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Flower count and pollen sterility percentage in relation to temperature regimes in groundnut (*Arachis hypogaea* L.) genotypes

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Abstract
A field experiment was conducted at MARS, University of Agricultural Sciences, Dharwad during 2016-17. The experiment consisted of three dates of sowing (D_1, D_2, and D_3) and five groundnut genotypes (Dh-86, G-2-52, Kadiri-9, TMV-2 and R-2001-2) laid out with factorial RBD design. Among the dates of sowing, D_3 temperature regime recorded significantly lower flower count (59.11) with higher pollen sterility per cent (12.73 %) and D1 temperature regime recorded significantly lower pollen sterility (8.241 %).Among genotypes, R-2001-2 recorded significantly higher flower count (100.47) with low pollen sterility per cent (8.573 %) which was on par with G-2- 52 with respect to pollen sterility only.

Keywords: Groundnut, Temperature regime, pollen sterility, flower count

Introduction
Groundnut (*Arachis hypogaea* L.) is an important oilseed and forage crop grown in the semi-arid tropics (SAT) of Africa and Asia. Heat and temperature-induced stresses are the major environmental factors affecting flower production and pollen viability. The optimum day/ night temperature for vegetative and reproductive growth and development in groundnut ranges from 25/25 °C [1] to 30/26 °C [2] and from 25/20 °C [1] to 26/22 °C [2], respectively. The reproductive phase of groundnut is more sensitive to heat stress than the vegetative phase [2]. The greatest sensitivity to hot days (38 oC) occurs from 6 days before to 15 days after flowering [3]. Therefore, the present investigation was an attempt to study the effect of temperature regimes on the flower production and pollen sterility of different groundnut genotypes and to identify the better performed genotype under heat stress.

Material and methods
The field experiment was conducted in *kharif*, 2016-17 at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad situated at 15012' N latitude and 76034'E longitude with an altitude of 678 above mean sea level. The experimental site consisted of medium deep black soil and the crop was raised in a plot size of 3.5 × 2.5 m with a spacing of 30 × 10 cm, fertilized with 25:50:25 kg of N: P_2O_5: K_2O. The temperature regimes were created through three dates of sowing ie, D_1 (24th MSW -15th June), D_2 (28th MSW -15th July), D_3 (33rd MSW -15th August) with five Genotypes **(**Dh-86, G-2-52, Kadiri-9, TMV-2 and R-2001-2). The T_{max} value was highest under 44th standard meteorological week (SMW) and lowest T_{min} value was recorded under 45th standard meteorological week (SMW).

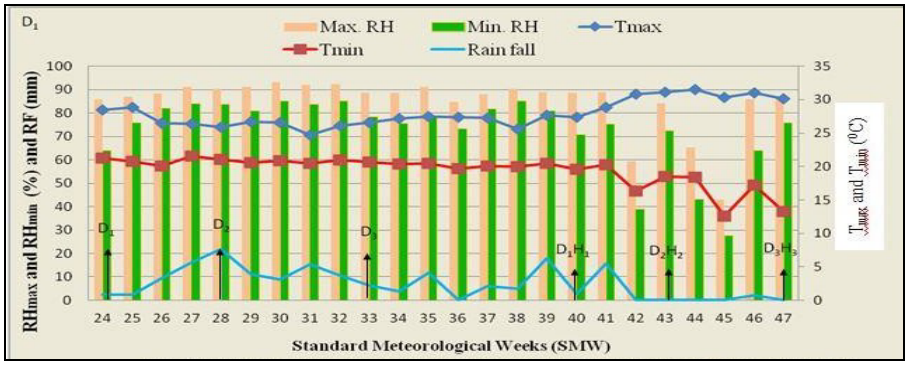

Fig 1: Weekly meteorlogical data at Main Agriculture research station (MARS), UAS, Dharwad

Flower count and pollen sterility was recorded in daily basis. Total number of flower produced per plant was calculated by counting daily flower production of five randomly chosen plants individually from the day of flower initiation and took average of it. Pollen sterility per cent was measured by using Acetocarmine staining solution (1.0 % acetocarmine stain + 45 % glacial acetic acid). Daily anthers of freshly collected flowers were mounted on slide and 20 microliter of Acetocarmine solution was added to it and covered with cover slip. After five minutes stained (fertile) and non- stained (sterile) pollens were counted by the help of compound microscope and percentage of pollen sterility was determined [4].

Results and discussion

In groundnut, the flowering is mostly dependant on temperature and photoperiod. So number of flower produced per plant depends on the temperature regimes and crop growth period. Kiran (2014) [7] reported a reduction in number of flowers and duration of flowering in chickpea at high temperature. Flower production in groundnut is highly influenced by day length, light intensity, humidity and mainly by temperature variation [3, 5, 6, 7, 8].

The above research studies supported the present investigation as D_2 temperature regime, having lower T_{max} value, recorded significantly higher flower production (89.47 plant^{-1}) in comparison to D_1 (67.04) and D_3 (59.11) temperature regimes. Under D_1 temperature regime the total number of flower production was less compared to D_2, which was attributed to the prevalence of lower temperature (12.1 oC) during flowering period (Fig. 1). Genotype R-2001-2 recorded total maximum number of flowers followed by Kadiri-9 under both 24th SMW (92.667 and 83.200, respectively) and 28th SMW (137.700 and 93.267, respectively). Whereas, minimum total number of flowers was produced in TMV-2 (46.200) and Dh-86 (47.367) under 24th and 28th SMW (D_1 and D_2 temperature regime), respectively. Whereas, profuse flowering per day was observed between 18th July 2016 to 30th July 2016 under 24th SMW (D_1 temperature regime) and between 23rd August to 8th September 2016 under 28th SMW (D_2 temperature regime). where the temperature ranged between 27 ^{0}C (T_{max}) and 20.3^{0}C (T_{min}) .

Table 1: Effect of temperature regimes on pollen sterility, flowers count, pod number and flower to pod ratio of different groundnut genotypes

	Pollen sterility (%)	No. of flowers plant-1	No. of pods plant-1	Flower: pod
Dates of sowing (D)				
12-06-2016 (D_1)	8.241c	67.04b	17.69a	3.989c
13-07-2016 (D_2)	10.66b	89.47a	11.33b	8.438a
13-08-2016 (D_3)	12.73a	59.11b	10.00b	6.429b
S. Em. ±	0.20	2.99	0.95	0.498
LSD @ 5 %	0.57	8.65	2.75	1.441
Genotypes (G)				
Dh-86 (G_1)	11.40b	46.43d	10.22b	5.346bc
G-2-52 (G_2)	8.442c	69.37bc	16.67a	4.706c
Kadiri-9 (G_3)	12.66a	77.98b	13.69ab	6.163abc
TMV-2 (G_4)	11.64b	64.84c	10.07b	8.007a
R-2001-2 (G_5)	8.573c	100.74a	14.40a	7.203ab
S. Em. ±	0.25	3.85	1.226	0.643
LSD @ 5 %	0.74	11.16	3.551	1.860
Interaction (DXG)				
D_1G_1	8.142ef	47.07f	15.13b-e	3.203e
D_1G_2	6.666g	66.07c-f	23.07a	2.981e
D_1G_3	10.57d	83.20b-d	18.20ab	4.699c-e
D_1G_4	8.791e	46.20f	14.60b-e	3.401e
D_1G_5	7.040fg	92.67b	17.47a-c	5.663b-e
D_2G_1	12.16c	47.37f	9.80d-f	4.943c-e
D_2G_2	7.320fg	83.17b-d	11.80b-f	7.071b-d
D_2G_3	13.47ab	93.27b	12.00b-f	8.419bc
D_2G_4	12.27bc	85.87bc	7.40f	12.946a
D_2G_5	8.057ef	137.70a	15.67b-d	8.809b
D_3G_1	13.89a	44.87f	5.73f	7.894bc
D_3G_2	11.34cd	58.87ef	15.13b-e	4.066de
D_3G_3	13.93a	57.47ef	10.87c-f	5.373b-e
D_3G_4	13.85a	62.47d-f	8.20ef	7.673b-d
D_3G_5	10.62d	71.87b-e	10.07d-f	7.137b-d
S. Em. ±	0.44	6.67	2.12	1.113
LSD @ 5 %	1.28	19.34	6.15	3.221

Note : D_1 (24th Standard Meteorological Week): 12-06-2016 date of sowing D_2 (28th Standard Meteorological Week): 13-07-2016 date of sowing D_3 (33rd Standard Meteorological Week): 13-08-2016 date of sowing
Alphabets in the column followed by the same letter do not differ significantly as per DMRT

Under 33rd SMW (D_3 temperature regime) genotype, R-2001-2 recorded maximum number of flower count (71.867) followed by TMV-2 (62.467) and minimum number of flowers were produced in Dh-86 (44.867). Whereas, profuse flowering per day was observed between 22nd September to 6th October and once again the fluctuation in temperature ranged between 27 ^{0}C to 20 ^{0}C (T_{max} and T_{min}).

The behaviour of flowering by different genotypes under varied temperature regimes indicated that all the genotypes recorded higher number of flowers during the period where, the T_{range} was minimum. Either the higher temperature (25 0C) or lower temperature (20 0C) increased or decreased inhibited the production of flowers. The fluctuation in total number of flowers produced differed to a greater extent

among the genotypes, Dh-86 produced all most same total number of flowers under three different temperature regimes (44, 47 and 45 number of flowers). Similarly other genotypes, the fluctuation in total number of flowers was higher e.g. G-2-52 (66.83 and 59 number of flowers); Kadiri-9 (83, 93 and 58 number of flowers); TMV-2 (46, 86 and 63 number of flowers) and R-2001-2 (93, 138 and 71 number of flowers). It interesting to note that the varied temperature regimes did not influenced the total flower production in Dh-86 when compared to other genotype. This indicates that the utilization of photosynthates for flower production was minimum in Dh-86. While, other genotypes utilized more photosynthates for flower production thereby more number of flowers were produced. The optimum temperature (31/18 0C) under present investigation was beneficial for higher number of flower production. However, the temperature regime of 29/19 0C and 33/15 0C reduced the total number of flower production in all the genotypes. This indicates higher temperature above 30 0C and lower temperature below 18 0C will have negative effect on flower production (Figure 2). Similar results were obtained by Bagnall and King (1991) [9].

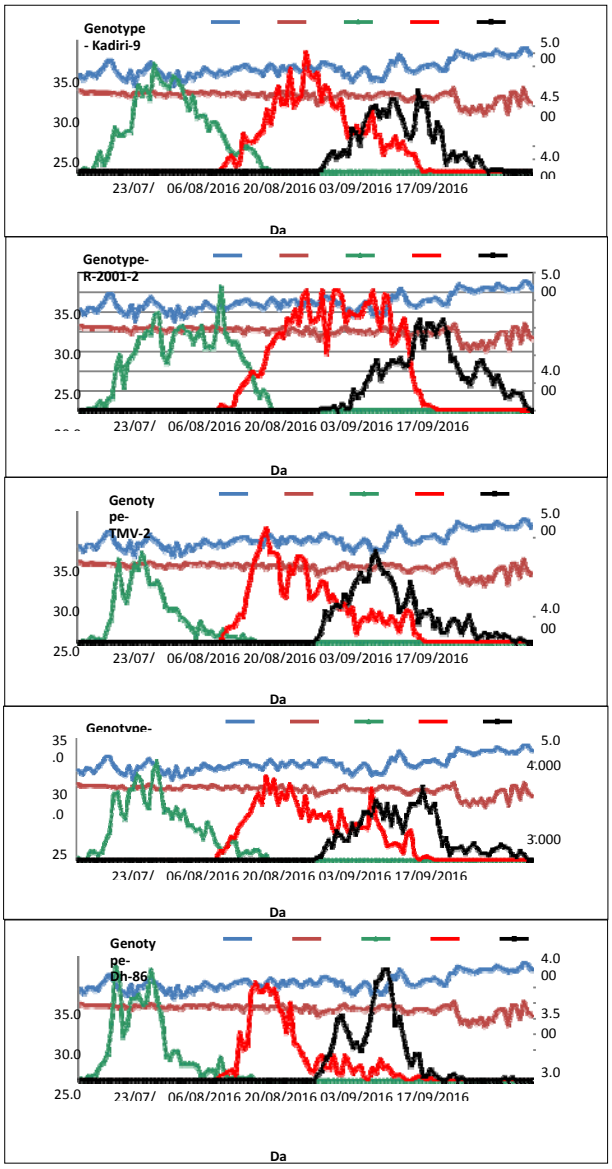

Fig 2: Effect of temperature regimes on flower count of different genotypes under D_1, D_2 and D_3 temperature regimes

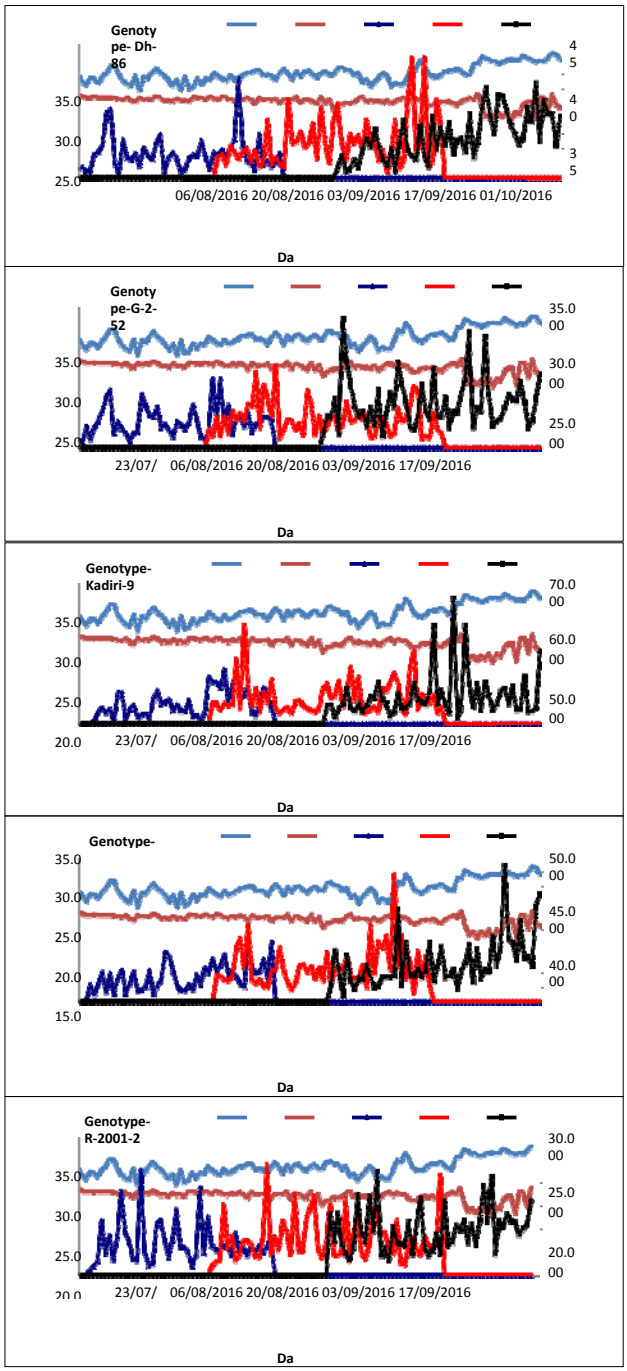

Fig 3: Effect of temperature regimes on pollen sterility percentage of different genotypes under D_1, D_2 and D_3 temperature regimes

High temperature during microsporogenesis causes low pollen viability, poor anther dehiscence and hence male sterility which may be associated with early degeneration of tapetal layer and reduction in carbohydrates in developing [10, 11, 12, 7, 8].

The mean maximum and mean minimum temperatures recorded were 29.4/23.0 ºC and 21.4/19.5 ºC, 30.9/24.0 ºC and 21.3/18.0 ºC, 32.8/24.0 ºC and 22.0/15.2 ºC under 24th, 28th and 33rd SMW, respectively. Under D_1temperature regime, genotypes Dh-86, G2-52, Kadiri-9, TMV-2 and R-2001-2 recorded (33.333 to 1.639%, 17.241 to 1.538 %, 26.667 to 1.389 %, 20.690 to 3.030 % and 22.581 to 2.041 per cent, respectively) maximum and minimum pollen sterility. Similarly under D_2 temperature regime, genotypes Dh-86, G2-52, Kadiri-9, TMV-2 and R- 2001-2 were recorded (40.741 to 2.198 %, 20.225 to 2.299 %, 48.980 to 4.762 %, 44.118 to 3.077 % and 24.000 to 1.923 per cent, respectively) maximum and minimum pollen sterility and under D_3 temperature regime genotypes Dh-86, G2-52, Kadiri-9, TMV-2 and R-2001-2 were recorded (32.000 to 2.326 %,

32.143 to 2.985 %, 62.069 to 3.125 %, 47.368 to 2.128 % and 29.032 to 3.371 per cent, respectively) maximum and minimum pollen sterility.

Daily observations on pollen sterility (Figure 3) indicated that variability among different genotypes was observed with respect to either T_{max} or T_{min}. The genotype, Dh-86 recorded maximum sterility under D_2 (22nd September to 29th September) and D_3 (13th October to 27th October). Under D_2, higher temperature around 30^0C and under D_3 both higher temperature (32 ^{0}C) and minimum temperature (< 20 0C) played an important role for development of microsporogenrsis which resulted in pollen sterility. Similar variations were observed with respect to other genotypes also. However, higher sterility was observed at later stages of flowering under D_3 temperature regimes, which coincided with both higher (32 0C) and lower (15 0C) temperature. Similar results were obtained by Ahmed *et al*. 10] and Presman *et al*. [12]. Prasad *et al*. (1999) [3] reported that short episodes of heat stress on pollen production and viability played an important role. Similar results of higher sterility during intermittent hot episodes of either high or low temperature was observed in the present study.

Peanut was significantly affected by sowing time as under ecological conditions and early sowing time at the mid-April led to increases in pod yield compared to late sowing time of peanut crops [13]. In present investigation similar results were obtained. Where, early sowing date (D_1 temperature regime) recorded significantly higher pod yield ha-1 (4,952 kg ha-1) which was decreased as the sowing delayed. There was no significant difference observed among genotypes. However, among interactions, Dh-86 (6,325 kg ha-1) recorded significantly higher pod yield followed by G-2-52 under D_1 temperature regimes.Among dates of sowing, 28th SMW (D2 temperature regime) recorded significantly higher flower to pod ratio (8.438) followed by 33rd SMW (D_3 temperature regime). However, among the genotypes, TMV-2 recorded significantly higher flower to pod ratio (8.007) followed by R-2001-2 (7.203). (Table: 1). Which, indicates the lower number of flowers may converted into pods or more flower abortion may be there under D_2 temperature regime.

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