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Heat unit requirement of field grown groundnut varieties

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Abstract: Field investigation was carried out to study the effect of temperature on the phenology of groundnut varieties during summer and *kharif* seasons at two locations. VRI 3 and TMV 7 attained maturity in 101 and 108 days in Thiruchengode and VRI 2 attained maturity in 112 days in Avinashi. The growing degree days and photo thermal units required from sowing to 50 per cent flowering and 50 per cent flowering to maturity phenophases were worked out. The average value of accumulated GDD from sowing to maturity was 2303°C days with co-efficient of variation of 11 per cent and photo thermal units are 27779°C day hours with the co-efficient of variation of 11 per cent in Thiruchengode. For Avinashi, the same phenophase required accumulated GDD of 2161°C days with co-efficient of variation of per cent and photo thermal units are 26012°C day hours with the co-efficient of variation of per cent. Two linear regression models were derived based on the phenophase-wise data pooled over different varieties across the locations for predicting the onset of maturity phenophase of the crop using either growing degree days or photo thermal units. Onset of particular phenophase depended upon the available growing degree days or photo thermal units which accounted for 94 per cent of the total variation.

Key words : Growing degree days, Photo thermal units, Phenophases, Groundnut.

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop in India. It occupies an area of 7.1 million ha with an annual production of 6.1 million tonnes. The average productivity of groundnut is 859 kg ha^{-1} (FAO, 2000). Groundnut is known for its rich source of vegetable fats, protein, cattle feed and concentrated organic manure. The crop is grown under rainfed condition in the semi-arid tropic of India, and commonly affected by mid season and terminal droughts. The potential productivity of groundnut depends on crop weather relations during the crop growth period, which in turn depends on time of sowing. Optimum time of sowing is identified for every crop to adjust the duration of crop growth phases coinciding with congenial weather conditions. The duration of each growth phase determines the accumulation and partitioning of dry matter in different organs (Dalton, 1967). Response of groundnut crop to environmental factors also determines the growth performance and yield. Bhatia *et al.* (1997) reported that initiation of flowering and the start of pod development stages were the most sensitive to variation in temperature and photoperiod. Start of different phenophases and their duration are the essential components of crop coefficients that are extensively used in dynamic crop simulation models.

Physiological and morphological development of plants are markedly influenced by temperature and day length. The concept of heat units based on cumulative effective temperature and crop phenology is used to describe the crop temperature relationships. Obviously the crop growth and phasic development are determined by heat units or growing degree days. The duration of particular stage of growth was directly related to temperature and thus crop phenophase could be predicted using the growing degree days (Wang, 1960). In view of potential significance of temperature on crop phenology, field studies were conducted on groundnut varieties to quantity the heat unit requirement.

Materials and Methods

Field experiments were conducted during summer 2001 (January to June) and *kharif* 2002 (June to September) at Thiruchengode (11°24'N

Table 1. Accumulated growing degree days (AGDD) and photothermal units (APTU) required to attain important phenophases in groundnut varieties

Thiruchengode	AGDD			APTU		
Phenophase	P1	P2	P3	P1	P2	P3
TNAU 281	830	1651	2481	9102	20314	29416
TMV 10	720	1846	2567	8406	22705	31165
TNAU 262	739	1701	2440	8682	20889	29572
VRI 3	580	1361	1942	6808	16489	23297
TNAU 325	756	1619	2376	8892	19866	28759
TMV 7	640	1456	2097	7516	17727	25243
VRI 2	640	1477	2118	7516	17992	25508
Red Pattani	679	1459	2138	7970	17789	25769
Local runner type	988	1747	2736	11676	21630	33306
Local bunch type	700	1438	2138	8218	17542	25760
Mean	727	1575	2303	8484	19294	27779
SD	115	159	252	1324	2064	3139
CV	16	10	11	16	11	11
AVINASHI						
VRI 2	734	1356	2090	9094	16089	25183
CO 3	847	1308	2155	10467	15475	25943
CO 4	793	1329	2122	9808	15752	25560
Local bunch type	943	1335	2278	11623	15740	27364
Mean	829	1332	2161	10248	15764	26012
SD	88	19	82	1074	251	952
CV	10	2	4	10	2	4

P1 - Sowing to 50 per cent flowering; P2 - 50 per cent flowering to maturity; P3 - Sowing to maturity

and 77°54'E) and Avinashi (11°21'N and 77°54'E) taluks in western agro climatic zone of Tamil Nadu. The on-farm experiments were laid out in a randomized block design with four replications. Ten groundnut varieties were chosen for Thiruchengode and four varieties were selected for Avinashi. The crop was sown on 19.01.2000 at Thiruchengode and on 28.07.2002 at Avinashi. The spacing adopted was 30cm x 10 cm. The crop was applied with recommended dose of fertilizer (10:10:45 kg NPK ha^{-1}) and irrigation was given as and when required at different critical growth stages.

Accumulated growing degree days (AGDD) and accumulated photothermal units (APTU) were computed by taking a base temperature of 10°C. The total sum of degree days for each phenophase were obtained by using the following formula.

$$AGDD = \sum_{l}^{N} \{(T\ max + T\ min)/2\} - Tb$$

Where T max, T min are daily maximum and minimum temperature (°C)
Tb is base temperature (°C)
l is date of sowing or start of phenophase
N is date of harvest or end of phenophase

APTU=(GDD) x (Day length)

Ten plants from each of the plots were selected randomly for periodical identification of phonological events. Whenever more than five plants from each plot attained a particular stage, the date were considered as the one for attainment of that stage. Linear regression models were derived between the days to attainment of a particular phonological stage and AGDD/ APTU.

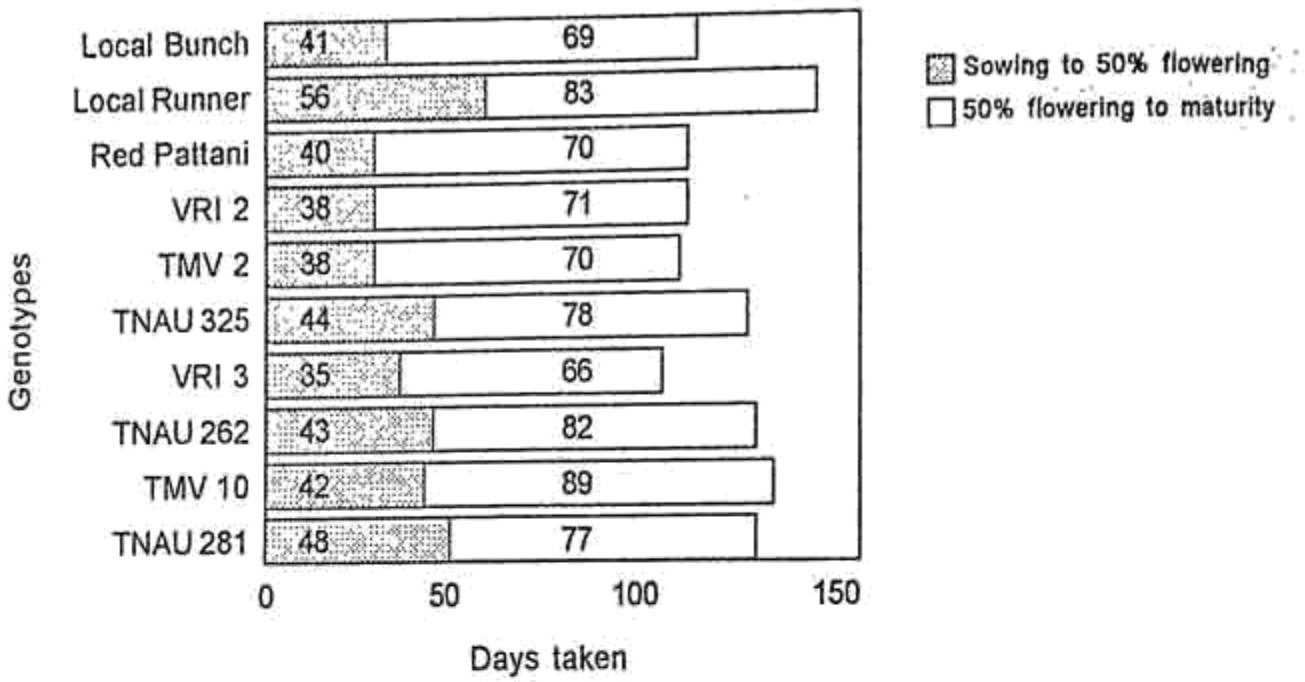
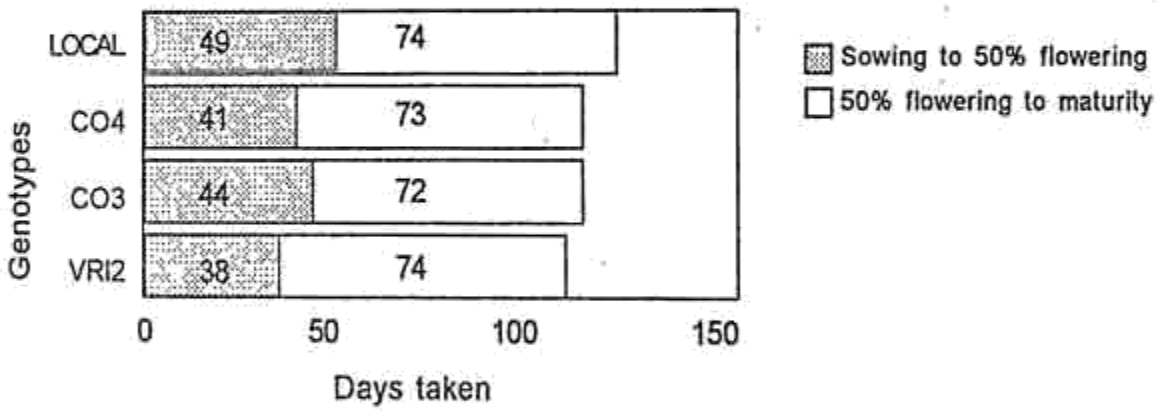


Fig.1(a) Phenology of groundnut varieties in Thiruchengode



(b) Phenology of groundnut varieties in Avinashi

Results and Discussion

Crop Phenology

The date of start and duration of different phenophases vary among the groundnut varieties at both the study locations (Fig.1). The number of days taken for 50 per cent flowering and maturity varied with varieties. At Thiruchengode, groundnut varieties, VRI 3 and TMV 7 took the lowest no. of days (101 and 108 days, respectively to attain physiological maturity. The local runner variety took the highest no of days (139 days) to attain maturity. At Avinashi VRI 2 reached maturity in 112 days, while the local bunch variety took 123 days to attain the same stage. Greater difference in total crop growth duration in general and days to attain a specific phenological phase in particular was observed among the groundnut varieties due to their inherent genetic variation (Nautiyal *et al.* 2002).

Growing degree days (GDD), photothermal units (PTU) and crop maturity

Growing degree days and photothermal units are widely used indices for describing the phenological responses of crop to temperature. The requirement of GDD and PTU for completion of different phenophase for different groundnut varieties were worked out and presented in Table 1. The VRI 3 variety required lowest accumulated GDD of 580°C, while the local runner type required 988°C to attain 50 per cent flowering at Thiruchengode. At Avinashi VRI 2 was quicker (734°C) compared to all

the other varieties. Among the varieties tried at Thiruchengode, VRI 3 has required accumulated GDD of 1942°C days and accumulated PTU of 23297°C day hours from sowing to maturity. Highest accumulated GDD (2736°C) and accumulated PTU of 23297°C day hours from sowing to maturity. Highest accumulated GDD (2736°C) and accumulated PTU (33306°C day hours) were recorded for the local runner type variety. The average value of accumulated GDD from sowing to maturity was 2303°C days with co-efficient of variation of 11.0 per cent, whereas the corresponding values for accumulated PTU was 27779°C day hours and 11.3 per cent, respectively. The coefficient of variation was greater for AGDD and APTU from sowing to 50 per cent flowering than from 50 per cent flowering to maturity.

At Avinashi, VRI 2 had showed lowest GDD of 2090°C days and PTU of 25183°C day hours. The local variety consumed the highest GDD and PTU of 2278°C and 27364°C day hours respectively. In general, seasonal difference in accumulated growing degree days (AGDD) was observed among the varieties. Crop sown in the month of January required longer duration due to low temperature during initial stages of crop growth.

Phenophasic models

The location specific linear regression models were used to predict the days to 50 per cent flowering and days to maturity (Table 2 and 3). To achieve the relationship, accumulated growing degree days (AGDD) and photothermal units (APTU) were used as independent variables. The phenophase wise data pooled over different varieties across the locations were derived from predicting the date of flowering and maturity. The observed and predicted values were compared and presented in Table 2 and 3. The model predicted the days to 50 per cent flowering

Table 2. Actual (Act), Predicted (Pre) and Deviation (Dev) of predicted from actual calendar days requiredto attain various phenophases of groundnut based on accumulated growing degree days (AGDD)

	Sowing to 50 percent flowering			50 per cent flowering to maturity			Sowing to maturity		
THIRUCHENGODE	Actual	Predicted	Deviation	Actual	Predicted	Deviation	Actual	Predicted	Deviation
TNAU 281	48.0	47.8	-0.2	77.0	79.0	2.0	125.0	126.5	1.5
TMV 10	42.0	42.1	0.1	89.0	88.1	-0.9	131.0	130.6	-0.4
TNAU 262	43.0	43.0	0.0	82.0	81.3	-0.7	125.0	124.5	-0.5
VRI 3	35.0	34.8	-0.2	66.0	65.5	-0.5	101.0	100.6	-0.4
TNAU 325	44.0	44.0	0.0	78.0	77.5	-0.5	122.0	121.4	-0.6
TMV 7	38.0	37.9	-0.1	70.0	69.9	-0.1	108.0	108.1	0.1
VRI 2	38.0	37.9	-0.1	71.0	70.9	-0.1	109.0	109.1	0.1
Red Pattani	40.0	39.8	-0.2	70.0	70.0	0.0	110.0	110.0	0.0
Local runner type	56.0	56.0	0.0	83.0	83.4	0.4	139.0	138.7	-0.3
Local bunch type	41.0	41.0	0.0	69.0	69.0	0.0	110.0	110.0	0.0
Mean	42.5	42.4		75.5	75.5		118.0	118.0	
SD	6.0	6.0		7.5	7.4		118.0	118.0	
RMSE			0.22			0.13			0.16
AVINASHI									
VRI 2	38.0	37.9	-0.1	74.0	74.2	0.2	112.0	112.0	0.0
CO 3	44.0	43.9	-0.1	72.0	72.1	0.1	116.0	115.9	-0.1
CO 4	41.0	41.0	0.0	73.0	73.1	0.1	114.0	113.9	-0.1
Local	49.0	49.0	0.0	74.0	73.3	-0.7	123.0	123.0	0.0
Mean	43.0	43.0		73.3	73.2		116.3	116.2	
SD	4.7	4.7		1.0	0.9		4.8	4.8	
RMSE			0.10			0.14			0.10

Table 3. Actual (Act), Predicted (Pre) and Deviation (Dev) of predicted from actual calendar days required to attain various phenophases of groundnut based on accumulated photothermal units (APTU)

	Sowing to 50 percent flowering			50 per cent flowering to maturity			Sowing to maturity		
THIRUCHENGODE	Actual	Predicted	Deviation	Actual	Predicted	Deviation	Actual	Predicted	Deviatio
TNAU 281	48.0	45.2	-2.8	77.0	79.1	2.1	125.0	124.3	-0.7
TMV 10	42.0	42.3	0.3	89.0	87.7	-1.3	131.0	130.5	-0.5
TNAU 262	43.0	43.3	0.3	82.0	81.2	-0.8	125.0	125.0	0.0
VRI 3	35.0	35.0	0.0	66.0	65.4	-0.6	101.0	101.3	0.3
TNAU 325	44.0	44.3	0.3	78.0	77.5	-0.5	122.0	122.0	0.0
TMV 7	38.0	38.1	0.1	70.0	69.8	-0.2	108.0	108.0	0.0
VRI 2	38.0	38.1	0.1	71.0	70.8	-0.2	109.0	108.2	-0.8
Red Pattani	40.0	40.2	0.2	70.0	70.0	0.0	110.0	110.3	0.3
Local runner type	56.0	56.6	0.6	83.0	83.8	0.8	139.0	138.3	-0.7
Local bunch type	41.0	41.3	0.3	69.0	69.2	0.2	110.0	110.0	0.0
Mean	42.5	42.4		75.5	75.5		118.0	117.8	
SD	6.0	5.9		7.5	7.4		12.1	11.9	
RMSE			0.19			0.16			0.66
AVINASHI									
VRI 2	38.0	37.9	-0.1	74.0	74.2	0.2	112.0	112.0	0.0
CO 3	44.0	44.0	0.0	72.0	72.3	0.3	116.0	115.9	-0.1
CO 4	41.0	41.0	0.0	73.0	73.2	0.2	114.0	113.9	-0.1
Local	49.0	49.0	0.0	74.0	73.1	-0.9	123.0	123.0	0.0
Mean	43.0	43.0		73.3	73.2		116.3	116.2	
SD	4.7	4.7		1.0	0.8		4.8	4.8	
RMSE			0.02			0.10			0.10

and days to maturity accurately among all the varieties irrespective of locations. The regression model obtained to predict the days to maturity using AGDD and APTU are presented in Fig.2a and 2b.

The model indicated that both the AGDD and APTU independently accounted for 94 per cent variability in days to maturity. A similar type of model to predict the phasic development using accumulated heat units has been reported by Patel *et al.* (1999). Hundal and Kingra (2000) also reported that accumulated growing degree days (AGDD) could be used as a best index to predict phenophase of soybean.

The results of the current investigation indicated that the date of occurrence of various phenophases can be accurately predicted by accumulating growing degree days and photothermal units. The actual and predicted days for important phenophase as obtained by the models are given in Table 2 and Table 3. The difference between the observed and predicted values varied from -0.9 to 2.0 days, when the predictions were based on GDD. The difference varied from 2.8 to -2.1 days when predictions are based on PTU.

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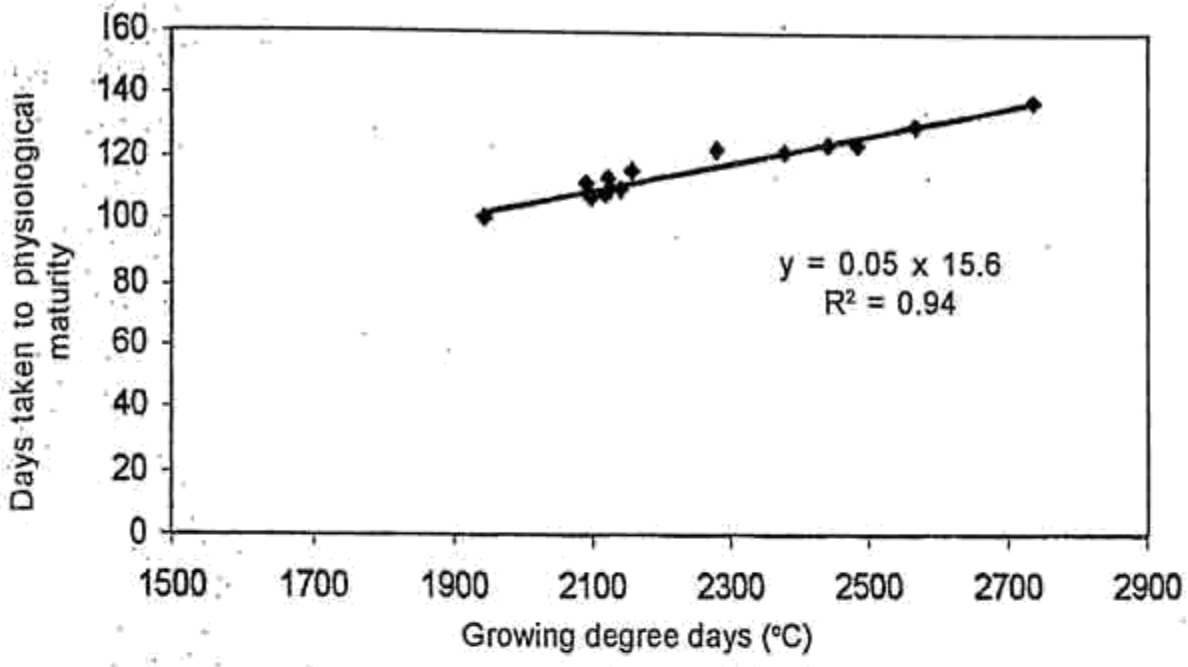

Fig.2(a). Relationship between accumulated growing degree days (°C) and days to maturity across the groundnut genotypes

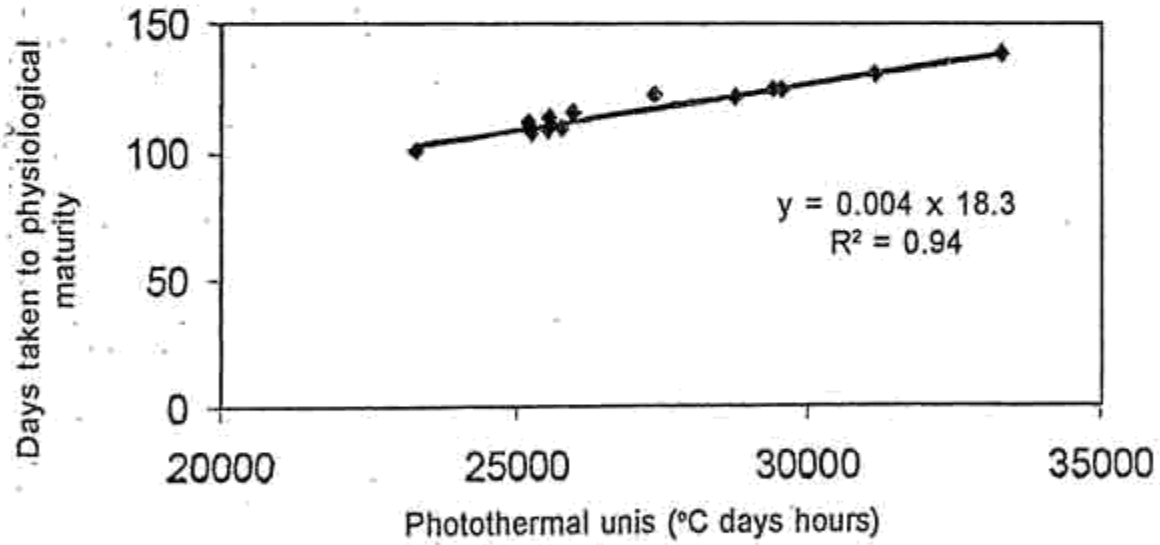

Fig.2(b). Relationship between accumulated photothermal units (°C day hours) and days to maturity across the groundnut genotypes

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