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RESEARCH PAPER

Impact of projected climate (2021-2030) on Bt Cotton hybrids in North Interior Karnataka

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Abstract: Cotton is one of the important fibre crops of north interior Karnataka (NIK) grown under both rainfed and irrigated conditions. However, the productivity of the crops including cotton is being threatened by climate change due to the increase in temperature and variable rainfall patterns. A study was taken up to find the effect of projected climate for the period from 2021 to 2030 on the productivity of selected Bt. Cotton hybrids across NIK. Experimental data required to calibrate, validate and run the model were collected from experiments conducted 2018 and 2019 at KVK Jalna, Kharpudi, Maharashtra as part of a WWF (World Wide Fund) project. CROPGRO model was used to run simulations under current (2011-2020) and projected climate (2021-2030) following recommended practices of UAS, Dharwad on black clay soil of each district of NIK. The maximum yield enhancement under the projected climate (2021-2030) was observed in Ankur_3028 (7.5 %) followed by ATM (4.6 %), Vada Sai Kiran (4.4 %), Vada Basant (3.7 %). The highest yields were simulated in Belgaum district among all the districts of NIK, and hybrid Ankur_3028 simulated the highest increment of 33.6 %, followed by ATM (30.6 %), RCH-659 (22 %), Brahma (18.2 %), Vada Basant (15.5 %) and Vada Sai Kiran (12.6 %).

Key words: Ankur_3028, ATM, Brahma, Cotton, DSSAT, Projected climate, RCH-659, Simulated yield, Vada Basant, Vada Sai Kiran

Introduction

Cotton (*Gossypium hirsutum* L.) is a member of the Malvaceae family and is one of India's most important cash and fibre crop, essential to both the industrial and agricultural economy of the nation (Rai *et al.,* 2021). It provides the principal raw material for the cotton textile industry (cotton fibre). In India, 40–50 million people are employed in the commerce and processing of cotton, while 6 million farmers rely solely on the crop for their subsistence. It is known as "white gold", the "King of Fibers" and is one of India's greatest capital crop because of its economic benefits to the country in terms of attracting foreign direct investment and creating jobs. According to ICAR - All India Coordinated Research Project on Cotton – Annual Report (2021-22) globally the cotton is grown on an area of 12650 thousand ha with a production of 5900 metric tons at 466 kg per ha^{-1} of productivity and Karnataka occupies an area of 6.37 lakh hectares producing 17.2 lakh bales with a productivity of 460 kg ha^{-1}.

According to future climate predictions by the IPCC using newly created representative concentration pathways (RCPs) for India under the Coupled Model Inter-comparison Project 5 (CMIP5), mean warming in India is likely to be in the range of 1.7-2 °C by 2030s and 3.3-4.8 °C by 2080s compared to pre-industrial times under the business-as-usual circumstance (between RCP 6 and RCP 8.5). Precipitation is expected to increase from the baseline of 1961-1990 by 4-5 % by 2030 and from 6–14 % by 2080, and there is a steady upward trajectory in the frequency of severe precipitation days (example: > 40 mm/ day) throughout the decades 2060 and beyond (Chaturvedi *et al.,* 2012).

Fields and climate control experiments, such as FACE, FATE, OTP, rainout shelters, and other agronomic studies, are currently being conducted all over the world in this context. These kinds of trials have their own drawbacks, including the need for a lot of time, labour, and resources. Additionally, including every component of the climate and its variations in field studies is logistically challenging. With the advent of crop simulation models (CSMs), it is now possible to predict the behaviour of a living plant by using the mathematical and conceptual relationships that control its growth in the continuum of soil, water, plant, and atmosphere. Crops also interact biophysically with soil, weather, inputs, and management methods. CSMs thus provide an explanation of how crops and their surroundings interact. In order to evaluate how climate change may affect crop yield under various management techniques, crop growth models are helpful.

The northern part of the South Indian state of Karnataka is known as North Interior Karnataka (NIK), and it is primarily made up of semi-arid plateau between 300 and 730 metres above mean sea level. It consists of 12 districts: Bagalakote, Belagavi, Ballari, Bidar, Dharwad, Gadag, Haveri, Kalaburagi, Koppal, Raichur, Vijayapura, and Yadagiri.

In each of the 12 districts of NIK, where there are local variations in climate, soil, topography, and agricultural management conditions wherein, both potential and actual yields are highly variable. Indeed, it is essential to understand the whole spectrum of climate change impacts on agriculture. It is crucial that the farmer selects appropriate agronomic techniques for the local climate, soil, and desired production. In order to determine how the predicted climate (2021-2030) will affect the yield of the cotton hybrids namely Ankur 3028, ATM, Brahma, RCH-659, Vada Basant, and Vada Sai Kiran in the NIK districts, this study was conducted. The enhanced climate adaptation solutions that would be suggested as a result of this work are crucial for ensuring regional food security. In order to carry out this study, the DSSAT crop simulation model, was used first to simulate potential yield under the existing climatic conditions in each district, and then to simulated the effects of climate change under the projected climatic conditions.

Material and methods

Experimental data for modeling

The experimental data of Bt Cotton genotypes to run the DSSAT- CROPGRO crop simulation model were collected from KVK Jalna, Kharpudi, Maharashtra under World Wide Fund (WWF) Project during *Kharif* (2018-19) and *Kharif* (2019-20) under rainfed conditions on clay soil at Krishi Vigyan Kendra (KVK) of Jalna, Maharashtra, located at 19°82' N latitude, 75°93' E longitude and at an altitude of 502 m above mean sea level. This research station comes under Maharashtra state in Central Plateau (Zone-7). The minimum data sets used in the model are represented in Table 1. The experimental data collected were used to build i) A-file which included the data recorded at the end of crop season *i.e.*, yield and yield attributes. ii) T-file which included time-series data from sowing to harvest which included plant height, the number of leaves, phenology, *etc.,* at different growth stages, iii) X-file which included crop management data *i.e.*, sowing date, planting method, spacing, sowing depth, plant population (number m^{-2}) and plant stand at emergence (number m^{-2}), tillage operations and its dates of operation, implement type used, depth of tillage and compost / FYM application dates, sources of inorganic fertilizer (N, P, and K), amount applied, method and depth of placement. These three files *viz*., A, T, and X files of the crop were built separately for each year.

The data on weather parameters such as daily rainfall (mm), mean maximum and minimum temperature (°C) and solar radiation (MJ m^{-2} day^{-1}) required to build weather file within the DSSAT model were downloaded from CMIP-6 for the experimental year 2018-19 and 2019-20 and used for calibration and validation. Weather of past 10 years (2011-2020) of 12 districts of NIK were downloaded from the CMIP-6 web portal (https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip6) for solar radiation, Tmax, Tmin, and rainfall for subsequent seasonal analysis. Yearly weather files for observed weather of 2018-19 and 2019-20 were built. These files were used to run the model for calibration (2018-19) followed by validation (2019-20).

The soil module within the DSSAT model requires data/ information on texture, colour, slope (%), nutrients like N, P, K (kg ha^{-1}), pH, OC (%), and BD (g cm^{-3}) across depth. The experiment from which the data was collected was laid out on black clay soil. The soil profile data up to a depth of 75-100 cm and 25-50 cm are collected to build soil module. In order to check the performance of selected hybrids across the 12 districts of NIK, soil profile data of black clay soil up to a depth of 125 cm were collected from the ICAR Krishi Geoportal website (http://geoportal.icar.gov.in). N, P, K (kg ha^{-1}) data of all the 12 districts for the initial management was collected from Soil health card web portal of the Ministry of Agriculture and Farmers Welfare, Govt. of India (https:soilhealth2.dac.gov.in/Health Card).

Results and discussion

The simulated yield across 12 districts of NIK in potential conditions on black clay soil under current climate (2011-2020) was the highest for RCH-659 (2522 kg ha^{-1}) followed by ATM (2428 kg ha^{-1}) and Vada Sai Kiran (2368 kg ha^{-1}) and the lowest yield was simulated for Ankur_3028 (2272 kg ha^{-1}). Under projected climate (2021-2030) the highest yield simulated for ATM (2540 kg ha^{-1}) followed by RCH-659 (2515 kg ha^{-1}) and Vada Sai Kiran (2472 kg ha^{-1}) and the lowest for Brahma (2276 kg ha^{-1}). Under projected climate (2021-2030) hybrid ATM simulated 45.2 per cent increase in yield but yield levels remained almost constant (0.2 %) for RCH-659 (2522 to 2515 kg ha^{-1}) (Table 2).

The simulated yield at harvest maturity under current climate (2011-2020) in rainfed condition for Ankur_3028 was 2272 kg ha^{-1}, whereas in potential condition it was 2703 kg ha^{-1}, which simulated highest increment of 609 kg ha^{-1}. Under projected climate (2021-2030) for Vada Basant in rainfed condition it was 2625 kg ha^{-1}, whereas in potential condition it was 2281 kg ha^{-1} with the highest increment of 200 kg ha^{-1}. Under projected climate (2021-2030) for Ankur_3028 in rainfed condition it was 2236 kg ha^{-1}, whereas in potential condition it was 2791 kg ha^{-1} with the highest increment of 555 kg ha^{-1} (Table 3) (Fig. 1).

In Koppal district under current climate (2011-2020) in rainfed condition, the simulated yield at harvest maturity was 687 kg ha^{-1} for RCH-659 whereas under projected climate (2021-2030) it was simulated at 1048 kg ha^{-1} with the highest

Table 1. Minimum data set (MDS) used in the model

Particulars	Data inputs
Weather	Daily Tmax(°C), Tmin (°C), rainfall (mm) and solar radiation (MJ m^{-2} day^{-1}).
Soil profile	Texture, colour, slope (%), nutrients like N, P, K (kg ha^{-1}), pH, OC (%) and BD (g cm^{-3}) across depth.
Cultivars	Vada Basant, Vada Sai Kiran, RCH-659, Ankur-3028, Brahma and ATM.
Planting	Sowing date, planting method, spacing, sowing depth, plant population (number m^{-2}) and plant stand at emergence (number m^{-2}).
Fertilizer	Compost / FYM, application dates, sources of inorganic fertilizer (N, P and K), amount applied, method and depth of placement.

Table 2. Simulated yield of Bt Cotton hybrids under current climate (2011-2020) and projected climate (2021-2030) in rainfed conditions on black clay soil averaged across 12 districts of NIK (±S.E. n=279)

Hybrids	Yield at harvest maturity (kg ha^{-1})			
	2011-2020(A)	2021-2030(B)	Difference of (B-A)	
			kg ha^{-1}	%
Ankur_3028	2272 (±57)	2443 (±56)	171	7.5
ATM	2428 (±70)	2540 (±56)	112	4.6
Brahma	2324 (±55)	2276 (±59)	48	2.1
RCH-659	2522 (±48)	2515 (±49)	7	0.2
Vada Basant	2281 (±56)	2364 (±54)	83	3.6
Vada Sai Kiran	2368 (±61)	2472 (±59)	104	4.4

increment of 52.5 per cent which is the highest increment across all the districts and hybrids. Belagavi district simulated highest yield under projected climate (2021-2030) compared to the current climate (2011-2020) was highest for Ankur_3028 (3102 kg ha^{-1}) followed by Vada Sai Kiran (3100 kg ha^{-1}) and ATM (3005 kg ha^{-1}) and lowest yield was simulated for Vada Basant (2999 kg ha^{-1}). Under projected climate (2021-2030) simulated highest yields for Ankur_3028 (4298 kg ha^{-1}) followed by RCH-659 (4292 kg ha^{-1}) and ATM (4152 kg ha^{-1}) and lowest for Brahma (3927 kg ha^{-1}). Under projected climate (2021-2030) RCH-659 simulated 43.1 per cent increase in yield followed by Ankur_3028 (38.5 %), ATM (38.2 %), Vada Basant (35.4 %), Brahma (30.8 %)

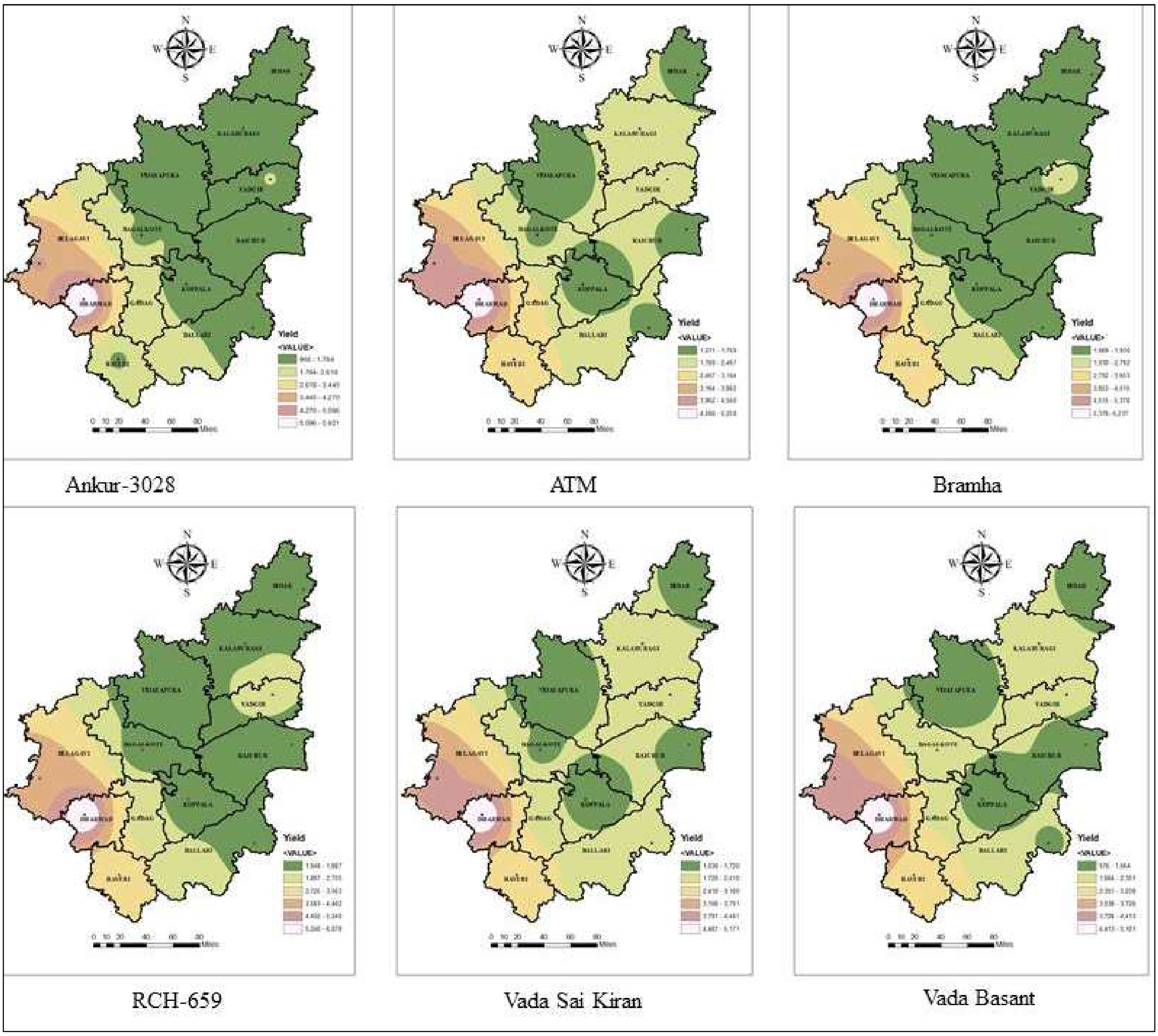

Fig. 1. Spatial distribution of simulated average yield of Bt. Cotton hybrids under projected climate (2021-2030) on black clay soils under rainfed condition across NIK (average of 10 years)

Table 3. Simulated yield of Bt Cotton hybrids under current climate (2011-2020) and projected climate (2021-2030) in rainfed and potential conditions on black clay soil averaged across 12 districts of NIK (±S.E. n=279)

Varieties	2011-2020		2021-2030		% difference of		
	Rainfed(A)	Potential(B)	Rainfed(C)	Potential(D)	B-A	C-A	D-C
Ankur_3028	2272 (±57)	2703(±59)	2236(±87)	2791(±46)	609	142	555
ATM	2428 (±70)	2851 (±70)	2460(±113)	3000 (±59)	483	92	540
Brahma	2324 (±55)	2787 (±51)	2424 (±102)	2806(±52)	555	192	382
RCH-659	2522 (±48)	2856 (±41)	2484 (±109)	2908(±42)	513	141	424
Vada Basant	2281 (±56)	2625 (±56)	2241 (±84)	2675 (±44)	584	200	434
Vada Sai Kiran	2368 (±61)	2692 (±58)	2306 (±102)	2819 (±56)	492	106	513

and Vada Sai Kiran (29.7 %). Kalburgi district simulated highest yield under projected climate (2021-2030) compared to the current climate (2011-2020) was highest for RCH-659 (1518 kg ha^{-1}) followed by ATM (1479 kg ha^{-1}) and Brahma (1436 kg ha^{-1}) and lowest yield was simulated for Vada Basant (1367 kg ha^{-1}). Under projected climate (2021-2030) simulated highest yields for ATM (1882 kg ha^{-1}) followed by RCH-659 (1869 kg ha^{-1}) and Brahma (1808 kg ha^{-1}) and lowest for Vada Basant (1740 kg ha^{-1}). Under projected climate (2021-2030) Vada Sai Kiran simulated 28.8 per cent increase in yield followed by ATM (27.2 %), Vada Basant (26.5 %), Brahma (25.9 %), Ankur_3028 (25.7 %) and RCH-659 (23.1 %). Koppal district simulated highest yield under projected climate (2021-2030) compared to the current climate (2011-2020) was highest for ATM (987 kg ha^{-1}) followed by Vada Sai Kiran (932 kg ha^{-1}) and Ankur_3028 (856 kg ha^{-1}) and lowest yield was simulated for RCH-659 (687 kg ha^{-1}). Under projected climate (2021-2030) simulated highest yields for Vada Sai Kiran (1130 kg ha^{-1}) followed by ATM (1124 kg ha^{-1}) and Brahma (1069 kg ha^{-1}) and lowest for Ankur_3028 (968 kg ha^{-1}). Under projected climate (2021-2030) RCH-659 simulated 52.5 per cent increase in yield followed by Brahma (35.5 %), Vada Basant(23.4 %), Vada Sai Kiran (21.2 %), ATM (13.9 %) and Ankur_3028 (13.1 %). Vijayapura district simulated lowest yield under projected climate (2021-2030) compared to the current climate (2011-2020) was lowest for Vada Basant (1021 kg ha^{-1}) followed by Ankur_3028 (1053 kg ha^{-1}) and Vada Sai Kiran (1475 kg ha^{-1}). Under projected climate (2021-2030) simulated highest yields for Vada Basant (989 kg ha^{-1}) followed by Ankur_3028 (1010 kg ha^{-1}) and Vada Sai Kiran (1030 kg ha^{-1}). Under projected climate (2021-2030), ATM simulated 30.5 per cent decrease in yield followed by Vada Sai Kiran (30.2 %), RCH-659 (26.0 %), Brahma (18.2 %), Ankur_3028 (4.1 %) and ATM (3.1 %) (Table 4).

In Vijayapura district, under current climate (2011-2020) simulated yield under potential condition for RCH-659 (2437 kg ha^{-1}) was the highest followed by ATM (1325 kg ha^{-1}), Ankur_3028 (1244 kg ha^{-1}), Vada Sai Kiran (1214 kg ha^{-1}) and Vada Basant (1197 kg ha^{-1}). Under projected climate (2021-2030) for ATM (3091 kg ha^{-1}) was the highest followed by RCH-659

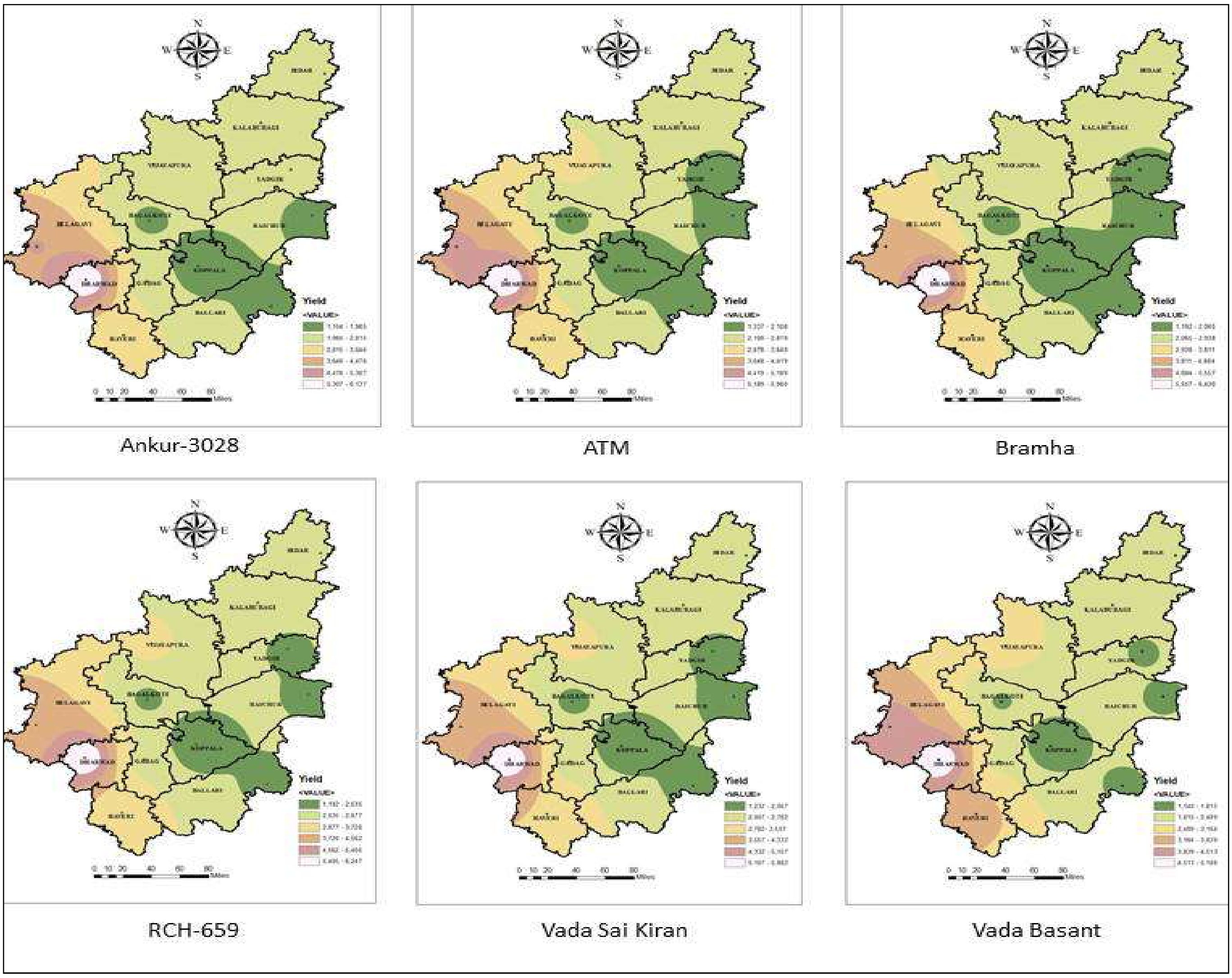

Fig. 2. Spatial distribution of simulated average yield of Bt Cotton hybrids under projected climate (2021-2030) on black clay soils under potential condition across NIK (average of 10 years)

Table 4. Average yield (kg ha^{-1}) and per cent yield difference of each of Bt. cotton hybrid under current climate (2011-2020) and projected climate (2021-2030) on black clay soil in each of 12 districts of NIK in rainfed condition and their ranking.

District	Hybrids	Current climate (2011-2020)	Projected climate (2021-2030)	% Difference	Ranking
Bagalkote	Ankur_3028	1640 (±34)	1724 (±30)	5.1	II
	ATM	1901(±41)	1662(±20)	-12.6	VI
	Brahma	1364(±26)	1580(±20)	15.8	I
	RCH-659	1413(±29)	1473(±20)	4.2	III
	Vada Basant	1614(±32)	1674(±29)	3.7	IV
	Vada Sai Kiran	1695(±36)	1598(±32)	-5.7	V
Bellary	Ankur_3028	1558 (±67)	1464(±54)	-6.0	VI
	ATM	1678 (±74)	1712(±61)	2.0	III
	Brahma	1695 (±70)	1653(±32)	-2.5	V
	RCH-659	1653 (±75)	1646(±68)	-0.4	IV
	Vada Basant	1598 (±70)	1639(±35)	2.6	II
	Vada Sai Kiran	1574 (±76)	1765(±58)	12.1	I
Belagavi	Ankur_3028	3102(±77)	4298(±10)	38.5	II
	ATM	3005(±74)	4152(±93)	38.2	III
	Brahma	3001(±70)	3927(±158)	30.8	V
	RCH-659	3000(±74)	4292(±81)	43.1	I
	Vada Basant	2999(±70)	4062(±114)	35.4	IV
	Vada Sai Kiran	3100(±77)	4020(±54)	29.7	VI
Bidar	Ankur_3028	1466 (±107)	1556 (±67)	6.1	IV
	ATM	1571 (±111)	1633 (±75)	3.9	VI
	Brahma	1471 (±106)	1585 (±70)	7.7	III
	RCH-659	1523 (±114)	1653 (±75)	8.5	II
	Vada Basant	1375 (±137)	1542 (±70)	12.1	I
	Vada Sai Kiran	1499 (±109)	1562 (±76)	4.2	V
Dharwad	Ankur_3028	5932(±199)	5923(±189)	-0.1	III
	ATM	5995(±187)	5259(±199)	-12.3	VI
	Brahma	5970(±213)	6239(±191)	4.5	I
	RCH-659	5980(±232)	6080(±133)	1.7	II
	Vada Basant	5157(±194)	5102(±142)	-1.1	IV
	Vada Sai Kiran	5693(±185)	5172(±152)	-9.1	V
Gadag	Ankur_3028	2356 (±57)	2364 (±55)	0.3	II
	ATM	2433 (±64)	2512 (±64)	3.2	I
	Brahma	2485 (±80)	2453 (±36)	-1.3	IV
	RCH-659	2453 (±75)	2426 (±67)	-1.1	III
	Vada Basant	2342 (±80)	2259 (±39)	-3.5	V
	Vada Sai Kiran	2362 (±66)	2235 (±57)	-5.3	VI
Haveri	Ankur_3028	1976 (±86)	1724 (±80)	-12.7	VI
	ATM	2876 (±112)	2682 (±82)	-6.7	V
	Brahma	2346 (±68)	2869 (±91)	22.3	II
	RCH-659	2839 (±61)	2873 (±72)	1.2	IV
	Vada Basant	2763 (±92)	2948 (±69)	6.7	III
	Vada Sai Kiran	1976 (±62)	2632 (±89)	33.2	I
Kalburgi	Ankur_3028	1403(±127)	1764(±33)	25.7	V
	ATM	1479(±85)	1882(±40)	27.2	II
	Brahma	1436(±89)	1808(±23)	25.9	IV
	RCH-659	1518(±90)	1869(±22)	23.1	VI
	Vada Basant	1367(±120)	1730(±32)	26.5	III
	Vada Sai Kiran	1404(±84)	1809(±39)	28.8	I
Koppal	Ankur_3028	856 (±21)	968 (±55)	13.1	VI
	ATM	987(±16)	1124 (±50)	13.9	V
	Brahma	789(±19)	1069 (±32)	35.5	II
	RCH-659	687(±12)	1048 (±35)	52.5	I
	Vada Basant	791(±19)	976 (±23)	23.4	III
	Vada Sai Kiran	932(±24)	1130 (±46)	21.2	IV
Raichur	Ankur_3028	1431(±122)	1404 (±125)	-1.9	III
	ATM	1651(±133)	1614 (±138)	-2.2	V
	Brahma	1561(±127)	1529 (±130)	-2.0	IV

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	RCH-659	1636(±132)	1589(±141)	-2.8	VI
	Vada Basant	1404(±124)	1380 (±125)	-1.7	II
	Vada Sai Kiran	1517(±123)	1524(±131)	0.5	I
Vijayapura	Ankur_3028	1053 (±183)	1010(±195)	-4.1	II
	ATM	1542 (±294)	1071(±210)	-30.5	VI
	Brahma	1634 (±290)	1336(±268)	-18.2	III
	RCH-659	1687 (±299)	1248(±255)	-26.0	IV
	Vada Basant	1021 (±198)	989(±193)	-3.1	I
	Vada Sai Kiran	1475 (±284)	1030 (±206)	-30.2	V
Yadagiri	Ankur_3028	1694 (±157)	1799 (±151)	6.2	I
	ATM	1984 (±162)	1996 (±162)	0.6	VI
	Brahma	1889 (±156)	1986 (±156)	5.1	III
	RCH-659	1973 (±163)	1989 (±163)	0.8	V
	Vada Basant	1664 (±155)	1747 (±155)	4.9	IV
	Vada Sai Kiran	1882 (±154)	1986 (±156)	5.5	II

Table 5. Average yield (kg ha^{-1}) and per cent yield difference of each of Bt cotton hybrid under current climate (2011-2020) and projected climate (2021-2030) on black clay soil in each of 12 districts of NIK in potential condition and their ranking

District	Hybrids	Current climate (2011-2020)	Projected climate (2021-2030)	% Difference	Ranking
Bagalkote	Ankur_3028	2848 (±54)	1724 (±30)	-38.1	V
	ATM	3081(±71)	1927 (±25)	-37.4	II
	Brahma	2904(±66)	1808(±23)	-37.7	III
	RCH-659	3013(±70)	1868 (±22)	-38.0	IV
	Vada Basant	2829 (±46)	1730 (±32)	-38.8	VI
	Vada Sai Kiran	2822 (±79)	1830 (±36)	-35.1	I
Bellary	Ankur_3028	2483 (±41)	1764(±33)	-28.9	III
	ATM	2668 (±33)	1882 (±40)	-29.4	V
	Brahma	2535(±27)	1808 (±23)	-28.7	I
	RCH-659	2642 (±30)	1869 (±22)	-29.2	IV
	Vada Basant	2435 (±22)	1730 (±32)	-28.8	II
	Vada Sai Kiran	2570(±26)	1809(±39)	-29.6	VI
Belagavi	Ankur_3028	3367 (±60)	4498(±105)	33.6	I
	ATM	3484 (±60)	4552(±93)	30.6	II
	Brahma	3406 (±52)	4027 (±158)	18.2	IV
	RCH-659	3600(±42)	4390(±81)	21.9	III
	Vada Basant	3602(±73)	4162(±114)	15.5	V
	Vada Sai Kiran	3658(±58)	4100(±54)	12.1	VI
Bidar	Ankur_3028	2303 (±27)	2499 (±23)	8.5	IV
	ATM	2498 (±50)	2666 (±25)	6.7	VI
	Brahma	2326 (±40)	2543 (±34)	9.3	III
	RCH-659	2437 (±44)	2617 (±29)	7.3	V
	Vada Basant	2267 (±32)	2481 (±23)	9.4	II
	Vada Sai Kiran	2340 (±40)	2594 (±27)	10.8	I
Dharwad	Ankur_3028	6676 (±110)	6139 (±57)	-8.0	IV
	ATM	6551 (±102)	5961 (±118)	-9.0	V
	Brahma	6817 (±56)	6432 (±66)	-5.6	II
	RCH-659	6594 (±108)	6249 (±47)	-5.2	I
	Vada Basant	5522(±88)	5189 (±65)	-6.0	III
	Vada Sai Kiran	6531 (±82)	5883 (±132)	-9.9	VI
Gadag	Ankur_3028	2430(±26)	4498 (±105)	85.1	I
	ATM	2617(±29)	4552 (±93)	73.9	II
	Brahma	2506(±45)	4027 (±158)	60.7	VI
	RCH-659	2596(±19)	4390 (±81)	69.1	IV
	Vada Basant	2400(±25)	4162(±114)	73.4	III
	Vada Sai Kiran	2462 (±35)	4100 (±54)	66.5	V
Haveri	Ankur_3028	2872 (±99)	2992 (±86)	4.2	III
	ATM	3243 (±120)	3012 (±87)	-7.1	VI
	Brahma	3132 (±71)	3013 (±94)	-3.8	V
	RCH-659	3191(±67)	3337 (±76)	4.6	II
	Vada Basant	3055 (±97)	3415 (±75)	11.8	I
	Vada Sai Kiran	3420 (±68)	3557 (±94)	4.0	IV

Kalaburgi	Ankur_3028	2483 (±41)	2500 (±30)	0.68	IV
	ATM	2668 (±33)	2685 (±37)	0.64	V
	Brahma	2535 (±27)	2576 (±34)	1.62	III
	RCH-659	2642 (±30)	2626 (±24)	-0.6	VI
	Vada Basant	2435 (±22)	2480 (±23)	1.84	I
	Vada Sai Kiran	2570 (±26)	2612 (±28)	1.63	II
Koppal	Ankur_3028	1001 (±23)	1154 (±64)	15.3	V
	ATM	1075 (±17)	1337 (±68)	24.4	I
	Brahma	1019(±16)	1192 (±37)	16.9	IV
	RCH-659	1075(±16)	1192 (±37)	10.9	VI
	Vada Basant	960(±16)	1140 (±33)	18.7	III
	Vada Sai Kiran	1007 (±23)	1232 (±58)	22.3	II
Raichur	Ankur_3028	1648 (±20)	1781(±18)	8.1	IV
	ATM	1768(±27)	1927(±25)	8.99	II
	Brahma	1683(±27)	1835 (±21)	10.1	I
	RCH-659	1811(±14)	1922 (±24)	6.1	VI
	Vada Basant	1624 (±19)	1741 (±22)	7.2	V
	Vada Sai Kiran	1673(±21)	1822 (±21)	8.91	III
Vijayapura	Ankur_3028	1244 (±187)	2802 (±61)	125.2	V
	ATM	1325(±226)	3091 (±65)	133.2	IV
	Brahma	1090 (±147)	2930 (±61)	168.8	I
	RCH-659	2437 (±44)	3041 (±64)	24.7	VI
	Vada Basant	1197 (±178)	2794 (±51)	133.4	III
	Vada Sai Kiran	1214(±197)	2925 (±62)	140.9	II
Yadagiri	Ankur_3028	2030 (±25)	2165 (±19)	6.6	I
	ATM	2203 (±36)	1882 (±40)	-14.5	VI
	Brahma	2078 (±27)	1808 (±23)	-12.9	III
	RCH-659	2174 (±30)	1869 (±22)	-14.0	V
	Vada Basant	2005 (±31)	1732(±32)	-13.6	IV
	Vada Sai Kiran	2047 (±26)	1809 (±39)	-11.6	II

(3041 kg ha^{-1}), Brahma (2930 kg ha^{-1}), Vada Sai Kiran (2925 kg ha^{-1}), Ankur_3028 (2802 kg ha^{-1}) and Vada Basant (2794 kg ha^{-1}). Under projected climate (2021-2030) simulated highest yields for Vada Basant (989 kg ha^{-1}) followed by Ankur_3028(1010 kg ha^{-1}) and Vada Sai Kiran (1030 kg ha^{-1}). Under projected climate (2021-2030) Brahma simulated 168.8 per cent increase in yield followed by Vada Sai Kiran (140.9 %), Vada Basant (133.4 %), ATM (133.2 %), Ankur_3028 (125.2 %) and RCH-659 (24.7 %). (Table 5) (Fig. 2)

In Gadag district under current climate (2011-2020) simulated yield under potential condition for ATM (2617 kg ha^{-1}) was the highest followed by RCH-659 (2596 kg ha^{-1}) and Brahma (2506 kg ha^{-1}). Under projected climate (2021-2030) for ATM (4552 kg ha^{-1}) was the highest followed by Ankur_3028 (4498 kg ha^{-1}) and RCH-659 (4390 kg ha^{-1}). Under projected climate (2021-2030) Ankur_3028 simulated 85.1 per cent increase in yield followed by ATM (73.9 %), Vada Basant (73.4 %), RCH-659 (69.1 %), Vada Sai Kiran (66.5 %) and Brahma (60.7 %) (Table 5).

Conclusion

Bt cotton is an important cash crop of NIK and its area is expanding and shifting across this region both under rainfed and irrigated condition. Changes in climate, especially rainfall pattern and rise in temperature will have direct bearing on crop's phenology, ET and water requirement, thus finally the yield across different soils. The analysis of impact of projected climate (2021-2030) on cotton hybrids (Ankur_3028, ATM, Brahma, RCH-659, Vada Basant and Vada Sai Kiran) using the DSSAT CROPGRO- COTTON model in NIK allowed understanding of the magnitude of yield variation due to climate change under projected climate (2021-2030). This study indicated that yield of cotton hybrids in NIK would be improved by irrigation rather than growing in rainfed condition, compared to under current climate (2011-2020). This will help farmers adopt the best performing genotypes for their location and realize better yields.

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