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RESEARCH NOTE

Response of groundnut genotypes to different temperature regimes in relation to thermal indices

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Field experiment was undertaken at the University of Agricultural Sciences, Dharwad during *kharif*, 2015 with four dates of sowing and four genotypes under factorial RBD. Among the temperature regimes, highest accumulation of heat units was found under 23rd standard week (D_1 temperature regime) and minimum was recorded in D_3 temperature regimes (29th standard week) for all phenological stages. Higher phenothermal index (PTI) for days to flower initiation, days to pod initiation and maturity was under D_4 temperature regime (32nd standard week) and least was recorded in D_2 temperature regime (26th standard week). Under delayed sowing, heat use efficiency and pod yield (kg ha^{-1}) decreased. Growing degree days was significantly, positively and PTI negatively correlated with yield.

Key words: Phenothermal index, Pod yield, Temperature regime

In India, groundnut (*Arachis hypogaea* L.) crop ranks first among the oil seed crops and is grown largely (83% of total groundnut area) under rainfed conditions during the main rainy season (Jun/Jul - Oct/Nov). High temperature influences physiological processes, growth and development and reduces allocation of assimilates to the reproductive organs through decreased pod set and seed growth rate. Further, with present trends of global warming, temperatures are likely to become hotter, and increase in mean air temperature of 2-3°C is predicted to reduce the groundnut yields by 23-36 per cent. Hence, an attempt was made understand through the study, underlying response of higher temperature in groundnut genotypes in relation to thermal indices and pod yield of the crop.

The field experiment was conducted at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2015-16 with four genotypes (TMV-2, G2-52, Dh-86 and Dh-216) and four different dates of sowing starting from 23rd (D_1), 26th (D_2), 29th (D_3) and 32nd (D_4) standard meteorological weeks (SMW) as temperature regimes, laid in a factorial randomised block design. The mean maximum temperature (36.7 °C) was recorded under 39th standard week 24th-30th Sept) followed by (32.4 °C) under 42nd standard week (15th -21st October), from 41st standard week to 44th standard weeks were found to be hottest weeks. Minimum temperature ranged from 17.9 to 22.2 °C during cropping period. Crop growth during initial stages of $D_1$and D_3 temperature regimes were exposed to high temperature stress while, D_1 and D_4 temperature regimes with optimum temperature. However, crop growth experienced terminal heat stress (at harvest) under the entire temperature regimes. The observation on thermal indices *viz.* Growing degree days (GDD), Phenothermal index (PTI), Heat use efficiency (HUE) along with yield were recorded by adopting appropriate procedures.

Thermal indices like GDD, PTI and HUE were influenced by different temperature regimes, different dates of sowing and genotypes (Table 1). Heat units, expressed in growing degree days, are frequently used to describe the timing of biological processes. Mean GDD for all phenological stages indicated significant differences with respect to temperature regimes, genotypes and their interactions. The GDD values followed increasing trend for all varieties, indicating that higher GDD values for higher number of days for different phenological stages. Heat units are there to predict the physiological maturity, as sowing delayed there was decrease in thermal units to attain physiological maturity as reported by Shravanakumar *et al.*, 2015; Kiran, 2014 and Rathod and Chimmad, 2016.

The normal sown crop (D_1 temperature regime) accumulated more heat units for flower initiation (961.6), 50 per cent flowering (1081), peg initiation (1324) and for physiological maturity (2972), which were followed by D_4, D_2 temperature regimes and least heat unit accumulation was recorded in D_3 temperature regime. This is because, during D_3 crop growth period both T_{max} and T_{min} showed minimum till pegging and suddenly increased towards maturity (Fig. 1) and total crop period was minimum (90.25 days). Among the genotypes, G2-52 took more thermal units for all phenological stages *viz.*, flower initiation (862.7), 50 per cent flowering (1025), peg initiation (1238) and physiological maturity (2951) followed by Dh-216, Dh-86 and least was recorded in TMV-2. The genotype G2-52 accumulated more heat sum for all phenological stages under D_1 temperature regimes, even under decreased mean T_{max} and T_{min} in D_3 temperature regime genotype G2-52 accumulated more heat units and it was observed from correlation study that more heat unit accumulation at physiological maturity was positively correlated with yield (0.688**).

Similarly, D_4 temperature regime recorded more PTI value in all growth stages of crop growth *i.e.* flower initiation (31.26), 50 per cent flowering (34.17), peg initiation (32.28) and physiological maturity (31.19), which was followed by D_1, D_3 and least by D_2 temperature regime (Table 2). This was attributed with delayed sowing, where in plants were exposed to high temperature and cropping period was also drastically reduced (Amgain, 2011 and Mukesh, 2015). Irrespective of dates of sowing both Dh-86 and G2-52 recorded maximum PTI value. The genotype, TMV-2 under D_4 temperature regime recorded maximum PTI followed by G2-52, Dh-86 and Dh-216 under same temperature regimes for attaining all phenological stages and minimum was recorded by all genotypes in D_2 temperature regime. Further it was confirmed that PTI for 50 per cent flowering (-0.553*) and physiological maturity (-0.665%*), associated significantly and negatively with yield.

Table 1. Effect of temperature regimes on growing degree days (GDD), phenothermal index (PTI) for flower initiation, 50% flowering, pod initiation and physiological maturity, heat use efficiency (HUE) and pod yield of groundnut genotypes

Treatment	GDD for flower initiation	GDD for 50 per cent flowering	GDD for peg initiation	GDD for physiological maturity	HUE for yield	PTI for DFI	PTI for DFF	PTI for DPI	PTI for DPM	Pod yield (kg ha^{-1})
23rd Standard week (D_1)	961.6^{a}	1081.0^{a}	1324^{a}	2972^{a}	1.174^{a}	29.82^{b}	29.82^{b}	35.57^{a}	29.43^{b}	3504^{a}
26th Standard week (D_2)	771.0^{c}	921.2^{c}	1196^{c}	2664^{c}	1.160^{a}	25.70^{d}	25.57^{d}	26.58^{d}	28.10^{d}	3083^{a}
29th Standard week (D_3)	833.3^{b}	920.0^{c}	1134^{d}	2712^{b}	0.759^{b}	28.49^{a}	28.53^{c}	28.90^{c}	30.06^{b}	2058^{b}
32nd Standard week (D_4)	836.1^{b}	1033.7^{b}	1211^{b}	2558^{d}	0.472^{c}	31.26^{a}	34.17^{a}	32.28^{b}	31.19^{a}	1211^{c}
LSD @5%	2.27	2.62	2.70	6.50	0.10	0.06	0.10	0.11	0.04	268
Genotypes (G)										
TMV-2 (G_1)	827.1^{c}	937.7^{d}	1194^{d}	2675^{b}	0.686^{b}	28.86^{a}	29.09^{b}	31.12^{a}	29.61^{b}	1845^{c}
G2-52 (G_2)	862.7^{a}	1025.0^{a}	1238^{a}	2951^{a}	1.023^{a}	28.83^{a}	29.70^{a}	30.17^{b}	29.80^{a}	3064^{a}
Dh-86 (G_3)	863.7^{a}	990.4^{c}	1202^{c}	2600^{c}	0.995^{a}	28.78^{a}	29.64^{a}	30.95^{a}	29.87^{a}	2612^{ab}
Dh-216 (G_4)	848.5^{b}	1002.0^{b}	1231^{b}	2680^{b}	0.861^{ab}	28.80^{a}	29.66^{a}	31.09^{a}	29.50^{c}	2334^{bc}
LSD @ 5%	2.27	2.62	2.70	6.50	0.10	0.06	0.10	0.11	0.04	268
Interactions (DxS)										
D_1G_1	954.2^{b}	1014.1^{f}	1258^{d}	2861^{d}	0.843^{fg}	29.82^{c}	29.83^{b}	35.94^{a}	29.40^{c}	2409^{cd}
D_1G_2	953.6^{b}	1163.2^{a}	1405^{a}	3261^{a}	1.419^{a}	29.80^{c}	29.83^{b}	35.13^{c}	29.38^{g}	4624^{a}
D_1G_3	984.6^{a}	1104.2^{b}	1347^{b}	2799^{e}	1.350^{a}	29.83^{c}	29.84^{b}	35.44^{b}	29.46^{ef}	3773^{b}
D_1G_4	954.2^{b}	1042.7^{d}	1288^{c}	2969^{b}	1.083^{c-e}	29.82^{c}	29.79^{b}	35.78^{a}	29.40^{fg}	3208^{b}
D_2G_1	770.9^{i}	928.8^{l}	1168^{g}	2598^{h}	0.958^{df}	25.70^{ef}	23.71^{e}	26.54^{g}	27.94^{i}	2491^{c}
D_2G_2	800.4^{g}	969.7^{g}	1226^{e}	2918^{c}	1.115^{b-d}	25.82^{e}	26.21^{d}	26.65^{g}	28.60^{h}	3247^{b}
D_2G_3	741.7^{j}	887.8^{k}	1138^{h}	2541^{j}	1.270^{a-c}	25.57^{f}	26.11^{d}	26.46^{g}	27.92^{i}	3219^{b}
D_2G_4	770.9^{i}	997.7^{g}	1254^{d}	2598^{h}	1.295^{ab}	25.70^{ef}	26.25^{d}	26.67^{g}	27.94^{i}	3374^{b}
D_3G_1	798.8^{g}	912.6^{i}	1127^{i}	2686^{f}	0.594^{hi}	28.53^{d}	28.52^{c}	28.90^{f}	29.84^{d}	1593^{ef}
D_3G_2	854.2^{d}	942.4^{i}	1216^{f}	2972^{b}	0.845^{fg}	28.47^{d}	28.56^{c}	28.94^{f}	30.02^{c}	2502^{c}
D_3G_3	854.2^{d}	912.6^{i}	1068^{k}	2595^{h}	1.891^{e-g}	28.47^{d}	28.52^{c}	28.86^{f}	30.89^{b}	2309^{cd}
D_3G_4	826.0^{f}	912.6^{i}	1127^{i}	2595^{h}	0.705^{gh}	28.48^{d}	28.52^{c}	28.90^{f}	29.48^{e}	1828de
D_4G_1	784.6^{h}	994.4^{g}	1225^{e}	2557^{i}	0.347^{j}	31.38^{a}	34.29	33.11^{d}	31.18^{a}	888.0^{g}
D_4G_2	842.8^{e}	1026.4^{e}	1109^{i}	2652^{g}	0.712^{gh}	31.21^{b}	34.21^{a}	29.97^{e}	31.20^{a}	1884de
D_4G_3	874.4^{c}	1057.0^{c}	1255^{d}	2465^{k}	0.467^{ij}	31.23^{b}	34.10^{a}	33.02^{d}	31.20^{a}	1148^{fg}
D_4G_4	842.8^{e}	1057.0^{c}	1255^{d}	2557^{i}	0.362^{j}	31.21^{b}	34.10^{a}	33.02^{d}	31.18^{a}	924.0^{g}
LSD @5%	4.54	5.23	5.00	13.00	0.19	0.13	0.20	0.22	0.07	535

D_1: 31.05.2015 to 06.06.2015 D_2: 21.06.2015 to 27.06.2015 D_3: 12.07.2015 to 18.07.2015 D_4: 02.08.2015 to 08.08.2015

Values in the column followed by the same letter do not differ significantly by DMRT

All the phenological stages under normal sowing, were served with more heat units accumulation comparatively to the late sown crops and heat use efficiency was found to be higher under normal planting as compared to the late plantings (Meena *et al.,* 2013). Similarly, in the present investigation, HUE was found maximum (Table l) in early/ normal sown crop *i.e.,* D_1 temperature regime (1.179 kg ha^{-1}/ °C day) and showed a decreasing trend from D_1 to D_4 temperature regime. Among genotypes, G2-52 recorded maximum HUE (1.023), which was on par with Dh-86 followed by the other genotypes. Genotype (G2-52 under D_1 temperature regime recorded significantly higher heat use efficiency (1.419) and least was observed under D_4, temperature regime in TMV-2, Dh-86 and Dh-216. Thus, it was confirmed that with delayed sowing HUE of the crop gradually decreases.

In general, pod yield recorded a decreasing trend from 23rd to 32nd standard week (D_1 to D_4 temperature regime). Significantly highest pod yield (3504 kg ha^{-1}) was recorded under 23rd standard week (D_1 temperature regime), which was on par with 26th standard week (3083 kg ha^{-1}) followed by. 29th standard week (2058 kg ha^{-1}) (D_2 and D_3 temperature regime, respectively). However, significantly lower pod yield was recorded under 32nd standard week (1211 kg ha^{-1}) (D_4 temperature regime). Among the genotypes, G2-52 recorded significantly maximum pod yield (3064 kg ha^{-1}), which was on par with Dh-86 (2612 kg ha^{-1}) followed by Dh-216 (2334 kg ha^{-1}). While, minimum pod yield was recorded by TMV-2 (1845 kg ha^{-1}). Among the interactions the genotype G2-52 under 23rd standard week (D, temperature regime) recorded significantly higher pod yield (4624 kg ha^{-1}). However, lowest was recorded by TMV-2 under 32nd standard week (D_4 temperature regime) (888 kg ha^{-1}) which was on par with Dh-216 (924 kg ha^{-1}) and Dh-86 (1148 kg ha^{-1}) under same temperature regime. The optimum soil temperature range for pod formation and development is between 31 °C and 33 °C and soil temperatures above 33 °C significantly reduces the number of mature pods and seed yield (Karanjikar *et al.,* 2004 and Pilumwong *et al.,* 2007).

Thus present experiment concludes that with delayed sowing plant exposed to high temperature stress results in reduction in heat unit accumulation and with reduced crop growth period, thus influences on reduction in heat use efficiency and pod yield of the crop.

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