

## Original Research Article

### **Temperature Requirement on growth and yield of Groundnut (*Arachis hypogaea* L.) under Dry Western Zone of India**

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#### **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 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<sub>2</sub>O<sub>5</sub>, 30-60 P<sub>2</sub>O<sub>5</sub> and 40 N-80 P<sub>2</sub>O<sub>5</sub> kg ha<sup>-1</sup>) 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, growth rate in every every sowing dates of TG 37A variety was observed statistically at par with each other. In semi-spreading 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 sowing date of 9 June. While the highest yields were recorded in TG 37A variety with 4 July sowing. 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<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> significantly enhanced the crop growth, Heat unit and yield over 20 kg N-40 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> but at par with 40 kg N-80 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>.

**Key words** Crop growth, Sowing date, Fertility levels, Heat unit, Yields

**Comment [H1]:** Did you impose the impose temperature treatment?

**Comment [H2]:** Temperature requirement could only be determined in a controlled environments with different temperatures imposed as treatments

**Comment [H3]:** I don't agree with this title as is does not capture the content of the research.

**Comment [H4]:** Temperature requirement does not mean fertilizer application and sowing date

**Comment [H5]:** to study.....? Here insert the objective of the research

**Comment [H6]:** Is this temperature requirement?

**Comment [H7]:** Insert conclusion here as well

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## 26 INTRODUCTION

27 Groundnut is an important oil crop in India. Between 2011-2012, India could produce groundnut  
28 of 6.94 mt [1]. In dry agricultural area, farmers have limited time for crop sowing, but in ~~irregular~~  
29 irregular irrigation is one of the most important non- monetary inputs affecting yield of crops.  
30 Sowing time of groundnut is well documented in other regions [13]. In Bikaner region, groundnut  
31 sowing is under irrigated conditions. It was started two decades ago in the command area of Indra  
32 Gandhi Nahar Pariyojana (IGNP) and later on it spread to tube well irrigated area of the region. At  
33 that time, dust storms were common in the region with minimum vegetation during optimum  
34 sowing time of May and June months leading to poor crop establishment due to which the farmers  
35 started sowing of groundnut in early summer in the months of April and May for better crop  
36 establishment with its harvesting in between October to November. This practice is still followed,  
37 despite reduction in frequency of dust storms in the region. The productivity is restrained by  
38 drought stress, the use of low levels of inputs by smallholders and marginal farmers in dry land  
39 areas, high incidence of aberrant weather conditions. ~~This ese~~ research was done in two varieties of  
40 groundnut to finde suitable sowing time to escape adverse situations.

**Comment [H8]:** The problem statement is not clear. How about fertility issues?

**Comment [H9]:** Is this to find suitable temperature?!!!!

## 41 Materials and Methods

42 **Experimental Site:** The experimental was conducted during *kharif* season of 2009 and  
43 2010 at Agronomy Research Farm, College of Agriculture, Bikaner (Rajasthan) under hyper  
44 arid condition, which is situated at a 28° 01'N latitude and 73 ° 22' E longitudes at an  
45 altitude of 234.70 meters above mean sea level (*Arabian* Sea).

46 **Soil:** The soil of the experimental site was loamy sand and having 156.33 kg ha<sup>-1</sup> alkaline  
47 permanganate oxidizable N[16], 16.05 kg ha<sup>-1</sup> available P [12], 221.0 kg ha<sup>-1</sup> 1 N ammonium  
48 acetate exchangeable K [15] and 0.80% organic carbon [8] The pH of soil was 8.4 (1:2.5 soil and  
49 water ratio). Field capacity, permanent wilting point and bulk density recorded were 8.4.0% (w/w),  
50 1.1.83% (w/w) and 1.66 Mg m<sup>-3</sup>, respectively in 0-30 cm soil depth.

51

52 [Cultural practices](#)

53 [Here the author must describe planting practices as planting, spacing, weeding, crop protection,](#)  
54 [harvesting, drying, processing etc](#)

55 **Statistics:** The experiment was laid out in split-plot design with three replications, assigning 32  
56 treatments consisting of four sowing dates (20 April, 15 May, 9 June and 4 July) and two varieties  
57 (HNG 10 and TG 37A) as main plot treatments and four fertility levels of nitrogen and phosphorus  
58 application (0, 20 N: 40 P<sub>2</sub>O<sub>5</sub>, 30 N: 60 P<sub>2</sub>O<sub>5</sub> and 40 N: 80 P<sub>2</sub>O<sub>5</sub> kg ha<sup>-1</sup>) as sub-plots. All the data  
59 obtained from groundnut for two consecutive years of trials were statistically analyzed using the *F*-  
60 test [5]. Critical difference (CD) values at *P*=0.05 were used for determine the significance of  
61 differences between mean values of treatments.

## 62 **Results and Discussion**

### 63 ***Crop and weather***

64 Maximum rainfall of 51.50 mm and 21.00 mm were recorded in the month of July 2009 and  
65 August 2010, respectively (Table 1). Highest temperature was observed in the month of May in  
66 both the years. Growth and development of groundnut were affected by different uncontrollable  
67 environmental conditions. Interaction effect was observed in different sowing environment and  
68 varieties on thermal temperatures. The heat unit efficiency went on increasing from vegetative  
69 growth to pod filling and physiological maturity of the crop. Among the sowing environment, heat  
70 unit efficiency was found to be higher in 9 June sowing than all other three sowing environments  
71 (Fig.1). Significantly higher heat unite efficiency was observed in HNG 10 variety compared with  
72 TG 37A variety HNG 10 variety used most heat units to reach maturity in vegetative growth [9].  
73 These results are also enclose agreement with the findings [6,11].

### 74 ***Temperature use efficiency***

75 Efficiency of utilization of temperature in terms of dry matter accumulation depends on crop type,  
76 genetic factors and sowing time and has great practical application [11] Initiation as well as  
77 duration of crop phenophases is an essential component of weather based dynamic crop growth  
78 rate and yield simulation models. Crop phenology can be used to specify the most appropriate date

**Comment [H10]:** This is not the appropriate word to use.

**Comment [H11]:** Sowing dates as treatment does not mean temperature effect. Temperature effect could only be assessed in a controlled environment such as the green house or using different environments/locations with varying temperatures

**Comment [H12]:** The sources of these nutrients must be stated. ie the fertilizers used and the composition of each

79 and time of specific development process. The duration of each phenophase determines the  
80 accumulation and partitioning of dry matter in different organs reported that the duration of a  
81 particular crop growth stages was directly related to temperature and this duration of particular  
82 species could be predicted using the sum of daily air temperature [9].

### 83 **Crop growth rate**

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

### 101 **Yields**

102 HNG 10 variety was recorded higher and almost similar pod and kernel yields under the first three  
103 sowing dates beginning from 20 April to 9 June (Table 3). Delayed sowing of this variety beyond 9  
104 June on 4 July resulted in significant reduction in these yields. On the contrary, yield of TG 37A  
105 variety progressively increased under later dates of sowing with the highest yields recorded under

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

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

132 yield is a cumulative function of haulm and pod yields, TG 37A variety was recorded almost  
133 similar biological yields with minor variations under various sowing dates due to certainly to  
134 opposing trends in haulm and pod yields recorded as affected by sowing dates. Thus, the  
135 cumulative effect of the variation in growth and yield attributes of the two varieties recorded with  
136 variation in sowing dates resulted variation in various yields of groundnut namely pod, kernel, oil,  
137 haulm and biological yields as a result of interaction effect between genetic constitution of the  
138 varieties and environmental factors, These results was also in close agreement with the findings [4,  
139 10].

#### 140 **Effect of fertility levels**

**Comment [H13]:** Is this effect of temperature?  
This must be captured in the title

141 Application of nitrogen and phosphorus up to 30 kg N-60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> was ~~observed~~ recorded  
142 higher -pod yield, kernel yield ~~and~~, haulm yield biological yield (Table 2) -over control and 20 kg  
143 N-40 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. Further increase in the fertility level up 40 kg N-80 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> was  
144 statistically at par with 30 kg N-60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>. Early and plentiful availability of nitrogen and  
145 phosphorus to plants favourably influenced the kernel development and kernel size, which  
146 ultimately resulted in, increased pod and seed index and shelling percentage. Improved overall  
147 growth and profuse branching due to nitrogen and phosphorus fertilization led to increased net  
148 photosynthesis on one hand and greater mobilization of photosynthates towards reproductive  
149 structures on the other might have increased the yield attributes significantly result was agreement  
150 with those of [2].

#### 151 **Conclusion**

152 Field study was recommended suitable sowing date of HNG 10 variety around 9 June and TG 37A  
153 variety for 4 July in western dry zone of India. Application of fertilizing dose recommended 30 kg  
154 N-60 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> for better growth and higher productivity of groundnut. However, groundnut  
155 crop use maximum temperature in June month for better growth.

**Comment [H14]:** You need to recast this  
statement using sound grammar

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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 <sup>-1</sup> ) | Kernel yield (q ha <sup>-1</sup> ) | Haulm yield (q ha <sup>-1</sup> ) | Biological yield (q ha <sup>-1</sup> ) | Harvest index (%) |
|-----------------------------------------------|---------------------------------|------------------------------------|-----------------------------------|----------------------------------------|-------------------|
| <b>Date of sowing</b>                         |                                 |                                    |                                   |                                        |                   |
| 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              |
| <b>Varieties</b>                              |                                 |                                    |                                   |                                        |                   |
| 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              |
| <b>Fertility levels</b>                       |                                 |                                    |                                   |                                        |                   |
| Control                                       | 28.04                           | 17.42                              | 47.11                             | 75.15                                  | 38.35             |
| 20kgN-40 kg P <sub>2</sub> O <sub>5</sub> /ha | 32.00                           | 20.35                              | 50.00                             | 82.00                                  | 40.22             |
| 30kgN-60 kg P <sub>2</sub> O <sub>5</sub> /ha | 33.53                           | 21.70                              | 53.65                             | 87.18                                  | 39.78             |
| 40kgN-80 kg P <sub>2</sub> O <sub>5</sub> /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 <sup>-1</sup> ) |        |       | Kernel yield (q ha <sup>-1</sup> ) |        |       | Haulm yield (q ha <sup>-1</sup> ) |        |       | Biological yield (q ha <sup>-1</sup> ) |        |       | 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              |        |       |

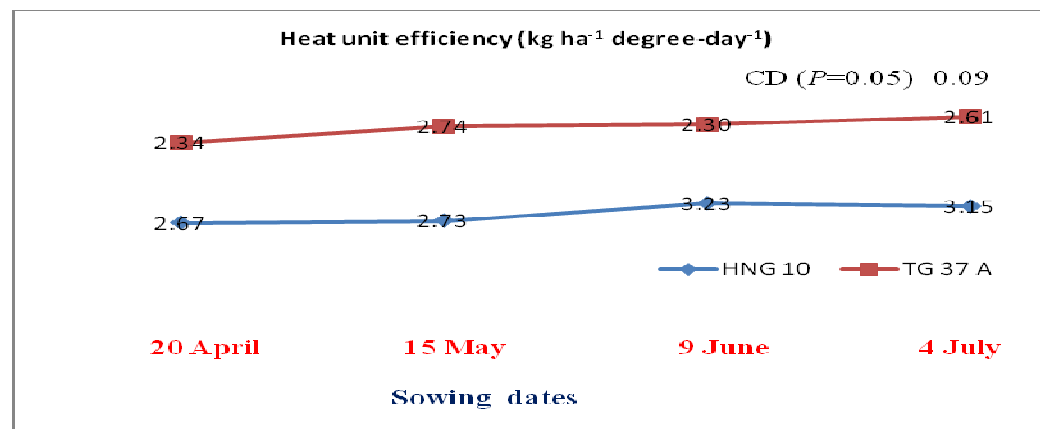


Fig. 1 Effect of sowing environments on heat unit efficiency of groundnut varieties (Pooled data of 2 years)

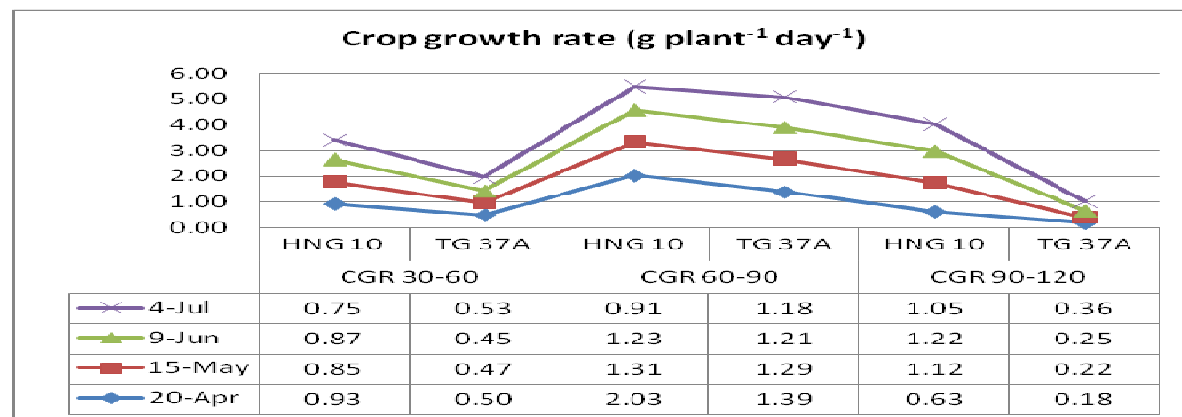


Fig. 2 Effect of sowing environments on crop growth rate of groundnut varieties cgrowth rate (Pooled data of 2 years)