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***Research Paper***

# Predicting the seed cotton yield with value added medium range weather forecast data using CROPGRO-Cotton model at Bhathinda, Punjab

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## ABSTRACT

In order to assess the potential of the medium-range weather forecast in predicting the cotton productivity using crop simulation model, the CROPGRO-cotton model was calibrated and validated with the experimental data which was collected during *kharif* 2021 in an experiment that was carried out with two *Bt* cotton hybrid (RCH 776 and RCH 773) and one non-*Bt* (F2228), and sown at five dates *i.e.,* April 25$^{th}$, May 05$^{th}$, May 15$^{th}$, May 25$^{th}$ and June 04$^{th}$ in split-plot design with three replications at Punjab Agricultural University (PAU) Regional Research Station, Bathinda. The validated model was further used to assess the cotton productivity under different sowing dates using medium range weather forecast data on rainfall, maximum temperature and minimum temperature obtained for the period 2013-2021. The results showed that simulated values with medium range weather forecast were in close agreement with the simulated values for phenology and yield of cotton. The simulated cotton yield using daily medium range weather forecast data showed more or less significant efficiency to capture year-to-year as well as date-wise variability in simulated cotton yield.

***Keywords****:* Medium-range weather forecast, CROPGRO-cotton model, *Bt*-cotton hybrids, date of sowing, Phenology and Seed cotton Yield.

Cotton is a prominent cash crop in the region of Punjab, signifying its crucial role in the economy. Cotton, known as the "White Gold" or the "King of Fibres," holds a pivotal position in India's agricultural and industrial sectors due to its immense value as a source of fibre. India is biggest producer in the world followed by China and USA accounting for about 23% of the world cotton production. During the year 2021-22, India had 12.50-million-hectare area and produced 5.81 million MT of cotton with productivity of 465kg ha$^{-1}$ (Anonymous, 2022a). While seeing the situation with cotton in Punjab during 2020-21, area was 3.04 lakh hectares along with 11.6 lakh bales production and 652 kg ha$^{-1}$ productivity (Anonymous, 2022b).

Weather forecasts contribute to food and livelihood certainty by providing us pre information to adjust critical agricultural decisions e.g., irrigation, fertilizer, weeds control, planting, harvesting (Apipattanavis *et al.,* 2010). Accurate and timely weather forecasts play a crucial role in reducing the overall expenses associated with crop cultivation while simultaneously boosting crop productivity within the field. Moreover, dependable weather predictions supply valuable insights for precisely evaluating the impact of weather conditions on agricultural operations. The extent to which crops are susceptible to climatic variations primarily hinges on their developmental stage during unexpected weather disturbances (Lansigan *et al*., 2000). Farmers can leverage weather forecasts to make informed decisions concerning crop selection, the timing of planting, and the implementation of protective measures for their crops. This strategic approach aims to maximize crop yields, enabling farmers to capitalize on favorable weather patterns and minimize the detrimental effects of adverse climate conditions on their agricultural endeavors (Cabrera *et al*., 2009).

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The availability of timely medium-range weather forecasts offers significant advantages for effectively managing unexpected weather deviations. Farmers can adapt their crop schedules and plan their agricultural activities to achieve optimal production, even in adverse weather conditions. Despite the existence of national and regional agro advisory services, there is a growing emphasis on establishing district-level agro advisory services to ensure that farmers can benefit to the fullest extent from weather-based agricultural advisory services (Lunagaria *et al*., 2009). Consequently, the significance of weather forecasting has gained importance due to the impact of climate change on crop production, both at the level of individual farmers and in crop-related decision-making (Cabrera *et al*., 2009). More than 60% of farmers have recognized the utility of weather predictions and Agromet Advisory Services (AAS) for determining irrigation timing, optimizing fertilizer application, managing pests and diseases, and planning crop harvesting (Khichar and Bishnoi, 2003).

Crop modeling provides not only predictive capabilities but also a deeper understanding of crop behavior. However, this benefit comes at the expense of requiring extensive input data and numerous parameters. When using locally customized and validated crop simulation models, it becomes possible to assess potential production outcomes for various management options across a range of forecasted climatic conditions. Temperature and precipitation forecasts imply that multi-day weather forecasts exhibit sufficient accuracy for making predictions related to crop yield and phenology (Asseng *et al*., 2016). So, keeping in view of the above facts, in the present study efforts have been made to quantify seed cotton yield by incorporating value-added medium-range weather predictions with the help of CROPGRO-cotton model in the south-western Punjab region.

## MATERIALS AND METHODS

***Experimental details***

The study was carried out in a split-plot design at Punjab Agricultural University (PAU), Regional Research Station, Bathinda (30°36'09" N, 74°28'55" E) during the *kharif* season of 2021. The main plot treatments included five sowing dates (April 25$^{th}$, May 5$^{th}$, May 15$^{th}$, June 4$^{th}$, and June 25$^{th}$), and the sub plots contained three plant spacing's (67.5cm, 75.0cm and 60cm). In a factorial split plot design with three replications, a total of sixty treatment combinations were investigated. Bathinda, in Punjab's southwest, experiences a semi-arid climate in the 5$^{th}$Agro Climatic Region. It receives an average annual rainfall of 456 mm, with 72% during the South-Western monsoon season (July-mid September) and the rest in winter. June sees high temperatures of 40-45°C, while January averages 6-8°C.

***CROPGRO-cotton model***

CROPGRO-Cotton in DSSAT evaluates cotton yield based on soil, weather, and management inputs, modelling daily growth, phenology, and key factors like growth stages, plant development, biomass, and water and nitrogen balances. It's a valuable tool for cotton yield analysis (Patil *et al.,* 2019). The genetic coefficients are scalar values that are transformed to physiological values within the model to explain the phenology and grain yield components of a particular variety. Genetic coefficient already calibrated by Dhir *et al.,* (2021) for the *Bt* cotton hybrid RCH-773, by Rotash Kumar (2020) for *Bt* cotton hybrid RCH-776 and by Mishra *et al.,* (2021) for non-*Bt* variety F-2228 BGII were used in the present study. Furthermore, the CROPGRO-cotton model was validated for these varieties using experimental data of 2021.

***Medium range weather forecast***

Medium range weather forecast (MRWF) data of Bhatinda for the period of 2013-2021 was obtained from the Meteorological Centre, Chandigarh and used as input parameters in CROPGRO-cotton model to simulate the yield of the cotton cultivars. The simulation result was also compared with the actual weather condition for year 2021. The same initial conditions like soil, management practices, genetic coefficients were used to run the CROPGRO-cotton model for different years (2013 – 2020).

## RESULTS AND DISCUSSION

***Validation of CROPGRO-cotton model***

Table 1 shows that the phenological stages (emergence, anthesis and maturity) simulated with the forecasted data of 2021 were in close agreement with that of with the actual data as evident from the statistical parameters RMSE, d-stat and $R^2$. The deviation between simulated days to anthesis by the actual and forecasted data was hardly differed by 1-2 days while the simulated maturity of the cotton cultivars were less than 5 days in early sown cotton and between 7 to 9 days under late sown crops with overall RMSE of 5.98 days. The $R^2$ of 0.98 in simulating the maturity of cotton cultivars indicates that the forecasted weather data can be used in CROPGRO-cotton model as input parameter to predict the phenology of cotton cultivars. The simulated seed cotton yield ranged from 1801 to 3154 kg ha$^{-1}$and 1789 to 3279 kg ha$^{-1}$ respectively with actual and forecasted weather. As evident from the Table 1, the deviation of the seed yields was less than 10% in most of the treatment combinations. Hence, the forecasted weather data can be used to predict the seed yield of cotton using the validated CROPGRO-cotton model for cotton cultivars under different sowing dates.

***Prediction of seed cotton yield***

The validated CROPGRO-cotton model was further used to predict the seed cotton yields of cotton cultivars using past forecasted data from 2013 to 2020 for three cotton cultivars under five dates of sowing and compared simulated with the actual past weather data. A comparison of simulated and predicted seed cotton yields (kg ha$^{-1}$), averaged for dates of sowing, varieties and years during 2013 to 2020 are presented in Table 2. Under different dates of sowings, the difference in simulated seed cotton yield over forecasted varied from 0.17 to 6.26% with $R^2$ between 0.62 to 0.92 indicating very close prediction, however, the RMSE values indicated that the error was found to increase with delay in sowing (Table 2). Similarly, for three varieties the deviations were less than 5.5% with $R^2$ between 0.62 to 0.85 and less than 401 kg ha$^{-1}$.

Out of eight years (2013-2020) of simulation analysis, the deviation in cotton seed yields were less than 10 % in six years except in 2016

**Table 1:** Simulated days to emergence, days to anthesis, days to maturity and seed cotton yield with actual and forecasted data as affected by sowing time and varieties during 2021.

| Sowing dates | Varieties | Emergence (DAS) | | | Anthesis (DAS) | | | Maturity (DAS) | | | Seed cotton yield (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Actual data | Forecasted | Deviation | Actual data | Forecasted | Deviation | Actual data | Forecasted | Deviation | Actual data | Forecasted | Deviation (%) |
| April 25th | RCH 776 | 8 | 7 | -1 | 63 | 61 | -2 | 165 | 162 | -3 | 3005 | 3058 | 0.03 |
| | RCH773 | 8 | 7 | -1 | 62 | 60 | -2 | 161 | 158 | -3 | 3065 | 3279 | -6.98 |
| | F 2228 | 8 | 7 | -1 | 69 | 67 | -2 | 167 | 163 | -4 | 2240 | 2116 | 5.53 |
| May 5th | RCH 776 | 8 | 8 | 0 | 63 | 62 | -1 | 166 | 163 | -3 | 3154 | 2931 | 7.07 |
| | RCH773 | 8 | 8 | 0 | 62 | 60 | -2 | 161 | 158 | -3 | 2956 | 2654 | 10.22 |
| | F 2228 | 8 | 8 | 0 | 68 | 67 | -1 | 168 | 164 | -4 | 2099 | 2074 | 1.77 |
| May 15th | RCH 776 | 7 | 7 | 0 | 61 | 60 | -1 | 168 | 163 | -5 | 2840 | 2806 | 1.19 |
| | RCH773 | 7 | 7 | 0 | 60 | 59 | -1 | 161 | 157 | -4 | 2993 | 2650 | 11.46 |
| | F 2228 | 7 | 7 | 0 | 66 | 66 | 0 | 170 | 165 | -5 | 2173 | 1986 | 8.60 |
| May 25th | RCH 776 | 8 | 7 | -1 | 61 | 60 | -1 | 176 | 168 | -8 | 2288 | 2299 | -0.48 |
| | RCH773 | 8 | 7 | -1 | 60 | 59 | -1 | 168 | 161 | -7 | 2244 | 2159 | 3.78 |
| | F 2228 | 8 | 7 | -1 | 66 | 65 | -1 | 178 | 170 | -8 | 2072 | 2097 | -1.20 |
| June 4th | RCH 776 | 9 | 9 | 0 | 61 | 60 | -1 | 189 | 180 | -9 | 1932 | 2159 | -11.74 |
| | RCH773 | 9 | 9 | 0 | 60 | 59 | -1 | 180 | 172 | -8 | 2250 | 2035 | 9.55 |
| | F 2228 | 9 | 9 | 0 | 66 | 66 | 0 | 190 | 181 | -9 | 1801 | 1789 | 0.66 |
| RMSE | | | 0.63 | | | 1.29 | | | 5.98 | | | 6.77 | |
| d-Stat. | | | 0.58 | | | 0.90 | | | 0.85 | | | 0.92 | |
| $R^2$ | | | 0.62 | | | 0.95 | | | 0.98 | | | 0.87 | |

**Table 2:** Comparison of simulated seed yield (kg ha$^{-1}$) of cotton cultivars under different dates of sowing using actual and forecasted weather during 2013-2020

| Treatments | Simulated yield using | | Deviation (%) | $R^2$ | RMSE | d-Stat. |
|---|---|---|---|---|---|---|
| | Actual data | Forecasted data | | | | |
| **Dates of sowing** | | | | | | |
| April 25th | 2787 | 2792 | 0.17 | 0.92 | 223.85 | 0.88 |
| May 5th | 2362 | 2490 | -5.14 | 0.71 | 347.46 | 0.70 |
| May 15th | 2330 | 2383 | -2.22 | 0.79 | 351.25 | 0.75 |
| May 25th | 1796 | 1916 | -6.26 | 0.62 | 369.28 | 0.65 |
| June 4th | 1669 | 1721 | -3.02 | 0.68 | 451.78 | 0.61 |
| **Varieties** | | | | | | |
| RCH 776 | 2428 | 2482 | -2.17 | 0.80 | 401.25 | 0.76 |
| RCH 773 | 2316 | 2451 | -5.50 | 0.62 | 385.85 | 0.64 |
| F 2228 | 1824 | 1849 | -1.35 | 0.85 | 243.72 | 0.81 |
| **Years** | | | | | | |
| 2013 | 2060 | 2276 | -9.49 | 0.77 | 232.46 | 0.75 |
| 2014 | 2652 | 2500 | 6.08 | 0.81 | 239.25 | 0.85 |
| 2015 | 1869 | 1911 | -2.19 | 0.81 | 531.84 | 0.79 |
| 2016 | 2252 | 1960 | -14.89 | 0.59 | 532.75 | 0.62 |
| 2017 | 2195 | 2052 | -6.96 | 0.78 | 469.42 | 0.72 |
| 2018 | 2287 | 2244 | -1.91 | 0.89 | 343.42 | 0.84 |
| 2019 | 2053 | 2438 | 15.79 | 0.71 | 282.85 | 0.75 |
| 2020 | 2046 | 2148 | 4.74 | 0.91 | 428.82 | 0.90 |

and 2019, when the deviations were more (Table 2). The $R^2$ ranged between 0.59 to 0.91 and RMSE between 232 to 532 kg ha$^{-1}$ which indicated that the validated CROPGRO-cotton can be used safely to predict the seed yield of cotton varieties under different sowing dates using medium range forecasted data.

## CONCLUSION

Results revealed that simulated phenology and seed yield of cotton using the medium range weather forecast were in close agreement with the simulated values using actual weather data in different years, for three cultivars under different dates of sowing. The study revealed that the daily medium-range weather forecast data demonstrated more or less substantial effectiveness in capturing year-to-year variability in cotton output as well as treatment-wise variability.

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## REFERENCES


Anonymous (2022a). Cotton Corporation of India (cotcorp.org.in)

Anonymous (2022b). Package of Practices for kharif Crops. Punjab Agricultural University, Ludhiana. Pp*:* 37-53.

Apipattanavis, S., Bert, F., Podesta, G. and Rajagopalan, B. (2010). Linking weather generators and crop models for assessment of climate forecast outcomes. *Agric. For. Meteorol.,* 150: 166–74. https://doi.org/10.1016/j.agrformet.2009.09.012

Asseng, S., McIntosh, P. C., Thomas, G., Ebert, E. E. and Khimashia, N. (2016). Is a 10-day rainfall forecast of value in dry-land wheat cropping? *Agric. For Meteorol.,* 216: 170-76. https://doi.org/10.1016/j.agrformet.2015.10.012

Cabrera, V. E., Solis, D., Baigorria, G. A. and Letson, D. (2009). Managing climate variability in agricultural analysis", In: Long J A and Wells D S (Eds.) Ocean Circulation and El Niño: New Research. Nova Science Publishers, Inc. Hauppauge, NY.

Dhir, A., Pal, R. K., Kingra, P. K., Mishra, S. K. and Sandhu, S. S. (2021). Cotton phenology and production response to sowing time, row orientation and plant spacing using CROPGRO-cotton model. *Mausam, 72*(3): 627-34. http://dx.doi.org/10.54302/mausam.v72i3.1312

Khichar, M. L. and Bishnoi, O. P. (2003). Accuracy of weather forecast for western agro climatic zone of Haryana during Kharif season. *Haryana. Agril. Univ. J. Res*., 33(2): 97 -101.

Lansigan, F. P., Santos, W. L. and Coladilla, J. O. (2000). Agronomic impacts of climate variability on rice production in the Philippines. *J. Agri. Ecosys. Env*., 82(1-3): 129-137. https://doi.org/10.1016/S0167-8809(00)00222-X

Lunagaria, M. M., Mishra, S. K. and Pandey, V. (2009). Verification and usability of medium range weather forecast for Anand region. *J. Agrometeorol*., 11(special issue): 228-233.

Mishra, S. K., Kaur, V. and Singh, K. (2021). Evaluation of DSSAT-CROPGRO-cotton model to simulate phenology, growth, and seed cotton yield in north western India. *Agron. J.,* 113(5): 3975-90. https://doi.org/10.1002/agj2.20788

Patil, D. D., Vyas Pandey, Vipul Kapadia, & A. C. Sadhu. (2019). Sensitivity analysis of CROPGRO- cotton model to intra-seasonal climatic variability in middle Gujarat. *J. Agrometeorol.*, *21*(2), 148–153. https://doi.org/10.54386/jam.v21i2.224

Rotash Kumar. (2020). Impact analysis of abiotic stress and its management in American cotton (Gossypium hirsutum L.)*. M.Sc. Dissertation, Punjab Agricultural University, Ludhiana, Punjab, India*.