

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~~ ^{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 P₂O₅, 30-60 P₂O₅ and 40 N-80 P₂O₅ 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~~ ^{every} growth rate in ~~all the~~ ^{TG 37A variety} sowing dates of ~~TG 37A~~ was observed statistically at par with each other. In semi-spreading ~~variety HNG 10 recorded~~ ^{HNG 10 variety was 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~~ ^{sowing date of 9 June}. ~~While, highest~~ ^{While the 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 P₂O₅ ha⁻¹ significantly enhanced the crop growth, Heat unit and yield over 20 ~~kg N~~ ^{kg N}-40 kg P₂O₅ ha⁻¹ but at par with 40 kg N-80 kg P₂O₅ ha⁻¹.

Key words Crop growth, ~~Date of sowing~~ ^{Sowing dates}, Fertility levels, Heat unit, Yields

INTRODUCTION

Groundnut is an important ~~oilseed crop play a major role in bridging the vegetable oil gap in the~~ ^{oil crop in India. Between 2011-2012, India could produce groundnut of 6.94 mt [1].} country. The total oilseed production in India during 2011-12 was 26.45 mt, of which groundnut

production was 6.94 mt, from 5.32 mha area with an average productivity around 1305 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~~ ^{between October to 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.~~ ^{These research was done in two varieties of groundnut to fine suitable sowing time to escape adverse situations.}

Materials and Methods

Experimental Site: ~~Experimental trail~~ ^{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 28° 01'N latitude and 73 ° 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.

Statistics: The experiment was laid out in split-plot design with three replications, assigning 32 treatments consisting of four ~~date of sowing~~ ^{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 P₂O₅, 30 N: 60 P₂O₅ and 40 N: 80 P₂O₅ 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~~ ^{were} 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~~ ⁱⁿ 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]~~ ^{HNG 10 variety compared with TG 37A variety} ^{HNG 10 variety used most heat units to reach maturity in vegetative growth [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~~ ^{was} 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

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~~ ^{HNG 10 variety} higher crop growth rate was observed than ~~TG-37A~~ ^{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 [10] (~~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~~ ^{HNG 10 variety was} 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 variety was} ~~TG-37A is~~ a Spanish bunch type and probably seems to be a variety of short duration maturity and determinate growth habit. ~~Thus~~ ^{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~~ ^{HNG 10 variety was} 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

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

114 Dates of sowing also had significant interaction effects with crop varieties on haulm and biological
 115 yields of groundnut (Table 3). The variety HNG 10 recorded the highest haulm and biological
 116 yields when planted on the earliest sowing date of 20 April. Sowing of this variety on latter dates
 117 resulted in significant reduction with each delay in sowing with the lowest haulm yield of 46.74 q
 118 ha⁻¹ and biological yield of 81.18 q ha⁻¹. This could be explained due to the similar variation in the
 119 maturity periods made available to this variety for overall growth. Thus the variation in the haulm
 120 yield recorded under different dates of sowing with the minimum haulm yield recorded in last date
 121 of sowing. The ~~variety HNG 10 also~~ ^{HNG 10 variety was} recorded almost similar variation in biological yield as that
 122 observed in haulm yield due to the effect of sowing dates. Since biological yield ~~is~~ ^{was} a cumulative
 123 function of haulm and pod yields, the variation in biological yield with sowing dates could be
 124 mainly attributed to the haulm yield with minor contribution from the pod yield, as the pod yield
 125 of this variety was almost similar in the three initial dates with reduction only under the last date of
 126 sowing. Similarly ~~variety TG 37A also~~ ^{TG 37A variety was} recorded significant reduction in haulm yield with every
 127 delay in sowing but the reduction was found to be considerably lower than that recorded in ~~HNG~~
 128 ~~10 due~~ ^{HNG 10 variety due to} probably to its determinate growth habit. This type of growth habit did not allow the
 129 variety to widen the variation in haulm yield with variation in maturity periods as affected by
 130 sowing dates. In contrast to haulm yield, the ~~variety TG 37A~~ ^{TG 37A variety was} recorded a reverse trend in pod yield
 131 as affected by ~~dates of sowing~~ ^{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, ~~variety TG 37A~~ ^{TG 37A variety was} recorded almost similar biological yields with minor variations under various sowing dates ~~due~~ ^{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 ~~are~~ ^{was} also in close agreement with the findings [4, 10].

140 *Effect of fertility levels*

Application of nitrogen and phosphorus up to 30 kg N-60 kg P₂O₅ ha⁻¹ was observed higher pod yield, kernel yield, haulm yield biological yield (Table 2) over control and 20 kg N-40 kg P₂O₅ ha⁻¹. Further increase the fertility level up 40 kg N-80 kg P₂O₅ ha⁻¹ was statistically at par with 30 kg N-60 kg P₂O₅ 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~~ ^{was} agreement with those of [2].

150 **References**

- 151 1. ASG. Agricultural statistics at a glance. Department of Agriculture and Co-operation, Ministry
152 of Agriculture Government of India, 128-185. 2012.
- 153 2. Bala, H M B, Ogunlela, V B, Kuchinda, N C and Tanimu, B. Response of two groundnut
154 (*Arachis hypogaea* L.) varieties to sowing date and NPK fertilizer rate in a semi-arid
155 environment: yield and yield attributes. Asian J. Crop Sci. **3**(3):130-134. 2011.
- 156 3. Canver, K, Kayank, A M. Effect of different planting dates on yield and yield components of
157 peanut (*Arachis hypogaea* L.). Turk J. Agri. **32**(1):521-528. 2008.

- 158 4. Gochar, R. Effect of cultivars and weed management on late sown groundnut (*Arachis hypogaea*
159 L.) in north western Rajasthan. *M.Sc. (Agri.) Thesis* submitted to SKRAU, Bikaner pp54.
160 2011.
- 161 5. Gomez, K A and Gomaz, A, Statistical Procedures for Agricultural Research. John Wiley &
162 Sons, Singapore.1984.
- 163 6. Gouri, V, Reddy, R, Narayansimha, SBS, and Rao, Y A. Thermal requirement of *rabi*
164 groundnut in Southern Telangana Zone of Andhra Pradesh. *J. Agromet.* 7(1): 09-94. 2005.
- 165 7. Hariprasanna, K L, Chuni and Radhekrishana, T. Relationship between flowering duration and
166 physical-quality traits as well as pod yield in groundnut (*Arachis hypogaea* L.) Indian J.
167 Agri.l Sci. 78(2):180-2. 2008.
- 168 8. Jackson, M. L., 1973. Soil Chem. Ana. Prentice Hall of India Pvt Ltd, New Delhi.
- 169 9. Kingra, P. K., Kaur, P. Effect of dates of sowing on thermal utilization and heat use efficiency
170 of groundnut cultivars in central Punjab. *J Agri. Ph.* 12(1):54-62. 2012.
- 171 10. Meena, R S, Yadav, R S, and Meena, VS. Response of Groundnut (*Arachis Hypogaea* L.)
172 Varieties to Sowing Dates and NP Fertilizers under Western Dry Zone of India. *B. J. Botn.*
173 43(2): 169-173. 2014.
- 174 11. Meena, RS, Yadav, RS, Meena and VS, Heat Unit Efficiency of Groundnut Varieties in
175 Scattered Planting with Various Fertility Levels. *The Bio.* , 9(1): 1189-1192. 2013.
- 176 12. Olsen, S R, Cole, CV, Watanabe, F S and Dean, L A. Estimation of available phosphorus in
177 soils by extraction with sodium bicarbonate. *USDA Circ.* No. 939, Washington. 1954.
- 178 13. Sardana, V and Kandhola, S. S. Productivity of semi-spreading and bunch type varieties of
179 groundnut as influenced by sowing dates. *An O.p Accs. J.* published by ICRISAT 5:1-3.
180 2007.
- 181 14. Sardana, V, Singh, S and Sheoran, P. Influence of sowing dates on the productivity of semi-
182 spreading and bunch type varieties of groundnut. *Indian J. Agri. Sc.*, 78(2):372-4. 2008.
- 183 15. Stanford, S, and English, L. Use of flame photometer in rapid soil tests for K and Ca. *Agron.*
184 *J.*, 41: 446-7. 1949.
- 185 16. Subbiah, B V and Asija, GL.. A rapid processor of determination of available nitrogen in
186 nitrogen in soil. *Curr. sci.* 25:259-260. 1956

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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

UNDER PEER REVIEW

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 (<i>P</i> =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 (<i>P</i> =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 ₂ O ₅ /ha	32.00	20.35	50.00	82.00	40.22
30kgN-60 kg P ₂ O ₅ /ha	33.53	21.70	53.65	87.18	39.78
40kgN-80 kg P ₂ O ₅ /ha	32.74	21.31	55.15	87.89	38.57
CD (<i>P</i> =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	

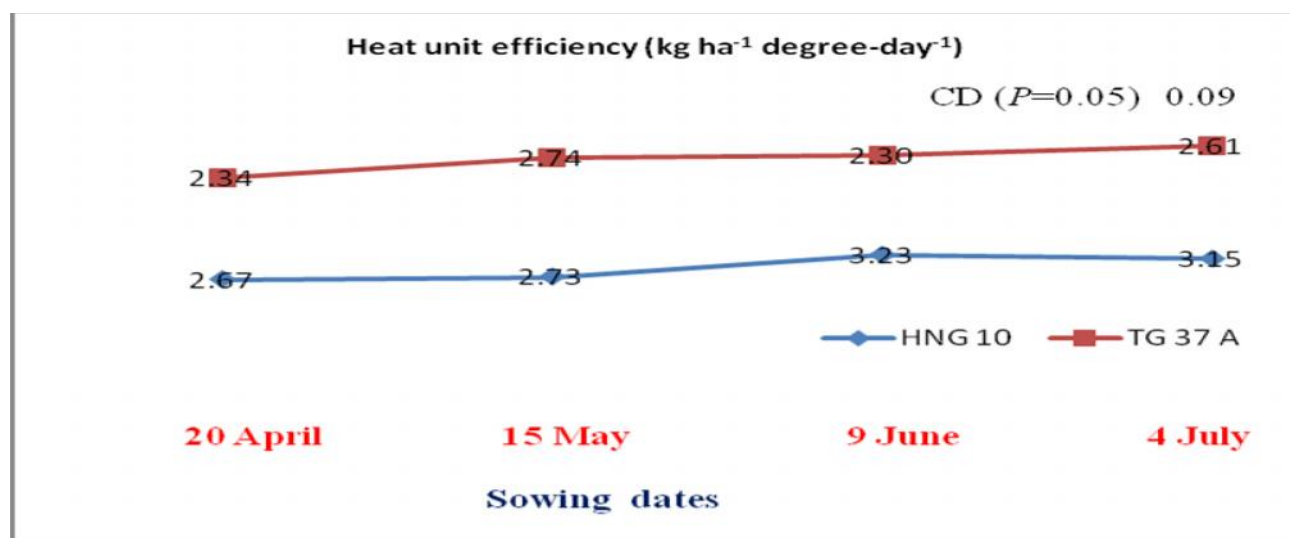


Fig. 1

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

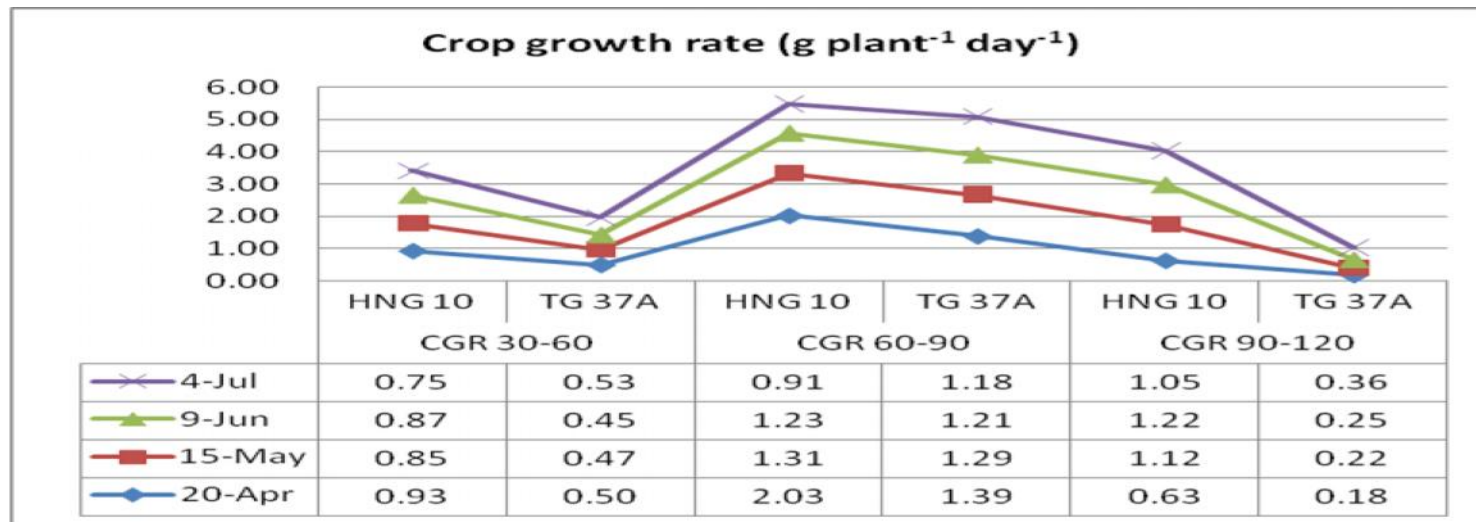


Figure 2 Effect of sowing environments on crop growth rate of groundnut varieties (Pooled data of 2 years)