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Impact of organic and inorganic conditioners on thermal indices at different growth stages of cowpea under Sodic soil conditions

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Abstract
The present study was conducted to identify the effect of marine gypsum (50% GR), biochar, rhizobium and PGPR on thermal indices of cowpea under saline soils. The cowpea is grown under arid and semi-arid regions of India and is a warm season legume crop. A field experiment was conducted during summer season to determine the effect of different treatments on thermal indices of cowpea at Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Manikandam block, Tiruchirappalli. The treatment T8 with marine gypsum (50% GR), biochar, rhizobium and PGPR recorded higher growing degree days (GDD), photothermal unit and heliothermal unit during 50% flowering, maturity and harvesting stage as compared to other treatments and control.

Keywords: Cowpea, growing degree days, photo thermal unit, helio thermal unit

1. Introduction

Cowpea (*Vigna unguiculata* L.) belongs to Fabaceae family and is an annual herbaceous legume crop, one of the most consumed and widely cultivated grain legumes globally, especially in the semiarid regions across Asia and Africa. In India, it is grown as a minor pulse crop in arid and semiarid areas of Punjab, Delhi, Haryana and West UP. It is cultivated widely in large area of Rajasthan, Maharashtra, Gujarat, Karnataka, Kerala and Tamilnadu. Cowpea has unique ability to enrich the soil through biological nitrogen fixation in symbiotic association with rhizobial strains. It requires less amounts of inputs for its growth, as the root nodules of it can fix the nitrogen from atmosphere, thus making it a most valuable crop for resource poor farmers. It is moderately sensitive to sodicity. It is most cultivated legume crop because of its wider adaptability and can even grow in harsh environments under dry land condition (Baidoo and Mochiah, 2014) [6]. It is more tolerant to heavy rainfall than other pulse crops, but cannot withstand the cold and frost (Agbicodo *et al.*, 2009) [1]. It proliferates better under optimum temperature between 27 to 35ºC (Bisikwa *et al.*, 2014) [3]. The climatic conditions like temperature and relative humidity have great impact on the crop development. The number of days to maturity of crop depends mainly on locations, sowing date and temperature. The minimum and maximum daily 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), helio thermal unit (HTU) and photo thermal unit (PTU) can be useful in identifying the changes in phonological behavior, crop growth and yield (Prakash *et al*., 2015) [2]. Hence, the present study was conducted to identify the impact of temperature indices on yield of cowpea under sodic soil conditions.

2. Material and Methods

A field experiment was carried out during summer 2021 to determine the thermal indices of cowpea CO (CP) - 7 variety at Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Manikandam block, Tiruchirappalli (10.7556 º N, 78.6024 º E, at 85 m altitude above mean sea level (AMSL).
Treatments consists of T_1 Control - No Amendments (C), T_2 Marine Gypsum (50% GR), T_3 Biochar, T_4 PGPR + Rhizobium, T_5 Biochar + PGPR + Rhizobium, T_6 Marine Gypsum (50% GR) + Biochar, T_7 Marine Gypsum (50% GR) + PGPR + Rhizobium, T_8 Marine Gypsum (50% GR) + Biochar + PGPR + Rhizobium. All the treatments are arranged in a randomized block design with three replications. Seeds of this variety was sown at 40 x 15 cm with a depth of 5 cm.

The standard crop management practices such as fertilizer doses and intercultural operations were followed. The daily meteorological data for the study period were collected from the meteorological observatory located in, Anbil Dharmalingam Agricultural College and Research Institute, Trichy, GDD were calculated following the procedure given by Gupta *et al*., 2017 [4]. HTU and PTU were determined by the equation proposed by Srivastava, 2011.

$$GDD = \frac{T\ max + T\ min}{2 - T\ base}$$

Where
T max = maximum temperature
T min = minimum temperature
T base = base temperature (10 °C)
HTU = GDD x Actual bright sunshine hours
PTU = GDD x maximum possible day length

3. Results and Discussion

The growing degree days was calculated during two stages of crop growth *viz*., flowering and harvest stage and data have been presented in Table 1. Growing degree days from crop sown to flowering was observed highest with 926.0, 907.0, 887.0 GDD in organic and inorganic amended sodic soil with marine gypsum (50% GR) along with biochar, PGPR and rhizobium (T_8), marine gypsum (50% GR) and biochar (T_6) and marine gypsum (50% GR) along with PGPR and rhizobium (T_7) respectively. Similarly, same trend was observed from flowering to harvest stage with 570.75, 567.75 and 566.25 GDD respectively. Lowest Accumulated growing degree days was observed in the unamended sodic soil with 726.75 and 555.75 GDD at flowering and harvest stage respectively. This shows that the plant developmental rate was faster with the combined application of gypsum, biochar, PGPR and rhizobium.

Similarly, during flowering and harvest stage, helio thermal units were calculated and presented in Table 2. The highest HTU values were recorded at flowering stage (8114.05) and harvest stage (4360.28) for the sodic soil amended with marine gypsum (50% GR) along with biochar, PGPR and rhizobium (T_8). It was followed by marine gypsum (50% GR) with biochar (T_6) and marine gypsum (50% GR) with PGPR and rhizobium (T_7). Lowest HTU values are recorded in control with 6636.85 and 4170.40 HTU at flowering and harvest stages respectively. The photo thermal units were calculated during flowering and harvest stage and presented in Table 3. The photo thermal unit values were recorded highest at flowering stage (11165.68) and harvest stage (7077.75) for the sodic soil amended with marine gypsum (50% GR) along with biochar, PGPR and rhizobium (T_8). It was followed by marine gypsum (50% GR) with biochar (T_6) and marine gypsum (50% GR) with PGPR and rhizobium (T_7). Lowest PTU values were recorded during flowering stage (8714.90) and harvest stage (6835.73) in unamended sodic soil. This indicates that the progress of the crop growth was higher with the combined application of gypsum, biochar, PGPR and rhizobium. The growth and development of crop was low under salinity stress conditions. The combined application of biochar, PGPR and rhizobium under gypsum amended soil has resulted in increased growth and development of the plant. Similar results were reported by Conversa *et al.* 2015 [8] and Kumar *et al.* 2017 [5] for increased growth and flowering of crop under combined application of biochar and biofertilizer.

Table 1: Effect of Marine Gypsum (50% GR), Biochar, Rhizobium and PGPR on Growing degree days of cowpea

Treatments	Accumulated Growing Degree Days (GDD)		
	Flowering	Harvest	Total
T_1: Control	726.75	555.75	1282.50
T_2: Marine gypsum (50% GR)	867.50	562.75	1430.25
T_3: Biochar	808.25	583.00	1391.25
T_4: PGPR + Rhizobium	787.75	582.00	1369.75
T_5: Biochar + PGPR + Rhizobium	828.25	584.00	1412.25
T_6: Marine Gypsum (50% GR) + Biochar	907.00	567.75	1474.75
T_7: Marine Gypsum (50% GR) + PGPR + Rhizobium	887.00	566.25	1453.25
T_8: Marine Gypsum (50% GR) + Biochar + PGPR + Rhizobium	926.00	570.75	1496.75

Table 2: Effect of Marine Gypsum (50% GR), Biochar, Rhizobium and PGPR on Helio Thermal Units of Cowpea (ºC days hours)

Treatments	Helio Thermal Units (ºC days hours)		
	Flowering	Harvest	Total
T_1: Control	6636.85	4170.40	10807.25
T_2: Marine gypsum (50% GR)	7663.85	4238.63	11902.48
T_3: Biochar	7175.13	4413.25	11588.38
T_4: PGPR + Rhizobium	7080.83	4378.55	11459.38
T_5: Biochar + PGPR + Rhizobium	7311.13	4409.55	11720.68
T_6: Marine Gypsum (50% GR) + Biochar	7965.85	4330.28	12296.13
T_7: Marine Gypsum (50% GR) + PGPR + Rhizobium	7819.85	4250.53	12070.38
T_8: Marine Gypsum (50% GR) + Biochar PGPR + Rhizobium	8114.05	4360.28	12474.33

Table 3: Effect of Marine Gypsum (50% GR), Biochar, Rhizobium and PGPR on Photo Thermal Units of Cowpea (ºC days hours)

Treatments	Photo Thermal Units (ºC days hours)		
	Flowering	Harvest	Total
T_1: Control	8714.90	6835.73	15550.63
T_2: Marine gypsum (50% GR)	10446.13	6959.40	17405.53
T_3: Biochar	9717.35	7196.78	16914.13

T_4: PGPR + Rhizobium	9465.20	7178.03	16643.23
T_5: Biochar + PGPR + Rhizobium	9963.35	7215.38	17178.73
T_6: Marine Gypsum (50% GR) + Biochar	10931.98	7034.25	17966.23
T_7: Marine Gypsum (50% GR) + PGPR + Rhizobium	10685.98	7009.35	17695.33
T_8: Marine Gypsum (50% GR) + Biochar + PGPR + Rhizobium	11165.68	7077.75	18243.43

4. Conclusion

The combined application of marine gypsum (50% GR) along with biochar, PGPR and rhizobium has recorded highest GDD, HTU and PTU values during flowering and harvest stage. The growth and progress of the crop was highest under combined application of gypsum, biochar, PGPR and rhizobium in sodic soils and that can be used to predict the yield of the crop.

5. References

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