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Short Communication

Simulating maize yield at enhanced level of temperature using CERES maize model

B.A. LONE[1], A. FAYAZ[2], S. QAYOOM[1], R.H. KANTH[3], Z.A. DAR[4], P. SINGH[5], S. KUMAR[6], NAJMAH ANDRABI[7] and NIGHAT MUSHTAQ[1]

[1]Agromet Section, SKUAST-Kashmir; [2]Chandigarh University, Chandigarh; [3]Division of Agronomy, FoA, Wadura, SKUAST-Kashmir; [4]Dryland AgricultureResearch Station SKUAST-Kashmir; [5]Directorate of Extension SKUAST-Kashmir; [6]Division of Soil ScienceSKUAST-Kashmir; [7]Division of Vegetable Science, SKUAST-Kashmir*

[*]Corresponding author: alonebilal127@gmail.com

Climate variability has been and continues to bethe principal source of fluctuations in global food production in countries of the developing world and is of serious concern.Agriculture, with its allied sectors, is highly dependent on weather conditions.Any weather aberrations cause atmospheric and other forms of stresses and in turn, will increase the vulnerability of these farmers to economic losses (Bal and Minhas, 2017).Climatic scenario from A1B scenario 2011-2090 extracted from PRECIS run shows that overall maximum and minimum temperature increase by 5.39°C (±1.76) and 5.08 °C(±1.37).Maize is cultivated on an area of 161.82 million hectares in the world with production of 844.36 million tonnes (FAO, 2017) and productivity of 5.22 tonnes ha^{-1}. The average yield of 1566 ha^{-1} (DES, 2015-16) of this crop has also nearly doubled since 2000. This increase in yield has been mainly achieved by increase in the area under high yielding varieties. However, the genetic potential of the improved varieties is at least three times of the present average yield of the state. Sweet corn grown under temperate conditions of Kashmir should be grown with integrated nutrient management approach (Rasool*et al*.,2015). A validated model with known genetic constants for varieties can be powerful tool for studying the performance of varieties in contrasting environments, soil types, diverse cultural practices and management inputs (Boote,1999). The DSSAT v 4.5 CERES-Maize Crop Simulation Model which was tested over a wide range of environments (Tsuji *et al*., 1994; Hoogenboom*et al*.,1999) has been used in present investigation. The fundamentaldifficulty in all the models was that, most of them were based on collection of hypothesis and hence cannot be validated inherently (Oreskes *et al.*, 1994). The CERES – maize model has been extensively tested under tropical conditions of Hawaii, Indonesia and Philippines (Singh, 1985) USA and Europe, Kenya (Keating *et al.*, 1991) and India (Rajireddy, 1991; Sheikh and Rao, 1996).

Long term weather data of Kashmir valley revealed (Fig. 1and 2) that there is increasing trend in both maximum and minimum temperature. Average annual maximum and minimum temperature has increased by 1°C during last 30 years. The objective of this study was to assess the impact of enhanced levels of temperature growth and yield of maize.

Field experiment was conducted for model calibration and validation. Experiment was laid in split-plot design assigning three planting dates 22nd May(D_1), 30th May (D_2) and 8thJune (D_3) main plots and Four Nitrogen levels 80 kgNha^{-1}(N_1),120 kgNha^{-1}(N_2),160 kgNha^{-1}(N_3) and 200 kgNha^{-1}(N_4)sub-plots at research farm Division of Agronomy at main Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar.Detailed soil and weather information from Srinagar location and season were collected according to the minimum data sets required for calibration of CERES–maize model.Soil was silty clay loam, with neutral in reaction and medium in available nitrogen, phosphorus and potassium.

On the basis of above the following environmental modifications (Max. temp +1, Max temp +2, Max temp +3, Max temp +4, Min Temp +1, Min temp +2, Min Temp +3, Max & Min+1, Max & Min+2, Max & Min+3, and Max & Min+4)were studied with respect to growth and yield of maize using CERES maize model.Yearly mean maximum and yearly mean minimum temperature from 1980 to 2016 at the location of the study reveals that there is increasing trend in both maximum and minimum temperature (Fig. 1 and 2). Using DSSAT, Jones and Thornton (2003) simulated the impact of climate change on maize production in Africa and Latin America and showed that there is 10 % decrease in aggregate maize production by 2055.

Table 1: Effect of enhanced levels of temperature on maize maturity, yield and deviation.

Treatment	Maturity date	Culm weight at maturity	Harvest weight at maturity	Biological weight at harvest	Deviation in days from normal maturity	Deviation from normal Tops weight yield kgha^{-1}	Deviation from normal Grain yield kg/ha
Normal	252	26276	4357	22109	-	-	-
(Max+1)	246	25851	4261	21776	-6	-425	-96
(Max+2)	243	25295	3843	21646	-9	-981	-514
(Max+3)	241	25047	3547	21698	-11	-1229	-810
(Max+4)	237	24257	3213	21236	-15	-2019	-1144
(Min+1)	247	26000	4110	22079	-5	-276	-247
(Min+2)	243	25032	3858	21360	-9	-1244	-499
(Min+3)	240	24690	3590	21294	-12	-1586	-767
(Max & Min+1)	242	25825	4141	21872	-10	-451	-216
(Max & Min+2)	237	24682	3250	21631	-15	-1594	-1107
(Max & Min+3)	232	23771	3041	20922	-20	-2505	-1316
(Max & Min+4)	226	22733	2671	20252			

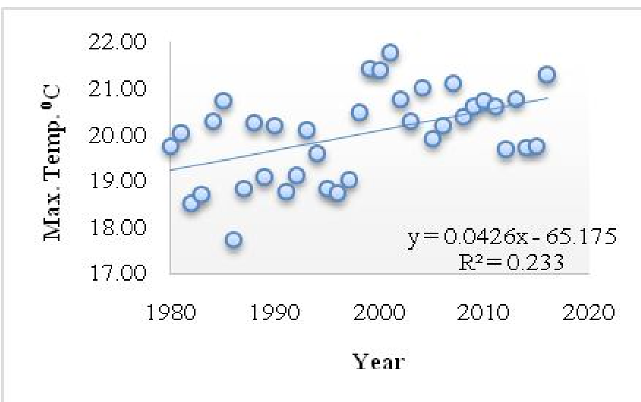

Fig. 1: Yearly mean max. temperature.

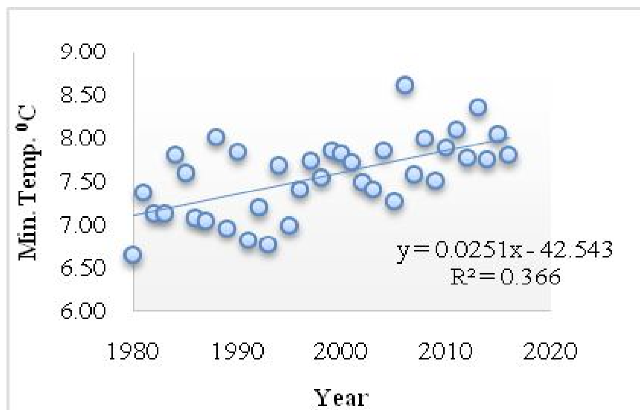

Fig 2: Yearly mean min. temperature.

Genetic coefficients of maize cultivar

Cultivar	Parameters					
	P-1	P-2	P-5	G-2	G-3	PHINT
C4	280	0.3000	789	650	6.030	48.00

Validation between observed data sets and simulated data sets was carried out with treatment combinations of twelve {Three planting dates 22nd May (D_1), 30th May (D_2) and 8th June (D_3) and four nitrogen levels 80kgNha^{-1} (N_1),120kgNha^{-1} (N_2),160kgNha^{-1} (N_3) and 200kgNha^{-1} (N_4)}. The agreement between simulated and observed LAI was good. Observed LAI ranged from 1.24 to 5.97compared to simulated 2.39 to 6.32for LAI under different treatment combinations (Fig. 3). The RMSE (Root mean square error) and Mean observed and predicted values for all the treatments were0.72 and 0.53.Maize sown on 30th May (D_1) gave the maximum observed LAI which decreased with delayed sowing. Observed and simulated grain yield ranged between 42.43 to 57.40 q ha^{-1}. The RMSE for the grain yield was 1.90 q ha^{-1} and mean value of 3.64indicating observed and simulated data matched well. The comparison of observed and predicted grain yields both over and underestimated by the model; however, the trend noted for the field-observed and model simulated grain yields matched well. The comparison of observed and predicted stover yields both over and underestimated by the model however, the trend noted for the field-observed and model simulated stover yields matched well. Simulated and observed yield biomass yield (q ha^{-1}) was good(Fig. 5and 6). Also Simulated biological

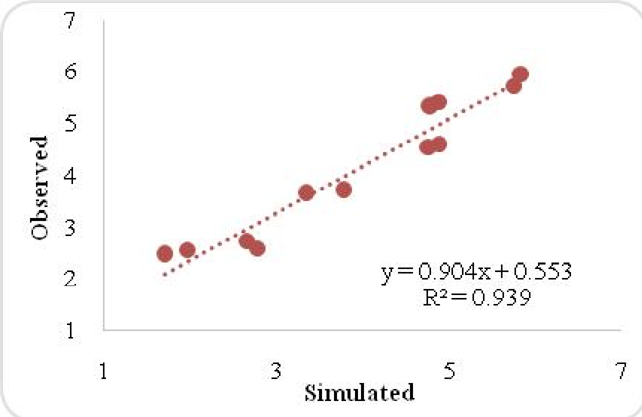

Fig. 3: Simulated vs observed LAI

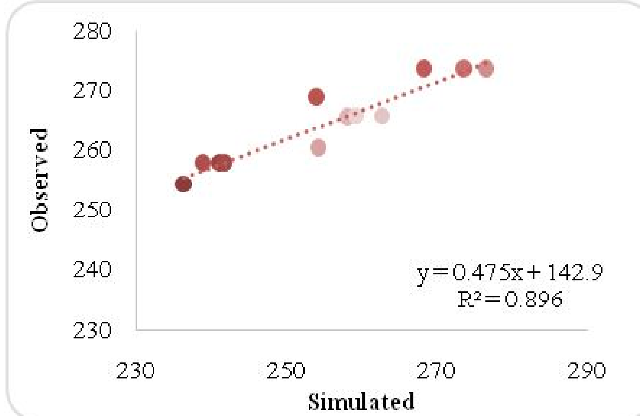

Fig. 4: Simulated vs observed biological weight q ha^{-1}

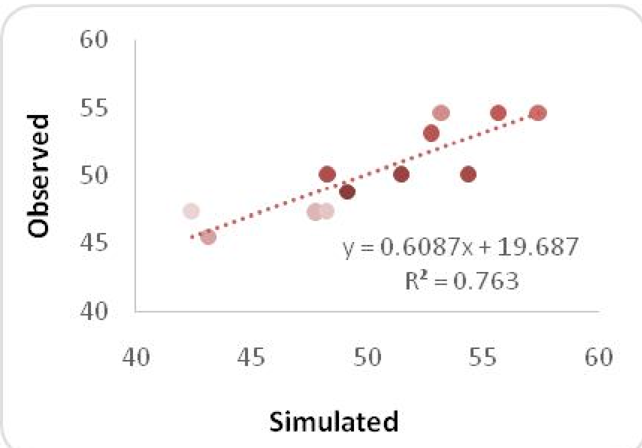

Fig. 5: Simulated vs observed grain yield weight q ha^{-1}

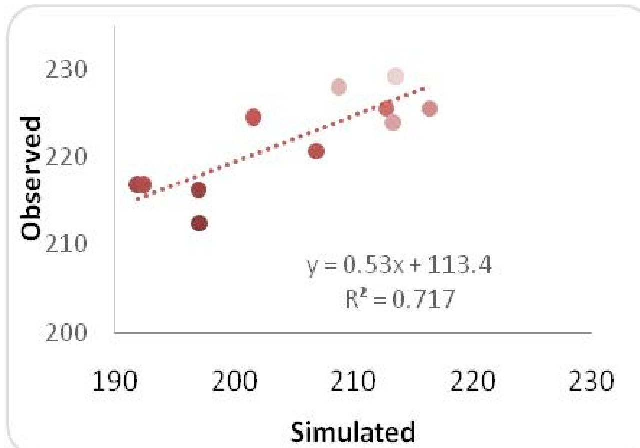

Fig. 6: Simulated vs observed stover yield weight q ha^{-1}

yield Vs observed biologicalyield predicted well (Fig.3and 4).

Deviation in maturity from normal was observed while increasing maximum temperature by 1˚C to 4˚C and minimum from 1˚C to3˚C and combination of both. Maize shows early maturity by 6 days with an increase in maximum temperature by 1˚C. Increase in maximum temperature by +2˚C, +3˚C and +4˚C maize crop matures earlier by 9, 11 and 15 days, respectively. Increase in minimum temperature alone also shows decrease in maturity date by 5, 9 and 12 days at an increase of +1˚C , +2˚C and +3˚C, respectively (Table 1). At combination of both maximum and minimum temperature increase by +1˚C maize matures earlier by 10 days. Increased level of maximum and minimum temperature by +2˚C, 3˚C and 4˚C, maize shorten its duration by 15, 20 and 26 days, respectively which implies the growth duration is decreased so yield also will be decreased at enhanced levels of temperature. Jones and Thornton (2003) also simulated the impact of climate change on maize production in Africa and Latin America and showed that there is 10 % decrease in aggregate maize production by 2055.

Tops weight goes on decreasing as maximum temperature was enhanced from normal to +1˚C, +2˚C , +3˚C and +4˚C and minimum temperature enhanced by +1˚C, +2˚C and +3˚C. Enhanced levels of (maximum and minimum temperature in combination) decreased the tops weight which may be attributed because of early maturity of crop. On higher temperature crop flowers earlier and days to maturity gets decreased and ultimately decreasesthe tops yield. Decrease of about 20 quintals was recorded when maximum temperature was enhanced by +4°C andabout 10 quintals decrease at +2°C. Enhancement of minimum temperature by +3°C shows decrease of about 16 quintals in tops weight. Maize grain yield goeson decreasing as we increase maximum or minimum temperature,decrease in grain yield ofabout 26% wasobserved at maximum temperature increase by +4°C.Enhancement of maximum temperature by +3°Cand +2 °Cdecreasedgrain yieldby 18% and 12%, respectively. Enhancement in minimum temperature by +1 °C, +2 °C + 3°C shows decreased in grain yield by 5.67%, 11.45% and 17.6%, respectively. Combination of both minimum and maximum temperature remarkably decreased grain yield at (maximum & minimum +2°C) up to 25.41% (Table 1). High temperature hastens the crop phenology; doubling temperature variability can reduce the maize yield up to 50%. Lone *et al.*(2019) also observed that by increase in maximum and minimum temperature anthesis and maturity of maize was earlierwith decrease in the yield.

The CSM-CERES-Maize Model was well validated under the temperate condition of Kashmir and has shown the great scope of using this model as a tool for estimating yield and yield gaps and study on different climatic scenarios. Increase in the maximum temperature, minimum temperature or combination of both adversely affect the growth and yield of maize under temperate conditions of Kashmir. Further studies need to be carried out with respect to different maize verities for tolerance against the enhanced levels of temperature for future use.

REFERENCES

Bal, S.K. and Minhas, P.S. (2017). Atmospheric Stressors: Challenges and Coping Strategies, In: "Abiotic Stress Management for Resilient Agriculture". (Eds. P.S. Minhas *et al.*).pp.9-50.Springers Nature Singapore Pte.Ltd.

Boote, K.J. (1999). Concepts for calibrating crop growth models. In *DSSAT Ver.*3-4: 181-194.

DES (2015-16). Economic Survey. Directorate of Economics & Statistics, Government of Jammu & Kashmir pp. 167.

FAO (2017). Http//faostat.fao.org/page Id 567#

Hoogenboom, G., Wilkens, P.W. and Tsuji, G.Y. (1999).DSSAT v 3 Volume 4.University of Hawaii, Honolulu, Hawii.

Jones, P.G. and Thornton, P.K. (2003). The potential impacts of climate change on maize production in Africa and Latin America in 2055. *Global Environ. Change,* 13: 51-59.

Keating, B.A., Godwin, D.C. and Watiki, J.M. (1991).Optimizing nitrogen inputs in response to climatic risk.In: *Climatic Risk in Crop Production: Models and Management for the Semi-arid Tropics and Subtropics* (Eds. Muchow, R.C. and others). CAG International, Wallingford, U. K.

Lone, B.A., Tripathi, S.,Fayaz,A., Singh, P., Qayoom, S.,Kumar, S. and Dar, Z.A. (2019). Simulating the Impact of Climate Change on Growth and Yield of Maize Using CERES-Maize Model under Temperate Kashmir. *Current J. Appl. Sci. Tech.,*35(1): 1-11.

Oreskes, N.K., Shrader, F. and Belitz, K. (1994).Verification, solidation and confirmation of numerical models in the earth science.*Science,*263: 641-646.

Rajireddy, D. (1991). Crop weather relationship in *rabi*maize (*Zea mays* L.) and testing of CERES-maize model for the middle Gujarat Agroclimatic zone. Ph. D. Thesis, Gujarat Agricultural University, Anand.

Rasool, S., Kanth,R.H., Hamid,S.,Raja,W.,Alie, B.A. and Dar,Z.A. (2015). Influence of integrated nutrient management on growth and yield of sweet corn (*zea mays* L. saccharata) under temperate conditions of Kashmir valley. *American J. Exp.Agric.,*7(5): 315-325.

Sheikh, A.M. and Rao, B.B. (1996). Crop growth modeling possibilities and limitation: An Indian perspective. In: *Climate variability and Agriculture*, (Eds. Y. B. Abrol, S. Gadgil and G. B. Pant) Narosa Publishing House, New Delhi pp. 356-374.

Singh, U. (1985). A crop growth model for predicting corn performance in the tropics.*Ph. D. Dissertation*, Agronomy and Soil Science department, University of Hawaii, USA.

Tsuji, G.Y., Uehara, G. and Balas, S. (1994).*DSSATv 3*.University of Hawaii, Honalulu, Hawaii.

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