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IMPACT ASSESSMENT OF CLIMATE CHANGE ON GROUNDNUT IN NORTH-SAURASHTRA AGRO-CLIMATIC ZONE OF GUJARAT

1. Groundnut is a major oilseed crop of India and also an important agricultural export commodity. Most of the groundnut annual acreage (82%) and production (85%) is concentrated in five states, *viz.*, Gujarat, Rajasthan, Andhra Pradesh, Karnataka and Tamil Nadu. Groundnut is major oilseeds crop of Gujarat with 1.68 million ha area and 3.94 million tonnes of production with 2343 kg ha^{-1} productivity (Anonymous, 2018). The major groundnut growing districts in Gujarat are Junagadh, Jamnagar, Amreli, Bhavnagar, Rajkot, Mehsana and Bhuj. The IPCC has reported that the global average temperature had increased by 0.74 °C over the last 100 years and projected temperature increase is about 1.8 to 4 °C by 2100 (IPCC, 2007). It is very likely that all regions will experience either declines in net benefits or increases in net costs for increases in temperature greater than about 2-3 °C. The developing countries are expected to experience larger percentage losses, global mean losses could be 1-5% GDP for 4 °C of warming (IPCC, 2007). Patel *et al*. (2015) has reported that increase in temperature and rainfall over different station of Gujarat revealed that there will be a rise in the mean rainfall and study its impact on different crops using DSSAT model.

Models can be used by policy makers to evaluate alternative management strategies, quickly, effectively and at no/low cost to minimize the likely impact of climate change. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. IPCC (2007) defines adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. Singh *et al*. (2012) evaluated various genetic traits of groundnut for enhancing its productivity and adaptation to climate change in groundnut growing regions of India. The intensive awareness and sensitisation, timely access to information and frequent contacts between researchers, extension officers and farmers to adopting such type of strategies against climate change.

In this paper an attempt has been made to assess the impact of climate change on groundnut yield and to find the adaptation strategies in rajkot district of north-saurashtra agroclimatic zone. For this purpose, looking to the wider acceptability, robustness, user friendly and higher versatility, the crop growth simulation model DSSAT v4.5 (Hoogenboom, 2000) has been considered for assessment of climate change on groundnut crop.

2. *Climate Change study* - The weather data of two period of 30 years each, one for base line, *i.e*., 1961-1990 and another for A_2 projected scenario, *i.e*., 2071-2100 were used for Rajkot district. The weather data were collected from Dry farming research station, Targhadia and the climate change projection under A_2 scenario was derived from PRECIS downscaled model output prepared by IITM Pune in a grid size of 0.4 degree. The monthly average of daily weather parameters of base line data was subtracted from the corresponding projected A_2 scenario data and the difference obtained were used for computing weather data for projected period using actual observed data. In case of rainfall, the percentage difference on monthly sum of 30 years average data, between projected output and base line output were used as correction factor. For baseline data, actual weather data were collected from Agrometeorological Observatory, Dry Farming research station, J.A.U., Targhadia, Rajkot, for thirty-year period have been used.

2.1. *Crop simulation model* - Parmar *et al*. (2013) has calibrated and validated PNUTGRO (DSSAT v.4.5) peanut model with experimental data of most popular North Saurashtra groundnut cultivar GG-2 and GG-20 under two dates of sowing (D_1:1st July & D_2:15th July) was used to study the impact of climate change on groundnut.

TABLE 1

Percent reduction in phenology and yield under A_2 scenario (2071-2100) as compared to Baseline (1961-1990) on groundnut

Phenology	D_1		D_2	
	GG-2	GG-20	GG-2	GG-20
Days to anthesis	5.9	15.2	9.3	16.7
First pod	2.4	12.8	7.9	8.3
First seed	3.5	5.6	3.9	4.1
Days to maturity	9.2	8.8	3.9	8.9
LAI	38.8	41.4	24.8	32.6
Haulm yield	8.3	21.3	22.1	23.1
Shelling %	9.2	11.7	12.6	11.6
Yield	28.0	30.3	29.0	31.7

The soil management and crop management data were also obtained from the study location.

2.2. *Development of adaptation strategies* - DSSAT model was used to evaluating possible low-cost adaptation strategies, *viz.*, shifting sowing by fifteen days early with additional irrigation and application of organic manure instead of chemical fertilizer in management file. The simulation runs were performed with different experiment files created for selected management options.

3. *Weather condition during projected period* - The average temperature increase during 2071-2100 was found 3.9 °C and 3.6 °C in both maximum and minimum temperature as compared to their baseline temperatures (33.7 and 20.1 °C) respectively. The rate of rise of *T*max and *T*min was 0.12 and 0.11 °C/year. PRECIS generated average rainfall results showed that Rajkot will receive 63% higher rainfall during projected period (2071-2100) as compared to their base line (1961-1990). The average mean annual rainfall was estimated as 1206.3 mm for projected period. The rate of increase of rainfall was found 2.1 mm on annual basis. Similar kind of temperature variation and rainfall trend was found by Kumar *et al.* (2010a&b) for Central Gujarat and Rupakumar *et al.* (2006), respectively using PRECIS model under A_2 scenario.

3.1. *Impact on groundnut phenological variation during projected period :* 3.2.1. *Days to anthesis* - Higher reduction in anthesis date was seen at the D_2 sowing in cv. GG-20 as compared to baseline anthesis day (Table 1). The average reduction in anthesis days was noticed 12% average [irrespective of cultivars and dates of sowing) similar results were found by (Yadav *et al*., 2017)].

TABLE 2

Mean groundnut yield during projected period (2071-2100) and adaptation strategies

Projected Years	Mean Projected Pod yield (kg ha^{-1})	Shifting sowing by fifteen days early with additional irrigation		Application of organic manure instead of chemical fertilizer	
		Yield (kg ha^{-1})	% Change	Yield (kg ha^{-1})	% Change
2071	1625	1750	7.7	1766	8.7
2075	980	1178	20.2	1104	12.7
2080	1422	1660	16.7	1578	11.0
2085	1356	1569	15.7	1489	9.8
2090	1250	1367	9.4	1384	10.7
2095	1189	1437	20.9	1287	8.2
2100	836	1046	25.1	987	18.1
Mean	1237	1430	16.5	1371	11.3

3.1.1. *First pod* - Higher first pod formation days reduction was noted in cv. GG-20 during D_1 sowing as compared D_2 sowing and mean first pod formation days reduction (irrespective of date and cultivars) was 8% as compared to baseline (Table 1).

3.1.2. *First seed* - It was not much variation in first seed reduction under different date of sowing and varieties. Lowest first seed reduction (3%) was noted in cv. GG-2 D_1 sowing while it was highest (6%) under D_1 sowing in GG-20. While average first seed reduction (irrespective of cultivars and dates of sowing) was noticed 4% as compared to baseline (Table 1).

3.1.3. *Days to maturity* - The result shows that low reduction in maturity days was noted at D_2 sowing in cv. GG-2 as compared D_1 sowing and mean maturity days reduction (irrespective of date and cultivars) was 8% as compared to baseline (Table 1). Similar types of results for phenological stages were obtained by Yadav *et al*. (2017).

3.1.4. *LAI* - The comparatively lower LAI reduction (29%) was noticed for D_2 sowing under climate change in both varieties, while on an average LAI reduction (irrespective of cultivars and dates of sowing) was noticed 34% as compared to baseline (Table 1).

3.1.5. *Haulm yield* - Impact of climate change on haulm yield less reduction (8%) in cv. GG-2 during D_1 sowing under A_2 scenario as compared to D_2 sowing. Mean haulm yield reduction (irrespective of cultivars and date of sowing) was (19 %) of baseline. Yadav *et al*. (2017) found similar result for groundnut crop at middle Gujarat.

3.1.6. *Shelling%* - There was no much variation in shelling% reduction under different date of sowing and varieties. Lowest shelling% reduction (9%) was noted in cv. GG-2 D_1 sowing while it was highest (13%) under D_2 sowing in cv. GG-2. While average shelling% reduction (irrespective of cultivars and dates of sowing) was noticed 11% as compared to baseline (Table 1).

3.1.7. *Pod yield* - The impact assessment of climate change on pod yield of peanut presented in Table 1. Result reviled that nearly 28 and 30% pod yield reduction as compared to baseline was noted in D_1 sowing of cv. GG-2 and GG-20, while it was 29 and 32% for D_2 sowing respectively. Sowing of groundnut during the D_1 rarely experiences moisture stress during reproductive stage especially pod development stage under normal rainfall distribution and was found most beneficial as compared to D_2 sowing under projected climate change the result supported to finding of Bhatia *et al*., (2005) and Singh *et al*. (2014).

3.2. *Adaptation strategies* - Impact of Climate change on groundnut yield reduction irrespective of cultivar showed in Table 2. The result revealed that on an average 28 to 32% mean yield reduction was noted on pod yield during projected period (2071-2100) as compared to baseline period. Minimize the impact of climate change on groundnut yield to increase productivity various adaptation strategies were simulated (Table 2).

3.2.1. *Shifting of sowing window* - Increase yield by shifting date of sowing over normal sowing date of groundnut under projected period of A_2 scenario is presented in Table 2. Results showed that shifting sowing by fifteen days early over normal sowing with one irrigation for proper moisture for seed germination gave nearly 16% higher yield over normal sowing under projected period. Similar types of results were observed by Singh *et al*. (2014).

3.2.2. *Adaptation by organic manure* - In this adaptation strategy showed recommended fertilizer dose in the form of organic manure and yields are compared with chemical fertilizer application. Results showed that by applying organic manure application to groundnut gave 11% more yield over normal fertilizer application under projected period (Table 1). Similar results were obtained by Yadav *et al.* (2017).

4. PRECIS model showed that there will be rise of maximum temperature and minimum temperature at a rate of 0.12 and 0.11 °C/year with 63% higher rainfall under projected period. Crop Simulation model assess the impact of climate change on groundnut yield and quantify 28 to 32% pod yield reduction and the possible benefits and prioritization of various agronomic adaptation options, as advancement of sowing by fifteen days with one pre sowing irrigation resulting 16% higher pod yield over normal sowing and application of organic manure instead of chemical fertilizer gave 11% more pod yield over normal fertilizer application during the projected period. However, the model can be used for crop production, yield variability, to evaluate the impact of climate change.

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P. K. PARMAR
M. J. VASANI*
H. R. PATEL*
S. B. YADAV*
V. PANDEY*

Department of Agricultural Engineering, Navsari Agricultural University, Navsari – 396 450, Gujarat, India
** Department of Agricultural Meteorology, BACA, Anand Agricultural University, Anand, Gujarat – 388 110, India*

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e mail: aspeeagmet@nau.in