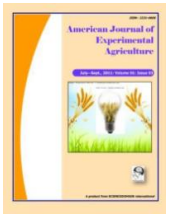

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Temperature Use Efficiency and Yield of Groundnut Varieties in Response to Sowing Dates and Fertility Levels in Western Dry Zone of India

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Authors' contributions

All authors contribute for designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author RSM carried out edited corrections and facilitated all e-mail correspondences .All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted in loamy sand soil during *kharif* season of 2009 and 2010 to evaluate the temperature use efficiency and yield of groundnut varieties in response sowing dates and fertility levels. The treatments consisted of four sowing dates (20 April, 15 May, 9 June and 4 July) and two varieties of groundnut (HNG 10 and TG 37A) as main-plot treatments and four fertility levels of nitrogen and phosphorus application (0, 20 N-40 P2O5, 30-60 P2O5 and 40 N-80 P2O5 kg ha^{-1}) as sub-plot making a total of 32 treatment combinations. The experiment was laid out in

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split-plot design with three replications and crop growth rate, yield parameters, harvest index and temperature use efficiency were recorded on crop. The results showed that significantly higher crop growth rate (CGR) at 30-60 and 60-90 days after sowing (DAS) was observed in HNG 10 variety. Further delays in sowing from 9 June significantly reduce crop growth rate. However, the growth rate of TG 37A variety was observed to be statistically at par among the sowing dates. In HNG 10 variety higher pod yield (3773, 3743 and 3738 kg ha^{-1}), kernel, haulm and biological yield were observed at par to each other from 20 April to 9 June sowing, respectively. Maximum heat unit efficiency (3.23 kg ha^{-1} degree- day-1) was observed on 9 June sowing date while the highest yield (2628 kg ha-1) was recorded in TG 37A variety with 4 July sowing. Harvest index in both the varieties was observed to be significantly higher in 4 July sowing date. All the fertility treatments produced significantly higher crop growth rate and yields than the treatments receiving no fertilizer application. Application of 30 kg N-60 kg P2O5 ha^{-1} significantly enhanced the crop growth and yield over 20 kg N-40 kg P2O5 ha^{-1} and control but at par with 40 kg N-80 kg P2O5 ha^{-1}. However, the crop uses maximum temperature in the month of June for better growth and yield. Thus, it could be concluded that the suitable sowing date of HNG 10 and TG 37A varieties in western dry zone of India are around 9 June and 4 July respectively. Application of 30 kg N-60 kg P2O5 ha^{-1} was optimum for growth and yield of the crop.

Keywords: CGR; groundnut; sowing date; fertility levels; heat unit efficiency; yields.

1. INTRODUCTION

Groundnut is an important oil crop in India. During 2011-2012, India could produce groundnut of 6.94 mt [1]. In dry agricultural area, farmers have limited time for crop sowing, but in regular irrigation is one of the most important non-monetary inputs affecting yield of crops. Sowing time of groundnut is well documented in other regions [2]. In Bikaner region, groundnut sows is under irrigated conditions. It 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 of April and May for better crop establishment with its harvesting in between October to November. In western dry zone of India some workers [3] reported application of 60 kg N/ha along with equal level of phosphorus as the appropriate fertilizer level while others recommended 20 kg N and 32 kg P_2O_5 ha^{-1} for groundnut. Due to the variation in the optimum fertilizer requirement for groundnut reported by research workers it has also become necessary to determine fertilizer requirement for the crop varieties of different maturity under different sowing dates. This research was conducted using two varieties of groundnut to find suitable sowing dates and fertilizer levels on growth and yield of groundnut in dry western zone of India.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment 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 73º 22' E longitudes at an altitude of 234.70 meters above mean sea level (*Arabian* Sea).

2.2 Soil

The soil of the experimental site was loamy sand and having 156.33 kg ha^{-1} alkaline permanganate oxidizable N [4], 16.05 kg ha^{-1} available P [5], 221.0 kg ha^{-1} 1 *N* ammonium acetate exchangeable K [6] and 0.80% organic carbon [7]. 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.

2.3 Temperature

On daily basis maximum and minimum daily air temperature data were recorded from Agro meteorological observatory, Agricultural Research Station, Bikaner. Temperature at which there is no growth which is also called base temperature, it is taken as 10°C [8] for groundnut growth and calculated temperature use efficiency. Interaction effect was observed in different sowing dates and varieties on use of

temperatures. The temperature use efficiency went on increasing from vegetative growth to pod filling and physiological maturity of the crop Nuttonson [9].

2.4 Cultural Practices

The seed treated with chloropyriphos at the rate of 2.5 ml/kg before sowing, HNG 10 and TG 37A were sown at the seed rate of 80 kg, 70 kg/ha, respectively. Row spacing of HNG 10 and TG 37A was 25 cm and 30 cm with 5 cm depth. Nitrogen and phosphorus were applied as per treatment using urea (46% N) and SSP 16% P_2O_5 as nutrient sources. The fertilizers were applied as basal application in the furrows just before sowing at a depth of 8-10 cm by "*pora*" method (indigenous). Gap filling and thinning was also done at appropriate stage. In addition to rainfall received during the both cropping seasons average 22.5, 19.5, 16.5 and 12.5 irrigations in HNG 10 and 16.5, 14.5, 13.4 and 11.5 life saving irrigations in TG 37A were given in 20 April, 15 May, 9 June and 4 July sowing respectively, irrigation through sprinkler system from time to time to ensure optimum growth, development and yield of groundnut. Hand weeding was done manually with the help of hand hoe to keep the field weed free. At the time of second weeding earthing up along the rows was also done for improvement in pegging. Groundnut was grown as per recommended practices and was harvested as per days to maturity both the years of experimentation. The crop was harvested manually by uprooting the whole plant when leaf veins started yellowing and about more than 90 per cent pods became fully mature. The plants from each net plot were harvested separately and stacked plot wise for sun drying and subsequent threshing.

2.5 Statistics

The experiment was laid out in split-plot design with three replications, assigning 32 treatments consisting of four sowing dates (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 and crop growth rate, yield parameters, harvest index and temperature use efficiency were recorded on crop. All the data obtained from groundnut for two consecutive years of trails were statistically analyzed using the *F*-test [10] Critical difference (CD) values at *P*=0.05 were used for determine the significance of differences during mean values of treatments.

3. RESULTS AND DISCUSSION

3.1 Crop and Weather

Maximum rainfall of 51.50 mm and 21.00 mm were recorded in July of 2009 and August 2010, respectively (Table 1). Highest temperature was observed in of May of both the years. Growth of groundnut was affected by different uncontrollable environmental conditions. Interaction effect was observed in different sowing dates 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 different sowing dates, heat unit efficiency was found to be higher in 9 June than all other three sowing dates (Fig.1). Significantly higher heat unite efficiency was observed in HNG 10 variety compared with TG 37A variety HNG 10 variety used most heat units to reach maturity in vegetative growth [11]. These results are also enclosed agreement with the findings [12].

3.2 Temperature Use Efficiency

Efficiency of utilization of temperature in terms of dry matter accumulation depends on crop type, genetic factors and sowing. Duration of crop phenophases is an essential component of weather based dynamic crop growth rate and yield simulation models. Crop phenology can be used to specify the most appropriate sowing date 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 [11].

3.3 Crop Growth Rate

Results showed that of tested varieties in the study, in HNG 10 variety higher crop growth rate was observed than TG 37A variety (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. The variable behaviour of these varieties could be explained in genetic constitution and variation in growth

habit of these varieties the similar interaction effect recorded on heat unit efficiency of these varieties. HNG 10 variety is semi-spreading variety which seems to have indeterminate growth habit 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 TG 37A variety was 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].

3.4 Yields

HNG 10 variety was recorded higher and almost similar pod yield (3773, 3743 and 3738 kg ha-^{1}), and kernel yields under the first three sowing dates beginning from 20 April to 9 June, respectively (Table 3). Delayed sowing of this variety beyond 9 June on 4 July resulted in significant reduction in these yield (3444 kg ha^{-1}). On the contrary, yield of TG 37A variety progressively increased under later dates of sowing with the highest yields recorded under the last sowing date of 4 July (2628 kg ha^{-1}). 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 an experiment conducted at Aydın (Turkey) on groundnut to determine the appropriate planting date for peanut under the ecological conditions of Aydın and to investigate the effect of different sowing dates on some agronomic traits, yield, and yield components of 3 commercial peanut cultivars (Gazipaşa, Florispan, and NC-7) and the local cultivar. Peanut growth is affected by planting date in semi-arid regions, such as Aydın, where high temperatures and drought stress occur during late crop development and maturation periods [13]. Similar field study conducted on groundnut with four varieties (TPG-41, TKG-19A, TG-37A and GG2) and recorded significantly higher pods per plant, kernel per pod and 100 kernel-weights in GG2 than other three varieties due to the varietal and environmental characteristics seed or kernel size and recovery of sound mature kernels are two important traits exhibiting considerable variability among the yield of groundnut verities [14].

Sowing dates also had significant interaction effects with crop varieties on haulm and biological yields of groundnut (Table 3). The HNG 10 variety was 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 4674 kg ha^{-1} and biological yield of 8118 kg ha^{-1}. This could be explained due to the similar variation in the maturity periods made available to this variety for overall growth [2]. 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 was 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 TG 37A variety was 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 variety due to 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 TG 37A variety was recorded a reverse trend in pod yield as affected by sowing dates with the lowest yield recorded under the first date of 20 April 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, TG 37A variety was recorded almost similar biological yields with minor variations under various sowing dates due to 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 was also in close agreement with the findings [15].

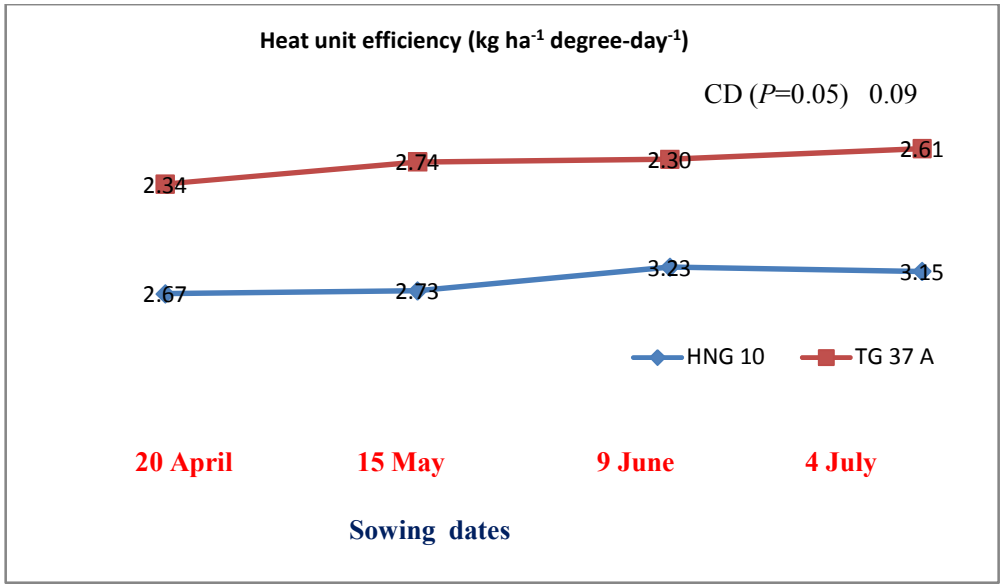
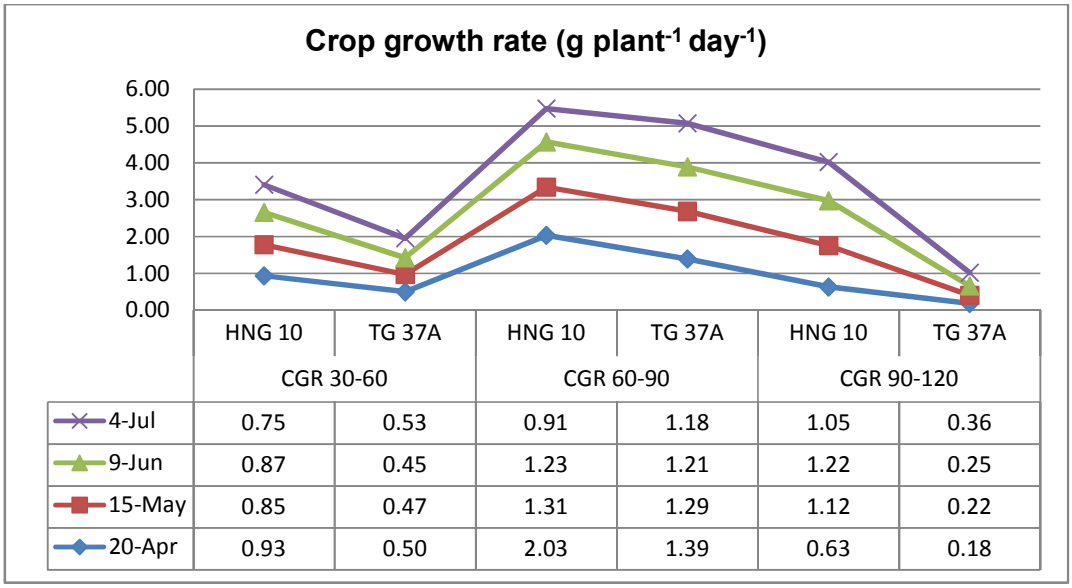


Fig. 1. Effect of sowing dates on heat unit efficency of groundnut (Pooled data of 2 years)



	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

Fig. 2. Effect of sowing dates on crop growth rate of groundnut (Pooled data of 2 years)

3.5 Effect of Fertility Levels

Application of nitrogen and phosphorus up to 30 kg N-60 kg P_2O_5 ha^{-1} was recorded higher pod yield, kernel yield, haulm yield and biological yield (Table 2) over control and 20 kg N-40 kg P_2O_5 ha^{-1}. Further increase in 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 with suitable temperature requirement towards reproductive structures on the other might have increased the yield attributes significantly result was agreement with those of [16].

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 sowing dates and fertility levels on yields and harvest index of groundnut (pooled data of 2 years)

Treatment	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index(%)
Sowing date					
20 April	2971	1891	6227	9198	32.53
15 May	3084	1962	5332	8416	38.00
09 June	3231	2100	4942	8173	40.86
04 July	3344	2125	4090	7434	45.53
CD (*P*=0.05)	1.62	1.07	1.81	1.93	1.57
Varieties					
HNG 10	3687	2327	6326	10013	37.64
TG 37A	2628	1712	3969	6597	40.82
CD (*P*=0.05)	1.15	0.76	1.28	1.36	1.11
Fertility levels					
Control	2804	1742	4711	7515	38.35
20kgN-40 kg P_2O_5 /ha	3200	2035	5000	8200	40.22
30kgN-60 kg P_2O_5 /ha	3353	2170	5365	8718	39.78
40kgN-80 kg P_2O_5 /ha	3274	2131	5515	8789	38.57
CD (*P*=0.05)	1.05	0.70	1.58	1.91	1.14

Table 3. Interaction effect of different sowing dates and varieties on yields of groundnut (pooled data of 2 years)

Treatment	Pod yield (kg ha^{-1})		Kernel yield (kg ha^{-1})		Haulm yield (kg ha^{-1})		Biological yield (kg ha^{-1})		Harvest index (%)	
	HNG 10	TG 37A	HNG 10	TG 37A	HNG 10	TG 37A	HNG 10	TG 37A	HNG 10	TG 37A
sowing date										
20 April	3773	2170	2365	1416	7830	4623	11603	6793	32.60	32.45
15 May	3743	2426	2346	1578	6563	4101	10305	6527	37.02	38.99
09 June	3789	2673	2444	1756	6238	3646	10027	6319	38.61	43.12
04 July	3444	3244	2151	2099	4674	3506	8118	6751	42.33	48.73
Mean	3687	2628	2327	17.12	6326	3969	10013	6597	37.64	40.82
CD (*P*=0.05)		2.30	1.52		2.56		2.73		2.22	

4. CONCLUSION

The present study indicates that suitable sowing date for HNG 10 variety to be around 9 June and TG 37A variety for 4 July and recommended fertilizing dose 30 kg N-60 kg P_2O_5 ha^{-1} for better growth and higher productivity of groundnut in western dry zone of India. However, groundnut crop use maximum temperature in June moth for better growth of HNG 10. These provide very clear picture of the amount, pattern and efficiency of heat energy consumption of the crops. These can also be used very effectively for forecasting the occurrence of different phenophases of the crops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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