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Original Research Article

Temperature Requirement for Crop Growth and Productivity of Groundnut (*Arachis hypogaea* L.) under Dry Western Zone of India

Abstract

A field experiment was conducted in loamy sand soil during *kharif* season of 2009 and 2010. The experiment was laid out in split-plot design with three replications, assigning 32 treatments consisting of four date of sowing (20 April, 15 May, 9 June and 4 July) and two varieties (HNG 10 and TG 37A) as main-plot treatments and four fertility levels of nitrogen and phosphorus application (0, 20 N-40 P_2O_5, 30-60 P_2O_5 and 40 N-80 P_2O_5 kg ha^{-1}) as sub-plot treatments. The results showed that significantly higher CGR at 30-60 and 60-90 DAS was observed in HNG 10 variety. Further delays in sowing significantly reduce crop growth rate. However, crop growth rate in all the sowing dates of TG 37A was observed statistically at par with each other. In semi-spreading variety HNG 10 recorded higher pod, kernel, haulm and biological yield were observed at par with each other from 20 April to 9 June sowing. Maximum heat unit efficiency was observed on 9 June sowing than all three sowing. While, highest yields were recorded in TG 37A variety with 4 July sowing than all three sowing dates. Harvest index in both the varieties was observed significantly higher in 4 July sowing. All the fertility treatments produced significantly higher crop growth rate, Heat unit and yields. Application of 30 kg N-60 kg P_2O_5 ha^{-1} significantly enhanced the crop growth, Heat unit and yield over 20 kgN-40 kg P_2O_5 ha^{-1} but at par with 40 kg N-80 kg P_2O_5 ha^{-1}.

Key words Crop growth, Date of sowing, Fertility levels, Heat unit, Yields

INTRODUCTION

Groundnut is an important oilseed crop play a major role in bridging the vegetable oil gap in the country. The total oilseed production in India during 2011-12 was 26.45 mt, of which groundnut

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production was 6.94 mt, from 5.32 mha area with an average productivity around1305 kg ha^{-1} [1]. In dry land agriculture, farmers have limited choice for sowing time, but in irrigated situation sowing time is one of the most important non- monetary inputs affecting yield of crops. Sowing time of groundnut is well documented in other regions [13]. In Bikaner region, all the cultivation of groundnut is under irrigated conditions. Groundnut cultivation in Bikaner region was started two decades ago in the command area of Indra Gandhi Nahar Pariyojana (IGNP) and later on it spread to tube well irrigated area of the region. At that time, dust storms were common in the region with minimum vegetation during optimum sowing time of May and June months leading to poor crop establishment due to which the farmers started sowing of groundnut in early summer in the months of April and May for better crop establishment with its harvesting in October-November. This practice is still followed, despite reduction in frequency of dust storms in the region. The productivity is restrained by drought stress, the use of low levels of inputs by smallholders and marginal farmers in dry land areas, high incidence of aberrant weather conditions.With these considerations an experiment was conducted on groundnut to find out suitable time of planting to escape adverse situations.

Materials and Methods

Experimental Site: Experimental trail was conducted during *kharif* season of 2009 and 2010 at Agronomy Research Farm, College of Agriculture, Bikaner (Rajasthan) under hyper arid condition, which is situated at a 28º 01'N latitude and 73 º 22' E longitudes at an altitude of 234.70 meters above mean sea level (*Arabian* Sea).

Soil: The soil of the experimental site was loamy sand and having 156.33 kg ha^{-1} alkaline permanganate oxidizable N[16], 16.05 kg ha^{-1} available P [12], 221.0 kg ha^{-1} 1 *N* ammonium acetate exchangeable K [15] and 0.80% organic carbon [8] The pH of soil was 8.4 (1:2.5 soil and water ratio). Field capacity, permanent wilting point and bulk density recorded were 8.4.0% (w/w), 1.1.83% (w/w) and 1.66 Mg m^{-3}, respectively in 0-30 cm soil depth.

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Statistics: The experiment was laid out in split-plot design with three replications, assigning 32 treatments consisting of four date of sowing (20 April, 15 May, 9 June and 4 July) and two varieties (HNG 10 and TG 37A) as main plot treatments and four fertility levels of nitrogen and phosphorus application (0, 20 N: 40 P_2O_5, 30 N: 60 P_2O_5 and 40 N: 80 P_2O_5 kg ha^{-1}) as sub-plots. All the data obtained from groundnut for two consecutive years of trails were statistically analyzed using the *F*-test [5]Critical difference (CD) values at *P*=0.05 were used for determine the significance of differences between mean values of treatments.

Results and Discussion

Crop and weather

Maximum rainfall of 51.50 mm and 21.00 mm were recorded in the month of July 2009 and August 2010, respectively (Table 1). Highest temperature was observed in the month of May in both the years. Growth and development of groundnut was affected by different uncontrollable environmental conditions. Interaction effect was observed in different sowing environment and varieties on thermal temperatures. The heat unit efficiency went on increasing from vegetative growth to pod filling and physiological maturity of the crop. Among the sowing environment, heat unit efficiency was found to be higher for 9 June sowing than all other three sowing environments (Fig.1). Significantly higher heat unite efficiency was observed in variety HNG 10 compared to TG 37A. Among the varieties HNG 10 consumed more heat units to reach maturity during all the crop growth seasons [9] The variety HNG 10 being of semi-spreading type, relatively of longer duration and indeterminate growth habit and mutant variety TG 37A being a bunch type short duration and determinate growth habit. These results are also enclose agreement with the findings [6,11].

Temperature use efficiency

Efficiency of utilization of temperature in terms of dry matter accumulation depends on crop type, genetic factors and sowing time and has great practical application [11] Initiation as well as duration of crop phenophases is an essential component of weather based dynamic crop growth

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rate and yield simulation models. Crop phenology can be used to specify the most appropriate date and time of specific development process. The duration of each phenophase determines the accumulation and partitioning of dry matter in different organs reported that the duration of a particular crop growth stages was directly related to temperature and this duration of particular species could be predicted using the sum of daily air temperature [9].

Crop growth rate

Results show that of tested varieties in the study, in HNG 10 higher crop growth rate was observed than TG-37A (Fig.2), primarily due to the differences in the genetic constitution and growth habit of these varieties as evidenced from the similar variation in crop growth rate of these varieties (Meena et al., 2014). The variable behaviour of these varieties could be explained in genetic constitution and variation in growth habit of these varieties as evidenced from the similar interaction effect recorded on heat unit efficiency of these varieties. HNG 10 is semi-spreading variety which seems to have indeterminate growth habit as evident from the considerable. This variety sown early was exposed to longer duration for vegetative growth due to its indeterminate growth habit. On the other hand, the variety sown on later dates was exposed to shorter duration for vegetative growth and there for recorded less crop growth at these dates. In contrast, the variety TG 37A is a Spanish bunch type and probably seems to be a variety of short duration maturity and determinate growth habit. Thus the variation in growth parameters of the two varieties with variation in sowing dates resulted due to interaction between genetic constitution of the varieties and growth factors like manures, fertilizers, moisture availability *vis-a-vis* environmental factor like temperature, day length, relative humidity, rainfall, wind velocity and biotic and abiotic factors which have a considerable bearing on important plant functions such as photosynthesis, respiration, transpiration, nutrient and water absorption *etc.* [11,14]

Yields

In the variety HNG 10 recorded higher and almost similar pod and kernel yields under the first three sowing dates beginning from 20 April to 9 June (Table 3). Delayed sowing of this variety beyond 9 June on 4 July resulted in significant reduction in these yields. On the contrary, yield of

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variety TG 37A progressively increased under later dates of sowing with the highest yields recorded under the last sowing date of 4 July. Since this is a short duration variety of determinate growth habit, it recorded the highest yields in the last date of sowing as this sowing date provided optimum maturity period requirement to this variety. The early sowing dates provided very longer than optimum periods and harsh environments to this variety of determinate growth habit, these dates recorded significantly lower yields. Since the pod, and kernel yields are cumulative function of the yield attributes, the variation in pod and kernel yields of these varieties as affected by sowing dates. These results are also in close agreement with the findings of [3,7].

Dates of sowing also had significant interaction effects with crop varieties on haulm and biological yields of groundnut (Table 3). The variety HNG 10 recorded the highest haulm and biological yields when planted on the earliest sowing date of 20 April. Sowing of this variety on latter dates resulted in significant reduction with each delay in sowing with the lowest haulm yield of 46.74 q ha^{-1} and biological yield of 81.18 q ha^{-1}. This could be explained due to the similar variation in the maturity periods made available to this variety for overall growth. Thus the variation in the haulm yield recorded under different dates of sowing with the minimum haulm yield recorded in last date of sowing. The variety HNG 10 also recorded almost similar variation in biological yield as that observed in haulm yield due to the effect of sowing dates. Since biological yield is a cumulative function of haulm and pod yields, the variation in biological yield with sowing dates could be mainly attributed to the haulm yield with minor contribution from the pod yield, as the pod yield of this variety was almost similar in the three initial dates with reduction only under the last date of sowing. Similarly variety TG 37A also recorded significant reduction in haulm yield with every delay in sowing but the reduction was found to be considerably lower than that recorded in HNG 10 due probably to its determinate growth habit. This type of growth habit did not allow the variety to widen the variation in haulm yield with variation in maturity periods as affected by sowing dates. In contrast to haulm yield, the variety TG 37A recorded a reverse trend in pod yield as affected by dates of sowing with the lowest yield recorded under the first date of 20 April

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sowing and the highest yield recorded under the last date of 4 July sowing. Since the biological yield is a cumulative function of haulm and pod yields, variety TG 37A recorded almost similar biological yields with minor variations under various sowing dates due certainly to opposing trends in haulm and pod yields recorded as affected by sowing dates. Thus, the cumulative effect of the variation in growth and yield attributes of the two varieties recorded with variation in sowing dates resulted variation in various yields of groundnut namely pod, kernel, oil, haulm and biological yields as a result of interaction effect between genetic constitution of the varieties and environmental factors, These results are also in close agreement with the findings [4, 10].

Effect of fertility levels

Application of nitrogen and phosphorus up to 30 kg N-60 kg P_2O_5 ha^{-1} was observed higher pod yield, kernel yield, haulm yield biological yield (Table 2) over control and 20 kg N-40 kg P_2O_5 ha^{-1}. Further increase the fertility level up 40 kg N-80 kg P_2O_5 ha^{-1} was statistically at par with 30 kg N-60 kg P_2O_5 ha^{-1}. Early and plentiful availability of nitrogen and phosphorus to plants favourably influenced the kernel development and kernel size, which ultimately resulted in, increased pod and seed index and shelling percentage. Improved overall growth and profuse branching due to nitrogen and phosphorus fertilization led to increased net photosynthesis on one hand and greater mobilization of photosynthates towards reproductive structures on the other might have increased the yield attributes significantly result are agreement with those of [2].

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Table 1 Temperature and rainfall data during growing seasons of groundnut (2009-2010)

Months	Temperature (°C)				Rainfall			
	Maximum	Minimum	Maximum	Minimum	Total Rainfall (mm)	Rainy days	Total Rainfall (mm)	Rainy days
	2009	2009	2010	2010	2009	2009	2010	2010
April	39.70	24.65	42.15	28.25	0.00	0.00	0.00	0.00
May	43.75	28.95	43.00	28.63	0.50	0.00	0.88	0.25
June	41.58	27.26	41.12	29.44	11.42	0.80	15.10	0.60
July	38.38	27.23	38.18	29.40	51.50	2.00	19.33	0.75
August	37.78	28.32	36.30	27.44	9.00	0.60	21.00	1.40
September	38.90	25.65	34.95	24.50	4.45	0.75	27.00	0.50
October	36.50	22.40	36.35	22.48	0.00	0.00	0.00	0.00
November	33.70	17.85	31.80	16.30	0.00	0.00	0.00	0.00
Monthly average	38.79	25.29	37.98	25.81	9.61	0.52	10.41	0.44

Table 2 Effect of different growing environments and fertility levels on yields and harvest index of groundnut (Pooled data of 2 years)

Treatment	Pod yield (q ha^{-1})	Kernel yield (q ha^{-1})	Haulm yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
Date of sowing					
20 April	29.71	18.91	62.27	91.98	32.53
15 May	30.84	19.62	53.32	84.16	38.00
09 June	32.31	21.00	49.42	81.73	40.86
04 July	33.44	21.25	40.90	74.34	45.53
CD (P=0.05)	1.62	1.07	1.81	1.93	1.57
Varieties					
HNG 10	36.87	23.27	63.26	100.13	37.64
TG 37A	26.28	17.12	39.69	65.97	40.82
CD (P=0.05)	1.15	0.76	1.28	1.36	1.11
Fertility levels					

Control	28.04	17.42	47.11	75.15	38.35
20kgN-40 kg P_2O_5 /ha	32.00	20.35	50.00	82.00	40.22
30kgN-60 kg P_2O_5 /ha	33.53	21.70	53.65	87.18	39.78
40kgN-80 kg P_2O_5 /ha	32.74	21.31	55.15	87.89	38.57
CD (*P*=0.05)	1.05	0.70	1.58	1.91	1.14

Table 3 Interaction effect of different growing environments and varieties on yields of groundnut (Pooled data of 2 years)

Treatment	**Pod yield (q ha^{-1})**			**Kernel yield (q ha^{-1})**			**Haulm yield (q ha^{-1})**			**Biological yield (q ha^{-1})**			**Harvest index (%)**		
	HNG 10	**TG 37A**	**Mean**	**HNG 10**	**TG 37A**	**Mean**	**HNG 10**	**TG 37A**	**Mean**	**HNG 10**	**TG 37A**	**Mean**	**HNG 10**	**TG 37A**	**Mean**
Date of sowing															
20 April	37.73	21.70	29.71	23.65	14.16	18.91	78.30	46.23	62.27	116.03	67.93	91.98	32.60	32.45	32.53
15 May	37.43	24.26	30.84	23.46	15.78	19.62	65.63	41.01	53.32	103.05	65.27	84.16	37.02	38.99	38.00
09 June	37.89	26.73	32.31	24.44	17.56	21.00	62.38	36.46	49.42	100.27	63.19	81.73	38.61	43.12	40.86
04 July	34.44	32.44	33.44	21.51	20.99	21.25	46.74	35.06	40.90	81.18	67.51	74.34	42.33	48.73	45.53

Mean	36.87	26.28	23.27	17.12	63.26	39.69	100.13	65.97	37.64	40.82
CD (*P*=0.05)		2.30	1.52		2.56		2.73		2.22	

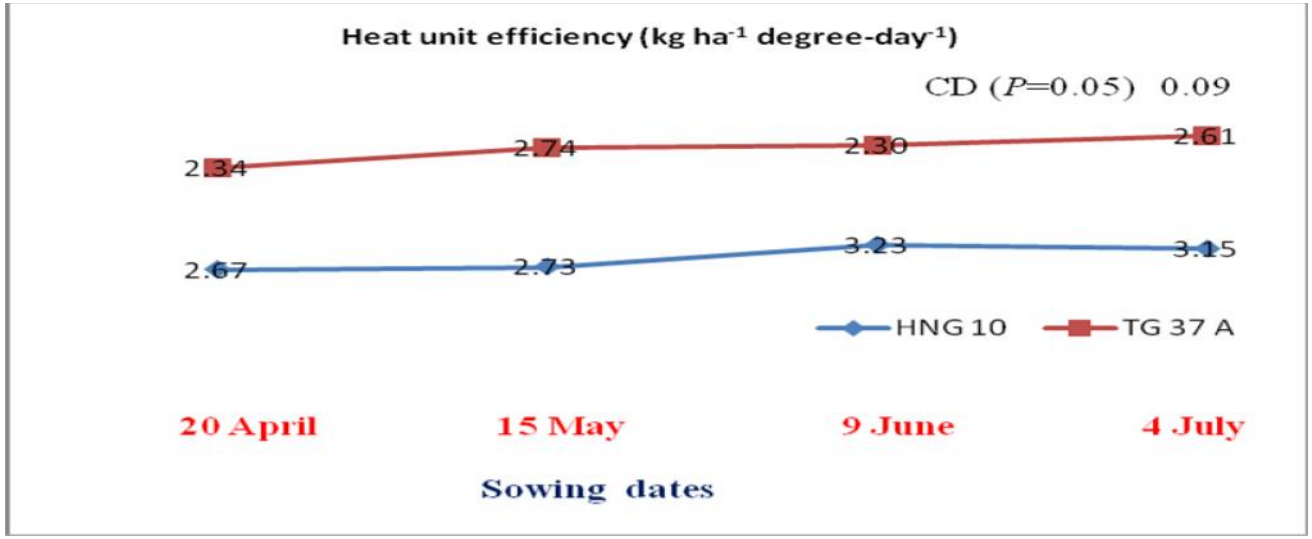
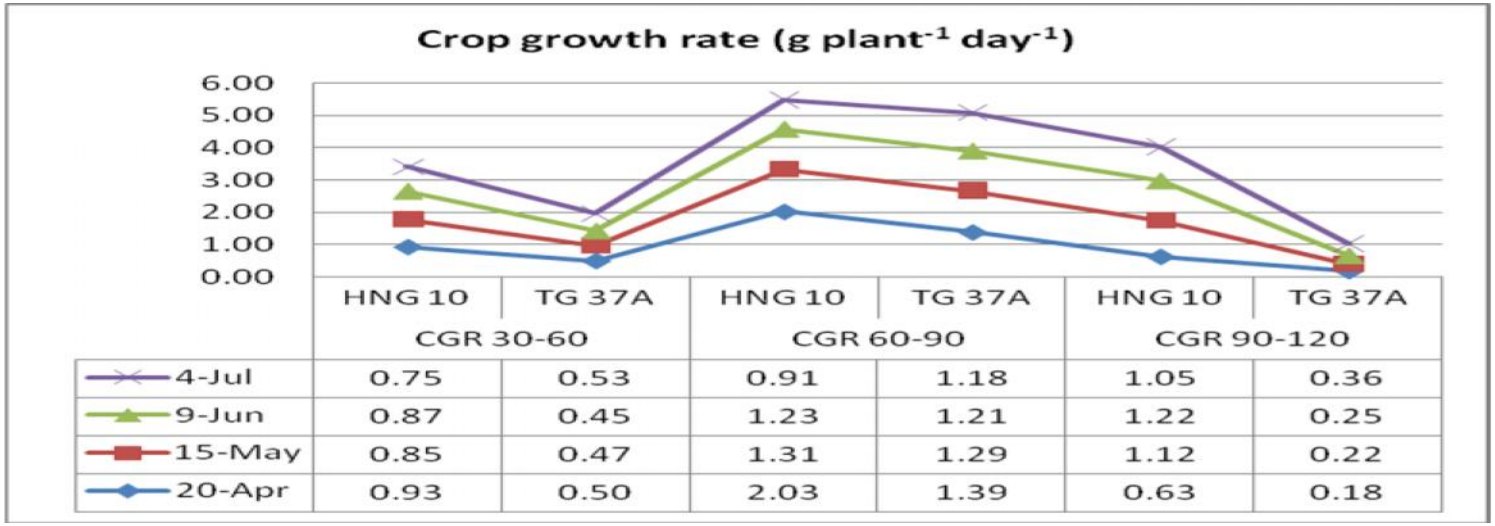


Figure 1 Effect of sowing enviroments on heat unit efficency of groundnut varieties (Pooled data of 2 years)



	HNG 10	TG 37A	HNG 10	TG 37A	HNG 10	TG 37A
	CGR 30-60		CGR 60-90		CGR 90-120	
4-Jul	0.75	0.53	0.91	1.18	1.05	0.36
9-Jun	0.87	0.45	1.23	1.21	1.22	0.25
15-May	0.85	0.47	1.31	1.29	1.12	0.22
20-Apr	0.93	0.50	2.03	1.39	0.63	0.18

Figure 2 Effect of sowing enviroments on crop growth rate of groundnut varieties cgrowth rate (Pooled data of 2 years)