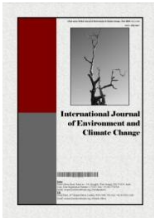

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Thermal Indices of Fodder Cowpea (*Vigna unguiculata* (L.) Walp.) Cultivars in Bundelkh and Region of Central India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

The present study was conducted to identify the impact of temperature indices on different phenophases and yield of cowpea varieties growing in Jhansi region of Uttar Pradesh, India. The cowpea is a warm season legume crop grown in arid and semi-arid regions of India. Traditionally, it is very important as a staple food and source of fodder for the African continent, India and other semi-arid regions. A field experiment was conducted during rainy seasons (July to October) of 2010 and 2011 to determine the thermal indices for fodder cowpea varieties at Central Research Farm, ICAR-IGFRI, Jhansi. All the data were subjected to ANOVA using PROC GLM procedure in SAS (v 9.3). In ANOVA, varieties, date of sowing and year effect is considered as fixed factors and replication as random factor. Crop sown on 12th July took higher accumulated growing degree days (GDD) during 50 % flowering (1111°C days) and maturity (2074°C days) as compared to crop sown during 4th August. Green fodder yield of variety Kohinoor recorded highest heat use efficiency (HUE) (32.4 kg ha-1°C day-1) over BL-2 and EC-4216 at the time of 50% flowering while it is at par with BL-1. From the results, it is found that early sown fodder cowpea recorded maximum duration, heat unit and heat use efficiency at maturity. The variety Kohinoor recorded the highest grain yield, lowest calendar days and highest HUE as compared to all other varieties

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Keywords: Green fodder; growing degree days; heat use efficiency; thermal indices.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is a warm season legume crop grown in arid and semi-arid regions of India. Traditionally, it is very important as a staple food and source of fodder for the African continent, India and other semi-arid regions [1]. In Asia, cowpea is grown in area of 0.15 million hectares with an annual production of 0.14 Mt (FAO STAT, 2016). In India, it is grown as a minor pulse crop in arid and semi-arid area of Punjab, Haryana, Delhi and West UP, however it is cultivated in large area in Rajasthan, Maharashtra, Gujarat, Karnataka, Kerala and Tamilnadu. Cowpea leaves and green pods are used as a fodder and vegetables, while dried grain is used in culinary preparations. As a legume crop it provides inexpensive source of quality protein for both rural and urban population, having an immense potential to contribute to the reduction of protein deficiency [2]. Cowpea nutritious grain contains approx. 21-31% protein, while it has been reported that its fodder contain about 20-24 % protein [3]. Cowpea is an important part of the traditional cropping systems, due to its ability to fix atmospheric nitrogen that improve soil fertility mainly in smallholder farming system where limited amount of fertilizer is been used. It can be intercropped with some broadly grown crops like maize, sorghum, sugarcane and pearl millet. It is drought tolerant, has a high heat tolerance capacity and well adapted to stressful environments where other crops fail to survive [4]. It is more tolerant to heavy rainfall than other pulse crops, but cannot withstand the cold and frost [4]. Cowpea crop proliferate better in optimum temperature lies between 27 to 35^{o}C [5,6]. The climatic conditions like temperature and relative humidity have great impact on crop development. The rate of plant growth and yield would be affected by change in climatic conditions [7]. The number of days to maturity of different varieties depends mainly on locations, date of sowing and temperature [8]. Daily minimum and maximum temperature is not a best predictor of crop development, as it may vary from year to year, among locations and from planting to maturity. Meteorological indices such as growing degree days (GDD), heliothermal unit (HTU) and photothermal unit (PTU) can be helpful to identify changes in phenological behavior, crop growth and yield [9]. Based on above facts, the present study was conducted to identify the impact of temperature indices on different phenophases and yield of cowpea varieties growing in Jhansi region of Uttar Pradesh.

2. MATERIALS AND METHODS

A field experiment was conducted during rainy seasons of 2010 and 2011 to determine the thermal indices for fodder cowpea varieties at Central Research Farm, ICAR-IGFRI, Jhansi (25°29’48.4” N, 78°33’35.6” E, and 233 m above the mean sea level). Treatments consist of two dates of sowing (12 July and 4 August) and four varieties (BL-1, BL-2, EC-4216 and Khoinoor). All the treatments are arranged in a factorial randomized complete block design with three replications. Seeds of these varieties were sown at 40 cm row spacing in 5× × 4 m^2 plots. Standard crop management practices were followed such as fertilizer doses and intercultural operations. Different phenophases (viz. 50% flowering, pod initiation and maturity) of fodder cowpea was recorded by regular field visit. The daily meteorological data for the study period were collected from the meteorological observatory located in, IGFRI, Jhansi (UP). Phenophase-wise GDD were calculated following the procedure given by Gupta et al. [10]. The base temperature of 10^{o}C [11] was used to calculate phenophase-wise GDD (Equation 1). HTU (Equation 2) and PTU (Equation 3) were determined by the equation proposed by Bhuva and Detroja [12].

$$GDD\ (℃\ day) = \sum\left(\frac{Tmax+Tmin}{2}\right) - Tb \sum\frac{Tmax+Tmin}{2}\ Tb \sum\frac{Tmax+Tmin}{2}\ Tb \qquad (1)$$

where, Tmax: Daily maximum temperature (℃), Tmin: Daily minimum temperature (℃), Tb: base temperature (10^{o}C for cowpea)

$$HTU\ (℃\ day\ hrs) = GDD \times BSS \quad (2)$$

where, BSS: Bright sunshine hours

$$PTU\ (℃\ day\ hrs) = GDD \times L \quad (3)$$

where, L: maximum day length hours in a season

All the data were subjected to ANOVA using PROC GLM procedure in SAS (v 9.3). In ANOVA, varieties, date of sowing and year effect were considered as fixed factors and replication as random factor.

3. RESULTS AND DISCUSSION

3.1 Fodder and Grain Yield

Among different cultivars, BL-2 recorded significantly ($p < 0.05$) higher green (354.21 q ha^{-1}) and dry fodder yield (46.9 q ha^{-1}), followed by the cultivar Kohinoor (337.2 and 42.3 q ha^{-1} respectively) compared to EC-4216 and BL-1 (Table 1). With respect to the date of sowing, 12th July had resulted in higher green fodder (331.5 q ha^{-1}) and dry fodder 44.6 q ha^{-1}) yield over 4th August (Table 1). The possible reason for the highest green and dry fodder yield on 12th July date of sowing might be due to conducive environmental condition than the delayed sowing (4th August). The similar observations under delayed sowing were also reported by various researchers [10,11], whereas, varieties Kohinoor and EC-4216 recorded higher grain yield (788.2-1133.3 kg ha^{-1}) over rest of the varieties (Table 1). Furthermore, the crop sown on 12th July had resulted in higher grain yield (934.3 kg ha^{-1}) over 4thAugust (844.3 kg ha^{-1}). The reason for the higher grain yield on 12th July sown crop might be due to prolonged reproductive phase of crop sown on 12thJuly (12th July(60 days) over 4th August (53 days) sown crops.

3.2 Phenology

The number of days taken to flowering and maturity varied significantly ($p < 0.05$) with different dates of sowing and varieties (Table 1). Among the varieties, BL-2 took maximum number of days to 50% flowering (66 days) and maturity (123 days) followed by Kohinoor (54 and 1111 days respectively). On the basis of date of sowing the number of days taken for 50 % flowering were significantly higher (57 days) during 12th July as compared to crop sown during 4th August (54 days). The late sown crop completed its vegetative and reproductive life cycle at an accelerated pace and leading to shorting of days taken to 50% flowering and maturity. Similar trend was also observed with the maturity period (Table 1).

3.3 Thermal Indices

Crops sown on 12th July took higher accumulated GDD during 50% flowering (1111°C days) and maturity (2074°C days) as compared to crop sown during 4th August (Table 1). GDD required at maturity reduced significantly with delayed sowing. This was due to longer period for 50% flowering in the normal growing conditions. Bhuva and Detroja [12] also reported a lower consumption of growing degree days under delayed sowing of pearl millet crop. The fluctuated high temperature during vegetative and reproductive phase decreased the duration of phenological events during late sown crop as compared to normal sowing. Variety BL-1 and EC 4216 recorded the lowest GDD (1932^{o}C days) at maturity stage. Significantly maximum GDD at maturity was recorded with BL-2.

Crop sown on 4th August required significantly ($p < 0.05$) higher HTU (5757^{o}C hrs) for fifty percent flowering (Table 1). This might be due the presence of lower temperature and sunshine for more days under late sown conditions. Whereas, HTU for maturity was found to be highest during 12th July sowing date compared to 4th August sowing date due to higher temperature during reproductive phase and thus led to reduction in the duration of crop (Table 2). Among varieties, HTU at 50% flowering were significantly ($p < 0.05$) higher (6909^{o}C hrs) in 'BL-2'and the lower in BL-1 (4779^{o}C hrs) than rest of the varieties. This might be due to its long and short duration characteristics, respectively. However, no differences were found among varieties in HTU at maturity except BL-2. Among cultivars, Kohinoor and BL-2 recorded significantly lowest (22983^{o}C days hrs) and highest (25526 ^{o}C days hrs) PTU at maturity, respectively (Table 2). PTI at 50% flowering and PTI at maturity were found significantly higher during early sown crop (12th July) (Table 2). Among different varieties, PTI at 50% flowering and at maturity were recorded significantly lower in BL-2 than BL-1, EC-4216 and Kohinoor due to its long duration phenophases.

3.4 Heat use Efficiency

Heat use efficiency of grain yield at maturity was significantly higher (0.47 kg ha^{-1}°C day^{-1}) for 12th July sown crop than 4th August sown crop (Table 2). Among the different varieties, grain yield of Kohinoor showed significantly the highest HUE (0.57 kg ha^{-1}°C day^{-1}) followed by BL-1 (0.47 kg ha^{-1}°C day^{-1}) and EC-4216, while variety BL-1 recorded significantly lowest (0.34 kg ha^{-1}°C day^{-1}) HUE over rest of the varieties due to its highest heat unit required for maturity. These findings are in agreement with the results of Gupta et al. [10]. However, dry matter yield did not show any significant difference among the varieties and date of sowing.

Table 1. Effect of sowing times and varieties on days to flowering, maturity grain yield and green & dry fodder yield of fodder cowpea (pooled for three years)

Treatment	Days to Flowering (in days)	Days to maturity (in days)	Grain yield (Kg/ha)	Straw yield (q/ha)	Green Fodder Yield at 50% Flowering (q/ha)	Dry Fodder Yield at 50% Flowering (q/ha)	GDDF * (°C days)	GDDPM* (°C days)	HTUF* °C days hrs)
Varieties									
BL-1	49.2	108.5	910.4	56.5	360.5	36.6	958	1944	4779
BL-2	65.5	123.5	732.6	60.0	404.0	41.6	1253	2120	6909
EC4216	51.1	110.6	788.2	56.0	396.9	37.8	995	1971	5092
Kohinoor	54.0	111.1	1133.3	52.4	395.7	36.6	1046	1977	5430
LSD (<0.05)	2.65	2.03	116.1	8.5	45.2	6.2	43.5	50	357
Time of sowing									
12 July	56.0	115.0	934.3	59.4	380.9	38.0	1110	2033	5344
3 August	53.0	111.0	844.3	52.8	398.4	38.3	1024	1873	5757
LSD (<0.05)	1.90	3.3	23.95	23.95	21.1	0.6	30.8	35	252

**F: 50% flowering; PM: Physical maturity*

Table 2. Effect of sowing times and varieties on days to flowering, maturity grain yield and green & dry fodder yield of fodder cowpea (pooled for three years)

Treatment	**HTUPM* (°C days hrs)**	**PTUF* (°C days hrs)**	**PTUPM* (°C days hrs)**	**PTIF* (°C)**	**PTIPM* (°C)**	**HUEGR* (kg ha^{-1} °C day^{-1})**	**HUEDR* (kg ha^{-1} °C day^{-1})**	**HUEGFY* (kg ha^{-1} °C day^{-1})**	**HUEDRF* (kg ha^{-1} °C day^{-1})**
Varieties									
BL-1	12902	12236	23615	19.5	17.9	0.47	2.9	31.2	2.3
BL-2	14123	15792	25528	19.1	17.2	0.34	2.8	28.4	2.2
EC4216	13099	12676	23911	19.5	17.8	0.40	2.8	29.5	1.9
Kohinoor	13102	13307	22983	19.5	17.9	0.57	2.7	32.5	2.1
LSD (<0.05)	410	522	546	0.07	0.21	0.05	1.2	2.43	0.23
Time of sowing									
12 July	13701	14196	26176	19.5	18.3	0.47	2.8	30.2	2.3
3 August	12413	12810	22343	19.2	17.0	0.42	2.8	30.5	2.0
LSD (<0.05)	289	369	386	0.04	0.15	0.03	0.5	0.75	0.16

**F: 50% flowering; PM: Physical maturity; GR: Grain Yield; DR: Dry matter yield at maturity; GFY and DRF: green fodder yield and Dry matter yield*

Green fodder yield of Kohinoor recorded highest HUE (32.4 kg ha^{-1}°C day^{-1}) over BL-2 and EC-4216 at the time of 50% flowering while it is at par with BL-1. However, HUE for dry fodder yield at 50 % flowering did not show any significant difference among the varieties and date of sowing.

4. CONCLUSION

Thus it may be concluded that early sown fodder cowpea recorded maximum duration, heat unit and heat use efficiency at maturity. The Variety Kohinoor recorded the highest grain yield, lowest calendar days and highest HUE as compared to other varieties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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