

GLOBAL WARMING AND ITS IMPACT ON CANE PRODUCTION UNDER PAKISTAN CONDITIONS

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Global warming is a long term universal challenge being faced in Agricultural sectors in all contents of the world. It is directly associated with increasing atmospheric CO₂ and other greenhouse gases like nitrous oxide and methane. It results in climatic change with change in rainfall pattern and the frequency of extreme high and low temperature events, floods, drought and other abiotic stresses.

The global surface mean temperature was reported to increase from 0.55° to 0.67° C in the last century and are projected to rise from 1.1° to 2.9° C (low emission) or 2.5° to 3.4° C (high emission) by the year 2100, relative to 1980-1999 period, depending on GHG emission level, regions and geographic locations (IPCC, 2014). Climatic changes have been observed in all the regions of the world, but divergent reports are available on their impact on agricultural productivity. According to Moorthy et al (2012) the temperature and precipitation trends did not have measurable impact on cotton, rice, sorghum and wheat, however cane yields were improved by 1%, over last 60 years (1951-2010). An increase in maximum temperature had adverse

effect on crop yields, and wheat yields were worst hit (Birthal et al (2014); it was further stipulated that rice yields would be reduced by 15% and wheat by 22% towards 2100 century. Kumar and Parikh (2001) projected large scale changes in climate would lead to significant reduction in wheat and rice yield by 2060; However there is no linear relationship between climatic factors and sugarcane productivity in India. Sugarcane crop would get benefit from increased winter temperature and rainfall. Comparing area and yield of five top leading countries for the period 1977-2013, impact of change is not conspicuous and increase in yield is still feasible in current environment. (zhao and Li, 2015).

Pakistan is not exception to this climate change that is threatening agricultural productivity. Pakistan is one of the most vulnerable countries to the consequence of climatic change, because of adverse geographical and climatic features. Pakistan is confined between huge series of high mountain ranges laden with glaciers in the North, hyper desert in South, and Arabian Sea in South-West. The sub-continent faces extreme variation in

temperatures and precipitation in upstream and downstream of river Indus and its tributaries with extreme variation in frequency and intensity of hydrological events. Climatically most parts of Pakistan are arid to semi-arid with significant spatial variability in climatic parameters. Coastal climate is confined within a narrow strip along the coast.

Climate of cultivated area

The cultivated area in mainland face hot dry summer with extreme temperature reaching 48°-52°C and moderate to severe winter temperature, that may occasionally drop down to freezing.

Annual average rainfall pattern is as under.

South	: 80 - 200 mm
Centre	: 200 - 600 mm
North	: 600 - 1600 mm

About 59 % of the annual rainfall is due to monsoon rains.

Agricultural sector predominantly depend on irrigation.

Generalized trends of climatic change quoted by Mahmood (2008) are projected as under:

Rise in mean temperature of 0.6° to 1.0° C in arid coastal areas, arid mountains, and hyper arid plains. 10 to 15 % decrease in both winter and summer rainfall in coastal belt and hyper arid plans. 18 – 32% increase in rainfall in monsoon zone, especially the sub-humid and humid areas.

5% decrease in R.H. in Baluchistan.

0.5 to 0.7 % increase in solar radiation over southern half of country.

3 – 5% decrease in cloud cover in central Pakistan with increase in sunshine hours.

3 – 5% increase in evapotranspiration rate due to 0.90° C temperature increase, expanding aridity, outside monsoon zone.

5% increase in net irrigation water requirements with no change in rainfall.

17 to 64% departure of rainfall from normal.

Frequency of heavy rains, with floods, hailstorm and heat waves is on rise.

The latest report of Ahmad et al (2013) indicate more interesting trends on temperature and precipitation. The mean temperature increased by 1.15° , 0.56° and 0.09° C in Baluchistan, Punjab and Sindh, respectively. The

winter temperature has registered more warming trend than the summer, thus reducing the winter season on both ends, resulting in prolonged summer. Overall rainfall show increasing trend in Punjab.

A decreasing trends in precipitation is observed in Sindh during 1960-2007 period. It may however be emphasized that these changes are not consistent and regular; the temperature and precipitation changes considerably vary with regions and crops. Besides the overall changes already quoted, annual variation in temperature and rainfall are different in different regions of Pakistan (Table-1).

The variations appear to be the highest in Baluchistan, followed by northern areas of KPK and FANA and are the lowest in Punjab and Sindh (Table-1). It means the temperature variation are not that extreme in the main cane growing regions of Pakistan?

Studies conducted at the University of Agriculture Faisalabad throw further light on temperature and precipitation pattern of Punjab. Comparing 1945-75 and 1975-2004 periods (Cheema et al, 2006). the data in Table-2 show some rise in temperature during winter months and a little drop during March, April, June and July months. The data also show increased precipitation.

These condition do show their impact on micro climate of the region.

Higher temperatures increase in mountain areas has tempted the glaciers to melt and release more water in rivers that tantamount to flood situation. The rising temperature during winters prolong the growth period of cane that may be helpful to enhance cane growth and improve yields. On the other hand rising temperature during winter, delay maturity, reduce harvesting period that would reduce sugar recovery.

Annual Precipitation in Pakistan and its provinces

Pakistan:1940-2007=+133 mm

Punjab 1901-1953 = -140 mm
1955-2007 = +228 mm

Sindh:1914-1960 = +13.6 mm
1961-2007 = -10.2 mm

Baluchistan: 1901-1953 = + 2.2 mm
1955-2007 = +56.4 mm

KPK: 1901-1953 = + 1.3 mm
1966-2007= + 75 mm

Impact of Climate Change

Impact of climate change may be noticed on:

Higher rate of glaciers melt, more water flow in rivers and extreme flood situation, due to higher temperature increase in mountain areas; as well as intensive rains.

The Climate change pertaining to the temperature variation, excessive moisture stress and excessive demand for irrigation water may have a growth promoting or depressing effect on field crops. These factors need to be discussed as how to mitigate the effect of high rate of evapotranspiration and how to meet the increasing demand for irrigation water.

As for as high rainfalls and floods, these are unpredictable natural calamities long-term planning is needed and government has to play its part. The impact of climate change on sugarcane growth and development, positive or negative may be discussed at this forum.

Cane Yield

The cane yield data of various contents of the world for the last 65 years show progressive increase in yield of cane (Table-3). Except the situation under cyclonic conditions all the contents and the countries have shown similar trends in cane yield. The advances in knowledge on production technology seem to have mitigated the effect of climate change.

The climate change if it is there is not a barrier to yield improvement. To study true impact of the climate, micro-climate of the environment of the concerned region should be kept in view. The Sugarcane crop grown under rain fed conditions would have different response to climate change than the crop grown in irrigated or partially

irrigated conditions. Thus cane crop in Zimbabwe, Brazil and some African countries would be more affected than that in Asian countries.

In the case of Pakistan the impact of climatic change is not much noticed on cane crop; in the initial stage progress in yield increment is slow, but after nineties the country made up fast. It indicates that the temperature increase reported so far has not shown negative effect on cane productivity. It could be linked with cane variety change; as well as sugar mills development efforts. It could also be taken in the sense that cane crop has wide adaptability to high or low temperature extremes. Considering the effect of CO₂, sugarcane beings C₄ plant, higher concentration of CO₂ does not harm cane crop, and rather it is likely to promote growth of cane.

Physio-chemical changes in cane plant

It is not that simple to study the effect of changes on biomass of cane plant. The temperature effect may opt the conditions favorable for:

Survival of cane pests like red mites and black bug during moisture stress in early and mid-crop growth stages.

In case the winter temperature is increased the hibernation stages of a number of pests would be delayed, calling for new pest control strategies.

Considering sugarcane diseases, new environments may provide conditions favorable for Sugarcane smut infection May induce conditions favorable for rust in early or late winter stages, during persistent cold rainy seasons (eg. cv SPF 234).

The researchers and development workers should be ready to face new crop disease or pests problems. Some physio-chemical measures may also be taken to induce moisture tolerance in plants by some growth regulators.

Sugar contents in cane

Sugarcane maturity is attained at low temperature and low humidity. Temperature around 10⁰-14⁰C is ideal for sugar synthesis and storage in cane stalks. A frost free long spell of cold nights during winter help produce more sugar in cane. Under the changed climate October, November and December are getting warm and dry. With slightly rise in temperature, winter season is delayed. This climatic change changes the ecosystem in different ways. This peculiar climatic effect does not reduces the vegetative growth of cane crop near harvesting. This situation prolongs growth which would have a yield promoting effect. And at the same time this change would delay cane maturity, reduce peak days of sugar recovery, reduce cane harvesting season and reduce the sugar recoveries of sugar factories. In this context present increasing

trends of temperature during winter is detrimental to harvest good sugars. This situation threatens the sugar industry to take up measures to sustain sugar contents in cane.

The data available on sugar recoveries show progressive improvement in sugar contents for the past six decades (Table-4.). In the initial stages the progress in recovery improvement was slow due to lack of good germplasm. From nineties good quality germplasm was imported which gradually helped improve sugar recoveries. Continued efforts can further produce varieties with good sugar contents. Still further rise in temperature may hamper the prevailing progress if high sugar varieties are not included in the programme. It calls for the urgent need to establish a good breeding programme in the country.

Other field crops

The global warming causing delayed occurrence of winter has a most deleterious effect on Rabi season crops, especially wheat. [The](#) growth period of wheat is getting short, which considerably reduce grain yield. In Agri. Sector this is the most destructive impact of climate change, and with time to come winter temperature are expected to rise further.

Measures to mitigate effects

Thus under prevailing conditions temperature

extremes are not much destructive for sugarcane; we don't find yield gap in sugarcane crop. However sugar recovery might be at stake. The presently changed temperature and rainfall do not directly hit the cane crop, it is the moisture stress and long spell of drought in pre-monsoon season that would affect crop growth. This situation calls for measures to mitigate the biotic effects, which could be excessive floods, long spell of drought or delayed winter season. This could be achieved by improving adaptability through land, crop and water management practices and genetic improvement of cane varieties.

Land and water management practices Cane area should not be expanded beyond available water resources;

The water available in our canal system is hardly enough to place 10 to 12 % area under cane in our cropping scheme. Practically growers place 30-40% area under cane, and this very factor tends to reduce yields. Efforts should be to enhance cane yields from given land resources.

All measures to be taken to improve water use efficiency

Water courses should be improved with suitable layout of cane fields for most efficient utilization of water.

Improve water holding capacity of soil through:

Deep ploughing

Improve organic status of soil by:

Incorporating

FYM/Sugarcane press mud.

Growing green manure crop in rotation.

Reduce chances of CO₂ adulteration in environment by:

Avoiding trash burning in cane fields.

Use trash as mulch in ratoon cane as well as freshly planted cane.

Trash also reduces surface temperature by 3-4°C during summer.

Trash provide conditions favorable for microbes to work on mineralization of nutrients.

In the long run trash is incorporated in cane fields to add organic matter in soil.

Reduce chances of N₂O and methane emission from crop fields:

This situation exists from poor drainage and improper method of fertilizer application.

Chhatta method of application should be avoided and fertilizer too be drilled near root zone.

Genetic improvement of cane varieties:

Cane varieties to play major role;

Grow drought tolerant varieties to evade moisture stress/heat stress.

Grow high sugar early maturing varieties to counter the chance of prolonging growth in temperature rise in early harvest season.

Grow high sugar late maturing varieties to prolong peak maturity season till late months.

Suggest profitable intercropping system to fetch maximum cash returns per unit area so as to sustain the interest of growers with sugarcane.

CONCLUSION

Pakistan is vulnerable to global warming problems affecting sugarcane production.

Besides their specific effect causing torrential rains, floods and overall drought, Increasing temperature cause higher evapo-transpiration and the crop is subject to severe moisture stress and is liable to demand more water.

Temperature rise during winter is liable to prolong vegetative growth and delay maturity in cane; thus reduce cane harvest season with low sugar harvests.

These are serious issues of depressing sugar yields.

Efforts are needed to sustain cane production by:

Conservation of available water.

Efficient use of water

Efficient use of land and other input resources to obtain higher yields per unit area.

Genetic improvement in cane varieties to sustain sugar yields under changed environments.

Making use of growth regulators to induce early maturity and sustain sugar in cane stalks.

Researchers have to look for new horizons in the field of biotechnology to induce stress tolerance for economic production of cane.

Table-1 Change in area- weighted annual maximum temperature in various regions of Pakistan*

Region	Annual Max. °C		Ann. Mean °C.	Ann. Min °C.
	1931 - 2007	1960 - 2007	1960 - 2007	1960 - 2007
KPK	0.61	0.96	0.15	-0.36
Punjab	- 0.95	- 0.02	0.56	1.16
Sindh	- 0.16	0.35	0.44	0.54
FANA	NA	0.91	0.16	- 0.45
Azad Kashmir	NA	0.82	0.30	- 0.35
Baluchistan	1.22	1.10	1.15	0.99
Pakistan	0.12	0.87	0.47	0.48

*Chaudhry et al (2009)

Table-2 Analysis of Temperature and rainfall data in Faisalabad over the last 60 years (1945-2004)*

Month	Average temperature ° C			Average rainfall mm		
	1945-74	1975-2004	Deviation	1945-74	1975-2004	Deviation
Jan	12.17	12.70	+ 0.53	13.8	11.2	- 2.6
Feb	14.93	15.10	+ 0.17	14.7	22.4	+ 7.7
Mar	19.99	19.70	- 0.29	19.4	24.6	+ 5.2
Apr	26.16	26.10	- 0.06	13.2	24.8	+ 11.6
May	31.11	31.60	+ 0.49	11.3	13.6	+ 2.3
Jun	34.32	33.90	- 0.42	22.0	38.9	+ 16.9
Jul	32.76	32.40	- 0.36	92.5	112.5	+ 20.0
Aug	31.66	31.80	+ 0.14	87.5	105.3	+ 17.8
Sept	30.33	30.00	- 0.33	26.0	40.0	+ 14.0
Oct	25.54	26.00	+ 0.46	6.6	4.4	- 2.2
Nov	18.79	19.90	+ 1.11	2.3	3.4	+ 1.1
Dec	13.58	14.80	+1.22	7.9	6.5	- 1.4
Total/Aver.	24.27	24.50		317.2	408.0	+ 90.8

*Cheema et al (2006)

Table-3 Sugarcane yield trends in various contents of the world during the last 65 years (1948-2013)*

Yield in tons per hectare

Continent	1948-53	1953-57	1969-71	1979-81	1989-91	1999-01	2012-13
World	42.5	46.7	52.2	56.5	61.2	64.7	70.8
Asia	32.2	33.9	48.6	52.0	59.2	63.6	67.5
Africa	52.8	56.9	66.3	61.9	60.7	61.0	63.4
N. C. America	48.6	58.8	52.1	58.7	60.8	57.9	81.4
S. America	43.6	44.5	57.1	58.4	63.7	69.0	74.5
Europe	64.1	71.8	77.5	57.4	80.1	93.9	85.2
Oceania	59.8	63.9	74.2	76.5	69.9	82.6	82.5
Pakistan	31.5	29.1	39.5	38.8	41.1	45.6	56.5

FAOSTAT*

Table-4 Periodic development in cane yield and sugar recoveries in Pakistan during 1947-2015 period

Period	Cane yield t ha ⁻¹	Sugar recovery %
1947-50	33.47	7.28
1950-60	28.68	7.95
1960-70	36.00	8.20
1970-80	36-37	8.61
1980-90	38-52	8.74
1990-00	45-44	8.53
2000-10	49-41	8.89
2010-15	56-14	9.81

REFERENCES

- IPCC, Summary for policy matters, in climatic change, 2014. Impacts, Adaptability and vulnerability Part 1. Field, C.B; V.R. Barros; D.J. Boken Eds. (2014) Cambridge Univ. Press, U.K.
- Mahmood, A. (2000). Climatic change and food security in Pakistan. Pak. Meteorological Dept.
- Cheema, M.A.; M. Farooq; R. Ahmad and H. Muneer (2006). Climatic trends in Faisalabad (Pakistan) over the last 60 years (1945-2004). Jour. Agri & Social Sciences. 1813-2235.
- Chaudhry, Q. Z.; G. Rasul and M. Afzall (2009). Climate change indicator of Pakistan. Technical Report No. PMD 22/2009. Pakistan Meteorological Department, Islamabad.
- Farooqi, A.B.; A.H. Khan and H. Mir.(2005). Climate Change Perspective in Pakistan. Pak. Jour. Meteor. 2 (3): 11-21.
- Zhao, D. and Y. R. Li. (2015). Climate and sugarcane production: Potential impact and mitigation strategies (2015). Int. Jour. Agro. ID 547386. [Http: dx.doi.org./10.1155/2015](http://dx.doi.org/10.1155/2015)
- Moorthy, A; W. Buermann and D. Rajagopal (2012). The impact of climate change on crop yields in India, from 1961 to 2010. (PDF) from Ucla.edu.
- P. O. Berthal; M.T. Khan; D.S. Nagi and S. Agrawal (2014). Impact of climate change on major food crops in India; Implication for food security. Agri. Economics Res. Review 27 (2): 145 – 155.
- Kumar, A. and P. Sharma (2014). Climate change and sugarcane productivity in India: An econometric analysis. Jour. Soc. and Development Sciences. 5 (2): 111-122.
- Mahmood, A. (2008). Climate change and food security in Pakistan (PDF Report). Pakistan Meteorological Department, Islamabad.
- M. Ahmad, M. Iqbal and M. A. Khan (2013). Climate Change Brief- Climate Change, Agriculture and Food Security in Pakistan: Adaptation Options and Strategies. Pakistan Institute Development Economics, Islamabad. IDRC/CRDI Report.