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Short Communication

Phase wise micrometeorological parameters influencing seed cotton yield in southern transitional zone of Karnataka

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Cotton (*Gossypium spp.*) is an important commercial fibre crop grown under diverse agro-climatic conditions and is popularly known as ‘White gold’. India has the distinction of having the largest area under cotton cultivation which is about 37 per cent of the world area under cotton cultivation with 13.48 million hectares and accounting to the production of 36.07 million bales. Despite being one of the world’s largest cotton growers, India’s productivity is around 455 kg ha^{-1}, which is lower than the global average yield of over 787 kg ha^{-1}. In terms of production, Karnataka is ranked fifth in the country. With the productivity of 485 kg ha^{-1}, Karnataka contributes about 2.33 million bales, accounting for about six per cent of the country’s total production.

Nearly 74 per cent of cotton area in Karnataka is under rainfed conditions. The microclimate is a factor of great importance in determining the yield and water loss from agricultural crops, the damage caused by the attack of various pests and diseases, and the success of the various measures which may be adopted to control such attacks. However, the correlations are not straightforward, in part because the crop surface itself has a significant moderating impact on the prevailing climatic conditions. Because of this, it is possible to anticipate that the crop’s microclimate will be very different from the environment of a nearby open location where typical climatological data is collected. (Stanhill and Fuchs, 1968). Micrometeorological parameters such as soil temperature, soil moisture and canopy temperature play a significant role in phenological development of crops. Hence, the present study was undertaken to understand the microclimatic factors during different phases of the cotton crop and their interactions with seed cotton yield.

A field experiment was conducted during *Kharif* 2021 at Centre for Climate Resilient Agriculture, College of Agriculture, Shivamogga to understand the relationship between micrometeorological parameters and cotton yield. The experiment comprised of three dates of sowing (S1:10th July, S2:25th July, S3: 10th August) with three levels of nitrogen (75% RDN, 100% RDN, 125% RDN) laid out in factorial randomized complete block design. Six phenophases were selected according to BBCH codes of phenology

P1 - Sowing to emergence (BBCH Code 00-09);

P2 - Emergence to pin head (BBCH Code 09-51);

P3 - Pin head to first flower (BBCH Code 51-60);

P4 - First flower to first boll maturity (BBCH Code 60-70);

P5 - First boll maturity to boll opening (BBCH Code 70-80); and

P6 - Boll opening to harvest (BBCH Code 80-99).

Micrometeorological parameters namely, soil temperature, soil moisture, canopy temperature and canopy temperature depression were measured at an interval of every 15 days. Soil temperature (^{o}C) was recorded in each treatment using a HI 98501 soil thermometer by inserting the steel penetration probe to the depth of 10 cm near five tagged plants in each treatment. Soil moisture was recorded using Lutron PMS - 714 moisture meter at 15 days interval by inserting the moisture meter probe to the depth of 10 cm near five tagged plants in each treatment. Canopy temperature (^{o}C) was recorded using Amici sense AS320 infrared thermometer. Observations were recorded by focusing the temperature sensor towards top of the plant canopy. Canopy temperature depression

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Table 1: Correlation between yield and micrometeorological parameters at different phenophases of cotton

Phases/parameters	P1	P2	P3	P4	P5	P6
Soil temperature	-0.510**	0.367*	-0.554**	0.528**	-0.005^{NS}	-0.544**
Soil moisture	-0.127^{NS}	0.485**	-0.233^{NS}	0.006^{NS}	0.388*	0.613**
Canopy temperature	-	0.392*	-0.286^{NS}	-0.392*	-0.093^{NS}	-0.218^{NS}
Canopy temperature depression	-	0.449*	-0.115^{NS}	0.421*	0.542**	0.469*

Where, n - 27, * - Significant at 5%, ** - Significant at 1%,

Table 2: Multiple linear regression equations fitted to explain the influence of micrometeorological parameters at different phenophases on seed cotton yield.

Phases/parameters	Regression Equation	R^2_{adj}
Soil moisture	Yield = 89.67 P2 -112.12 P5 + 132.16* P6 + 851.54	0.33
Soil temperature	Yield = 51.81 P1 + 62.20 P2 - 122.45 P3 + 92.57 P4 - 85.88 P6 + 1736.50	0.23
Canopy temperature	Yield = 44.67 P2 - 148.20 P4 + 4420.60	0.15
Canopy temperature depression	Yield = 68.96 P2 -651.30 P4 + 118.53 P5 + 624.02** P6 + 4603.57	0.46

Where, n - 27, * - Significant at 5%, ** - Significant at 1%,

(CTD) was calculated by subtracting mean air temperature from the canopy temperature. Observations were recorded between 11:00 am to 1:00 pm. Correlation studies between the final seed cotton yield and microclimatic parameters were made and multiple linear regression equations were fitted for significant correlations to quantify the effect of the micrometeorological parameters.

The results of correlation analysis are presented in Table 1. The multiple linear regression equations quantifying the effect of prevailed micrometeorological conditions at different phenophases of cotton is presented in Table 2.

Soil temperature

Soil temperature from emergence to pin head stage (r = 0.367) and first flower to first boll maturity (r = 0.528) had significant positive relationship with seed cotton yield. Whereas, significant negative relationship between seed cotton yield and soil temperature is observed for phenophases sowing to emergence (r= -0.510), pin head to first flower stage (r = -0.554) and from boll opening to harvest (r = -0.544). Soil temperature is an important variable governing plant growth and development. Significant positive relationship between soil temperature and seed cotton yield was observed for phenophases, emergence to pin head stage and first flower to first boll maturity stage. Warm soil encourages rapid, uniform establishment and promote the crop growth and development. Similarly, significant negative relationship has been observed for the phenophases, sowing to emergence, pin head to first flower and from boll opening to harvest stages. Significant negative correlation is also observed between soil temperature and soil moisture for the phenophase boll opening to harvest indicating deficit moisture conditions (r = -0.87**). The regression analysis indicated that, for every unit rise in soil temperature, soil moisture decreased by 0.96 per cent. The soil temperature was 1.5 ^{o}C higher in August 10th crop compared to the crop sown on July 10th. This moisture stress condition with non-uniform soil temperature regimes hampered the normal source-sink translocation resulting in lower boll weight and lower number of bolls in late sown crops.

Soil moisture

Significant positive correlations between soil moisture and seed cotton yield were observed for the phenophases, emergence to pin head stage (r = 0.485), first boll maturity to first boll opening stage (r = 0.388) and from boll opening to harvest stage (r = 0.613). Positive relationship during emergence to pin head stage indicated the better availability of moisture for crop development. Zhang *et al*., (2017) reported that insufficient moisture at early growth stage restricts root growth and development and consequently impairs functioning of the aerial parts in cotton. This phase comprises of major vegetative growth of the crop such as development of main stem nodes, monopodial and sympodial branching, stem elongation and expansion of leaf area. For all these morphological and physiological changes to occur sufficient moisture is necessary. Karademir *et al.*, (2012) noticed the reduction in leaf area by 30 per cent due to lack of moisture during this phase. Also, for the stage of first boll maturity to initial boll opening stage, availability of optimum soil moisture stimulates the proper boll opening. Similarly, sufficient soil moisture during the phase of boll opening to harvest promote assimilation of photosynthates from source to bolls and good boll bursting. Insufficient moisture at this stage substantially limits cotton yield production by inhibiting carbon assimilation and biomass accumulation. Inhibited carbohydrate production coupled with depletion of stored reserves (*i.e*., starch) due to continuous respiration, reduce the translocation of assimilates to reproductive organs. This consequently induces abscission of reproductive structures and boll size reduction (Zahoor *et al.*, 2017).

Canopy temperature

The present study depicted that canopy temperature from emergence to pin head stage (r = 0.392*) had significant positive relationship with seed cotton yield. Significant negative relationship between canopy temperature and seed cotton yield was observed for the phenophase first flower to first boll maturity (-0.392*). The crop canopy temperature relies on energy exchange between the crop surface and the atmosphere, which is determined by sensible heat flux and the latent heat flux in Soil-Plant-Atmosphere Continuum. Therefore, the crop canopy temperature closely correlated to the water deficit stress could be used to monitor crop water status. Optimum canopy temperature coupled with sufficient soil moisture during emergence to pin head stage created a congenial condition for canopy development. During the phenophase, first flower to first boll maturity, canopy temperature was higher than ambient air temperature. The canopy temperature was about 1.6 °C higher than ambient temperature conditions in July 25th sown crop and 1.9 °C higher in August 10th sown crop compared to 1.2 °C under July 10th sown crop. This increased canopy temperature created warmer canopies affecting normal physiological processes like transpiration and stomatal conductance.

Canopy temperature depression (CTD)

Deviation of temperature of plant canopies from the ambient temperature is known as canopy temperature depression. This has been recognized as an indicator of overall plant water status. The correlations between CTD and yield of a crop can be used as an indicator of drought stress tolerance of a crop (Blum *et al*., 1989). Lower the value of CTD, cooler is the canopy indicating normal stomatal conductance and transpiration activity in the plants. Significant positive relationship between seed cotton yield and canopy temperature depression was observed for the phenophases emergence to pinhead (r = 0.449*), first flower to first boll maturity stage (r = 0.421*), first boll maturity to boll opening stage (r = 0.542**) and boll opening to harvest stage (r = 0.469*). Average canopy temperature depression was much higher in crops sown on July 25th and August 10th (-1.8 °C, -1.6 °C, -4.5°C and -5.5 °C for July 25th sown crop and -1.3 °C, -1.9 °C, -5.4 °C and -5.7 °C for August 10th sown crop, respectively) compared to crop sown on July 10th (-1.1 °C, -1.2 °C, -1.3 and -5.5 °C, respectively) for these phenophases. Yoshida and Shioya (1976) stated that under limited soil moisture conditions due to decrease in stomatal conductance, canopy temperature rises and causes subsequent decrease in canopy temperature depression value. The value of CTD is more negative under water stress or water deficit conditions. More considerately, higher values of CTD have significantly impaired the assimilate translocation to developing bolls leading to lower number of bolls per plant and also reduced boll weight finally impacting the final seed cotton yield.

The present investigation quantified the relationship between seed cotton yield and micrometeorological parameters at different phenophases of crop growth period. Micrometeorological parameters posed a significant impact on final yield through its modifying effect in the crop canopy in comparison to adjacent environment. Phenophase wise delineation of effect of micrometeorological parameters identified the individual effect of these parameters on final seed cotton yield. Cotton, being majorly grown under rainfed conditions is majorly influenced by changes in microclimatic conditions. Suitable modifications in the microclimate during these particular phenophases can help achieve higher cotton productivity.

Conflict of Interest Statement: The author(s) declare(s) that there is no conflict of interest.

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