Contemporary Research in India (ISSN 2231-2137): Vol. 8: Issue: 3 Sept., 2018 (www.contemporaryresearchindia.net)

RESPONSE OF PEARL MILLET VARIETIES TO HEAT UNITS UNDER DIFFERENT SOWING WINDOWS IN THE SCARCITY ZONE OF MAHARASHTRA

Wankhede, S. Y., Jadhav J. D., Shaikh, A. A.

Department of Agricultural Meteorology, College of Agriculture, Pune

Received: 24/07/2018	Edited: 02/08/2018	Accepted: 11/08/2018

Abstract: *A field experiment was conducted during Kharif season of 2015 at Zonal Agricultural Research Station, Solapur, MPKV, Rahuri, Maharashtra (India). To study the phenology, and various agro meteorologicalindices viz., accumulated growing degree days (GDD) and helio thermal units (HTU) of selected pearl millet cultivars grown under different dates of sowing. The experiment was conducted in split plot design with three replications. Nine treatment combinations were formed considering different cultivars viz., V_1 Shanti (RHRBH-9808), V_2 Mahyco Hybrid (MRB-204) and V_3 Dhanashakti (ICTP-8203) and sowing windows viz., (S_1) 26^{th} MW (26^{th} June - 01^{st}July), (S_2) 30^{th} MW (23^{rd} July-29^{th} July) S_3-34^{th} MW (20^{th}Aug-26^{th} Aug). The crop sown on 30^{th} MW took maximum calendar days, growing degree days and heliothermal units to attain different phenological stages till physiological maturity. The photothermal units shows declining trend towards the delayed of sowing windows. Among cultivars, Shanti (RHRBH-9808) consumed highest growing degree days and heliothermal unit as compared to other varieties was sowing at sowing windows.*

Keywords: *Pearl millet, Growing degree days, Heliothermal unit, Photothermal unit, Sowing windows, Variety.*

Introduction

Pearl millet (*Pennisetum glaucum* [L.] R. Br.) formerly known as (*P. americanum* [L] Leeke) is a variety of the millet family also known as pearl, bulrush, spiked or cat-tail millet. It is the staple food for drier parts of India, particularly the arid and semi-arid regions of India. It is generally grown under rainfedconditions in arid and semi-arid regions of the world.

Pearl millet, which accounts for about two-thirds of India's millet production, is grown in the drier areas of the country, mainly in the states of Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana (FAO, 1996).

Sowing time is the most important non-monetary input affecting yields of crop. Time of sowing varies with the variety, agro climatic conditions and crop growing season. In fact, proper planting date is important for maximizing cereal grain yields (Witt, 1996) because optimum seeding dates establish healthy and vigorous plants. A significant reduction in grain yield is associated with delayed seeding for a wide range of climatic conditions (Knapp and Knapp, 1978, Dahlke *et al.* 1993). Lawn *et al.* (1993) found that differences in development of cereals sown at different times may be explained by considering an optimum temperature. Planting time recommendations for pearl millet and grain sorghum are commonly made based on calendar day (day of the year) and/or soil temperature (Mick 1997 and Andrews *et. al.* 1998). It was reported that the drastic reduction in yield under delayed sowing (Ramshe *et al.*1986).

In order to bring out country as a whole to a level on which other countries as standing as far as agricultural production is concerned, it is very essential to emphasize on such aspects. Some of the basic principle of factor contributing towards the increase in per hectare yield of pearl millet crops as suitable cultivars with required heritable potentiality, proper sowing times and prevalence of congenial weather conditions. Even in photo and thermo insensitive crop, it is critical input for higher yield.

During crop growth period, the occurrence of various phenological events can be estimated by computing accumulated growing degree days (Gouri *et. al*., 2005). Accumulated growing degree days (GDD) provides an estimate of harvest date as well as development stages of crop (Ketring and Wheless, 1989). Various developmental stages as well as harvest date of crop can be estimated from the knowledge of accumulated GDD. Thermal time can be used as a tool for characterizing thermal responses in different crops as it is an independent variable to describe plant development (Dwyer and Stewart, 1986). Heat use efficiency (HUE), *i.e.*, efficiencyofheatutilizationintermsofdrymatteraccumu lation, depends on genetic factors, crop type and sowing time and has great practical application (Rao *et al.,* 1999). Hence, the study was taken up to find out the heat units requirement for different pearl millet varieties, viz. Shanti (RHRBH-9808), Mahyco Hybrid (MRB-204) and Dhanashakti (ICTP-8203) under different sowing windowsin the Scarcity Zone of Maharashtra.

Materials and Methods

The present invitation entitled "Requirement of heat units for different pearl millet varieties under different sowing windows in the Scarcity Zone of Maharashtra" was carried during *kharif*, 2015 at Zonal Agricultural Research Station, Solapur, Maharashtra State (India). The experiment was conducted in split plot design with three replications. Nine treatment combinations were formed considering different cultivars *viz.* V_1Shanti (RHRBH-9808), V_2 Mahyco Hybrid (MRB-204) and V_3 Dhanashakti (ICTP-8203) and sowing windows *viz.* (S_1) 26th MW (26th June-01st July), (S_2)- 30th MW (23rd July-29th July) S_3-34th MW (20th Aug-26th Aug).

The soil comes under the vertisol (medium black) medium black and clayey loam in texture and slightly alkaline (pH-7.4) in nature and having the uniform depth up to 90 cm. The altitude is about 483.6 M above mean sea level. The highest temperature ever recorded was 46 0 C in May during 1988. The monsoon lasts from June to the end of September, with moderate rainfall. It has an average rainfall of about of 545 mm per year. The annual maximum and minimum temperature ranged between 25.0 to 43.20C and 7.3 to 27.10 C, respectively. During the kharif season, the maximum temperature ranged between 29.0 to 40.80C with an average of 34.70C, 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 67 to 98 per cent with an average of 80 per cent and the afternoon RH ranged between 24 to 95 per cent during the crop growing period.

The basal dose of fertilizer i.e. 50 kg N+25 kg P2O5 ha-1 was applied through urea and single super phosphate. However, 25 kg N and 25 kg P_2O_5 ha-1 was applied as a basal dose and remaining 25 kg N ha-1 was applied at 30 DAS.

The gross and net plot sizes were 15.0 x 6.3 m2 and 10.0 x 4.5 m2, respectively. All the cultivars are were dibbled as per different sowing windows at a spacing of 45 cm x 20 cm, during Kharif, 2015. The soil was clayey loam in texture and acidic in reaction (pH 7.4)

The agro climatic indices namely growing degree days, helio thermal units, photo thermal units were worked out.Phenological observations.The crop was observed at frequent intervals (2 or 3 days) to observe the phenological events closely. The phenological events recorded were emergence, 3 leaf, panicleinitiation, flag leaf, 50 % flowering, soft dough, hard dough, physiological maturity.

Growing degree days (GDD)

Cumulative growing degree days were determined by summing the daily mean temperature above base temperature, expressed in degree day. For *Pearl millet crop*, Tbase is considered 10 °C (Ong, C.K. 1983). This was determined by using the following formula as per (Nuttonson, 1995):

$$GDD = \frac{(Tmax + Tmin)}{2} - Tbase \quad \text{…. (1)}$$

Where,

Tmax = Daily maximum temperature (°C) Tmin = Daily minimum temperature (°C)

Tbase = Minimum threshold/Base temperature (°C)

Heliothermal units (HTU)

The heliothermal units for a day represent the product of GDD and the hours of bright sunshine for that day. The sum of HTU for particular phenophases of interest was determined according to the equation:

HTU = Σ {GDD × BSS (n)} …….(2)

Where,

GDD = growing degree days

BSS (n) = bright sun shine hours (hrs)

Results and Discussion

Growing degree days (GDD)

The data regarding mean helio thermal units as influenced periodically by different treatments are presented in Table 1. It was revealed that the growing degree days (GDD) required was 967-12430 days, 1668-21050 days, 1400-16100 days for crop sown on 26th, 30th, and 34th MW respectively. Similar findings were also reported by Kingra and Kaur (2012). Further, it was seen that crop sown on 30th MW required highest growing degree days to attain physiological maturity. However, among the cultivars the values were higher in Shanti (RHRBH-9808) followed by Mahyco hybrid (MRB-204) and Dhanashakti (ICTP-8203) cultivar. This is due to more duration required by crop sown on 30th MW and Shanti cultivar. Further, it was also noticed that the early sown crop not received fairly good amount of rainfall during its growth period due to which soil moisture available was less, however, late sown crop favors' due to moisture availability during flowering and grain filling stage which resulted in more duration required for maturity and good yield.

In short the crop sown on 30th MW required more number of days to attain various growth stages. This is due to existence of favorable condition for crop growth and development. This is because the GDD which is a function of temperature which in turn is a function of bright sunshine hours. The heat units required for attaining each stage increased as the sowing was delayed by every two weeks, these results conformed to the findings of Maiti and Soto (1990), Maiti et al. (1995), Andhale (2001), Anil Kumar et al. (2008).

Helio thermal units

The helio thermal units (HTU) defined as the accumulated product of GDD and bright sunshine hours between the developmental thresholds for each day.The data regarding mean helio thermal units as influenced periodically by different treatments are presented in Table 2.

The HTU is the product of GDD and the mean daily hours of bright sunshine.. The table revealed that the heliothermal units (HTU) required were 4442-5356^{0}C, 7256-8340^{0}C, and 6742-6943^{0}Cfor crop sown on 26th, 30th, and 34th MW respectively. The lowest HTU were in MW-26^{0}C, *i.e.* 4442 than rest of the treatments due to variation of temperature, bright sunshine and dry spell occurred during the crop growing season.

Further, it was seen that crop sown on 30th MW (7256-8340^{0}C) observed highest heliohermal units (HTU) to attain physiological maturity. However, among the cultivars the values were highest in Shanti followed by Mahyco hybrid and Dhanashakti cultivar. In short the crop sown on 26th MW (4442-5356^{0}C) observed lowest number of helio thermal units due to variation of temperature, bright sunshine and dry spell occurred during the crop growing season. The helio thermal units directly or indirectly affect the grain yield of pearl millet by delaying flowering and ear head formation.

Whereas, the HTU were the lowest in (Dhanashakti) *i.e.* 4442^{0}C when the crop was sown on 26th MW than Mahyco hybrid and Shanti due to variation in temperature, growing period, bright sunshine and dry spell occurred during the crop growing season. Similar results were also reported by Girijesh *et al.* in (2011).

Conclusion

The present study indicates that the application of heat units provides a scientific basis for determining the effect of temperature and radiation or photo period on phonological behavior of the crop. These provide very clear picture of the amount, pattern and efficiency of heat energy consumption at different sowing windows and the phenological stages of the crops.

Table 1: Growing degree days (^{0}C) required to attain growth stages in pearl millet as periodically affected by different treatment combinations

Treatment	Phenological stages							
	Emer.	3 leaf	PI	Flag leaf	50 % flowering	Soft dough	Hard dough	Phy. Maturity
S_1V_1	46	33	283	274	140	167	130	170
Cumulative	46	79	362	636	776	943	1073	1243
S_1V_2	43	31	256	238	131	114	102	149
Cumulative	43	74	330	568	699	813	915	1064
S_1V_3	31	27	233	228	96	103	102	147
Cumulative	31	58	291	519	615	718	820	967
S_2V_1	66	56	496	413	288	260	244	282
Cumulative	66	122	618	1031	1319	1579	1823	2105
S_2V_2	61	43	416	352	266	233	212	227
Cumulative	61	104	520	872	1138	1371	1583	1810
S_2V_3	46	42	383	332	255	187	197	212
Cumulative	46	88	471	803	1058	1245	1456	1668
S_3V_1	53	49	338	259	238	200	213	202
Cumulative	53	102	440	699	937	1137	1350	1552
S_3V_2	45	35	283	298	215	183	177	164
Cumulative	45	80	363	661	876	1059	1236	1400
S_3V_3	51	39	382	347	253	191	193	201
Cumulative	51	90	472	819	1072	1263	1409	1610

Table 2: HTU (^{0}Days) required to attain growth stages in pearl millet as periodically affected by different treatment combinations

Treatment	Phenological stage							
	Emer.	3 leaf	PI	Flag leaf	50 % flowering	Soft dough	Hard dough	Phy. Maturity
S_1V_1	724	567	13369	2672	3216	7211	8510	5356
Cumulative	724	1291	14660	17332	20548	27759	36269	41625
S_1V_2	475	309	13298	2356	3222	9060	7538	5348
Cumulative	475	785	1483	16439	19661	28720	36259	41607
S_1V_3	470	302	13122	2247	3217	8982	7440	4442
Cumulative	470	772	13894	16141	19358	28340	35780	40222
S_2V_1	682	677	18778	2634	4751	12512	10774	8340
Cumulative	682	1360	20138	22772	27522	40035	50808	59148
S_2V_2	659	511	16850	2562	4371	9149	10370	7342
Cumulative	659	1170	18020	20582	24954	34102	44472	51814
S_2V_3	476	362	16640	2409	4742	8943	10332	7256
Cumulative	476	838	17474	19887	24629	33572	43904	51160
S_3V_1	721	668	22476	3328	4854	11477	9455	6920
Cumulative	721	1389	23865	27193	32047	43524	52979	59899
S_3V_2	711	631	19651	3409	6884	10292	10129	6943
Cumulative	711	1341	20992	24401	28285	38584	48743	55686
S_3V_3	730	671	15285	2801	3402	7056	9928	6742
Cumulative	730	1401	16686	19487	22889	29944	39873	46615

References:

Andhale, R.P. Shinde, S.H. and Pawar, V.S. 2003. Effect of sowing dates on growth and yield of pearl millet during summer season.*J. Agromet.* 5(2): 102-105.

Anil Kumar, Pandey, V., Shekh, A.M. and Manoj Kumar 2008. Growth and yield response of soybean (Glycine max L.) in relation to temperature, photoperiod and sunshine duration at Anand, Gujarat, India. *American Eurasian J. Agron.* 1 (2) : 45-50.

Dahlke, B.J., Oplinger, E.S., Gaska, J.M. and Martinka, M.J. 1993. Influence of planting date and seedling rate on winter wheat grain yield and yield components. *J. Prod. Agric.* 6: 408-414.

Dwyer, L.M. and Stewart, D.W. 1986. Leaf area development in field grown maize. J. Agron., 78: 334-48. FAOSTAT. 2014. FAO Statistical databases, http://www.fao.org, Food and Agriculture Organization (FAO)of the United Nations, Rome.

FAO. 1996. The world sorghum and millet economies: facts trends and outlook. FAO Document Repository W1808/E.

Girijesh, G.K., Kumaraswamy, A.S., Sridhara, S., Dinesh Kumar, M., Vageesh, T.S and Nataraju, S.P. 2011. Heat use efficiency and helio-thermal units for maize genotypes as influenced by dates of sowing under southern transitional zone of Karnataka state. *I. J. Sci. and Nature.* 2(3) 2011: 529 – 533.

Gouri, V., Reddy, D.R., Rao, S.B.S.N. and Rao, A.Y. 2005. Thermal requirement of rabi groundnut in southern Telangana zone of Andhra Pradesh. *J. Agrometeorol.*, 7(1): 90-94.

Ji, B., Sun, Y., Yang, S. and Wan, J. 2007. Artificial neutral networks for rice yield prediction in mountainous regions, *J. Agric Sci.*, 145(3): 249–61.

Ketring, D.L. and Wheless, T.G. 1989. Thermal requirement for phenological development of peanut, *J. Agron.*, 8(16): 910-17.

Kingra P.K. and Prabhjyot-Kaur.(2012). Effect of Dates of Sowing on Thermal Utilisation and Heat Use Efficiency of Groundnut Cultivars in Central Punjab. *J. Agric. Physics.* 12 (1):54-62.

Knapp, W.R. and Knapp, J. S. 1978. Response of winter wheat to date of planting and fall fertilization. *Agron. J.* 70: 1048-1053.

Lawn, R.J., Summerfield, R.J., Ellis, R.H., Roberts, E.H., Chay, P.M., Brouwer, J.B., Rose, J.L. and Yeates, S.J. 1993. Towards the reliable prediction of time to flowering in six annual crops. VI Applications in crop improvement. *Exptt. Agric.*, 31: 89-108.

Maiti, R.K. and Soto, G.G.L. 1990. Effect of four sowing dates environments on growth, development and yield potentials of 15 pearl millet cultivars. (*Pennisetum americanum* L.) *J. Exptl. Bot.* 41 : 233.

Maiti, R.K., Lopej, U.P. and Gamboa, L.A.F. 1995. Effect of sowing dates on physiological maturity, grain filling and germination of 15 pearl millet cultivars. *Internat sorghum and Millet Newsl.* 36 pp.57.

Nuttonson, M.Y. 1995. Wheat climate relationship and use phenology in ascertaining the thermal and photothermal requirement of wheat. *American Institute of Crop Ecology*, Washington DC, pp. 338.

Ong, C.K. 1983. Response to Temperature in a Stand of Pearl Millet (Pennisetumtyphoides S. & H.) *J. of Exp. Bot.* Volume 34, Issue 12, 1 December 1983, Pages 1731–1739.

Ramshe, D.G., Patil, B.R. and Umrani, N.K. 1986. Effects of planting time and nitrogen on yield of pearl millet varieties. *J. Maharashtra agric. Univ.*, 11(2): 162-163.

Witt, M.D. 1996. Delayed planting opportunities with winter wheat in the Central Great Plains. *J. Prod. Agric.* 9: 74-78.