Original Research Article

Optimization of sowing window for Bt Cotton using DSSAT Seasonal Analysis Tool in Nagarkurnool district of Telangana State

ABSTRACT

Aims: A study was carried out to find out the optimum sowing time with the validated CROPGRO-Cotton model using DSSAT v 4.7 seasonal analysis tool under rainfed situation at mandal level in Nagarkurnool district of Telangana state

Study design:CROPGRO-Cotton model using DSSAT v 4.7 seasonal analysis tool.

Place and Duration of Study: Nagarkurnool district, 2023.

Methodology: Cotton production was affected with changing climate in several ways and its impact on rainfed agriculture was higher and influences the Indian economy. The prevailing weather conditions during different phenophases of the crop influences the seed cotton yield. There is a need to optimize the sowing time so that the timing of critical growth stages to minimize stresses and enhance resource utilization. The adjusting of sowing environment proved to be an adaptation management technique for realising higher seed cotton yield.
A well calibrated and validated model was used for long term simulations using DSSAT seasonal analysis tool programme with Mallika Bt as test variety for 100 different scenarios (20 mandals × 5 sowing dates) using 32 years historical daily weather data from 1991 to 2022 starting sowing time from 1stJune to 1stAugust at 15 days interval in twenty mandals of the district.

Results: The simulation results showed, significantly higher seed cotton yield (1505 kg ha-1) was predicted with crop sown on 1st June followed by 1st July sown crop (1337 kg/ha) which was comparable with 16th June (1324 kg/ha) and significantly differed with delayed sowings of 16th July sown crop (1203 kg/ha) and 1st August sown crop (1192 kg/ha). Among the different mandals of the district, the model simulated higher seed cotton yield (2136-2530 kg/ha) in Amrabad mandal and lower yields in Thimmajipet mandal (596-997 kg/ha) under different sowing environments.

Conclusion: Based on simulation scenarios, higher seed cotton yield can be obtained when crop sown between 1st June to 1st July in different mandals of the Nagarkurnool district of Telangana State. The mandals which have less yield potential and realising poor yields by the farmers can be advocated with location specific alternate best management practices to get the higher cotton yield.

Keywords: BtCotton, Seasonal analysis, CROPGRO-Cotton Model, Rainfed situation

1. INTRODUCTION

Cotton is one of the most important commercial crops cultivated in India and accounts for around 25% of the total global cotton production. It plays a major role in sustaining the livelihood of an estimated 6 million cotton farmers and 40-50 million people engaged in related activity such as cotton processing & trade. The Indian Textile Industry consumes a diverse range of fibres and yams and the ratio of use of cotton to non - cotton fibres in India is around 60:40 whereas it is 30:70 in the rest of the world. Apart from being the provider of a basic necessity of life i.e. clothing which is next only to food, cotton is also one of the largest contributor to India's net foreign exchange by way of exports in the form of raw cotton, intermediate products such as yam and fabrics to ultimate finished products in the form of garments, made ups and knitwear. Due to its economic importance in India, it is also termed as "White-Gold". India got 1st place in the world in cotton acreage with 120.55 lakh hectares area under cotton cultivation i.e. around 36% of world area of 331 lakh hectares. Around 67% of India's cotton is grown on rain-fed areas and 33% on irrigated area. In terms of productivity, India is on 40th rank with yield of 445 kg/ha. India is one of the largest cotton producing country in the world with estimated production of 315.43 lakh bales (5.36 Million Metric Tonnes during cotton season 2021 -22 which is 21% of world cotton production of 1522 lakh bales (25.89 Million Metric Tonnes). India is one of the largest consumer of cotton with estimated consumption of 326 lakh bales (5.54 Million Metric Tonnes i.e. 21% of world cotton consumption of 1538 lakh bales (26.16 Million Metric Tonnes).

The impact of climate change on cotton crop is gaining momentum because of its association with the national economy and providing livelihood security to 60 million people including all stakeholders of the cotton value chain (Sankaranarayanan et al. 2010). The changing climate has threatened the productivity of the agriculture sector making it vulnerable both economically and physically to climate unevenness and change. Productivity is being affected by many climate change variables including rainfall, high temperature, changes in sowing and harvesting dates, water availability and land suitability (Balathandayutham and Mayilswami 2015). Climate change may not have huge overall effects but regional effects are more extensive.Variable sowing time is mostly dependent upon climate, species specificity and agro-climate (rainfed vs. irrigated). Most favourable sowing time provides favourable situation for adequate crop growth as it escorts to the realization of the productivity potential of the crop (Sankaranarayanan et al. 2011a).

Crop growth models such as the Decision Support System for Agrotechnology Transfer (DSSAT), allow researchers to conduct several hypothetical experiments rapidly and inexpensively, facilitating the development and evaluation of management strategies. DSSAT is a process-based model (Hoogenboom et al., 2015) that uses meteorological, soil, and crop management data to predict the growth and development of a particular crop in a set location. DSSAT has over 42 crop modules, each of which is designed to mimic the behaviour of a specific crop. The CROPGRO-Cotton (Jones et al., 2003) module in the DSSAT Cropping System Model (CSM) was used in this study.

Crop growth and development are important aspects of DSSAT model evaluation and evaluation of DSSAT CROPGRO-Cotton model using phenological stages, in-season crop growth and development data, and crop yield has been attempted by Mahadevappa et al. (2017). The objective of this research was to use the evaluated model to determine the optimum sowing time to realize maximize yield under five sowing dates in twenty mandals of the Nagarkurnool district and identify the most effective date of sowing strategy for maximizing yield.

Comment [A1]: very long paragraph, I suggest better dividing the concepts into uniform and not excessively long paragraphs.

Comment [A2]: Outdated reference. I suggest updating.

2. MATERIAL AND METHODS

A study was conducted on performance of Bt Cotton using Mallika Bt Hybrid in different mandals of Nagarkurnool district located in Telangana state under different sowing environments over 32 years using seasonal analysis tool of CROPGRO-Cotton model of DSSAT 4.7 version. The Nagarkurnool district receives 480 mm of normal rainfall during south west monsoon season was the main source of soil moisture for the rainfed crops especially for the cotton grown in the district. The treatments comprised of five dates of sowing (1st June, 16th June, 1st July, 16th July and 1st August) in twenty mandals of the district comprising a total of 100 scenarios using the daily weather data for 32 years starting from 1991 to 2022. The recommended dose of 150 kg of Nitrogen applied in four equal splits at 20, 40, 60 and 80 days after sowing. A well calibrated and validated genetic coefficients developed by the Mahadevappa et al. (2018) were used for running the seasonal analysis tool. The data were analyzed statistically applying one way analysis of variance technique and critical difference for examining treatment means for their significance was tested with Tukey`s (HSD) test.

Comment [A3]: Here it needs improvements. Bring in figures and rearrange the materials and methods sections. Adequately describe everything that was evaluated and how it was evaluated. Start with the characteristics of soils and crops, climatic conditions and computational models.

3. RESULTS AND DISCUSSION

An analysis was carried out using DSSAT seasonal analysis tool and simulations were generated. The simulation scenarios of different sowing dates subjected to one way analysis of variance and means were compared with Tukey's HSD test.

Significantly higher mean above ground biomass production (2283 kg ha^{-1}) was predicted with crop sown on 1st June under rainfed situation followed by 1st July sown crop (2038 kg ha^{-1}) and which was on par with 16th June sown crop (2015 kg ha^{-1}) and significantly lower seed cotton yield (1730 kg ha^{-1}) was predicted when crop sown on 1st August in Nagarkurnool district. Significantly higher mean seed cotton yield (1505 kg ha^{-1}) was predicted with crop sown on 1st June under rainfed situation followed by 1st July sown crop (1337 kg ha^{-1}) and which was on par with 16th June sown crop (1324 kg ha^{-1}) and significantly lower seed cotton yield (1192 kg ha^{-1}) was predicted when crop sown on 1st August in Nagarkurnool district. Similar observations were recorded with respect to cotton seed yield.

Table 1: Tukey's test (HSD) for seed cotton yield, cotton seed yield and above ground biomass (kg ha^{-1}) under different sowing dates

Sowing date	Mean above ground biomass	Mean Seed cotton yield	Mean Cotton Seed yield
1st June	2283 [a]	1505 [a]	1021 [a]
16th June	2015 [bc]	1324 [bc]	889 [bc]
1st July	2038 [bc]	1337 [bc]	897 [bc]
16th July	1796 [d]	1203 [d]	795 [d]
1st August	1730 [e]	1192 [e]	786 [e]

The simulation scenarios showed that the median seed cotton yield decreased consistently with delay in sowing of the crop from June to August. Similarly, the box plot showed that crop sown on 1st June has considerably less variability with higher median seed cotton yield than delayed sowings (Fig. 1). Further this reduced variability gave the least downside risk (risk for achieving low yields) when compared to later dates which had more variability in yields.

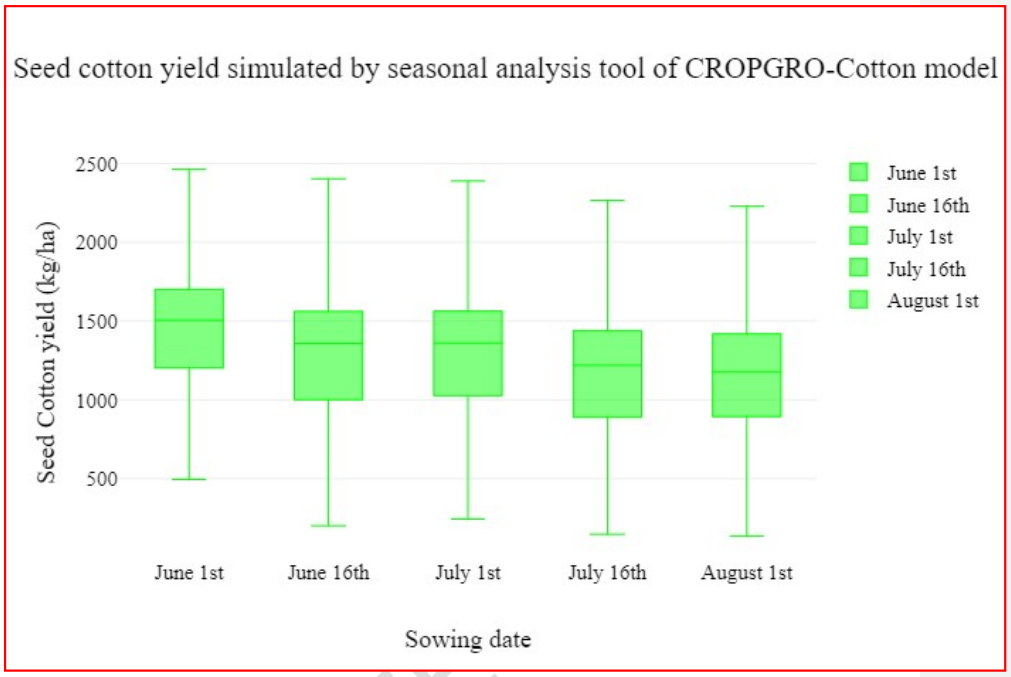

Fig.1: Seed cotton yield simulated by seasonal analysis tool of CROPGRO-Cotton model

However, the date of onset of south west monsoon, which is the only source for soil moisture, has a significant role on time of sowing of the rainfed crops in a given region. The normal onset of south west monsoon in this region is 13th June. The normal rainfall of the district during summer season (March-May) amounts to 55 mm facilitates the farmers for land preparation and to be ready for sowing of rainfed crops after onset of monsoon. The model also predicted significantly higher median seed cotton yield when crop sown on 16th June and 1st July with less down risk of achieving lower seed cotton yields after 1st June sown crop over the delayed sowings. Considering the date of onset of monsoon, it is advisable to go for sowing of rainfed cotton from 16th June to 1st July to benefit the favourable weather realise the on in the district.

Further, the simulation scenarios showed that the above ground biomass production / tops weight at maturity decreased consistently with delay in sowing of the crop from June to August. The bens plot showed that crop sown on 1st June has considerably less variability with higher median seed cotton yield than delayed sowings (Fig. 2). Further this reduced variability gave the least downside risk (risk for achieving low yields) when compared to later dates which had more variability in yields.

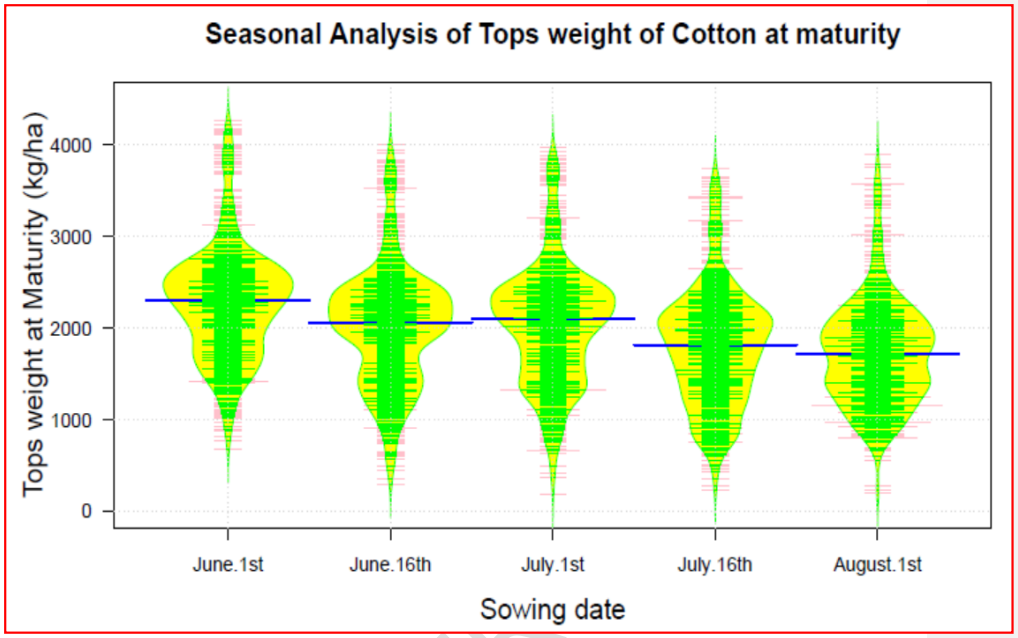

Fig.2: Above ground biomass / tops weight (kg/ha) at maturity simulated by seasonal analysis tool of CROPGRO-Cotton model under rainfed situation in Nagarkurnool district

Among the different mandals of the Nagarkurnool district, simulation scenarios showed that the median seed cotton yield decreased consistently with postponement of sowings from June to August. Among the different mandals of the district, the model simulated higher seed cotton yield (2136-2530 kg/ha) in Amrabad mandal and lower yields in Thimmajipeta mandal (596-997 kg/ha) under different sowing environments.

The significantly higher mean above ground biomass (2283 kg ha^{-1}) was predicted with crop sown on 1st June under rainfed situation followed by 1st July sown crop (2038 kg ha^{-1}) and which was on par with 16th June sown crop (2015 kg ha^{-1}) and significantly lower seed cotton yield (1730 kg ha^{-1}) was predicted when crop sown on 1st August in Nagarkurnool district. Among the different mandals of the district, the model simulated higher above ground biomass (3086-3782 kg/ha) in Amrabad mandal and lower yields in Thimmajipeta mandal (899-1535 kg/ha) under different sowing environments. Based on the model predictions mandals are grouped into below 1000, 1001-1500, 1501-2000 and above 2000 kg ha^{-1} categories of seed cotton yield production mandals (Table 2 and Fig 3) with different sowing environments. More than 75% mandals have the capability to produce 1001-1500 kg ha^{-1} seed cotton yield when crop sown between 1st June to 1st July.

Table 2: Potentiality of the mandals of the Nagarkurnool district under different sowing dates for Seed Cotton Yield under rainfed situation as predicted by CROPGRO-Cotton model

Seed cotton yield (kg/ha)/ Sowing time	1st June	16th June	1st July	16th July	1st August	Average
>1000	Lingal, Vangoor, Thimmajipeta	Lingal, Vangoor, Thimmajipeta, Kollapur	Lingal, Vangoor, Thimmajipeta, Kollapur	Lingal, Vangoor, Thimmajipeta, Kollapur	Lingal, Vangoor, Thimmajipeta, Kollapur	Lingal, Vangoor, Thimmajipeta, Kollapur
1001-1500	Kollapur, Charakonda, Kodair, Bijinapalle, Padra, Balmoor, Veldanda	Charakonda, Kodair, Bijinapalle, Padra, Balmoor, Veldanda, Kalwakurthy, Urkonda, Uppunuthala, PeddakothapalleTelkapalle, Pentlavelli	Charakonda, Kodair, Bijinapalle, Padra, Balmoor, Veldanda, Kalwakurthy, Urkonda, Uppunuthala, PeddakothapalleTelkapalle, Pentlavelli	Charakonda, Kodair, Bijinapalle, Padra, Balmoor, Veldanda, Kalwakurthy, Urkonda, Uppunuthala, PeddakothapalleTelkapalle, Tadoor, Pentlavelli, NagarKurnool	Charakonda, Kodair, Bijinapalle, Padra, Balmoor, Veldanda, Kalwakurthy, Urkonda, Uppunuthala, PeddakothapalleTelkapalle, Tadoor, Pentlavelli, NagarKurnool	Charakonda, Kodair, Bijinapalle, Padra, Balmoor, Veldanda, Kalwakurthy, Urkonda, Uppunuthala, PeddakothapalleTelkapalle, Tadoor, Pentlavelli
1501-2000	Kalwakurthy, Urkonda, Uppunuthala, Peddakothapalle, Telkapalle, Tadoor, Pentlavelli, NagarKurnool	Tadoor, NagarKurnool	Tadoor, NagarKurnool	Achampet	Achampet	NagarKurnool, Achampet
2001-2530	Achampet, Amrabad	Amrabad	Amrabad	Amrabad	Amrabad	Amrabad

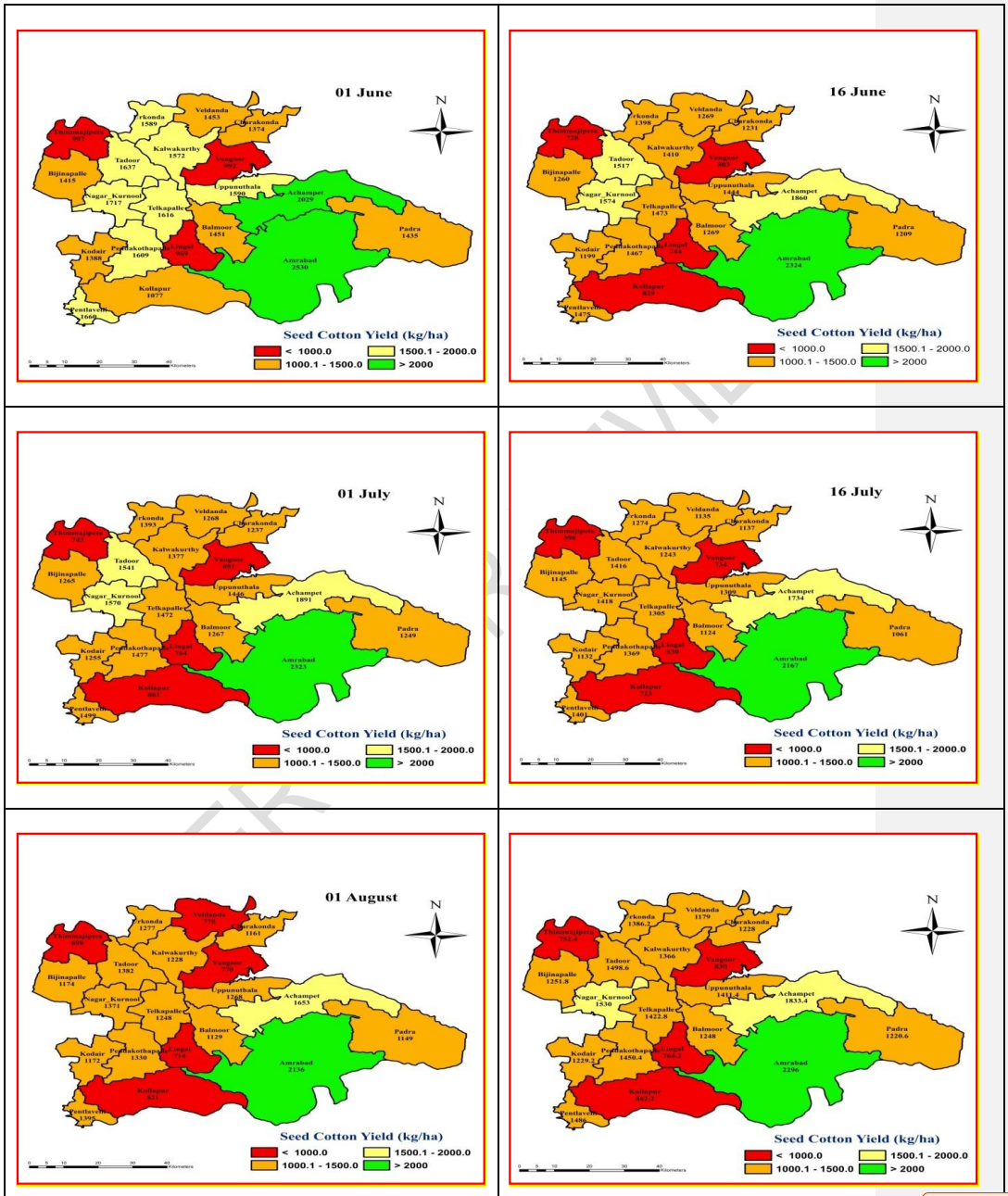

Fig. 3: Seed cotton yield as influenced by different sowing dates predicted by seasonal analysis tool of CROPGRO-Cotton model over 32 years period (1991-2022)

Comment [A4]: This section needs profound changes. In each result it is necessary to bring theoretical references to support the findings of your study.

4. CONCLUSION

Based on simulation scenarios, higher seed cotton yield can be obtained when crop sown between 1st June to 1st July in different mandals of the Nagarkurnool district of Telangana State. The mandals which have less yield potential and realising poor yields by the farmers can be advocated with location specific alternate best management practices to get the higher seed cotton yield.

Comment [A5]: In conclusion, it is worth being succinct. Was the prediction model effective? What was the innovation factor of your work? In this section, try to be direct and bring the news that your research has brought to your peers.

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Comment [A6]: I suggest updating the bases and adding more research to your manuscript.