (4538.55 ^{0}C), BDN-716 (4242.37 ^{0}C) and BDN-711 (4036.0 ^{0}C), respectively. HTU required during all phenophases was highest in D_1 i.e. 26060.8^{0}C day hour as compared to remaining dates of sowing. In case of varieties, BSMR-736 required highest total HTU i.e. 27962.86 ^{0}C day hour, as compared to other varieties. PTU required during all phenophases was highest in D_1 i.e. 49264.09 ^{0}C day hour, as compared to remaining treatments. In case of varieties, BSMR-736 required highest total PTU i.e. 53293.92 ^{0}C day hour, as compared to other three varieties. It might be due to genotypical differences in crop duration and yield.

Keywords: Pigeon pea, yield, GDD, HTU, PTU

1. Introduction
Pigeon pea is the fourth most important food legume in the world after Dry bean (*Phaseolus vulgaris* L.), Field pea (*Pisum sativum*) and Chick pea (*Cicer arientinum* L.). It is also known as Arhar, Tur dal, Red gram, Congo pea. It is an important legume crop of rainfed agriculture in semi-arid tropics. The Indian sub-continent, eastern Africa and Central America, in that order, are the world's three main pigeon pea producing regions. Pulses occupy unique position not only in Indian agriculture, but also in Indian diet. A very large proportion of Indian population is vegetarian and amongst the items of the diet, the pulses are richest source of protein. Besides, rich source of protein, they also maintain soil fertility through the biological nitrogen fixation. Pigeon pea is one of the most important pulse crop in India in terms of both area and production. Pigeon pea being drought resistant can be grown in areas with less than 650 mm rainfall (Shinde, 2016) [10].
Thermal time requirement study for arid legumes at CAZRI, Jodhpur during 1991 to 2001 reveled that legumes maintained under unstressed conditions required more growing degree days (1430-2259 ^{0}C day) to reach flowering and physiological maturity in comparison to the rainfed crop (1400-2039 ^{0}C day). On an average, the thermal time required for each leaf production on main shoot was about 64 ^{0}C day during good rainfall year 2001, compared to 88 ^{0}C day for the crop grown in a low rainfall year 2000 (Rao and Singh, 2004) [9]. Maximum bud blooming and pod setting in pigeon pea were observed when the minimum and maximum day temperature ranged between 13 and 25 ^{0}C, respectively. Maximum floral bud drop was recorded at lower temperature i.e. 6-4 ^{0}C (minimum) and 12-14 ^{0}C (maximum) with 100% relative humidity, while maximum pod drop was recorded at higher temperature regimes, i.e. 22-24 ^{0}C maximum and 12-14 ^{0}C minimum (Pandey 2004) [5]. Thermal units required to attain different phonological periods and a linear regression model based on the phenophase-

wise data was derived for predicting the onset of a particular phenophase of the crop. In pigeon pea, the thermal units required to reach physiological maturity ranged from 2220 to 2609 day degree centigrade (^{0}C d) in 1992, while in 1993 it ranged from 2372 to 2654 (^{0}C d) with a coefficient of variation of 5.7 per cent (Patel *et al*. 1999) [6].

Crop sown on May 15 accumulated 515 and 173 higher growing degree days (GDD) than crop sown on June 15 for 50 % flowering in 2005 and 2006, respectively. Crop sown on May 15 accumulated 2768 and 2737 GDD till physiological maturity in the year 2005 and 2006 respectively. Similarly, crop sown on June 1 accumulated 2656 and 2582 GDD and crop sown on June 15 accumulated 2446 and 2459 GDD till physiological maturity respectively. Crop sown on May 15 accumulated 322 and 278 higher GDD than June 15 sown crop for maturity in 2005 and 2006, respectively. Total accumulation of GDD decreased with delay in sowing date and this was due to days taken to maturity decreased with delay in sowing date. May 15 sown crop produced significantly higher grain yield (10.3 and 35.0 % in 2005 and 15.6 and 18.9 % in 2006, respectively) than June 1 and June 15 sown crop, respectively (Ram *et. al*. 2011) [8].

Materials & Methods

A field experiment with pigeon pea was conducted during the *kharif* season of 2017 on the experimental farm of Department of Agricultural Meteorology located at College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.). Agro-climatically, Parbhani is situated at latitude, longitude and altitude of 19^0 16' N, 76^{0}47'E and 409 m, respectively. An experiment was laid out in split plot design with three replications. The layout consisted of total 36 experimental units i.e. four dates of sowing *viz*., D_1, D_2, D_3 and D_4 and three varieties *viz.*, V_1, V_2 and V_3 with gross plot size of 5.4 m x 5.0 m and net plot size of 4.5 m x 4.0 m. The weather condition in respect of rainfall, temperature, relative humidity, sunshine hours of the relevant crop growing period were obtained from the Department of Agricultural Meteorology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.).

All energy requirement parameters were calculated for five duration *viz.*, Sowing to Germination (P_1), Germination to Bud emergence (P_2), Bud emergence to Flower emergence (P_3), Flower emergence to Pod emergence (P_4) and Pod emergence to Harvest (P_5).

Growing degree days (GDD) (^{0}C day)

Growing degree days is defined as the sum over the growing season of a crop of the difference between the daily temperature and a reference temperature. GDD was expressed in terms of ^{0}C day. The growing degree days was worked out by considering the base temperature of 10 ^{0}C. The total growing degree days for different phenophases
were determined by the following formula :

$$\text{Accumulated GDD } (^0\text{C day}) = \sum_{Ds}^{Dh} [(T\,max + T\,min)/2] - Tb$$

Where,

GDD	=	Growing degree days
T max	=	Daily maximum temperature (^{0}C)
T min	=	Daily minimum temperature (^{0}C)
Tb	=	Base temperature (10 ^{0}C)
Ds	=	Date of sowing
Dh	=	Date of harvest

Helio-thermal units (HTU) (^{0}C day hrs)

The helio-thermal units may be defined as the accumulated product of GDD and Bright sun shine hours between the developmental thresholds for each day. HTU was expressed in terms of ^{0}C day hrs. The HTU is the product of GDD and mean daily hours of bright sunshine. The sum of HTU for each phenophase was worked out by following equation which was given by Nagamani *et al.,* (2015) [3].

HTU = GDD x BSS

Where,

HTU = Helio-thermal Units
GDD = Growing degree days
BSS = Bright sunshine hours

Photo thermal unit (PTU)

PTU may be defined as "the product of growing degree days and the day length" expressed in terms of ^{0}C day hrs. PTU was computed by using following formula. This was proposed by Gudadhe *et al*., (2013) [2].

PTU = GDD x Day length

Where,

PTU	=	Photo Thermal Units
GDD	=	Growing Degree days

Results and Discussion

Growing Degree Days (GDD)

Growing degree-days (GDD) calculated for the duration between P_1 : Emergence to branching, P_2 :Branching to floral bud initiation, P_3 : Floral bud initiation to 50% flowering, P_4 : 50% flowering to 50% pod formation, P_5 : 50% pod formation to physiological maturity showed significant difference among four pigeon pea genotype, under varied sown situation. The data presented in Table 1 showed that total GDD required during total crop growth period was highest in D_1 i.e. 4188.8^{0}C, followed by D_2 was 3966.5^{0}C day, D_3 i.e. 3814.2^{0}C day and D_4 was 3620.7 ^{0}C day, respectively. It is cleared that when temperature of air was maximum then it will definitely affect the GDD of pigeon pea crop. The result indicated that the total GDD accumulated from the emergence to physiological maturity ranged between 3620.7 to 4188.8 ^{0}C days among all sowing dates. Similar results were also reported by Patel *et al.* (1999) [6], Patel *et al*. (2000) [7] and Gowda *et al.* (2013) [1]. The data analysis of the growing period indicated higher values of GDD from vegetative to harvesting phase as in V_3-BSMR-736 (4538.55 ^{0}Cd), followed by V_2-BDN-716 (4242.37 ^{0}Cd), while the lowest GDD values recorded in V_1-BDN-711 (4036.00 ^{0}Cd) genotype. It might be due to the genotypical differences in crop duration and yield.

Table 1: Phenophase-wise Agro-meteorological indices as **i**nfluenced by various treatments of pigeon pea during *Kharif* season sowing dates and Varieties.

Growing Degree Days (GDD)						
Treatments	**P_1**	**P_2**	**P_3**	**P_4**	**P_5**	**Total**
Date of sowing						
D1 (25MW)	399.3	301.4	1842.5	832.9	812.7	4188.8
D2 (27MW)	406.0	267.4	1885.6	752.8	654.7	3966.5
D3 (29MW)	310.1	351.8	1794.8	763.2	594.3	3814.2
D4 (31MW)	404.8	245.8	1847.9	655.2	467.1	3620.7
Varieties						
BDN-711	304.5	377.5	1762.4	1141.4	450.2	4036.00
BDN-716	370.7	329.95	1815.9	1211.2	514.8	4242.37
BSMR-736	399.3	301.35	1842.5	832.9	1062.5	4538.55
Helio-thermal units (HTU)						
Date of sowing						
D1 (25MW)	2914.8	1748.1	8659.7	5830.3	6907.9	26060.8
D2 (27MW)	1827.0	1069.6	10582.6	5495.4	5695.8	24670.4
D3 (29MW)	1023.3	1934.9	10589.3	6639.8	4873.2	25060.5
D4 (31MW)	2185.9	859.9	12565.7	5765.7	3830.2	25207.4
Varieties						
BDN-711	1918.35	2378.25	8283.28	7190.82	2836.26	22607.56
BDN-716	2335.41	2078.68	11440.17	7630.56	3243.24	27782.68
BSMR-736	2515.59	1898.50	11607.75	5247.27	6693.75	27962.86
Photo-thermal units (PTU)						
Date of sowing						
D1 (25MW)	5318.67	3794.62	21520.4	9520.04	9110.36	49264.09
D2 (27MW)	5168.38	3238.21	21307.28	8506.64	7280.26	45500.77
D3 (29MW)	4000.29	4274.37	20963.26	8700.48	6679.93	44618.32
D4 (31MW)	5080.24	2938.57	20696.48	7154.78	4951.26	41821.33
Varieties						
BDN-711	3988.55	4724.37	13418.02	13126.1	4592.04	39849.08
BDN-716	4893.24	4091.38	11790.02	13565.44	5404.4	40377.78
BSMR-736	5190.9	3676.47	23031.5	9495.06	11900	53293.92

P_1: Emergence to branching,
P_2: Branching to floral bud initiation,
P_3: Floral bud initiation to 50% flowering,
P_4:50% flowering to 50% pod formation,
P_5:50% pod formation to physiological maturity

Helio thermal unit (HTU) (^{0}C day hrs)

The HTU required to attain different phenophases in pigeon pea varieties revealed that the sowing dates could have marked influence on HTU accumulated. The data presented in Table 1. showed that total HTU required during total crop growth period was highest in D_1 i.e. 26060.8 ^{0}C day hrs followed by D_4 was 25207.4 ^{0}C day hrs, D3 was 25060.5 ^{0}C day hrs and D_2 i.e. was 24670.4 ^{0}C day hrs. The variation in HTU amongst sowing dates was because of reduction in growing period, increase in length of bright sunshine hours as well as less GDD accumulated in delayed sowings. However, in general, decreasing trend in total accumulated HTU with delayed sowing date was observed. These results are in conformity with Patel *et al.* (2000) [7], Nagamani *et al.* (2015) [3] and Nikam (2016) [4]. The data analysis indicated that higher value of HTU recorded in BSMR-736 (27962.86 ^{0}C day hrs) followed by BDN-716 (27782.68 ^{0}C day hrs), were the lowest HTU value recorded in BDN-711 (22607.56 ^{0}C day hrs) genotype. It may be due to varietal characters i.e. the early maturity nature of BDN-711 and mid-late maturing nature of BSMR-736 (Table 1). These results are in corroboration with Patel *et al.* (2000) [7] and Singh *et al.* (2016).

Photo thermal unit (PTU) (^{0}C day hrs)

Amongst the sowing date, significant differences in PTU were found at all the phenophase. The results indicated that the total PTU accumulated from emergence to physiological maturity ranged between 40821.33 to 49264.09 ^{0}C day hrs among all sowing dates. The data presented in Table 1.showed that total PTU required during total crop growth period was highest in D_1 i.e. 49264.09 ^{0}C day hrs followed by D_2 was 45500.77 ^{0}C day hrs, D_3 was 44618.32 ^{0}C day hrs and D_4 i.e. was 41821.33 ^{0}C day hrs. The results indicated that the total PTU accumulated from emergence to physiological maturity ranged between 40821.33 to 49264.09 ^{0}C day hrs among all sowing dates. The data analysis indicated that higher value of PTU recorded in BSMR-736 (53293.92 ^{0}C day hrs) followed by BDN-716 (40377.78 ^{0}C day hrs), were the lowest PTU value recorded in BDN-711 (39849.08 ^{0}C day hrs) genotype. It may be due to genotypic variation and varietal characteristics of the early maturity nature of BDN-711 and mid-late maturing nature of BDN-716 and BSMR-736. Similar result was also reported by (Nikam, 2016) [4].

Conclusion

On the basis of observations and analysis of data, total crop growth period was highest in D_1 (MW 25) followed by D_2 (MW 27), D_3 (MW 29) and D_4 (MW 31). In case of three cultivars Pigeon pea BSMR-736 recorded highest value of GDD, PTU and HTU respectively, in total crop growth period followed by BDN-716 and BDN-711.This might be due to genotypical differences in crop duration and yield.

References

1. Gowda YTP, Manjunatha SB. Thermal requirement of maize as influenced by planting dates and cropping systems. Research Journal of Agricultural Sciences. 2013; 4(2):207-210.
2. Gudadhe NN, Neeraj Kumar RR, Pisal BM, Mote, Dhonde MB. Evaluation of agrometeorological indices in relation to crop phenology of cotton (*Gossippium* spp.) and chickpea (*Cicer aritinum* L.) at Rahuri region of Maharashtra. Trends in Biosciences. 2013; 6(3):246-250.
3. Nagamani C, Sumanthi V, Reddy GP. Performance of *rabi* pigeon pea under varied times of sowing nutrient dose and foliar sprays. Progressive Agriculture. 2015; 15(2):25.
4. Nikam SM. Studies of weather indices in pigeon pea (*Cajanus cajan* (L.) Millsp. M. Sc. (Agro-Meteorology) thesis submitted to Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M. S.), India, 2016.
5. Pandey N. Ascendancy of genotypes and stress temperature on flowering behavior in long duration pigeon pea. Legume Research. 2004; 27(3):177-182.
6. Patel NR, Shekh AM, Bapujirao B, Chaudhari GB, Khushu MK. An assessment of phenology, thermal time and phasic development model of pigeon pea (*Cajanus cajan* (L.) Millisp.). Journal of Agrometeorology. 1999; 1(2):149-154.
7. Patel NR, Mehta AN, Shekh AM. Weather factors influencing phenology and yield of pigeon pea (*Cajanus cajan* (L.) Millisp.). Journal of Agrometeorology. 2000; 2(1):21-29. 8 ref.
8. Ram H, Singh G, Sekhon HS, Khanna V. Effect of sowing time on the performance of pigeonpea genotypes. Journal of Food Legumes. 2011; 24(3):207-210.
9. Rao CA, Singh PS. A critique of the heat unit approach to plant approach response studies. Ecology. 2004; 41:785-790.
10. Shinde B. Impact of variable weather on growth and yield of pigeon pea (*Cajanus cajan* (L.) Millisp.). M.Sc. Agri. Thesis (Unpublished) submitted to Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani-431402 (M.S.) India, 2016, 1-2.