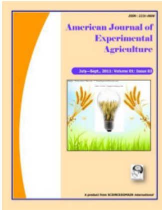

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Changing Agro-Climate: Tropical Tubers and Roots as a Challenge for Sustainable Livelihood in India

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Authors' contributions

This work was carried out in collaboration between both authors. Author SRP designed the study, managed the literature searches, wrote the protocol, performed the statistical analysis, and wrote the manuscript. Author SKT supervised the research and checked the final documents to give a proper shape. All authors read and approved the final manuscript.

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ABSTRACT

The present study was undertaken for adaptability and sustainability of sweet potato with respect to climate change in Odisha, India. Climate change contributed to erratic rainfall pattern, shift of sowing and harvesting period of crops, incidence of diseases/pests in crops. So, there is a need to develop a comprehensive master plan for strategically planning conservation and food security in the wake of climate change impacts. It was identified the primary challenges of farmers which ensured them to grow adaptive and sustainable tuber crops in changing agro-climate. Tropical root and tuber crops contribute 6% of the average daily requirement and considered as third important crop. It is considered as a cheap source of food and energy particularly suitable for the poor section population which also capable enough to withstand biotic and a biotic stresses. Experiments were conducted with short season variety of sweet potato in fluctuating agro-climate like change in temperature and humidity in order to find its sustainability. Different treatments which comprises of (80%, 100% and 150%) moisture on dry basis (field capacity) and temperature like low as 20-25ºC

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and high as 45-50ºC. The result showed that different agro-climatic parameter treatments led to no significant yield loss in sweet potato.

Keywords: Climate change; tuber and roots; livelihood.

1. INTRODUCTION

The general consensus is that changes in temperature and precipitation result in changes in land and water regimes that consequently affect agricultural productivity. Although estimates suggest that global food production is likely to be robust, experts predict tropical regions seen reduction in agricultural yields due to climate change. The latest inter governmental panel on climate change report suggest that global mean temperature of the next century could be between 1.4-5.8ºC [1]. Although the precise extent of the changes their consequence is subject to considerable scientific uncertain, there is one issue on which there is a broad agreement [2]. Developing countries are especially vulnerable to climate change has been agricultural productivity depends on climate change and developing countries mostly employ workforce and is responsible for around quantum of GDP [3]. While contemporary policy emissions include climate change, there has been relatively limited discussion about climate impacts due to some obstacles. First, climate variability is already a problem both in developed and developing countries. Second, moderate climate change provides added impetus by promotion of local adaptation. That is, adaptation to climate change variability (including extreme events) at the national and local levels leads to reduction of the magnitude of impact of climate change. Consequently, several key themes have emerged from the current literature on adaptations to climate change. First, given the range of current vulnerability and diversity of expected impacts, there is no single recommended formula for adaptation. Second, responsibility for adaptations will be in the hands of private individuals as well as government. Third, the temporal dimension of policy responses is likely to have a significant role by facilitating adaptation climate change [1]. One set of measures will decrease the short-term vulnerabilities of the agricultural sector through adaptations to weather effects. These measures will therefore address concerns with climate variability. Another set of strategies that reduce vulnerability to climate change will thus be necessary. This second set of adaptation measures include options such as improving water management practices, by adopting and utilizing new technologies, and changing crop types and location.

Indian agriculture is facing challenges due to factors such as increased competition for land, water and labor from non-agricultural sectors and increasing climate variability. It is associated with global warming which results in considerable seasonal/annual fluctuations in food production. All agricultural commodities even today are sensitive to such variability. Droughts, floods, tropical cyclones, heavy precipitation events, hot extreme sand heat waves are known to negatively impact agricultural production, and farmers' livelihood. It has been projected by recent report of [4] and a few other global studies [4] that unless we adapt to unfavorable climatic parameters i.e. high temperature there is a probability of 10-40% loss in crop production in India by 2080-2100 due to global warming, despite beneficial aspects of increased CO_2. A recent meta-analysis of CO_2 enrichment experiments in fields has shown that in the field environment, 550 ppm CO_2 leads to a benefit of 8-10% in yield in wheat and rice, up to 15% in soybean, and almost negligible in maize and sorghum; but increase in temperature may alter these result [5].

Root and tuber crops such as cassava, yam, sweet potato and cocoyam are important source of energy in daily diets and constitute a major part of the rural Indian staple diet. With an estimated per capita consumption of 15.4 kg of cassava, 43.3 kg of yam they account for 28% of per capita food consumption; making them a major source of food and government savings on revenue [6]. Root and tuber crops as part of agricultural export generate about 1.5% of government earnings and employs about 10% of the population. Experimental research has shown that root crop yield response to climate change vary widely, depending on species or cultivar, soil properties, pest and pathogens. The need to assess effects of climate change on root crop by it's demand, incomes in farm, and selling price was moderately emphasized.

This report is an assessment of the consequences and adaptation responses to climate change. Sweet potato (*Ipomoea batatas* L.) is a popular tuber crop species, grown in developing countries in small scale which is primarily used as food; some are used to sell in market with other farm produce [7]. This crop is popular for its relative short period growth and widely adaptable to uncertain climate [8]. Sweet potato require adequate soil moisture for high yield [9] hence it is best adapted in high rainfall region or irrigation facilities as high moisture content required for tuber initiation and prolongation [10]. However, sweet potato is cultivated in India only as rain fed crop in most agro ecosystem and yield varies according to region. Hence, primary factor for improvement of this popular tuber crop yield is retaining greater proportion of moisture by modifying soil environment [11].

Organic matter is the primary source of small farm agriculture [12], it is also required for water recantation. Thus, traditional agriculture of tropics has relied on organic amendment to maintain yield especially in dry seasons that phenomenon has been demonstrated in many studies [3,13] in rain fed environment. In spite of, all the suggested climatic parameters like high moisture requirement for it's high yield, sweet potato resist fluctuation in moisture content (soil moisture) and temperature variability by less difference with normal yield. The objective of this experiment therefore was to determine the variability of yield of sweet potato with reference to climate changing parameters.

2. MATERIALS AND METHODS

Field experiment was carried out at specified region on experimental basis in a small plot in agri-business management department, Orissa University of Agriculture and Technology, Odisha to study the effect of soil moisture level and varied temperature on sweet potato yield (*Ipomoea batatas*). Strategy was to plant slips in raised beds with a center ridge 26-30 cm higher than the surrounding area. Each slip was planted at a depth of approximately 5-8 cm (with the leaves sticking above the ground) in month of April. At an intra row distance of 30-45 cm inches and inter- row space of three feet apart, so that the plants have adequate room to spread out. After transplanting, it is needed to water each slip immediately and do so every (4-5 days) interval until the plants have been established. Typically it is not needed to irrigate the plants after they are established unless the area in which tuber planted with limited rainfall. Weed early after plant establishment and once to twice as this allows the vines to produce large tubers.

About one month after transplanting, with respect to planting, it absolutely needs watering treatment which comprises of three water levels like 300 mm, 600 mm, 800 mm of it and temperature like low temperature 20-25ºC and high temperature 45-50ºC. Date of planting of vines that was conducted by college of agriculture student was noted .The plot size was of 4×4 m^2 approximately. Chemical and physical properties of soil were analyzed before cultivation and reported in Table 1. The permanent wilting point (PWP) and field capacity (FC) of the trial soil was determined before planting. Plant distances were 0.3 m apart. A distance of 1.75 m was left between two irrigation treatments .Total amount of irrigation water was calculated by class A pan evaporation (which is the class A pan evapometer).The normal agro metrological data of class A pan evaporation was obtained and expressed in mm/day. Drip irrigation was used for the cultivation season. Total amount of drip irrigation water applied was calculated with the aid of water flow-meter for each treatment (EC of water irrigation 0.8 dS/m). Irrigation treatments were named as low, medium and high respectively. The EC of the irrigation ranged 0.7 to 0.9 dS/m. Sweet potato was harvested in last of September i.e. 30th and total yield for each treatment were calculated separately.

2.1 Analytical Tools used

Water use efficiency (WUE) was calculated accordingly to the following equation:

$$\text{WUE}\left(\text{kg}/\text{m}^3\right) = \frac{\text{Total yield}\left(\text{kg}/\text{ha}\right)}{\text{Total applied water}\left(m^3/\text{ha}\right)} \quad (1)$$

Variable temperature treatment was done in three different ways like keeping plants in normal growing season, others in low temperature treatment like growing plant in controlled condition in green house and others for high temperature. All plots were same in dimension i.e. 4×4 m^2.

2.2 Varietal Coefficients

Simulations were carried out assuming successfully optimized resources in terms of soil moisture and sowing time. Respective coefficients for crops were taken for the dominant Indian varieties from the previous published studies. These were calibrated for each grid by simulating the performance of low, medium and high temperature tolerant varieties grown during very late, late, and timely sown periods respectively. The best combination was taken for the baseline and impact assessment.

3. RESULTS AND DISCUSSION

Agricultural production and marketing policies, which is concerning about climate change, affects food availability and food security. The implication is that food demand and supply balance and price trends beyond the early part of the 21st century will be low. Climatic conditions often interact with socio-economic conditions to determine food security. Climate variability tends to have the greatest impact on people who are landless, poor, or isolated. Changes in socio-economic conditions can lead to dramatic changes in food security. Disadvantageous terms of trade, poor infrastructure, and armed conflict also make it more difficult for people to cope with the effects of climatic extremes. For example, while food security would anyway have been a problem during severe famine 1950s and 1960s in India, economic recession and civil strife were major causes of the widespread famine.

Effect of different irrigation levels on sweet potato yield was illustrated in Table 2. Regarding the effect of different irrigation treatments, it was found that 100% irrigation yielded highest followed by 80% irrigation and the lowest yield was obtained by 150% irrigation treatment.

Relevant to the effect of different irrigation levels on water use efficiency show that higher level of irrigation led to decrease in water use efficiency for all irrigation treatment and also same result for lower amount of irrigation. The result in this study increases in water level above 100% lead to decline in water use efficiency.

The correlation coefficient was significant (p-value≤ 0.001); this means same trend was found in predicted and observed data for yield. P test value was not significant (p-value 0.132; this means no difference between observed and predicted value i.e. there is no difference in yield of sweet potato due to change in climatic parameter. Result of validation of the experiments indicates that the SUBSTOR –sweet potato crop model is validated to grow in Odisha. It was noticed that the output data from SUBSTOR – sweet potato crop (predicted data) were in harmony with the observed data in fresh vine yield.

In case of different temperature treatments, result show that high temperature treated vine yielded highest followed by low temperature during growth period, lowest yield was obtained by low temperature treatment in Table 3.

But in either varied temperature or varied water treatments declining yield was very small i.e. not significantly different. Both production and productivity are declining in adverse climatic condition but calculated very low in amount.

The correlation coefficient was significant (p-value 0.154); this means that same trend was found in predicted and observed data for yield. P test value was not significant (p-value 0.154); this means from SUBSTOR - sweet potato crop yield same vine as observed data was same harmony with predicted data with varied temperature and soil moisture. Effect of different irrigation levels on sweet potato was illustrated in Table 3 regarding the effect of different irrigation treatment; it was found that 30-35 ºC temperature treatment yields highest followed by 45-50 ºC temperature. The lowest yield was obtained by 20-25 ºC temperature treatment. The result in this study generally agreed with increased and decreased in temperature above 30-35 ºC lead to decline in yield.

Table 1. Chemical and physical properties of soil before cultivation

Chemical properties						
EC, m/moh	**pH**	**Ca++, meq/1**	**Mg++, Meq/1**	**Na+, Meq/1**	**K+, Meq/1**	**Cl^-, Meq/1**
2.5	6.8	25	11	12.5	1.5	11.5
Physical properties						
Sand, %	**Clay, %**	**Slit, %**	**Texture**	**FC, %**	**PWP, %**	**Bulk density, Mgm^{-3}**
73.2	12.2	24.6	Sandy loam	20.34	7.45	1.957

Table 2. Effects of different irrigation percentage on water use efficiency as actual and estimated sweet potato yield

Soil moisture (%)	Water (dm^3)	WUE (kg/m^2)	Vine fresh yield (kg/ha)		
			actual	estimated	yield change
80	2505	5.42	18296	18324	-28
100	3267	5.01	20211	20225	-14
150	3756	2.90	16798	16846	-48
Mean	3176	4.43	18435	18498	-63

T-test results for observed and predicted yield values: Correlation Coefficient R = 0.9989; t-test = -0.169; p-value = 0.132

Table 3. Effects of different temperatures on actual and estimated sweet potato yield in kg/ha

Temperature (º) treatment	Yield	Actual	Estimated	Yield change
20-25	2023	22553	22783	-230
30-35	2556	23412	23457	-45
45-50	2401	26999	27329	-330
Mean	2316	24321	24553	-232

T-test results for observed and predicted yield values: Correlation coefficient R = 0.989
t-test = -0.189; p-value = 0.154

4. CONCLUSION

It could be concluded that SUBSTOR model for sweet potato yield can be successfully used in Odisha. Highest yield was found in case of 80% moisture and in case of 30-35 ºC temperature treatment. Though yield was reduced due to varied temperature and moisture treatment but negative impact of those parameters were not significant. Hence it can be concluded that climate change cannot adversely affect the fresh yield of sweet potato vine.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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