



Research Article

INFLUENCE OF THERMAL INDICES AND RAINWATER USE EFFICIENCY OF PIGEONPEA AND COTTON INTER CROPPING (1:1) UNDER RAINFED CONDITION

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Abstract: A field trial was conducted during *kharif*, 2017-18 and 2018-19 with split plot design in clay soils of Regional Agricultural Research Station, Lam, Guntur-34. The experiment consisting of six treatments and each treatment replicated thrice. The main plots treatments consisting of two dates of sowings viz., mid-July & mid-August and sub-plot treatments consisting of cropping systems viz., cotton sole crop, pigeonpea sole crop and cotton + pigeonpea in 1:1 ratio. Heat Use Efficiency (HUE), Heliothermal use efficiency (HTUE), Radiation Use Efficiency (RUE) and Rain Water Use Efficiency (RWUE) were calculated to know the impact of these indices on crop yield under rainfed conditions. The pooled mean of the experimental results revealed that HUE, RWUE were significantly influenced by sowing dates, and crops, between the sowing dates, mid-August sown recorded highest HUE of 0.612 Kg ha⁻¹°C⁻¹ and RWUE of 8.731 kg ha⁻¹mm⁻¹. Among the crops Cotton+pigeonpea in 1:1 ratio also significantly influenced by HUE, HTUE, RUE and RWUE and the findings revealed that Cotton+pigeonpea in 1:1 ratio recorded maximum yield (cotton equivalent yield=1894.0 kg ha⁻¹) and also highest HUE (0.666 Kg ha⁻¹°C⁻¹), HTUE (0.125 Kg ha⁻¹°C⁻¹ 22. hr⁻¹), RUE (0.601mJm⁻¹) and RWUE (7.594kg ha⁻¹mm⁻¹) during the cropping seasons.

Keywords: Equivalent Yield, Rainfed, Pigeonpea

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Introduction

Cotton and pigeonpea are extensively growing as *kharif* crops in the state of Andhra Pradesh and were grown as a sole crops in an area of 5.5 L ha and 2.4 L ha respectively on heavy black cotton to marginal soils where the annual mean rainfall around 700-950 mm. Intercropping is always preferred over sole cropping as intercropping systems minimize weather risks, ensure yield and income from the component crops in an abnormal year and enhance resource use efficiency. Pigeonpea has been found to be unique and highly preferred component crop across rainfed production systems [1]. In Andhra Pradesh cotton was generally intercropped with short duration *kharif* pulses like greengram, blackgram and the harvesting of these short duration *kharif* pulses coincides with monsoon rains could resulted in loss of grain yield but restores the green matter to the soil. In place of short duration pulses, an erect non spreading medium duration pigeonpea varieties introduced as an intercrop in the cotton which will have an advantage for utilization of monsoon rains and sunshine hours in the crop growth period in addition to the restoration of organic matter and nitrogen fixation and would also get benefited from application of pesticides for management pests and diseases in cotton also holds good for pests and disease management in redgram. Benefits to introduce pigeonpea as an intercrop in cotton is soil restoration by heavy leaf fall and symbiotic fixation of soil nitrogen (*Rhizobium*) may reduce fertilizers in cotton. Price fluctuation of cotton and pigeonpea has to be minimized by adopting intercropping due to realization of better market price to any one of the crops. Pigeonpea can be fitted into many cropping systems and its growth pattern and suitability under vast agro-climatic conditions makes it one of the most widely accepted crops under various cropping systems. Schulz and Janssens (2000) [2] observed that the effective intercropped cotton yield was significantly higher than in mono-crop situations. The intercrops where cotton had a larger plant density as compared to pigeonpea, had higher land equivalent ratios, cash value, as well as total biomass.

Pigeonpea varieties (short, medium and long duration) reacted very differently to the intercropping treatments at Serere Agricultural and Animal Research Institute (SAARI) in the Soroti district, Uganda. Therefore, the present investigation was initiated by using erect, non-spreading medium duration LRG-393 pigeonpea variety developed at Regional Agril. Research Station, Lam, Guntur, Andhra Pradesh.

Material and Methods

Field experiment was framed and conducted during 2017-18 and 2018-19 at Regional Agricultural Research Station, Lam, Guntur (latitude:16°18'11" N, longitude 80°29'11" E), Andhra Pradesh. The climate is subtropical with annual rainfall of 950 mm. The soil of the experiment field was clay loam in texture, neutral to slightly alkaline in reaction (pH 7.8 to 8.2) medium in organic carbon content (0.51%), low in available K (1099 kg/ha). The experiment was laid out in Split plot design with three replications.

The treatments consist of two dates of sowings as main plots i.e., mid-July and mid-August and three cropping systems viz., cotton sole crop, pigeonpea sole crop, cotton+ pigeonpea intercropping in 1:1 ratio as sub- plots. Recommended packages of practices were being practiced during the experimentation. Entire phosphorus was applied in the form of single super phosphate as basal and nitrogen and potassium were applied in splits in the form of urea and murate of potash. Necessary and need based plant protection was taken up during the experimentation. Thermal indices, HUE was derived by using growing degree days (GDD) and yield, HTUE was derived by using Heliothermal units (HTU) and yield, RUE was calculated by using daily records of bright sunshine hours (BSS) and yield data recorded during the experimentation, and RWUE was estimated by using the daily rainfall data and yield data recorded during the experimentation. GDD was calculated by using the daily records of T_{max}, T_{min} and T_{base} HTU was calculated by using the GDD and BSS accumulated during the cropping period,

Table-1 Yield of sole cotton, sole pigeonpea and cotton+ pigeonpea in 1:1 ratio as influenced by thermal indices and sowing dates.

Treatments	HUE (Kg ha ⁻¹ °C ⁻¹)	HTUE (Kg ha ⁻¹ °C ⁻¹ hr ⁻¹)	RUE (mJm ⁻²)	RWUE (kg ha ⁻¹ mm ⁻¹)	Mean Yield (kg ha ⁻¹)
Main plots: Sowing Dates					
Mid July	0.509	0.101	0.496	4.082	1649.3
MidAugust	0.612	0.111	0.520	8.731	1539.6
Sem+	0.018	0.004	0.016	0.207	49.0
CD (0.05)	0.082*	NS	NS	0.931*	NS
CV (%)	8.01	9.45	7.58	7.913	7.52
Sub-plots: Crops					
Sole Cotton	0.551	0.105	0.506	6.096	1597.0
Sole Pigeonpea	0.464	0.088	0.416	5.529	1293.0
Cotton + pigeonpea#	0.666*	0.125*	0.601*	7.594*	1894.0*
Sem+	0.016	0.003	0.014	0.203	44.70
CD (0.05)	0.048	0.008	0.020	0.624	137.7
CV (%)	5.58	4.980	0.043	6.323	5.6
Interaction	Sig	Sig	Sig	Sig	Sig

Cotton equivalent yield

by following equations as proposed by Sreenivas *et al.*, (2008) [3]. Base temperature for the cotton and pigeonpea was taken as 10°C [4] and solar radiation was calculated by using the standard units and conversions *i.e.*, one bright sunshine hour is equal to 3.66 mJm⁻² of solar radiation.

$$\text{Growing Degree Days (GDD)} = \sum (T_{\max} + T_{\min}) / T_{\text{base}} \times 2$$

Heat Use Efficiency (HUE) (Kg ha⁻¹°C⁻¹) = Yield ÷ ∑GDD

Helio Thermal Units (HTU) = GDD x SSH (bright)

Helio Thermal Use Efficiency (HTUE) (Kg ha⁻¹°C⁻¹hr⁻¹) = Yield ÷ HTU

Radiation use efficiency (RUE) (mJm⁻²) = yield ÷ Solar radiation

Solar radiation = 1BSSH = 3.66 (mJm⁻²)

Rain Water Use Efficiency (RWUE) (kg ha⁻¹mm⁻¹) = Yield ÷ Total rainfall

Results and Discussion

Weather observations

Weather parameters experienced by crops during the period of experimentation was furnished in [Fig-1] and that the crops received an amount of 496.5 mm rainfall in 30 rainy days, mean T_{max} and T_{min} are 32.8 and 22.0°C and mean BSSH was 4.8 hrs.

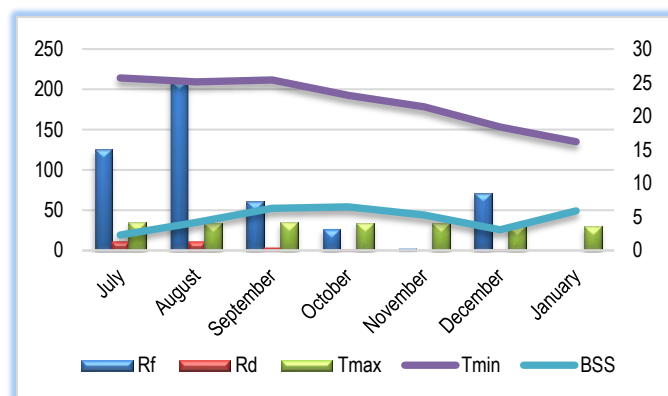


Fig-1 Temporal variation of air temperature and bright sun shine hours during crop growing period

Heat use efficiency (HUE)

Heat use efficiency was significantly influenced by main plot as well as sub plot treatments, between two dates of sowings, highest HUE was recorded with mid-August sown crop (0.612 Kg ha⁻¹°C⁻¹), among sub plot treatments highest HUE was recorded in cotton+pigeonpea as inter crop in 1:1 ratio (0.666 Kg ha⁻¹°C⁻¹), and the interaction was found significant this might be due to most favourable temperature conditions for both the crops during the experimentation and the results are in accordance with the study of Ratnam, *et al* (2018) [5].

Heliothermal use efficiency

Heliothermal use efficiency was not significantly influenced by the sowing dates,

but it was significantly influenced by the crops, HTUE was more in cotton+pigeonpea as an inter crop in 1:1 ratio (0.125 Kg ha⁻¹°C⁻¹hr⁻¹) and the interaction was found significant. This might be due to intercrop has taken the advantage of optimum temperature and sunlight during the crop growth stages these findings are in conformation with Girijesh, *et al.* (2011) [6].

Radiation use efficiency

Similar trend was also noticed with radiation use efficiency on date of sowings and crops and this might be due to the intercrop converted the intercepted radiation more efficiently into grain yield than the sole crops these results are similar to the results of Kermah, *et al.*, (2017) [7].

Rain water use efficiency

Rainwater use efficiency was significantly influenced by sowing dates and crops, highest water use efficiency was recorded with Mid-August date of sowing (8.731 kg ha⁻¹mm⁻¹) and more in cotton+pigeonpea inter crop sown in 1:1 ratio (7.594 kg ha⁻¹mm⁻¹), this might be due to the effective utilization of rainfall in terms of soil moisture in intercropping system than in sole crop and these findings are in accordance with Kathmale, *et al.*, (2011) [8].

Yield

In Main plots, mid-July sown crop and in sub plots cotton+redgram sown as an inter crop in 1:1 ratio recorded significantly higher yield, this might be due to early sown crop get an advantage in utilization of all the resources like rain, temperature and solar radiation and less competition existing between cotton and redgram may be the reason for obtaining higher yields. Further it might be due to redgram as belongs to legume group hence no worry on the completion of major nutrient like nitrogen and these results are in conformity with Rao, *et.al* (2003) [9-11].

Conclusion: Study can be concluded that, under rainfed conditions of the Krishna agro climatic zone of South Coastal Andhra Pradesh cotton + pigeonpea as an intercrop is advantageous over sole cropping of cotton/ pigeonpea due to efficient utilization of Rainfall and Sunlight during the crop period

Application of research: Study of pigeonpea and cotton inter cropping system

Research Category: Cropping system

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Study area / Sample Collection: Regional Agricultural Research Station, Lam, Guntur, 522 034, Andhra Pradesh

Cultivar / Variety / Breed name: Pigeonpea and Cotton

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

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