Evaluation of adaptation strategies under A2 climate change scenario using InfoCrop model for *kharif* maize in middle Gujarat region

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ABSTRACT

Thirty years (2071-2100) projected climatic data under A2 scenario along with thirty years (1961-1990) actual observed data suitably adjusted to the baseline period were used for climate change impact study on maize cultivars (GM-3 and GS-2) in Dahod district of middle Gujarat. For purpose of evaluating different adaptation options, different realistic hypothetical set of crop management data such as additional irrigation, fertilizer and organic manure were used using InfoCrop model. It was found that two supplementary irrigations given at tasseling and silking stages increased 18 per cent yield over rainfed maize when it was sown during first July for cv. GS-2. The application of additional dose of chemical fertilizer (50 per cent extra) and organic manure + chemical fertilizer (50 per cent) at knee height and tesseling stages gave 10 and 8 per cent higher yield, respectively.

Key words: Climate change, InfoCrop, baseline, adaptation strategies, maize, simulation, A2 scenarios etc.

Maize (*Zea mays* L.) occupies a pride place among course cereal crop in India, next to rice and wheat (Mondal *et al.,* 1981). In India, it is grown in an area of 8.21 million ha with a production of 19.77 million tonne with an average productivity of 2435 kg ha^{-1} (Anon., 2010a). Out of the total geographical area of 188 lakh ha, about 8.47 lakh ha are under maize in Gujarat (Anon., 2010b). In Gujarat, its cultivation is mainly confined to Sabarkantha, Dahod, Panchamahals, Vadodara and Kheda districts. During last 10 years there is an increasing trend in area, production and productivity in maize.

In the context of climate change, effective adaptation strategies are the one that reduces the present and future climate change impact. Singh *et al.,* (2010) studied climate change impact on maize yield and yield attributes by using the results from different scenarios (A1B 2030, A1B 2080, A2 2080 and B2 2080). They found that adaptation in terms of sowing improved variety with additional amount of nitrogen had positive gain by about 24 per cent in A1B 2030 and 14.8 per cent in B2 2080 scenarios. Agustin (2006) suggested that under CO_2 fertilization, simple measures such as change in planting dates or N rate would not be sufficient for enhancing productivity at Uruguay. He observed that supplementary irrigation gave overall yield increases in maize with 20 per cent under A2 and B2 scenarios. Negassa *et al.,* (2007) studied integrated use of organic fertilizers and found encouraging results in increasing maize grain yield

and improving soil chemical properties at eastern Ethiopia. Khan *et al.,* (2009) observed that farmyard manure application @ 20 t ha^{-1} combined with 60 kg N ha^{-1} performed better than all other treatments in giving higher thousand-grain weight, more leaf area index, greater grain and biological yields except grains per cob in maize at Peshawar. Sinha and Swaminathan (1991) suggested that cultural operations should be adjusted to overcome the problem of less productivity**.** Application of 10 t ha^{-1} FYM along with 100 per cent NPK recorded the highest productivity in maize (Kumar *et al.,* 2005).

In this paper an attempt was made to evaluate the available adaptation strategies to maize crop under climate change scenario especially during *kharif season* using InfoCrop model.

MATERIALS AND METHODS

Climate data

For baseline data, 30 years (1960-90) weather data were collected from Agrometeorological Observatory, Agriculture Research Station, A.A.U., Dahod (20˚ 50'N, 75˚ 18'E and 313m MSL). Differences were observed between PRECIS baseline daily weather data and actual weather data for the same period (Tripathy *et al.,* 2009). In the present study in order to make rely on the weather data, the differences between PRECIS baseline (1961-1990) and projected (2071-2100) were to be modified and accordingly, thirty

Table 1 : Mean rainfall, temperature and simulated maize yield during base line (1961-90) and projected period (2071-2100).

Particulars		Baseline period (1961-90)	Projected period (2071-2100)	% change
Rainfall (mm)		972.5	1391.7	43.1
Maximum temperature (°C)		32.6	36.8	12.9
Minimum temperature (°C)		19.4	23.7	22.2
Grain yield (kg ha^{-1})				
GS-2	D_1 (1st July)	2823	1729	-38.8
	D_2 (15th July)	2772	1378	-50.3
GM-3	D_1 (1st July)	2673	1672	-37.4
	D_2 (15th July)	2595	1529	-41.0

Table 2 : Change in yield due to different adaptation options (additional irrigation, fertilizer and organic manure with fertilizers). *kharif* maize yield cv. GS-2.

Projected years	Mean projected grain yield (kg ha^{-1})	Additional irrigation		Additional fertilizers		Organic manure + fertilizers	
		Grain yield (kg ha^{-1})	% change	Grain yield (kg ha^{-1})	% change	Grain yield (kg ha^{-1})	% change
2071-75	1654	1989	20.3	1825	10.3	1781	7.7
2076-80	1567	1846	17.8	1724	10.0	1701	8.6
2081-85	1739	2017	16.0	1917	10.2	1883	8.3
2086-90	1707	2014	18.0	1870	9.5	1840	7.8
2091-95	1963	2309	17.6	2145	9.3	2086	6.3
2096-2100	1763	2076	17.8	1937	9.9	1899	7.7
mean	1732	2042	18	1903	10	1865	8

year monthly average of daily climate data for baseline period were subtracted from corresponding projected A$_2$ scenario data for various parameters and the differences obtained were used for computing climate data for projected period.

InfoCrop model

The experimental data (2004-2007) collected at Main Maize Research Station (MMRS), Anand Agricultural University, Godhra, Gujarat were used for calibration and validation of InfoCrop model for *kharif* maize cv. GM-3 and GS-2. The soil management and crop management data were also obtained from the study location.

Adaptation strategies

For purpose of evaluating different adaptation options like shifting in season, application of additional irrigation at teaseling and silking and additional dose of fertilizers and along with organic manure and also to indentify best adaptation mechanism, different realistic hypothetical

set of crop management data were used using InfoCrop version 1.0 simulation model.

RESULTS AND DISCUSSION

Projected climatic scenario

The projected climatic parameters generated through PRECIS output for rainfall, maximum and minimum temperature are presented in Table 1. The projected maximum temperature is likely to be highest (39.9 °C) in 2077 and lowest (33.0 °C) in 2072. Similarly, the average annual minimum temperature for the projected period is likely to rise by 4.3 °C with maximum (25.1 °C) in 2089 and minimum (22.2 °C) in 2088. The rate of rise of maximum temperature and minimum temperature was 0.003 and 0.002 °C/year. PRECIS generated rainfall results indicated that Dahod will receive 43 per cent higher rainfall during projected period (2071-2100) as compared to their base line (1961-1990). The average mean annual rainfall was estimated to be 1392 mm for projected period. The rate of increase of rainfall was

found to be 0.22 mm on annual basis. Similar kind of temperature variation and rainfall trend was found by Kumar *et al.,* (2010) for Central Gujarat, Rupakumar *et. al.,* (2006) for New Delhi and Challinor and Wheeler (2008) for Western Ghats used PRECIS model under A_2 scenario.

Variation in kharif maize yield during projected period

Results showed that the mean yield of cv. GS-2 was higher as compared to cv. GM-3 during baseline period. The mean yield under A_2 scenario in early sowing of cv. GS-2 was found higher (1729 kg ha^{-1}) as compared to GM-3 (1672 kg ha^{-1}) while under late sowing GM-3 recorded higher (1529 kg ha^{-1}) yield as compared to cv. GS-2 (1378 kg ha^{-1}) (Table 1). Similar results for yield reduction had been obtained by Singh *et al.,* (2010) at New Delhi and Rao *et al.,* (2010) at Hyderabad for irrigated wheat and maize crops, respectively.

Adaptation measures

During projected period there was drastic reduction in grain yield irrespective of cultivar and dates of sowing in *kharif* yield (Table 1). Nearly, 37 to 50 per cent yield reduction was noted during projected period in *kharif* maize as compared to base line yield of both the cultivars. So it is highly advisable to reduce the area under *kharif* maize and increase the area under *rabi* cultivation. After the identification of problem of getting reduced maize grain yield during *kharif* season to increase maize productivity during this season various adaptation measures were tried and simulated (Table 2).

Adaptation by additional irrigation: The percentage gain from additional irrigation given over rain fed maize under projected period of A_2 for cv. GS-2 (D_1 sowing) is presented in Table 2. Results showed that by applying two supplementary irrigations by check basin method one at teaselling and the other at silking stage to *kharif* maize gave nearly 18 per cent higher mean grain yield over rain fed condition during projected period. Similar types of results were observed by Kumar *et. al.,* (2010) and Agustin (2006).

Adaptation by additional fertilizer application: This adaptation was tried for yield enhancement of maize by applying 50 per cent extra dose of fertilizer by top dressing method at two phenological stages (knee high and tasseling) of GS-2 during 1st July sowing under projected period and results showed that by applying additional doses of fertilizer to *kharif* maize gave around 10 per cent more mean grain yield over normal fertilizer application under projected period. Results were in good conformity with the findings of Kumar

et. al., (2010) and Singh *et. al.,* (2010).

Adaptation by organic manure : Under this adaptation measure top dressing fertilizer at tasselling and silking stages was given by mixing with 50 per cent organic manure and 50 per cent chemical fertilizers in comparison to normal top dressing dose of fertilizer under projected period of A2 in *kharif* GS-2 in D_1 sowing (Table 2). Results showed that by applying organic manure with fertilizer application to *kharif* maize gave 8 per cent more mean grain yield over normal fertilizer application under projected period. Similar results were obtained by Kumar *et. al.,* (2010) and Khan *et. al.,* (2009).

CONCLUSION

Some short-term adaptation strategies were used to optimize the maize productivity without major system change against the impact of climate change. These short-term adjustments were found to be the first defence tools against climate change. It was concluded from above findings that two supplementary irrigation given at tasseling and silking stages proved more beneficial than additional fertilizer application and organic manure.

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