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Measurement of Canopy Temperature under Different Growing Environment of Pigeonpea (*Cajanus cajan* (L.) Millsp) Crop

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ABSTRACT

A field experiment was conducted during kharif season of 2011 at Agro-meteorological Research Farm of N.D. University of Agriculture & Technology, Kumarganj, Faizabad (U.P.) as to study the crop-weather interaction studies in pigeonpea (Cajanus cajan (L.) Millsp). The experiment was conducted with Split plot design. The treatment consisted 9 combinations comprised of three sowing dates of sowing on June 25^th^ (D_1), July 05^th^ (D_2) and July 15^th^ (D_3) were considered as main plot treatment and three varieties viz., Narendra Arhar-1 (V_1), Narendra Arhar-2 (V_2) and Bahar (V_3) were sub-plot. Thermal use efficiency was recorded significantly highest at all the phenophases in sowing done on June 25^th^ of pigeonpea sowing Narendra Arhar-2 variety we found more thermal efficient and intercepted more solar radiation for growth, development and yields of pigeonpea crop. Relationship between accumulated GDD and dry matter accumulation of pigeonpea sown on June 25 developed. Dry matter was linearly correlated with accumulated GDD (R^2=0.95) indicating that dry matter increased with increase of accumulated GDD. Relationship, between canopy temperature during ripening stage and seed yield of pigeonpea developed. Trend line indicate that seed yield decreased linearly with increase of canopy temperature with R^2 = 0.98. Yield decreased by 50 kg with every increase of 1 °C canopy temperature.

Key words: *Canopy temperature, sowing date, efficiencies, pigeonpea cultivars, thermal heat, sowing temperature.*

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp) commonly known as red gram or arhar is a very old pulse crop of this country after chickpea. Pigeonpea is the second most important pulse crop in India. It is mainly cultivated and consumed in developing countries of the world. India is the largest producer and consumer of pigeonpea in the world. It accounts for about 11.8 per cent of the total pulse area and 17 per cent of total pulse production of the country. It is the rich source of protein and supplies a major share of the protein requirement of the vegetarian population of the country.

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It contains about 22 per cent protein which is almost three times than that of cereals. The pigeonpea grown India on an area of 3.71 million hectares with production of 2.78 million tonnes with, the average yield 7.50 q/ha.[1]. In Uttar Pradesh, it is cultivated on an area of 0.29 million hectares with an annual production of 0.17 million tonnes. The average productivity of this crop in U.P. is 6.06 q/ha.[1]. The major pigeonpea producing states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat and Jharkhand[1]. The date of sowing causes the change in crop growing environment specially the thermal requirement and radiation received by the crop canopy. The biochemical processes leading to growth of plant and chlorophyll formation governed by thermal as well as radiation received by the crop canopy.

MATERIALS AND METHOD

The field experiment was conducted during *Kharif* season 2011 at Agronomical Research Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.). Geographically, experimental site is situated at 26^0 47' N latitude, 82^0 12' E longitude and at an altitude of 113 meters above mean sea level in the north Indo-gangetic plain. The centre enjoys the sub-tropical climatic often subjected to extremes of weather condition *i.e.* cold winter and hot summer.

Micro meteorological parameters:

Canopy temperature (^{0}C):

Canopy temperature was recorded with the help of thermo hygrometer within canopy of the pigeonpea crop during entire crop growth period.

Accumulated heat unit (Growing degree days):

Accumulated heat unit different phenological stages were calculated by following formula;

$$\text{Accumulated heat unit} = \frac{\text{Max. temperature} + \text{Min. temperature}}{2} - \text{Base temperature}$$

Base temperature for pigeonpea crop = 10 ^{0}C.

Thermal use efficiency (g/m^2/^{0}days):

Thermal use efficiency is the dry matter production per unit of heat unit used by the crop. Thermal use efficiency calculated as follows;

$$\text{Thermal use efficiency} = \frac{\text{Total dry matter (g/m}^2\text{)}}{\text{Accumulated heat unit (}^0\text{days)}}$$

Solar radiation interception (%):

Solar radiation interception was measured at 30 days intervals were calculated by following formula;

$$\text{LI} = \frac{\text{LI (top of canopy) LI (bottom of canopy)}}{\text{LI at top of canopy}} \text{x100}$$

Where, LI = Light interception

RESULT AND DISCUSSION

Micro-meteorological studies

Canopy temperature (^{0}C)

Data pertaining to canopy temperature (^{0}C) as affected by sowing dates and sowing temperature and varieties are given in Table-1. A perusal of data presented in table quite evident that canopy temperature was markedly varied due to sowing dates. Highest canopy temperature during ripening phase was recorded in delayed sowing. Similar results were reported by Shamim *et al.*[4], in pearl millet-soybean intercropping. Highest canopy temperature among varieties was recorded in Bahar followed by Narendra Arhar-2 and lowest was in Narendra Arhar-1 variety of pigeonpea during ripening phase of crop under investigation. Relationship between canopy temperature during ripening stage and seed yield of pigeonpea developed (Fig-1). Trend line indicated that seed yield increased linearly with increase of canopy temperature with R^2 = 0.98 % yield decreased by 50 kg with every increase of 1^0 C canopy temperature.

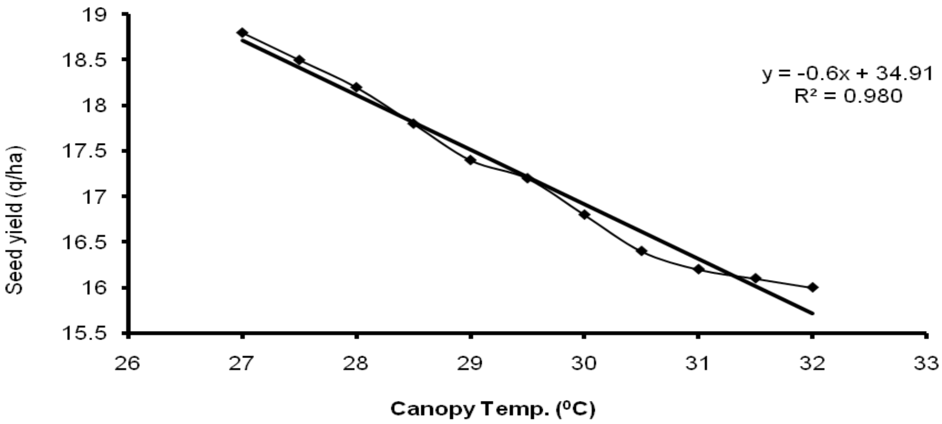

Fig.-1: Relationship between canopy temperature during ripening stage and seed yield (q/ha) in pigeonpea.

Table 1: Canopy temperature (^{0}C) of pigeonpea as influenced by different date of sowing and varieties

Treatments	Days after sowing								
	30	60	90	120	150	180	210	240	At harvest
Sowing dates/ Sowing temperature									
25June/33^{0}C	30	31.5	32.0	29.5	26.5	14.0	19.0	25.0	28.5
5 July/31 ^{0}C	24.5	33.0	31.0	27.5	23.5	16.5	21.0	27.0	28.5
15 July/27^{0}C	30.5	32.5	32.5	27.5	23.0	12.0	20.0	26.5	33.5
Varieties									
N. Arhar-1	29.5	30.0	30.0	27.5	25.0	13.5	17.0	23.0	26.5
N. Arhar-2	28.5	31.5	29.0	28.5	26.5	15.9	22.0	26.0	28.0
Bahar	29.5	31.0	28.5	29.0	24.0	13.0	21.0	27.5	30.5

Accumulated heat unit (Growing degree days):

Data pertaining to accumulated GDD requirement of pigeonpea at different phenophases as affected by sowing dates/ temperature and varieties have been presented in table-2**.** The maximum heat unit (GDD) requirement from sowing to maturity (4109.2 ^{0}C) were recorded with sowing temperature 33 ^{0}C (June 25th), while minimum growing degree days 3665.4 ^{0}C days was observed under sowing temperature of 27 ^{0}C (occurred on July, 15th). Different varieties had marked variation on the growing degree days of pigeonpea. Maximum GDD/heat unit requirement from sowing to maturity (3959.7 ^{0}days) were obtained in Narendra Arhar-1 followed by 3872.5^0 days in Narendra Arhar-2 and minimum in Bahar variety (3791.8 ^{0} days). . Higher growing degree days and thermal use efficiency found in Narendra Arhar-2 followed by Narendra Arhar-1 variety and lowest in Bahar at all the phenological stages mainly due to longer growth duration which resulted in more GDD/ heat units. Similar results of decreasing trend in accumulated GDD with delayed sowing were reported by Kumar[3].

Table 2: Accumulated heat unit (^{0}C days) at different phenophases of pigeonpea as affected by treatments

Treatments	Phenophases						
	Emerg.	4-Leaf stage	Flowering emergence	50 % pod initiation	Pod initiation	50% Podding	Maturity
Sowing dates/ Sowing temperature							
25 June/33 ^{0}C	110.0	330.1	2608.3	2982.2	3293.5	3525.9	4109.2
5 July/31 ^{0}C	126.9	322.5	2501.4	2817.2	3127.4	3402.7	3849.5
15 July/27 ^{0}C	129.4	299.1	2400.2	2645.1	2975.2	3224.2	3665.4
Varieties							
N. Arhar-1	128.7	311.8	2538.9	2833.4	3169.0	3449.6	3959.7
N. Arhar-2	122.0	313.3	2498.4	2806.8	3120.4	3363.5	3872.5
Bahar	155.5	306.7	2472.6	2804.4	3106.7	3339.6	3791.8

Thermal use efficiency (g/m^2/ ^{0}Cdays):

Data pertaining to thermal use efficiency as affected by sowing dates/ sowing temperatures and varieties have been presented in Table- 3. Thermal use efficiency increased successfully till four leaf stages thereafter declined gradually upto 50% flowering then increased till maturity stages. Higher thermal use efficiency was recorded when sowing was done on sowing June, 25th with temperature 33 ^{0}C followed by sowing done on July, 05th while lowest thermal use efficiency was recorded when sowing was done on July, 15th with sowing temperature 27 ^{0}C. Among the varieties, maximum thermal use efficiency was recorded under Narendra Arhar-2 followed by Narendra Arhar-1 while minimum thermal use efficiency was recorded under Bahar variety. Higher accumulated GDD/ heat unit were found in sowing temperature 33^{0}C (June, 25th) followed by crop sown on July, 05th (sowing temperature 31^{0}C) at all the phonological stages mainly due to the fact that they have taken larger days for from sowing to maturity. Thermal use efficiency was higher in the crop sown on June, 25th with sowing temperature 33^{0}C, while it was lower in July, 15th which indicated that the crop exposed sub-optimal thermal regime with delay in sowing (with sowing temperature 27^{0}C). Similar results were obtained by (Kumar *et al*., 2008) that HUE reduced in delayed sowing was due to less biomass production and less number of accumulated heat unit consumed in delayed sown pigeonpea. Higher thermal use efficiency (g m^{-20}days) was obtained in Narendra Arhar-2 followed by Narendra Arhar-1 variety mainly due to accumulation of proportionately higher biomass per unit of heat/ GDD used.

Table 3: Thermal use efficiency (g/m^2/^{0}C days) of pigeonpea at phenological stages as influenced by dates of sowing and varieties

Treatments	Phenophases						
	Emerg	4-Leaf stage	Flowering emergence	50 % pod initiation	Pod initiation	50% Podding	Maturity
Sowing dates/ Sowing temperature							
25 June/33^{0}C	0.75	0.77	.027	0.29	0.35	0.35	0.33
5 July/31 ^{0}C	0.60	0.65	0.26	0.30	0.35	0.35	0.31
15 July/27 ^{0}C	0.57	0.67	0.25	0.30	0.35	0.34	0.30
Varieties							
N. Arhar-1	0.58	0.67	0.25	0.29	0.34	0.33	0.30
N. Arhar-2	0.68	0.70	0.28	0.31	0.37	0.37	0.33
Bahar	0.66	0.68	0.25	0.28	0.34	0.34	0.30

Solar radiation light interception (%):

Data pertaining to solar radiation interception as affected by sowing dates/sowing temperature and varieties are given in table- 4. Results indicated that solar radiation interception increased successively till 210 DAS and thereafter gradually declined irrespective of treatments. It is evident from the data that higher solar radiation interception during ripening was recorded when sowing was done on June, 25th (33 ^{0}C) followed by July, 05th sowing. A variation in solar radiation interception was recorded in various varieties of pigeonpea. The highest interception was recorded in Narendra Arhar-2 followed by Narendra Arhar-1 variety while lowest interception of solar radiation was recorded in Bahar variety. Solar radiation interception increased upto 210 DAS and declined at maturity due to leaf senescence. Higher solar radiation interception during reproductive stage was found in sowing temperature 33^{0}C (June, 25th) might be due to comparatively greater interception of PAR in the crop sown on June, 25th. Similar results obtained by Kar and Kumar[2]. Solar radiation interception was markedly influenced by different varieties. Interception increased upto 210 DAS thereafter declined at maturity due to leaf senescence. Higher solar radiation interception was observed in Narendra Arhar-2 and Narendra Arhar-1 due to both higher number of fully opened leaves and more vigorous growth.

Table 4: Solar radiation light interception (%) of pigeonpea as influenced by different dates of sowing and varieties

Treatments	Days after sowing								
	30	60	90	120	150	180	210	240	At harvest
Sowing dates/ Sowing temperature									
25 June/33 ^{0}C	8.7	16.97	26.34	35.32	48.52	64.73	73.35	43.68	13.70
5 July/31 ^{0}C	9.58	19.28	41.38	50.44	63.18	75.28	86.21	38.51	11.40
15 July/27 ^{0}C	6.68	13.25	24.35	34.68	39.82	49.64	68.69	27.15	9.50
Varieties									
N. Arhar-1	9.25	16.28	26.26	37.58	45.80	58.74	80.25	32.58	11.26
N. Arhar-2	9.32	18.51	28.53	38.27	49.17	64.38	82.65	34.93	12.12
Bahar	7.38	15.43	27.11	33.02	42.50	54.32	76.31	30.59	10.42

CONCLUSION

Increase in canopy temperature during ripening decreased the seed yield of pigeonpea, yield decreased by about 50 kg ha^{-1} with increase of every 1^{0}C canopy temperature during ripening. June, 25th sowing produced significantly higher growth, yield attributes and yield due to fulfilment of optimum thermal requirement for various plant processes. High temperature during reproductive stage adversely affected the number of pods plant^{-1}, number of seed pod^{-1} which ultimately resulted the lowest seed yield in delayed sowing. Narendra Arhar-2 variety was found more conducive for growth development and yield. Accumulated GDD 4109 ^{0}C days from sowing to maturity and canopy temperature during ripening 26 ^{0}C identified congenial environment as to harvest the optimum yield under prevailing weather conditions of the region.

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