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Research Paper

EFFECTS OF CLIMATE CHANGE ON COTTON AND OPTIONS TO MITIGATE AND ADAPTION

AGRICULTURE

KEYWORDS: Atmospheric CO_2, boll, climate, cotton, temperature, yield.

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ABSTRACT

Climate change is effect on cotton production as a result of higher concentrations of CO2 and increases in temperature. Cotton has certain resilience to high temperatures and drought due to its vertical taproot. The crop is however sensitive to water availability, particularly at the height of flowering and boll formation. Rising temperatures favour plant development, unless day temperatures exceed 32°C. Increases in atmospheric CO_2 will also favour plant development. In order to produce cotton lint, 5019m^3/ton of blue and 15198m^3/ton green water were required, making Indian cotton one of the most water-intensive cotton of the country. In term increased pests, water stress, diseases, and weather extremes will pose adaptation challenges. Limited increases in temperatures could favour cotton plant growth and lengthen during the cotton growing season. It has not been established that 41.8ºC is the upper limit, particularly in India, has shown that heat stress is a big constraint to increasing yields.

Introduction

Cotton is a perennial with an indeterminate growth habit. Climate change impacts on cotton growth and development that influence yield and fibre quality will most likely be a result of the net effects of increases in CO2 concentration, reduced water availability and increased atmospheric evaporative demand as a result of lower rainfall and relative humidity and increases in temperature (Ton, 2011). Cotton is grown on every continent except Antarctica, and in over 60 countries in the world. In India and many countries, cotton is one of the primary economic bases which provide employment and income for millions of people involved in its production, processing, and marketing (Chaudhry *et al.*, 2003). All processes leading to square, blossom and boll initiation, and maturation are temperature-dependent

Impact of climatic changes on cotton

Cotton plants respond to changing environments. The response depends on the stage of development of the plant. Key stages in cotton plant development are: a) conditions at the time of planting, b) plant development in early season, c) flowering, d) boll formation and e) conditions towards the end of the season. Indian cotton production has a very high evaporative (800-1000mm). Rain comes during a short period of time (but with a large quantity) which results in low yields. Calculations were made to estimate the water footprint of cotton by Chapagain *et al.*, 2006. They also showed that in order to produced cotton lint 5019 m^{3}ton^{-1} of blue (irrigation water) and 15198 m^{3}ton^{-1} of green (rainfall) water were required, making Indian cotton one of the most water-intensive cotton in the world, using approximately 15% of the water resources of the country (ICAC.2007).

Effect of high temperatures on leaf Photosynthesis

Climate change may increase the frequency of these high temperatures. Cotton plants maintain optimum growing temperatures by opening stomata in the leaves, allowing water to pass out and evaporate, thus cooling leaves (transpiration). Excessively high temperatures (greater than 35°C) during the day can reduce photosynthesis while warm nights (above 25°C) mean that leaf temperature remains high, and respiration remains high, consuming stored assimilates. Maintenance respiration approximately doubles for every 10°C rise in temperature (Figure 1).

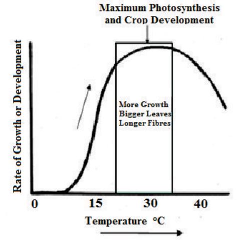

Figure 1: Effect of high temperatures on leaf Photosynthesis

Effects of climate on CO2 level

Cotton will grow more vigorously as the amount of CO2 in the air increases. Leaves will likely be larger, thereby giving plants a greater photosynthetic surface area, which subsequently facilitates growth. With more atmospheric CO2, greater numbers of branches and fruiting sites will likely develop, and this in turn, should ultimately provide for higher lint yields (ICAC, 2007). According to Reddy *et al.* (1998), at temperatures greater than 30º C most of the fruit was aborted regardless of CO2 concentration (Figure 2).

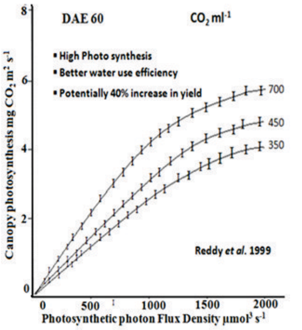

Figure 2: Effects of photosynthetic photon flux density on canopy (Source: Bange M., 2007).

Effects of high temperature on boll retention

Boll retention is more sensitive to high temperatures can produce bud shedding, which is the most common reason for loss of fruit forms, boll size and the maturation period both decreased as the temperature increased (Reddy *et al.*, 1999). It determined that boll growth decreases significantly and fruit is shed 3-5 days after blossom in temperatures over 32ºC (ICAC, 2007). Thus, the upper limit of cotton for blossom and fruit period is 32ºC (Table 1). Cotton is

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successfully grown at 28.2ºC in China and 37.6ºC in India, 36.8º C in Pakistan and 41.8ºC in Sudan. It has not been established that 41.8ºC is the upper limit, but in India, Pakistan and Syria, has shown that heat stress is a big constraint to increasing yields. These countries successfully developed heat tolerant varieties during the 1970s and 1980s (ICAC, 2007).

Table 1: Optimum climate needs for cotton crop.

Growth Stage	Average Daily Temperature Celsius*	Average Daily Temperature Fahrenheit*	Daily Crop Water Use (mm)*
Planting (Soil)	18° Minimum	65° Minimum	>0
Planting (Air)	>21°	>70°	
Vegetative Growth	21°-27°	70°-80	1-2
1st Square	-	_	2-4
Reproductive Growth	27°-32°	80°-90°	3-8
Peak Bloom	-	-	8
1st Open Boll	-	-	8-4
Maturation	21°-32°	70°-90°	4

Effect of high temperature on cotton quality

Quality is less sensitive to high temperatures than yield. In general, cotton growing in a hot climate will have a higher micronaire due to the thicker rings of cellulose that are deposited daily in the fiber. Cotton fiber needs a minimum of 40 to 50 days to mature regardless of temperature (Bange, M., 2007). As photosynthesis increases with temperature in the absence of water stress, more resources are available to mature the fibres thus increasing micronaire.

Effect of temperature on the seed cotton yield

When hot temperatures occur prior to bloom or after boll set, yield is often increased. Hot temperatures pre-bloom speed the arrival of the bloom period and occur at a time when water use is low and the root system is still expanding into fresh soil moisture. Hot temperatures after boll set hasten the maturation and opening of the crop. High night temperatures are detrimental to young boll set and boll size regardless of the moisture status, because the plant does not cool itself at night. Minimum night temperatures in the 80's decrease yield due to the high respiration and reduced supply of carbohydrates, resulting in the same "adjustment of boll load".

Effect of temperature on the agronomy of cotton

Cotton needs favourable growing conditions with respect to temperature, sunshine and soil moisture. Cotton requires a total of 105 to 125 days of sufficient soil moisture to grow. In tropical regions, 2 to 4 mm of water are needed daily at the beginning and the end of the growing period, while at the height of flowering 5 to 7 mm are required daily according to climatic zone (Figure 3). If a flower bud, flower or boll is shed, the cotton plant quickly tries to compensate that loss through the production of more flower buds or even retaining buds that would otherwise have been shed (Chaudhry and Guitchounts, 2003).

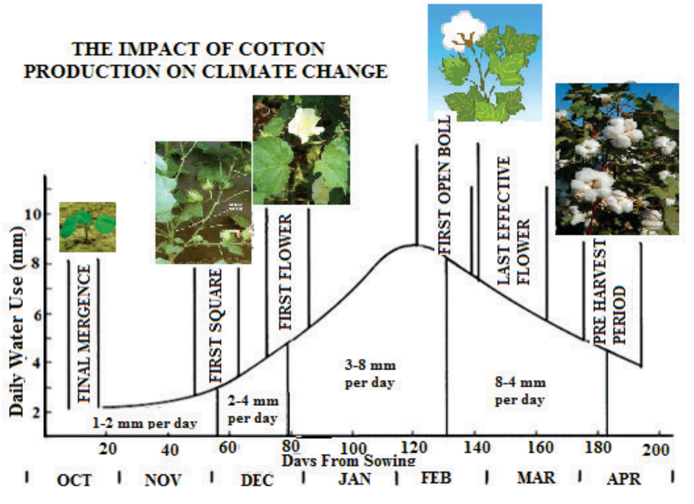

Figure 3. Different growth stages for cotton and their demand for water. (Source Freeland *et al*, 2007).

Effect of temperature on attack of insect pest and diseases

Insects are a recognized threat to cotton production throughout the world. Wu et al. (2007) reported that (Bt) cotton shows less Bt toxin after exposure to elevated CO2, which might affect plant-bollworm interactions. Karl *et al.* (2009) state that higher temperatures that reduce the effectiveness of certain classes of pesticides (pyrethroids and spinosad). Higher CO2 levels will increase the severity of diseases, induce fungal growth and spore formation, and will destroy more plant tissue.

Effect of temperature on water availability

Plants need adequate water to grow and to maintain their temperature within an optimal range. The amount and timing of water availability during the growing season, through precipitation or irrigation, are critical for cotton. If water supply variability increases, it will affect plant growth and cause reduced yields (Karl *et al.*, 2009). However, yields for irrigated cotton are much higher (3,000–4,000 kg of seed cotton/ha) than in rain-fed cotton (1,000–2,000 kg of seed cotton ha^{-1}). Therefore, no less than73% of all cotton fibre worldwide has actually been grown under some conditions of irrigation (full or supplementary irrigation). The water footprint is defined as the total volume of fresh water that is used to produce a unit of a good or service. Cotton's share of the global agricultural water footprint is estimated at 3%. This is proportionate to cotton's global land use footprint of 2.5%, but will of course be very pronounced in large irrigated production areas.

Overall impact of climate changes in India

India is the second largest producer of cotton worldwide. Cotton is grown in India in three distinct zones: Central, South and North. Temperatures are expected to increase all over India. Rainfall intensity during monsoons may become an increasing problem. Higher temperatures in already hot areas may hinder cotton development and fruit formation. Rain-fed cotton production may suffer from higher climate variability leading to periods of drought or flooding. Irrigated cotton, particularly in northern India, may suffer from lower water availability due to the upstream reduction of snow and ice from Himalayan and Tibetan Plateau glaciers and snow fields (UNFCCC, 2008).

OPTIONS TO ADAPTATION AGAINST CLIMATE CHANGE

As climate change alters the economics of production, rural cotton farming communities will have to formulate different adaptation strategies. The following options can be distinguished to adapt to climate change:

1) Stop any unnecessary loss of nutrients for the farming system, preventing soil erosion and abandoning the burning of cotton crop residues where still applied.

2) Favour a cropland design that has plant diversity and that favours soil fertility management, e.g., through the inclusion of cover crops or perennials.

3) Adjust sowing dates to offset moisture stress during the warm period, to prevent pest out breaks and to make best use of the length of the growing season.

4) Minimize the period that land lays bare, in order to slow down loss of organic matter and soil humidity and soil erosion in general.

5) Minimize soil tillage in order to prevent loss of soil organic matter – a natural source of soil fertility and storing water for plant uptake.

6) Breed cotton varieties that are more resistant to heat stress, drought spells, weeds, pests and diseases, etc.

7) Optimize the use of sustainable, natural fertilizing sources in cotton production, including nitrogen-fixing bacteria, crop rotations, compost and composted manure.

8) Optimize the efficiency of additional fertilizer use where required, because of its costs and carbon fuel footprint. Synthetic fertilizer use is particularly high in irrigation.

9) Optimize the water use efficiency in the production of irrigated cotton, because of the irrigation water's costs and carbon fuel footprint.

10) Optimize the use of pesticides, herbicides and defoliants because of their costs and carbon fuel footprint.

References

1. Bange, M. (2007).Effects of climate changes on cotton growth and development. In:The Australian Cotton Grower, pp:41-45. |2. Chaudhry, M. Rafiq and Andrei Guitchounts, (2003).Cotton Facts, International Cotton Advisory Committee, Technical Paper No.25 of the Common Fund for Commodities. The UN, New York. |3. Chapagain, K.A. Hoekstra, Y.A. Savenije, G.H. and Gautam, R., (2006).The water footprint of cotton consumption: An assessment of the impact of worldwide consumption of cotton producing countries. Economics, 60:186-203. |4. Freeland, B.T., Pettigrew, B., Thaxton, P. and Andrews, L.G.(2007).Chapter 13A:Agro-meteorology and cotton production. Draft 3rd Edition of Gamp, Guide to Agricultural Meteorological Practices (WMO No.134). | 5. ICAC (2007).Global warming and cotton production –Part 1. In:ICAC Recorder, 25(4):12-16. International Cotton Advisory Committee. |6. Karl, T.R., Melillo, J.M. and Peterson, T.C. (2009).Global climate change impacts in the United States. Cambridge Uni. Press,USA. |7. Reddy, K.R., Hodges, H.F. and. McKinion, J.M (1998).Photosynthesis and environmental factors. In: Proc. Beltwide Cotton Conf., San Diego, California, Vol.2. Memphis, Natl. Cotton Counc. Am. |8. Reddy, K.R., Davidonis, G.H., Johnson, A.S. and Vinyard, B.T. (1999).Temperature regime and CO2 enrichment alter cotton boll development and fiber properties. Agron. J., 91:851–858. |9.Ton, P. (2011). Cotton and Climate Change. Impacts and options to mitigate and adapt. International Trade Centre (ITC) UNCTAD/ WTO, Switzerland. |10. UNFCCC (2008).Climate change: Impacts, vulnerabilities and adaptation in developing countries. UN Framework Convention on Climate Change. |11. Wu G., Chen, F.J., Ge, F. and Sun, Y.C. (2007).Effects of elevated carbon dioxide on thegrowth and foliar chemistry of transgenic Bt cotton. In: Journal of Integrative Plant Biology 49(9):1361-1369.

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