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Effect of Sowing Windows on Growth and Yield of Groundnut (*Arachis hypogaea* L.) Genotypes

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A B S T R A C T

In general groundnut (*Arachis hypogaea* L.) crop is subjected to varied climatic conditions and monsoon vagaries in particular, as it is mostly grown under rainfed conditions during *Kharif*. It is necessary to select a suitable groundnut genotype and sowing window as a non-monetary input to reduce the effect of climate on crop yield. Field experiment was conducted at AHRS, Bavikere, UAHS, Shivamogga, to study the influence of sowing windows on growth and yield of groundnut genotypes under rainfed conditions during *Kharif*-2017 in sandy loam soil. The four groundnut genotypes *viz.*, GKVK-5, GPBD-4, G2-52 and TMV-2 and four sowing windows *viz.*, II fortnight of June, I fortnight of July, II fortnight of July and I fortnight of August were selected. The experiment was laid out in Randomized Complete Block Design with factorial concept using two factors, each with four levels replicated thrice. The experimental results revealed that, the genotype GKVK-5 recorded significantly higher pod yield (16.73 q ha^{-1}), shelling percentage and kernel yield. While, the crop sown during II fortnight of June recorded significantly higher pod yield, shelling percentage and kernel yield compared to delay in sowing. As delay in sowing decreased the crop growth and development.

Introduction

Groundnut is an important oilseed crop grown under rainfed conditions. It is a very sensitive crop to climatic variations, especially rainfall, temperature and radiation (Banik *et al.*, 2009). As the crop is grown under rainfed conditions, adequate soil moisture is required during pegging and pod development stages, to get better yield. Prathima *et al.*, (2012) reported that the photosynthetic activity of the crop is severely affected under moisture stress conditions, which reduces the crop growth and development, thereby, reducing the pod yield. Further, lack of moisture during pegging and pod filling, reduces the number of pods per plant, while that during pod development produces shriveled seeds and thereby, reduces the pod yield. Variation in any of the weather parameter causes reduction in the pod yield. Thus, it is necessary to grow the genotype which can withstand weather aberrations by adapting to varied sowing windows. Nagaeswara Rao (1992) revealed that improved genotypes contribute 25 to 28 per cent to the yield increase, while improved management practices contributed 30 to 32 per cent. Hence, an investigation was conducted to study the influence of sowing windows on growth and yield of groundnut genotypes.

Materials and Methods

Field experiment was conducted at AHRS, Bavikere, UAHS, Shivamogga during *Kharif*-2017 under rainfed conditions. The soil of the experimental site was sandy loam with acidic pH (5.7), 1.73 g kg^{-1} organic carbon, 220.90:34.30:167.40 kg available N, P_2O_5, K_2O ha^{-1}. The experiment was laid out in randomized block Design with factorial concept, containing sixteen treatment combinations with three replications.

The groundnut genotypes and sowing windows were the two factors, each with four levels. The four genotypes selected were GKVK-5, GPBD-4, G2-52 and TMV-2, while the four sowing windows were II fortnight of June, I fortnight of July, II fortnight of July and I fortnight of August. Nutrients were applied @ 25:50:25 kg NPK ha^{-1} in the form of urea, SSP and MOP, respectively along with 10 t of farm yard manure. Gypsum was applied during the time of ear thing up @ 500 kg ha^{-1}.

The seeds were sown at a depth of 5 cm with 30 x 15 cm spacing. The data on the parameters like number of branches per plant, leaf area (dm^2 $plant^{-1}$), total dry matter (g $plant^{-1}$), pod yield (q ha^{-1}) and shelling percentage were recorded and LAI, LAD, CGR and kernel yield were calculated from the recorded parameters. The amount of rainfall received during the crop growth period and water requirement of the crop at different growth stages are presented in Figure 1. The actual sunshine hours during the crop growth period and the normal sunshine hours of the research station is presented in Figure 2.

Results and Discussion

The weather parameters such as rainfall and sunshine played a critical role on the crop growth, which in turn decides the crop yield. Apart from the total amount of rainfall received, proper distribution of rainfall throughout the crop growth period is also important as seen in Figure 1. The crop requires 400-500 mm of total rainfall. Among the sowing windows, the crop sown during II fortnight of June received 444.5 mm of total rainfall, which was well distributed in 33 rainy days. Pod filling and pod development stage, received (66 mm and 126.6 mm of rainfall, respectively). The data pertaining to the number of branches per plant, total dry matter and CGR are presented in table 1. The genotype GKVK-5 recorded significantly higher number of branches per plant (10.40), total dry matter (12.99 g $plant^{-1}$) and CGR (8.15 g m^{-2} day^{-1}), which might be due to better physio-morphological characters of GKVK-5. Similar results were reported by Mohite *et al.,* (2017).

Among the sowing windows, thecrop sown during II fortnight of June recorded significantly higher number of branches per plant (11.18), total dry matter (12.73 g $plant^{-1}$) and CGR (7.93 g $m^{-2}day^{-1}$). This might be due to the proper distribution of rainfall during critical growth period of the crop and long day conditions exposed the crop to better sunlight for longer duration which produce more photosynthates and CGR for growth and development of the plant, during early sown conditions. Exposure of the crop to short day conditions reduces the vegetative growth and thereby reduces CGR (Meena *et al.,* 2015). Thus, the crop sown during I fortnight of August recorded lower CGR (6.24 g m^{-2} day^{-1}). Increase in the number of branches and crop growth rate increased the total dry matter per plant when the crop was sown during II fortnight of June.

Table.1 Influence of different sowing windows on number of branches, total dry matter and CGR of groundnut genotypes

Genotypes (G)	Sowing windows (S)														
	Number of branches ($plant^{-1}$)					Total dry matter (g $plant^{-1}$)					CGR (g m^{-2} day^{-1})				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
G_1	11.87	10.83	10.53	8.37	**10.40**	14.76	13.55	12.06	11.60	**12.99**	9.41	8.57	7.47	7.16	**8.15**
G_2	11.10	10.53	10.07	7.30	**9.75**	12.11	10.46	9.92	9.84	**10.58**	7.49	6.31	5.94	5.93	**6.42**
G_3	11.40	10.77	10.27	7.80	**10.06**	13.09	12.07	11.40	10.38	**11.73**	8.20	7.49	7.03	6.31	**7.26**
G_4	10.33	8.63	9.17	7.27	**8.85**	10.95	9.89	9.45	9.34	**9.91**	6.63	5.90	5.62	5.58	**5.93**
Mean	**11.18**	**10.19**	**10.01**	**7.68**	**9.76**	**12.73**	**11.50**	**10.71**	**10.29**	**11.30**	**7.93**	**7.07**	**6.51**	**6.24**	**6.94**

	Branches S.Em±	Branches C.D. (p=0.05)	Total dry matter S.Em±	Total dry matter C.D. (p=0.05)	CGR S.Em±	CGR C.D. (p=0.05)
Genotypes	0.11	0.32	0.13	0.37	0.24	0.68
Sowing windows	0.11	0.32	0.13	0.37	0.24	0.68
G × S	0.22	0.64	0.25	0.74	0.47	1.36

G_1: GKVK-5	S_1: II fortnight of June	**DAS:** Days after sowing	**NS:** Non-significant
G_2: GPBD-4	S_2: I fortnight of July		
G_3: G2-52	S_3: II fortnight of July		
G_4: TMV-2	S_4: I fortnight of August		

Table.2 Influence of different sowing windows on leaf area, LAI and LAD of groundnut genotypes

Genotypes (G)	Sowing windows (S)														
	Leaf area (dm^2 plant^{-1})					LAI					LAD (days)				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
G_1	9.27	8.81	8.78	8.52	**8.85**	2.06	1.96	1.95	1.89	**1.97**	63.87	60.38	60.00	57.49	**60.43**
G_2	9.10	8.54	7.91	7.88	**8.36**	2.02	1.90	1.76	1.75	**1.86**	61.08	57.09	54.08	53.40	**56.41**
G_3	9.17	8.74	8.45	7.99	**8.59**	2.04	1.94	1.88	1.78	**1.91**	62.83	59.63	58.08	55.29	**58.96**
G_4	8.91	8.44	7.98	7.27	**8.15**	1.98	1.88	1.77	1.62	**1.81**	59.62	56.00	53.33	50.83	**54.95**
Mean	**9.11**	**8.63**	**8.28**	**7.92**	**8.49**	**2.02**	**1.92**	**1.84**	**1.76**	**1.89**	**61.85**	**58.27**	**56.37**	**54.25**	**57.69**

	S.Em±	C.D. (p=0.05)	S.Em±	C.D. (p=0.05)	S.Em±	C.D. (p=0.05)
Genotypes	0.07	0.19	0.01	0.04	0.59	1.72
Sowing windows	0.07	0.19	0.01	0.04	0.59	1.72
G × S	0.13	0.39	0.03	0.09	1.19	3.43

G_1: GKVK-5	S_1: II fortnight of June	**DAS:** Days after sowing	**NS:** Non-significant
G_2: GPBD-4	S_2: I fortnight of July		
G_3: G2-52	S_3: II fortnight of July		
G_4: TMV-2	S_4: I fortnight of August		

Table.3 Influence of different sowing windows on pod number per plant, shelling per cent and kernel yield of groundnut genotypes

Genotypes (G)	Sowing windows (S)														
	Pod number per plant					Shelling per cent					Kernel yield (q ha^{-1})				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
G_1	12.39	12.32	10.95	10.23	**11.47**	74.00	73.33	72.60	70.67	**72.65**	13.37	13.18	11.59	10.54	**12.17**
G_2	11.59	10.25	8.88	7.71	**9.61**	73.33	72.33	71.33	63.00	**70.00**	10.99	9.58	8.18	6.28	**8.76**
G_3	14.43	13.97	13.37	11.59	**13.34**	73.00	72.00	69.33	68.33	**70.67**	11.81	11.06	9.52	8.13	**10.13**
G_4	8.55	7.93	7.45	7.00	**7.73**	72.27	71.67	70.33	61.33	**68.90**	8.37	7.70	7.10	5.82	**7.25**
Mean	**11.74**	**11.12**	**10.16**	**9.13**	**10.54**	**73.15**	**72.33**	**70.90**	**65.83**	**70.55**	**11.13**	**10.38**	**9.10**	**7.69**	**9.58**

	Pod number: S.Em±	Pod number: C.D. (p=0.05)	Shelling: S.Em±	Shelling: C.D. (p=0.05)	Kernel yield: S.Em±	Kernel yield: C.D. (p=0.05)
Genotypes	0.19	0.55	0.80	2.31	0.14	0.40
Sowing windows	0.19	0.55	0.80	2.31	0.14	0.40
G × S	0.38	1.09	1.60	NS	0.28	0.80

G_1: GKVK-5	S_1: II fortnight of June	**DAS:** Days after sowing	**NS:** Non-significant
G_2: GPBD-4	S_2: I fortnight of July		
G_3: G2-52	S_3: II fortnight of July		
G_4: TMV-2	S_4: I fortnight of August		

Fig.1 Water required by the crop and the amount of rainfall received during different crop growth stages

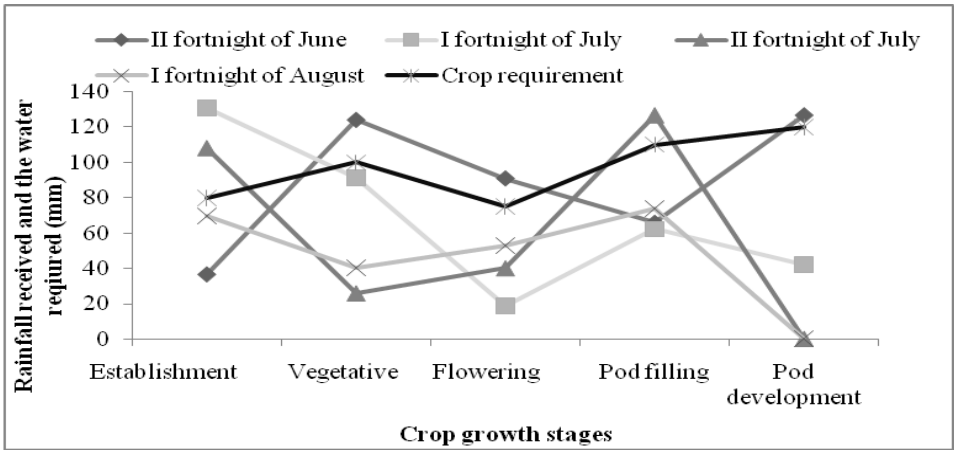


Fig.2 Actual and normal sunshine hours during the crop growth period

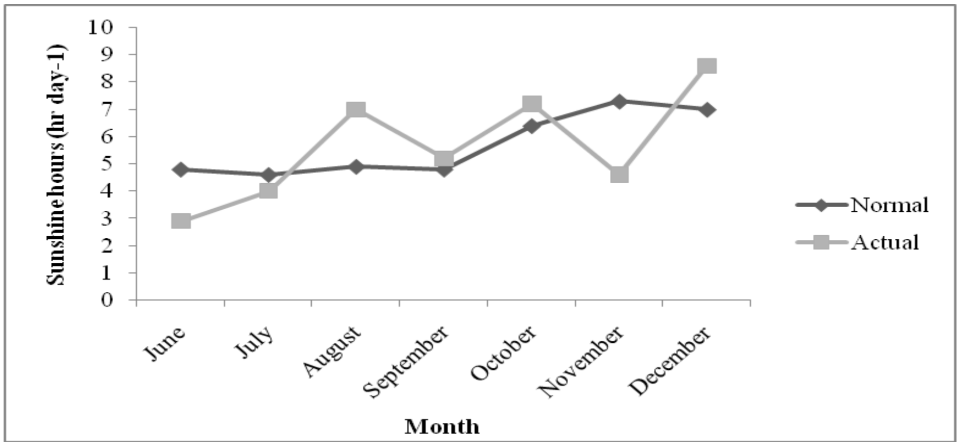
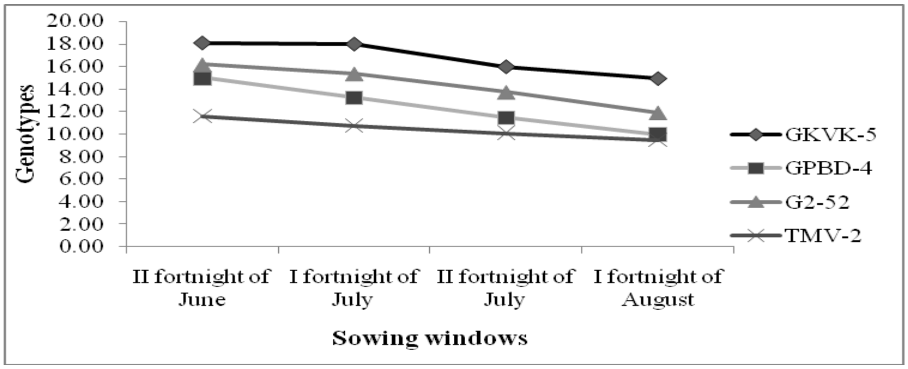


Fig.3 Influence of different sowing windows on pod yield of groundnut genotypes



With the delay in sowing, the number of branches, total dry matter and CGR decreased during I fortnight of July, II fortnight of July and lowest during I fortnight of August. This was due to the moisture stress during late sown conditions. Prathima *et al.*, (2012) stated that the crop growth reduces due to water stress, which reduces the assimilates of photosynthates.

The interaction effect of genotypes and sowing windows revealed that the genotype GKVK-5 (8.85 dm^2 $plant^{-1}$ and 1.97, respectively) this was followed by G2-52 (8.59 dm^2 $plant^{-1}$ and 1.91, respectively), GPBD-4 (8.36 dm^2 $plant^{-1}$ and 1.86, respectively) and TMV-2 (8.15 dm^2 $plant^{-1}$ and 1.81, respectively). Increase in the leaf area was due to increase in number of branches, which increases the number of leaves per plant. Bhargavi *et al.*, (2016) reported similar results with different spacing treatments in groundnut and stated that increase in the number of leaves increases the leaf area. Increase in the leaf area increases LAI, which further increases LAD, where the genotype GKVK-5 recorded significantly higher LAD (60.43 days), which was on par with G2-52(58.96 days) (Table 2).

The crop sown during II fortnight of June recorded significantly higher leaf area, LAI and LAD (9.11 dm2 $plant^{-1}$, 2.02 and 61.85 days, respectively) (Table 2). This was followed by the crop sown during I fortnight of July (8.63 dm^2 $plant^{-1}$, 1.92 and 58.27 days, respectively), II fortnight of July (8.28 dm^2 $plant^{-1}$, 1.84 and 56.37 days, respectively). Delay in sowing reduced the leaf area, LAI and LAD. This might be due to the stressed condition on the plant with delay in sowing, caused by lack of rainfall which decreased from 444.5 mm during II fortnight of June to 236.2 mm during I fortnight of August. The vegetative growth reduces as the days become shorted with delayed sowing. This reduced GKVK-5 sown during II fortnight of June recorded higher number of branches (11.87 $plant^{-1}$), total dry matter (14.76 g $plant^{-1}$) and CGR (9.41 g m^{-2} day^{-1}) compared to other treatment combinations. This might be due to the combination of genetic character and also the optimum weather conditions during the crop growth. Similar results were reported by Mohite *et al.*, (2017).

Significantly higher leaf area and LAI (Table 2) were recorded in the genotype the leaf area, as the plant cannot intercept more radiations due to short-day conditions and thereby, reduces the LAI and LAD. Agarwal *et al.*, (1996) and Kumar *et al.*, (2011) in niger crop reported that delay in sowing reduces the duration of vegetative growth, thereby, producing less number of leaves per plant and thus, decreased leaf area due to soil moisture stress than the early sown crop. The genotype GKVK-5 sown during II fortnight of June recorded higher leaf area (9.27 dm^2 $plant^{-1}$), LAI (2.06) and (63.87 days) compared to other treatment combinations.

Pod yield (Fig. 3) was found to be significantly higher in the genotype GKVK-5 (16.73 q ha^{-1}) compared to G2-52 (14.29 q ha^{-1}), GPBD-4 (12.42 q ha^{-1}) and TMV- 2 (10.48 q ha^{-1}). Increase in the pod yield was due to increase in the growth parameters *viz.*, number of branches, total dry matter, CGR, leaf area, LAI and LAD. Increase in the growth parameter provides better translocation of photosynthates to the sink and thereby, increases the pod yield. Thus, variation in the growth parameters varies the pod yield between the genotypes. Mohite *et al.*, (2017) and Naik *et al.*, (2018) also obtained similar results.

The pod yield decreased to 59.63 per plant with delay in sowing from II fortnight of June to I fortnight of August. The crop sown during II fortnight of June recorded significantly higher pod yield (15.20 q ha^{-1}), which was due to favorable weather conditions prevailed during crop growth period and similar findings were reported by Canavar and Kaynak (2008) and Bala *et al*., (2011). Chandrika *et al*., (2008) reported that the effect of rainfall was greater on vegetative growth of the crop under late sown conditions. Canavar and Kynak (2010) also opined that short- day conditions reduces the crop growth period and unsuitable conditions like lack of rainfall under delayed sowing are unfavourable to the crop growth due to stressed conditions and thereby, reduces the pod yield. Early sowing of groundnut rarely experiences moisture stress during reproductive stage, especially pod development stage under normal rainfall distribution and was found to be more beneficial compared to delayed sowing (Patel *et al.*, 2013).

Kernel yield depends on the pod yield and shelling per cent. Significantly higher kernel yield was recorded in the genotype GKVK-5 (12.17 q ha^{-1}) (Table 3) due to better shelling per cent (72.65). However, higher number of pods per plant was observed in G2-52 (13.34) and lower in TMV-2 (7.73). This might be due to the genetic characteristic of the genotype (Mohite *et al.*, 2017).

Kernel yield was found significantly higher when the crop was sown during II fortnight of June (11.93 q ha^{-1}) (Table 3) than delayed sowing during I fortnight of August (7.69 q ha^{-1}). This was due to the higher pod yield and shelling per cent.

Thus, it can be concluded that, the early sowing (II fortnight of June) can produce higher pod yield due to better vegetative growth, which can translocate photosynthates to the sink and can escape moisture stress conditions during critical growth period, compared to delayed sowing (I fortnight of August). The genotype GKVK-5 was found to perform better compared to G2-52, GPBD-4 and TMV-2, which produced higher pod yield, due to its genotypic characteristics

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