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RESEARCH NOTE

Performance of maize hybrid NK-6240 under current climate in different districts of north interior Karnataka

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Abstract: Maize (*Zea mays*) is one of the important commercial crops of north interior Karnataka (NIK) cultivated under both rainfed and irrigated conditions. NK-6240 is a promising private hybrid used by the farmers of NIK. Quantifying the yield potential of this hybrid across 12 districts of NIK having an area of 88,361 km^2 helps to categorise the areas which are more suitable to realize high yields and areas where the urgent measures are needed to improve the yield levels. For this, calibrated and validated DSSAT-CERES model was used to run simulations under current climate for the period from 1988 to 2018 in rainfed conditions on both black and red soils across eight dates of sowing in 12 districts of NIK. This study found that average grain yield simulated under current climate (1988-2018) in rainfed condition was the highest in Bidar (8066 kg ha^{-1}) district followed by Dharwad (7872 kg ha^{-1}), Bagalakote (7847 kg ha^{-1}) and Gadag (7523 kg ha^{-1}) while the lowest yield was simulated in Koppal (4878 kg ha^{-1}) district followed by Ballari (5782 kg ha^{-1}), Raichur (5954 kg ha^{-1}) and Yadagiri (6452 kg ha^{-1}). The difference in yield between the highest and lowest was 3188 kg ha^{-1} *i.e.*, 65 per cent. Hence, this study concluded that under current climate Bidar, Dharwad and Bagalakote districts are the best districts to grow maize hybrid NK-6240 and the districts whose current rainfed yields are low needs to employ irrigation at critical stages to enhance yield.

Key words: Current climate, Maize hybrid NK-6240, North interior Karnataka

Maize (*Zea mays* L.) is a member of the grass family Poaceae, a cereal grain crop which was first cultivated in ancient Central America. Currently, maize is grown globally on an area of 192.45 m ha producing 1,113 m t at a productivity of 5.7 t/ha. The USA produces more than 32 per cent of the global maize output whereas, China, Brazil, Argentina, Bolivia and India are the other major countries. India produces about 2.5 per cent of the world's total production. In India during 2019-20, it was grown on an area of 9.2 m ha producing 28.90 m t with a productivity of 3.12 t/ha of which 72 per cent is grown in *Kharif* and 28 per cent during *Rabi* (Anon., 2020). Karnataka is the top producer of maize in India contributing 14 per cent to India's total maize production, followed by Maharashtra and Madhya Pradesh (Anon., 2019).

The importance of the rainfed agriculture can be gauged from the fact that it contributes to 40 per cent of the country's food production; accounts for much of the national average under coarse cereals (85 %), pulses (83 %), oilseeds (70 %) and holds 60 per cent of the total livestock populations (Venkateswarlu and Prasad 2012).Quantifying the yield potential of maize across the districts helps to categorise the areas which are more suitable and areas where the urgent measures are needed to improve the yield levels. However, identifying and quantifying the yield across the larger areas through field experiments involves many years of data collection to find solutions field experiments workout time consuming and expensive. Hence, for such type of studies process based dynamic crop simulation models have been developed to predict crop growth, development and yield using systems approach that integrate knowledge of the underlying physical processes.

Jones and Kiniry back in 1986 reported that CERES–Maize model was one of the widely used models among the number of maize models that existed. Since then DSSAT-CERES maize has been used quite extensively across the world. The latest version DSSAT 4.7 was released in April 2019 and is a dynamic model that estimates the timing of different phenological stages of the crop growth rate and the partitioning of biomass to growing organs (roots, stem, leaves, and kernels) with a daily time step as the model simulates crop responses to changes in climate, management variables and soils. In this study an attempt has been made to assess the yield level of maize hybrid NK-6240 under rainfed conditions across 12 districts of north interior Karnataka using CERES-Maize model with a hypothesis that yield varies across districts of NIK based on climate and soil.

The experimental crop data of maize hybrid NK-6240 to calibrate and validate crop simulation model were collected from the AICRP- Maize scheme experiments carried out during *Kharif* season of 2017-18 and 2018-19 under both rainfed and irrigated condition on deep black soils at the Main Agricultural Research Station (MARS) of University of Agricultural Sciences, Dharwad, located at 15°26' N latitude, 75°07' E longitude and at an altitude of 678 m above mean sea level.

The crop data on daily 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 recorded from the Meteorological Observatory, the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad for the experimental year 2017-18 and 2018-19. Historic weather of 31 years (1988-2018) for each of 12 districts of NIK were downloaded from NASA power web portal (www.power.larc.nasa.gov) for subsequent seasonal analysis. Yearly weather files of 2017-18 and 2018-19 for Dharwad as well as one combined file for the whole period of 1988-2018 (31 years) for each of 12 districts were built using Weatherman software within the DSSAT ensemble. These files were used to run the model for calibration (2017-18) followed by validation (2018-19) and also for sequential analysis over 31 years (1988-2018) to estimate yield. The soil module within 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 crop data collected were laid out on black clay soil. Composite soil samples were collected before the start of experiment and analyzed. In order to simulate the yield levels across the 12 districts of NIK, soil profile data of both black and red soils up to a depth of 125 cm and 35 cm, respectively, of all these 12 districts were collected from ICAR KrishiGeoportal website (http://geoportal.icar.gov.in). The N, P, K (kg ha^{-1}) data of all the 12 districts for 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/HealthCard).The model was calibrated using 2017-18 experimental data and was validated using 2018-19 experimental data for the maize hybrid NK-6240 using GenCalc software embedded within DSSAT model with a satisfactory accuracy of 90 per cent for both phenology and yield parameters and the genetic coefficients optimized for NK-6240 are presented in Table 1.

The seasonal analysis simulations were run for each of 12 districts of NIK under rainfed conditions using district level historic weather data of 31 years (1988-2018) (Figure 1 and 2) to generate average yields of maize hybrid NK/6240 for each district separately under rainfed and potential conditions grown across eight different dates of sowing at weekly interval from 22nd May to 15th July on two predominant representative black and red soils. In the present study, yield level of maize hybrid NK-6240 in each of the 12 districts of NIK was estimated on both black and red soils.

Simulated average grain yield of maize hybrid NK-6240 under current climate (1988-2018) on black soils in rainfed conditions was 7126 kg ha^{-1}. Among the 12 districts of NIK the highest yield was simulated in Bidar (8416), closely followed by Dharwad (8319) and Bagalakote (8309) districts whereas, the lowest yield was simulated in Koppal (4737) followed by Raichur (6035) and Ballari (6099) districts.

The productivity is primarily governed by the climatic conditions (temperature and rainfall) including soil, hence the hypothesis that the performance of maize is not uniform across districts of NIK was proved (Table 2).

Simulated average grain yield of maize hybrid NK-6240 under current climate (1988-2018) on red soils in rainfed conditions was 6685 kg ha^{-1} lower by 441 kg ha^{-1}compared to the average yield on black soil. Among 12 districts of NIK the highest yield was simulated in Belagavi (7735 kg ha^{-1}), followed by Bidar (7716 kg ha^{-1}) and Haveri (7575 kg ha^{-1}) districts and the lowest yield was recorded in Koppal (5018) followed by Ballari (5464 kg ha^{-1}) and Raichur (5873 kg ha^{-1}) districts. Here also a wide variability in minimum and maximum yields recorded over the simulation period among districts. The average minimum yield of 5018 kg ha^{1} on red soils for Koppal district was 54 per cent less than the average maximum simulated yield of

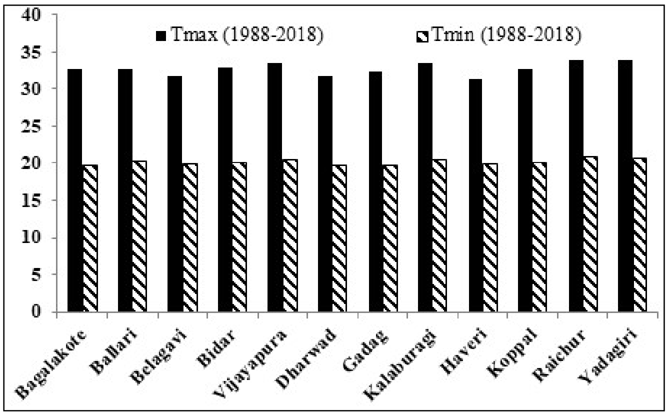

Fig. 1. Maximum and minimum temperature in ÚC (average of 31 years) under current climate (1988-2018) across 12 districts of NIK.

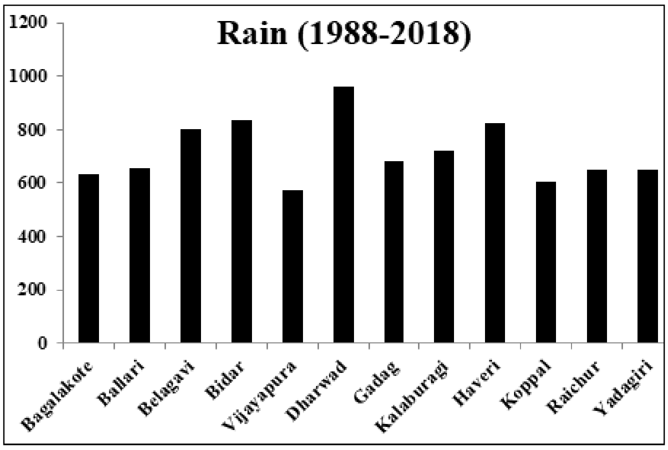

Fig. 2 Annual rainfall in mm (average of 31 years) under current climate (1988-2018) across 12 districts of NIK.

Table 1. Codes description and genetic coefficients used in genotype file of DSSAT for maize hybrid NK-6240.

Coefficient	Description code	Optimised values
P1	Thermal time from seedling emergence to the end of the juvenile phase (expressed in degree days base temperature of 8^{o}C) during which the plant is not responsive to changes in photoperiod.	221.5
P2	Extent to which development (expressed as days) is delayed for each hour increase in photoperiod above the longest photoperiod at which development proceeds at a maximum rate (which is considered to be 12.5 hours).	0.0860
P5	Thermal time from silking to physiological maturity (expressed in degree days above a base temperature of 8 ^{o}C)	1014
G2	Maximum possible number of kernels per plant.	195.8
G3	Kernel filling rate during the linear grain filling stage and under optimum conditions (mg/day).	20.64
PHINT	Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.	28.83

Table 2. Simulated average grain yield (kg ha^{-1}) maize hybrid NK-6240 current climate (1988-2018) on both black and red soils across 12 districts of NIK. (Values are average of 31 years).

Districts	Black soil		Red soil		Average of Balck and Red soil
	Rainfed	Ranking	Rainfed	Ranking	
Bagalakote	8309	III	7385	V	7847
Ballari	6099	X	5464	XI	5781
Belagavi	6592	IX	7735	I	7163
Bidar	8416	I	7716	II	8066
Dharwad	8319	II	7424	IV	7872
Gadag	7996	V	7050	VI	7523
Haveri	7080	VI	7575	III	7328
Kalaburgi	8139	IV	6815	VII	7477
Koppal	4737	XII	5018	XII	4878
Raichur	6035	XI	5873	X	5954
Vijayapura	6931	VII	6139	VIII	6535
Yadagiri	6875	VIII	6029	IX	6452
Average	7127	-	6685	-	6906

7735 kg ha^{-1} for Belagavi district (Table 2). This study showed that in NIK region across all 12 districts maize hybrid NK-6240 performed well on black soils than in red soils during *kharif* season, and an average of 65 per cent yield gap existed between the highest yielding district and lowest yielding district. This indicated that farmers must grow this maize hybrid in Bidar, Dharwad and Bagalakote districts on black soils, and Belagavi, Bidar and Haveri districts on red soils.

Average grain yield simulated under current climate (1988-2018) in rainfed condition was the highest in Bidar (8066 kg ha^{-1}) district followed by Dharwad (7872), Bagalakote (7847) and Gadag (7523) and was the lowest in Koppal (4878 kg ha^{-1}) district, followed by Ballari (5781), Raichur (5954) and Yadagiri (6452).Therefore, under current climate maize hybrid NK-6240 gives the highest yield in Bidar district closely followed by Dharwad district.

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