The Andhra Agric. J 64 (2): 313-316, 2017

Climate Change - Technological options for Rice Crop in Bapatla Coastal Agro-eco System

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ABSTRACT

Climate changeis widely accepted as the single most pressing issue facing society not only in India, but also in Andhra Pradesh. Therefore, there is a need to find out new models of agricultural development to combat the negative impacts of climate change. In addition, proactive steps have to be taken to ensure the economic development of agriculture in the state of A P. in general and Bapatla region of Gunture District in particular as more than 60% of the population in the district are farmers. With this back drop, the weather data on rainfall and temperature from 1979 to 2014 were analysed to know the trends in limate change in the Bapatla coastal agro-eco system. The initial trends of changes in climate in the Bapatla agro-ecological region are occurring as per the global ecosystem trends. As a result the yields of rice crop are also changing. Analysis for climate change using, the technics viz., Murthy's weather health indices and DSSAT - CROPGROW software revealed that there are strong negative effects of elevated temperatures on reproductive processes and yield rice crop growth in the region. Also, there were no beneficial effects of elevated co_2 on reproductive processes of rice crop. Added to this these effects were negative at higher temperatures for this crop. For further definite results the data has to be subjected to few more important simulations using much refined data and statistical methods, inculding a new "pluviothermal concept", which is expected to solve climate change and agriculture issues in coastal ecosystems of A.P.

Key words: *Climate change, Technological, Weather health indices.*

One of the major challenges the human kind facing is to provide an equitable standard of living for the current and future geernations: adequate food, water, energy, safety, shelter and a healthy environment. Human induced climate change and increasing climate variability as well as other global environmental issues such as land degradation, loss of biological diversity, increasing pollution of the atmosphere and fresh water and stratospheric ozone depletion threaten human ability to meet these needs. Therefore, the science of climate change and variability and their likely impacts on agriculture assumed significance (Siva Kumar, 2017).

1.1Temperature changes on the Earth

Instrumental observations over the past 157 years show that temperatures at the surface have risen globally, with important regional variations. For the global average, warming in the last century has occurred in two phases, from the 1910s to the 1940s (0.35^{o}C), and more strongly from the 1970s to the present (0.55^{o}C). An increasing rate of warming has taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years. Above the surface global observations since the late 1950s show that the troposphere (up to 10 km) has warmed at a slightly greater rate than the surface, while the stratosphere (10-30 km) has cooled markedly since 1979. This is in accord with physical expectations and most model results. Confirmation of global warming comes from warming of the oceans, rising sea levels, glaciers melting, sea ice retreating in the Arctic and diminished snow cover in the Northern Hemisphere.

1.2 Precipitation Changes on Earth

Observations show that changes are occurring in the amount, intensity, frequency and type of precipitation. These aspects of precipitation generally exhibit large natural variability, and El Nino and changes in atmospheric circulation patterns such as the North Atlantic Oscillation have a substantial influence. Pronounced long-term trends from 1900 to 2005 have been observed in precipitation amount in some places significantly wetter in eastern North and South America, northern Europe and northern and central Asia, but drier in the Sahel, southern Africa, the Mediterranean and southern Asia. More precipitation now falls as rain rather than snow in northern regions. Widespread increases in heavy precipitation events have been observed, even in places where total amounts have decreased. These changes are associated with increased water vapour in the atmosphere arising from the warming of the world's oceans, especially at lower latitudes. There are also increases in some regions in the occurrences of both droughts and floods.

1.Objectives:

With the foregoing information, the objectives of the present investigation were 1) to determine the changes in rainfall and temperature pattern and their distributions due to climate change in different seasons in Bapatla region and 2) to quantify the effects of above optimum (elevated) temperatures on photosynthesis, vegetative, reproductive and yield of rice crop at ambient and elevated CO_2.

MATERIAL AND METHODS

3.1 Rainfall and Temperature:

The rainfall and temperature data from 1979-2014 were analysed statistically according to Ghosh et.al., (2014) and Zaman et.al (1982).

3.2 Air Temperature

3.2 A. Daily mean temperature

The daily mean temperature is obtained by dividing the sum of the maximum temperature and the minimum temperature recorded during the 24-hour day by 2.

$$\frac{\text{Maximum temperature} + \text{Minimum temperature during the 24 hours day}}{2}$$

The daily mean temperature is the basic temperature value that was used to calculate other temperature values namely the mean monthly temperature, the annual range of temperature, etc.

3.2 B. Daily range of temperature

It is obtained by subtracting the minimum temperature from the maximum temperature of the 24-hour day.

3.2 C. Mean monthly temperature

The mean monthly temperature of a month was calculated by adding the daily mean temperature for all the days of the month and dividing the sum by the number of days of the month.

3.2 D. Daily normal temperature

It is the mean daily temperature of the same day of the data available years(preferred is 30 years for climate for change).

3.3 Software:

Murthy's weather health indices and software on murthywhm.in and the DSSAT-CROPGROW models were used for climate change processes and its impact on different plant physiological processes and final yield of rice crop.

RESULTS AND DISCUSSION

Weather data from 1979 to 2014 on rainfall(Table 2) and temperature (Table 3) was statistically analysed to find the trends in climate change. For the 35 year period the Winter season (January-February) rainfall ranged from 8.30 mm in 1979-83 to 47.66 mm in 1984-88; the Summer

Table 1. Rice Yields in Bapatla from 1991 to 2014 (kgs/ha).

Season	Kharif	Rabi	Average	Season	Kharif	Rabi	Average
1991	2910	3157	3033.5	2003	2833	2917	2875
1992	3005	3002	3003.5	2004	3469	3338	3403.5
1993	3395	2849	3122	2005	3090	3549	3319.5
1994	2700	2870	2785	2006	2716	3489	3102.5
1995	3117	2781	2949	2007	3445	3548	3496.5
1996	3272	3603	3437.5	2008	3408	3654	3531
1997	2951	3566	3258.5	2009	3586	3413	3499.5
1998	3181	3532	3356.5	2010	2397	3456	2926.5
1999	3297	3696	3496.5	2011	3836	3547	3691.5
2000	3371	3908	3639.5	2012	3479	3576	3527.5
2001	3432	4031	3731.5	2013	3259	3810	3534.5
2002	3187	2719	2953	2014	3913	3763	3838

Table 2. Rainfall (mm) Trends of Bapatla from 1979 to 2014.

Season	1979-1983	1984-1988	1989-1993	1994-1999	2000-2004	2005-2009	2010-2014
Winter (JAN-FEB)	8.300	47.660	31.740	37.040	25.240	25.880	42.860
Summer (MAR-MAY)	30.600	24.620	59.260	94.320	66.020	71.880	55.686
SW Monsoon (JUN-SEP)	550.088	456.201	588.980	530.550	591.107	570.259	548.592
NE Monsoon (OCT-DEC)	239.530	280.512	341.136	420.131	247.638	317.535	347.709

Table 3. Temperature (°C) Trends of Bapatla from 1979 to 2014.

Season	1979-1983	1984-1988	1989-1993	1994-1999	2000-2004	2005-2009	2010-2014
Winter (JAN-FEB)	24.385	24.311	24.006	24.220	24.289	24.487	24.534
Summer (MAR-MAY)	29.981	30.046	29.654	29.551	29.911	30.064	30.217
SW Monsoon (JUN-SEP)	30.286	30.290	29.860	30.464	29.976	30.715	30.658
NE Monsoon (OCT-DEC)	25.767	25.599	25.527	25.775	25.604	26.112	26.056

season (March-May) rainfall ranged from 24.62 mm in 1984-88 to 94.32 mm in 1994-99; The SW monsoon (June- September) season rainfall ranged from 456.20 in 1984-88 to 588.98 mm in 1989-93; similarly for NE monsoon(October – December)ranges were from 239.53 mm in 1979-83 and 420,13 in 1994-99.These trends are confirming the global rainfall changes for climate change(Murthy, 2015 and Sivakumar, 2017).

On the same analogy the range of temperatures (°C) for Winter season ranged from 24.006 in 1989-93 to 24.534 in 2010-14; for Summer season from 29.551 in 1994-99 to 30.217 in 2010-14; for SW monsoon season from 29.860 in 1989-93 to 30. 658 in 2010-14 and for NE monsoon from 25.527 in 1989-93 to 26.112 in 2005-2009. Similar to rainfall trends the temperature trends were also following the global trends (Murthy, 2016 and Sivakumar, 2017).

Keeping these rainfall and temperature changes as basis, the sensitivity analysis was done using both Murthy's GDD based weather health concept and the DSSAT- CROPGROW models to know the reasons for changes in rice crop yields (Table1). It was observed on rice crop in Bapatla region that the elevated temperatures (28°C/ 36°C) had no effect on photosynthesis;the elevated CO_2(350/ 750 micro moles per mol) increased photosynthesis; both elevated temperatures and CO_2increased vegetative growth; the elevated temperature had strong negative effects on reproductive processes and inhibited panicle emergence, test weight and final rice grain yield. It could be inferred that decreased test weight at elevated temperature was mainly due to decreased seed filling duration (Murthy 2015). Interestingly, the elevated CO_2 had no influence on test weight. There are no beneficial effects of elevated CO_2 on reproductive processes. Initial trends and simulations with limited data (useful to establish general trends) indicated that the yield loss could be 9 % for every 0.99 degree centigrade rise in temperature above normal temperatures for different seasons for rice crop in Bapatla region of Andhra Pradesh.

The technological options suggested as adaptation strategies are (Sivakumar 2017)

- Changing nursery raising and transplanting/ direct seeded sowing dates as per weather analysis
- Varietal changes
- Developing new heat and drought tolerant varieties
- INM, IPM and weather based rice crop growing

Note: The authors strongly suggest for more refined simulations to establish further useful conclusions.

Acknowledgements:

The authors express their gratitude to WMO, Geneva, Switzerland; India Meteorological Department and Department of Science and Technology of Government of India for their funding and weather data for the study.

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(Received on 27.12.2016 and revised on 31.1.2017)