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Thermal requirement for pearl millet crop

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Abstract A field experiment was conducted for five successive years on pearl millet (*Pennisetum americanum*) with different sowing dates to evaluate the impact of thermal energy on growth and development of the crop. The accumulated heat units and number of days for various growth stages (seedling emergence, first tiller, panicle initiation, ear emergence, flowering initiation, 50% flowering and physiological maturity) decreased under delayed seeding. The variation in accumulated heat units and number of days required for various growth stages did not indicate any definite trend. The early crop received maximum thermal energy compared to later seeded crop in all the years of experimentation.

Key words pearl millet, sowing date, regression equation, growing degree days

Pearl millet, being a staple food crop, is grown during monsoon season on 1.8 million ha area in Maharashtra. Of this, 85% area is sown in the low rainfall scarcity zone of Maharashtra. The average yield of the crop is only 700 kg ha^{-1}. The constraints to the crop production are climate, crop genotypes, soil moisture and soil depth.

The physiological and morphological development of pearl millet is markedly influenced by temperature and day length. Agronomic application of the temperature impacts on crop plants has led to the development of the concept of heat units or growing degree days (GDD). The concept assumes that each plant has a specific threshold temperature below which growth does not occur.

The concept of heat units has been applied to relate the phenological development of crops to predict maturity and yield (Keitzar & Singh 1981, Swan *et al.* 1987). However, in the case of pearl millet, the relationship between heat units and growth stages has not been adequately quantified for dryland conditions. This study attempts to understand phenophase development of pearl millet in relation to its immediate thermal environment.

Materials and Methods

A field experiment on pearl millet (*Pennisetum americanum* var. WCC-75) was carried out at the Dry Farming Research Station, Solapur (17^o 41′ N, 75^o 44′ E, altitude 479 m) in rainy cropping season for five successive years (1988 to 1992) on a medium deep vertisol (45 cm depth). The pH of the soil was 7.3. The soil was poor in organic carbon (0.28 %), medium in available phosphorus (0.21 kg ha^{-1}) and rich in available potassium (499 kg ha^{-1}). The experimental treatments consisted of 3 dates of sowing, 15 days apart. The experiment was replicated thrice. The net plot size was 15 x 3.60 m. The crop was given 50 kg N and 25 kg P_2O_5 ha^{-1} at sowing. The seeding was scheduled after the receipt of sufficient rainfall and when soil moisture reserves were enough. The dates of sowing for different years was 22 June 88, 10 June 89, 8 June 90, 11 June 91 and 24 June 92. The subsequent sowings were at 15-day interval in each case.

The number of days required to attain a given growth stage was recorded when 50% plants reached the specific growth stage. The crop growth stages studied were seedling emergence, occurrence of first tiller, panicle initiation, ear emergence, flowering initiation, 50% flowering and physiological maturity. The heat units (grow-

Table 1 *Growing degree days and days required to attain various physiological growth stages in pearl millet*

Year	Sowing date	Growth stages						
		Emergence	Tillering	Panicle initiation	Ear emergence	Flowering initiation	50% Flowering	Maturity
1988	S1	96 (4)	458 (20)	857 (41)	930 (47)	1128 (54)	1215 (58)	1932 (94)
	S2	92 (4)	455 (21)	822 (38)	900 (42)	1040 (49)	1119 (52)	1937 (92)
	S3	91 (30)	395 (19)	788 (37)	901 (42)	980 (46)	1064 (50)	1918 (91)
	C.V.	2 (13)	7 (4)	3 (4)	2 (5)	6 (7)	5 (6)	1 (1)
1989	S1	128 (6)	625 (23)	909 (42)	1054 (49)	1179 (54)	1253 (58)	1992 (92)
	S2	91 (4)	503 (23)	546 (39)	955 (44)	1085 (50)	1215 (56)	1913 (90)
	S3	89 (4)	451 (21)	905 (42)	991 (46)	1102 (51)	1253 (58)	1884 (87)
	C.V.	18 (20)	14 (4)	3 (3)	4 (5)	4 (3)	1 (2)	3 (2)
1990	S1	97 (4)	345 (15)	759 (30)	844 (36)	998 (42)	1133 (48)	2114 (90)
	S2	93 (3)	332 (14)	717 (32)	842 (37)	950 (41)	1090 (46)	2080 (89)
	S3	96 (4)	312 (13)	713 (30)	848 (36)	943 (40)	1066 (46)	2091 (90)
	C.V.	2 (13)	4 (6)	3 (3)	0.3 (1)	3 (2)	3 (2)	0.7 (0.5)
1991	S1	85 (3)	322 (14)	701 (31)	827 (37)	891 (40)	993 (45)	1883 (86)
	S2	93 (4)	329 (15)	649 (30)	753 (35)	839 (39)	947 (44)	1761 (81)
	S3	68 (4)	329 (15)	623 (29)	754 (35)	818 (38)	945 (44)	1756 (80)
	C.V.	13 (13)	1 (3)	5 (3)	5 (3)	4 (2)	2 (1)	3 (3)
1992	S1	143 (6)	380 (15)	863 (35)	982 (40)	1081 (43)	1238 (52)	2202 (93)
	S2	99 (4)	315 (13)	814 (34)	964 (41)	1052 (46)	1195 (51)	2018 (86)
	S3	124 (5)	308 (13)	812 (35)	967 (42)	1036 (45)	1176 (50)	1918 (83)
	C.V.	15 (16)	10 (7)	3 (2)	0.8 (2)	2 (3)	2 (2)	6 (5)

Figures in parentheses indicate the number of days required to attain the various physiological growth stages

ing degree days) were calculated as per the following formula given by Iwata (1984) :

$$\text{GDD} = \frac{\text{Maximum} + \text{Minimum}}{2} - \text{Base temperature}$$

The GDD were recorded by summing the daily GDD from sowing to various growth stages. The daily meteorological data recorded at the meteorological observatory were utilised. The GDD were calculated for different dates of sowing.

Results and Discussion

The GDD requirement for reaching different growth stages from seeding decreased with delay in sowing in all the years (Table 1). The differences between first and second sowing were more pronounced than for the second and third sowing. The results are similar to those reported by Patel & Mehta (1987). Late seeding increased the period to reach successive growth stages due to receipt of rainfall during crop growth period, which enhanced the crop growth. The late seeded crop suffered for want of thermal energy due to low temperature. The results are in line with the report of Diwansingh *et al.* (1993).

In general, the crop sown earlier required more period for attaining the various growth stages, this might be due to more available soil moisture. In the case of late seeding, plants matured earlier due to moisture stress and hence the plants completed their life cycle earlier. Chandrasagar *et al.* (1985) also reported that the early seeded crop attribute full utilization of rain water right from its sowing, dry seeding and earlier favourable climatic conditions. The data also reveal that the coefficient of variation was high during emergence and occurrence of first tiller stage, while there was no clear variation between other stages.

The regression equation between GDD and number of days to attain various physiological growth stages was worked out (Fig. 1). The equation is as follows :–

$$Y = 14.9 + 21.97\,x \quad R^2 = 0.99$$

where, Y = accumulated GDD and
x = number of days required to attain the growth stages

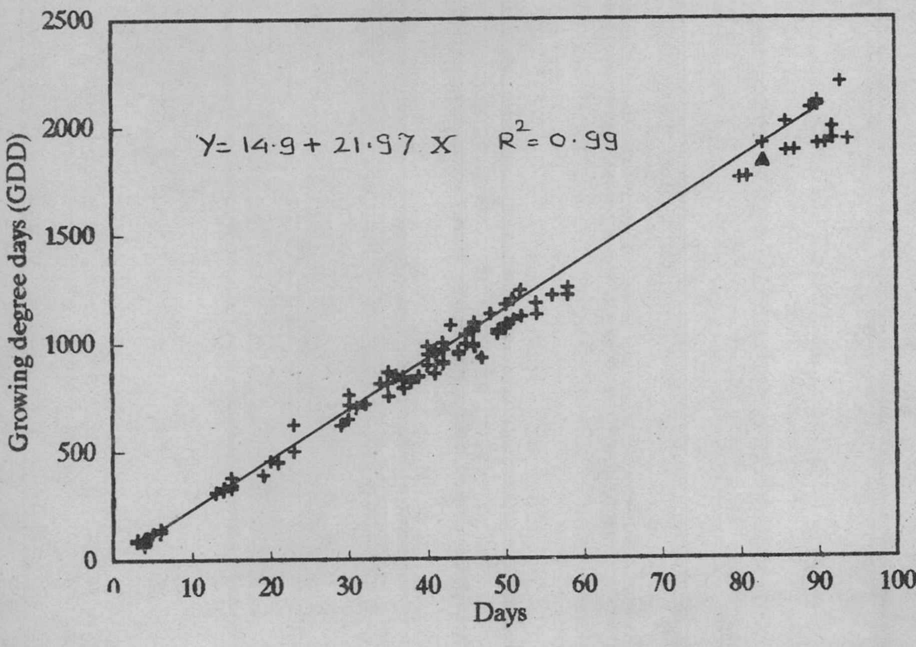

Fig 1 Relationship between GDD and days to attain physiological growth stages

From this equation, by knowing the number of days required to attain the growth stage, the GDD requirement can be calculated for pearl millet crop under scarcity zone of Maharashtra.

In conclusion, the results of this study show that pearl millet should be sown soon after the onset of rainy season so that more GDD are accumulated. This would lead to better production under dryland conditions.

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