International Journal of Bio-resource and Stress Management 2016, 7(4) Special:720-724 DOI: 10.5958/0976-4038.2016.00110.X

Short Research Article

Micro-Climatic Study of Pigeonpea [*Cajanus cajan* (L.) Millap.] Genotype Under Variable Weather Conditions

Ajit Singh*, S. R. Mishra, A. K. Singh and A. N. Mishra

Division of Agricultural Meteorology, NDUA &T, Kumarganj, Faizabad, U.P. (224 229), India

Article History

Manuscript No. ARISE 1
Received in 23rd April, 2016
Received in revised form 12th July, 2016
Accepted in final form 1st August, 2016

Correspondence to

**E-mail*: karanpanwar036@gmail.com

Keywords

Micro climate, pigeonpea, genotype, weather conditions

Abstract

A field experiment was conducted during *kharif* season of 2012 at Agrometeorological Research Farm of N.D. University of Agriculture and Technology Kumarganj, Faizabad (U.P). The treatment comprised of three sowing dates viz., July 06th, July 16th and July 26th were kept as main plot and three varieties viz., Narendra Arhar-1, Narendra Arhar-2 and Bahar were kept as sup-plot. The results revealed that sowing on July 06th produced significantly higher growth, yield attributes and yield of pigeon pea due to fulfilment of optimum thermal requirement for various plant processes. Lowest seed yield was observed under late sown (July 26th) condition due to higher temperature during reproductive stage. July 26th reduced the crop duration by 23 days over sowing on July 16th and 10 days over sowing done on July 06th. Thermal use efficiency was recorded significantly highest in late sown condition (July 06th). Narendra Arhar-2 variety was highest thermal efficient as it intercepted highest solar radiation for growth, development and yields. Relationship between accumulated GDD and LAI of pigeonpea sown on July 06th revealed that LAI increased with increase of accumulated GDD up to 2000 °C days (R^2=0.85). Accumulated GDD and dry matter accumulation of pigeon pea sown on July 06th was linearly correlated with accumulated GDD (R^2=0.95) indicating that dry matter increased with increase of accumulated GDD. Seed yield was decreased linearly with increase of canopy temperature and it decreased by 45 kg with every increase of 1 °C canopy temperature.

1. Introduction

Pulses are the essential component in the human diet. These crops are wonderful gift of nature. They are often referred to as poor man's meat, since they are cheaper than meat and yet a source of high quality protein, carbohydrates and other essential micro-nutrients (Mishra and Chand, 2009). Growth and development of pigeonpea varies from location to location due to variability in agro-climatic and soil-water related parameters. Even in the same location, variability in growth takes place due to different sowing dates, cultivars and other cultural and management practices (Ahlawat and Rana, 2005). Sowing dates an important factor in increasing crop production which brings variation in microclimate like light intensity, evapo-transpiration and temperature of soil surface. Pigeonpea is primarily grown between 14° and 30° latitudes where the mean annual rainfall range between 600 and 1500 mm. Pigeonpea is known to be thermo and photosensitive crop. It is grown in the areas where day length varies from 11 to 14hrs and large differences in temperature are experienced, largely due to variations in altitude and latitude.

The appraised microclimatic characteristics were: global radiation, photosynthetic and radiation balance, air, leaf and soil temperatures and soil humidity. Shading caused significant reduction in incident global solar radiation, photo-synthetically active radiation and net radiation, and attenuated maximum leaf, air and soil temperatures, during the day. Shade also reduced the rate of cooling of night air and leaf temperatures, especially during nights with radiative frost (Chaudhari et al., 2004). Soil moisture at 0–10 cm depth was higher under shade. Keeping above facts in view, the investigation was under taken.

Adapted to arid and semi-arid climates of the tropical and sub-tropical regions of the world (Rao et al., 2003). Pigeonpea is a leguminous crop that has been cultivated for human consumption and many other uses in many parts of the world. During 2012–13, in India, it was cultivated on an area of 3.69 million hectares with a production of 2.75 mt and productivity of 753 kg ha^{-1} (INDIASTAT, 2014). It contains high level of proteins and important amino acids such a methion–ine, lysine and tryptophan. Sowing time, a non–monetary input, has considerable influence on growth and yield of pigeonpea crop (Wilson et al., 2012; Egbe et al., 2013). Sowing at the optimum time gives higher yields due to suitable weather conditions that prevail at all the growth stages. Early sown crop may accumulate excessive dry matter resulting in reduced pod develop-ment, while late sown crop may have less biomass accumulation and consequently reduced yields. De-layed sowings beyond the optimum period result in low grain yields of pigeonpea (Kumar et al., 2008). In addition, genotypes may vary in productivity (Singh, 2006; Egbe and Vange, 2008; Bhavi et al., 2013; Umesh et al., 2013) and the yield potential of the genotypes can be fully exploited by providing appropriate micro-climate temperature at different growth and develop-ment phases.

Earlier, the recommended time of sowing of pigeonpea in Punjab state was the first fortnight of June. How-ever, with the changing climate, the optimum time of sowing may vary. Furthermore, when the crop was sown during first fortnight of June, many times the maturity of the crop is delayed (Ram et al., 2011). More over, long duration genotypes produce higher yield than early maturing genotypes, but they take more time to mature which may delay the sowing of succeeding crop.

2. Materials and Methods

The field experiment was conducted during *kharif* season 2012 at Agromet. Research Farm of Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad (U.P.). Geographically, experimental site is situated at 26°47´ N latitude, 82°12´ E longitude and at an altitude of 113 meters above mean sea level in the north Indo-genetic plain.

Nine treatment combinations comprised of three dates of sowing viz., 06th July, 16th July, and 26th July, were kept as main plot with three varieties viz., Narendra Arhar-1, Narendra Arhar-2 and Bahar kept as sub plot. The experiment was replicated four times. Accumulated heat unit at different phenological stages were calculated by following formula;

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

Base temperature for pigeonpea crop=10 °C.

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

Relative humidity is the ratio between the amount of water vapour required for saturation at a particular temperature and pressure. It can be expressed as percentage or ratio.

$$\text{RH} = \frac{\text{Water vapour present in the air}}{\text{Water vapour required for saturation}} \times 100$$

Thermal use efficiency is the dry matter production unit^{-1} of heat unit used by the crop. Thermal use efficiency calculated as follows;

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

Radiation use efficiencywas measured at 30 days intervals the help of by following formula;

$$\text{RUE (g MJ}^{-1}\text{)} = \frac{\text{Total dry matter (g m}^{-2}\text{)}}{\text{Cumulative APAR MJ/M}^2}$$

Where, RUE=Radiation use efficiency; APAR=Absorbed photosynthetic active radiation

3. Results and Discussion

Accumulated GDD requirement of pigeonpea at different phenophases as affected by sowing dates or sowing temperatures and varieties are presented in Table 1. The maximum heat unit (GDD) requirement from sowing to maturity (4096.1 °C day) were recorded with sowing temperature 29 °C (July 06th), while minimum growing degree days 3687.6 °C days was under sowing temperature of 33 °C (occurred on July 26th). Different varieties had marked variation on the growing degree days of pigeonpea. Maximum GDD/heat unit requirement from sowing to maturity (3938.1 °C days) obtained in cv. Narendra Arhar-1

Table 1: Accumulated heat unit (°C days) at different phenophases of pigeonpea as affected by treatments

Treatments	Phenophases						
	Emergence	4-Leaf stage	Flowering emergence	50% flowering	Pod initiation	50% Pod formation	Maturity
Sowing dates/Sowing temperature							
6 July/29 °C	114.5	328.0	2560.8	2853.5	3097.1	3399.8	4096.1
16 July/31.5 °C	114.2	309.5	2417.3	2663.8	2904.9	3341.4	3892.9
26 July/33 °C	121.5	296.2	2326.0	2497.0	2776.6	3203.6	3687.6
Varieties							
N. Arhar-1	119.6	309.8	2532.2	2822.9	2987.4	3379.7	3938.1
N. Arhar-2	120.0	302.0	2408.7	2899.8	2935.8	3221.4	3864.7
Bahar	118.5	280.3	2348.3	2742.4	2817.5	3109.1	3741.5

followed by 3864.7 °C days in cv. Narendra Arhar-2 while minimum was in Bahar variety (3741.5 °C days).

Canopy temperature (°C) as affected by sowing dates or sowing temperatures and varieties are given in Table 2. Canopy temperature was markedly varied due to sowing dates. Highest canopy temperature was recorded under delayed sown condition (26th July). While in varieties it was recorded in cv. Narendra Arhar-1 followed by cv. Bahar. Relationship between canopy temperature during ripening stage and seed yield of pigeonpea revealed that LAI increased with increase of accumulated GDD up to 2000 °C days (R^2=0.85) as given in Figure 1. Accumulated GDD and dry matter accumulation of pigeonpea sown on July 06th was linearly correlated with accumulated GDD (R^2=0.95) as presented in Figure 2. Seed yield decreased linearly with increase of canopy temperature with R^2=0.98 as given in Figure 3. Yield decreased by 45 kg with every increase of 1 °C canopy temperature.

Table 2: Canopy temperature (°C) 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									
6 July/29 °C	30.5	32.0	36.0	30.5	27.5	13.5	23.5	32.0	35.5
16 July/31.5 °C	34.0	30.0	34.5	28.0	25.0	26.5	19.0	33.5	33.0
26 July/33 °C	35.5	35.0	32.0	27.5	14.5	22.5	27.0	35.0	34.5
Varieties									
N. Arhar-1	28.0	29.5	34.0	28.5	26.0	12.0	21.5	31.0	33.5
N. Arhar-2	35.0	28.0	33.0	29.0	26.5	24.5	20.5	32.0	31.0
Bahar	34.5	33.5	31.0	25.0	16.0	23.5	28.0	34.0	32.0

Relative humidity was markedly varied due to sowing dates (Table 3). Highest relative humidity was recorded in delayed sowing. While in varieties it was recorded in Bahar variety followed by cv. Narendra Arhar-1 during ripening phase of crop.

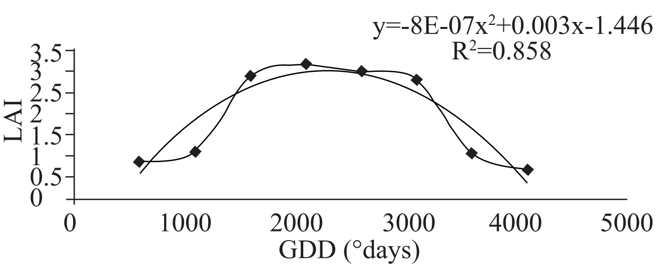

Figure1: Relationship between GDD and leaf area index of pigeonpea sown on June

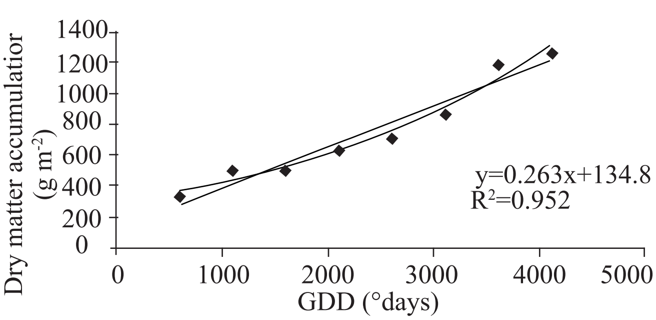

Figure 2: Relationship between GDD and dry matter accumulation (g m^{-2}) of pigeonpea sown on June, 25

The thermal use efficiency as affected by sowing dates/sowing temperatures and varieties have been presented in (Table 4) Thermal use efficiency increased successfully till four leaf stage there after declined gradually up to 50% flowering and then increased successively till maturity stages. Higher thermal use efficiency was recorded when sowing was done on sowing July 06th with temperature 29 °C followed by sowing done on July 16th with sowing temperature 31.5 °C while lowest thermal use efficiency was recorded when sowing was done on July 26th with sowing temperature 33 °C. Among the varieties, maximum thermal use efficiency was recorded under cv. Narendra Arhar-2 followed by cv. Narendra Arhar-1 while minimum thermal use efficiency was recorded under Bahar variety.

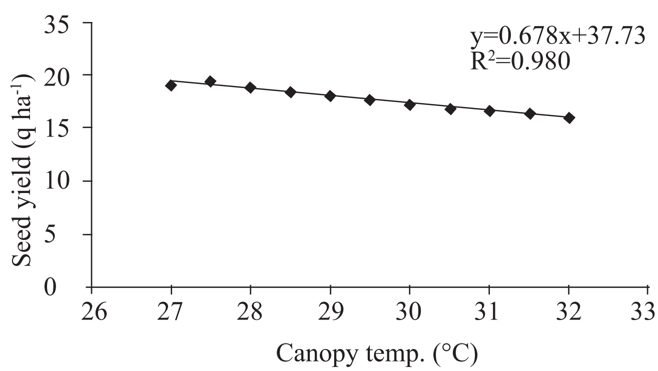

Figure 3: Relationship between canopy temperature during ripening stage and seed yield (q ha^{-1}) in pigeonpea sown on June, 25

The Radiation use efficiency as affected by sowing dates/ sowing temperature and varieties are given in (Table 5) Results indicated that Radiation use efficiency increased successively till 210 DAS and thereafter gradually declined irrespective of treatments. Pigeonpea sown on evident from the data that higher Radiation use efficiency during ripening was recorded when sowing was done on July, 06th (29 °C) higher Solar radiation light interception (%) at all the stage followed by July 16th (31.5 °C) sowing and July 26th (33 °C) sowing all the stage. Narendra Arhar-1 variety while lowest Radiation use efficiency was recorded in Bahar variety all stage of pigeonpea. Lowest Radiation use efficiency was recorded in cv. Narendra Arhar–2.

Table 3: Relative humidity within the canopy (%) of pigeonpea under different dates of sowing

Treatments	Days after sowing								
	30	60	90	120	150	180	210	240	At harvest
Sowing dates/Sowing temperature									
6 July/29 °C	57	60	59	39	37	39	55	32	21
16 July/31.5 °C	73	84	61	64	58	45	81	34	23
26 July/33 °C	82	92	62	76	77	88	90	38	49
Varieties									
N. Arhar-1	76	85	54	68	70	80	82	31	41
N. Arhar-2	68	77	46	60	62	71	64	23	32
Bahar	80	90	59	73	75	85	88	36	46

Table 4: Thermal use efficiency (g m^{-2} $°C^{-1}$ days) of pigeonpea at phenological stages as influenced by dates of sowing and varieties

Treatments	Phenophases								
	Emergence	4-Leaf stage	Flowering emergence	50% flowering	Pod initiation	50% pod formation	Maturity	240	At harvest
Sowing dates/Sowing temperature									
6 July/29 °C	0.73	0.71	0.30	0.34	0.40	0.37	0.34	32	21
16 July/31.5 °C	0.68	0.69	0.29	0.32	0.39	0.36	0.33	34	23
26 July/33 °C	0.62	0.68	0.27	0.31	0.37	0.35	0.31	38	49
Varieties									
N. Arhar-1	0.64	0.68	0.26	0.30	0.37	0.34	0.33	31	41
N. Arhar-2	0.70	0.74	0.29	0.31	0.40	0.39	0.36	23	32
Bahar	0.65	0.74	0.27	0.30	0.38	0.37	0.34	36	46

Table 5: Radiation use efficiency 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									
6 July/29 °C	0.89	0.98	1.14	1.23	1.27	1.60	1.38	1.32	1.15
16 July/31.5 °C	0.87	0.95	1.12	1.10	1.25	1.52	1.32	1.25	1.08
26 July/33 °C	0.86	0.90	1.08	1.18	1.20	1.45	1.29	1.24	1.02
Varieties									
N. Arhar-1	0.85	0.92	1.08	1.16	1.22	1.49	1.30	1.24	1.05
N. Arhar-2	0.85	0.93	1.05	1.17	1.23	1.49	1.31	1.25	1.08
Bahar	0.87	0.96	1.13	1.21	1.27	1.54	1.36	1.27	1.10

4. Conclusion

July 06th sown crop with sowing temperature 29 °C produced significantly higher growth, yield attributes and yield of pigeonpea. Narendra Arhar-2 variety was found more conducive for growth and development of pigeonpea under variable growing environment.Accumulated GDD 4096 °C days from sowing to maturity produced the optimum yield weather conditions.Radiation use efficiency increased till 210 DAS of pigeonpea crop. Increase in canopy temperature seed yield of pigeonpea decreased by about 45 ha^{-1} with every 1 °C canopy temperature increase during ripening phase.

5. References

Ahlawat, I.P.S., Rana, D.S., 2005. Concept of efficient water use in pulses. In: Singh, G., Sekhon, H.S., Kolar, J.s. (Eds), Pulses Agrotech Publishing Academy, Udaipur, India 313–339.

Bhavi, R., Desai, B.K., kumar, S.N., 2013. Effect of planting geometry on the yield, nutrient availability and economics of pigeonpea genotypes. Trends in Biosciences 6(6), 773–775.

Chaudhari, G.B., Shekh, A.M., Patel, K.I., Kumar, M., 2004. Relationship between pigeonpea leaf area index and actual evapotranspiration. Journal of Agrometeorology, 6, Special Issue 33–37, 7.

Egbe, M.O., Vange, T., 2008. Yield and agronomic characteristics of 30 pigeonpea genotypes at otobi in southern Guinea Savanna of Nigeria. Life Science Journal, 5, 70–80.

Egbe, M.O., Aku, A.A., Odebiyi, S., 2013. Effect of Planting Dates on the performance of pigeonpea varieties in southern guinea savanna ecology of Nigeria. Journal of Biology, Agriculture and Healthcare 3(8), 22–28.

INDIASTAT, 2014. Avaiable at http//www.indiastat.com

Kumar, N., Gopinath, K.A., Srivastva, A.K., Mahajan, V., 2008. Performance of pigeonpea (*Cajanus cajan* L. Millsp.) at different sowing dates in the mid-hills of Indian Himalaya. Archives of Agronomy and Soil Science 54, 507–514.

Mishra, A., Chand, M., 2009. Effect of weather on phenology and yield of pigeonpea (*Cajanus cajan*) in central plain zone of Uttar Pradesh. Current Advances in Agricultural Science 1(1), 11–13.

Ram, H., Singh, G., Sekhon, H.S., Khanna, V., 2011. Effect of sowing time on the performance of pigeonpea genotypes. Journal of Food Legumes 24(3), 207–210.

Rao, S.C., Phillip, W.A., Mayeux, H.S., Pathak, S.C., 2003. Potential grain and forage production of early maturing pigeonpea in the southern great plains. Crop Science 43, 2212–2217.

Singh, R.S., 2006. Performance of late duration pigeonpea varieties under delayed planting. Indian Journal of Pulses Research 19, 255–256.

Umesh, M.R., Shankar, M.A., Ananda, N., 2013. Yield, nutrient uptake and economics of pigeonpea (*Cajanus cajan* L.) genotypes under nutrient supply levels in dryland alfisols of Karnataka. Indian Journal of Agronomy 58(4), 554–559.

Wilson, C., Hui, D., Nwaneri, E., Wang, J., Deng, Q., Duseja, D., Tegegne, F., 2012. Effects of planting dates, densities, and varieties on ecophysiology of pigeonpea of south eastern United States. Agricultural Sciences 3(2), 147–152.