K B Hebbar

Mitigating climatic changes for sustainable coconut production

Coconut plantation during the last 3-4 years is facing the severe threat of climate change in Karnataka, Tamil Nadu, Kerala and Andhra Pradesh, the major coconut-growing states. Lakhs of coconut trees withered during summer seasons of 2013 and 2014 in south interior Karnataka due to scanty rainfall. Almost similar fatality happened in some districts of Tamil Nadu. During summer of 2016, vast tracts of coconut withered in northern Kerala due to extended drought. Though some trees recover with the arrival of monsoon but the production will be affected at least for 3 years. On the other hand in the east coast of Andhra Pradesh and Orissa, a large number of trees were uprooted due to cyclones. In 2015, all along the west coast, plants had scorching of leaves due to salt spray effect. On the top of all this, temperature has been increasing and rainfall decreasing significantly since 1980s in tune with the global warming especially across the high ranges, followed by the low lands where coconut is predominantly grown. Therefore sustainable production approaches are required for adapting to new climates.

GLOBAL climate change models predict daily mean temperature to increase by 1.0-3.7°C by end of the 21st century with increase in variability in rainfall and increased frequency of extreme weather events like heat waves, cold waves, drought and floods. Climate has always been in a state of flux, but the current rate of change is much faster, and the range of weather variables much broader than ever seen before in modern agriculture. Climate change has far reaching implications for coconut production, quality and approaches are required for adapting to new climates. Action must be taken now to adapt in a timely manner and prevent unpredictable and undesirable outcomes. New crop varieties, cropping systems, and agricultural management strategies are needed to provide options to farmers to counterweight these changes.

CLIMATE CHANGE IMPACT

In open top chamber (OTC) experiments, it was observed that coconut seedling growth was promoted with [ECO_2] while, elevated temperature [ET] 3°C above ambient reduced the growth. 700 ppm [ECO_2] increased plant height, leaf area and biomass production of coconut seedlings by 18%, 16% and 15%, respectively as compared to ambient 380 ppm. The higher root

Drought affected coconut garden

Response of coconut seedling to (a) 550 ppm CO_2 and (b) 700 ppm CO_2

biomass accumulation indicated better CO_2 sequestration with [ECO_2]. Higher growth was due to both increased leaf area and photosynthesis. On the other hand, ET significantly reduced both photosynthesis and leaf area and thus the plant growth.

In open top chamber (OTC) experiments, it was further observed that the stimulatory effect of CO_2 under drought was less and it could increase the biomass by only 8% at 700 ppm CO_2. However, both under normal and water limited condition there was reduced stomatal conductance and transpiration with elevated CO_2. Thus, water requirement to produce unit biomass in ECO_2 treatment is less. This indicated that, at the present level of moisture available, coconut would produce more biomass under future climate. However, with the projected reduction in precipitation under future climate, the biomass production and nut production may be reduced unless corrective measures are taken. Similar to the above ground biomass, below ground biomass i.e, root biomass too increased with elevated CO_2. Thus, it is expected that there will be higher carbon sequestration under future climate which is an important option to mitigate the climate change effect.

High temperature on the other hand can have both negative and positive impacts on growth and production in coconut. The negative impacts such as added heat stress, especially in areas at low to mid-latitudes already at risk today such as south interior Karnataka and Tamil Nadu, but they also may lead to positive impacts in currently cold-limited high-latitude regions of Asom and West Bengal. High temperature increases both photorespiration and the dark respiration and thus the total biomass production go down. Pollen of crops, since they have to stay viable in the field after anthesis until pollination, is exposed to temperature and humidity fluctuations in the atmosphere for a longer period. Also, the pollen development and anthesis stages have been found to be highly sensitive to temperature changes. This leads to shedding of buttons during dry periods.

Crop growth simulation models indicated that crop yields including cropped area are likely to decline in the ensuing decades under the projected global warming and climate change scenario. Climate change adaptation strategies and awareness are particularly important for managing the risks posed by climate-variability and change, not only on plantation crops but also across all the society linked sectors that are sensitive to weather and climate. Various agroclimatic techniques have been used to effectively manage some of the risks posed by climate change to plantation crop productivity.

Identified Germplasm/Variety

Coconut yield drops when it experiences drought, excessive heat, deviating from the optimum for growth during key stages, including pollination, flowering, and nut development periods. Drought and heat are the important abiotic stresses affecting coconut yield. WUE has been shown to vary among varieties of talls and dwarfs and also among ecotypes of the same variety. WUE in coconut is regulated by either efficient water uptake by root systems or controlled water loss through better regulation of stomatal movement. Tall genotypes Kalpadhenu and FMST had high WUE due to better root system. On the other hand under water deficit stress dwarf maintained higher WUE due to better stomatal regulation. Stress tolerant plants in addition to possessing higher photosynthesis, accumulated more epicuticular waxes on the leaves for better conservation of moisture.

In coconut, wide genotypic variability was found for *in-vitro* pollen germination at different temperatures. Tall variety like WCT, FMST, hybrid MYD×WCT and to certain extent the dwarf variety COD showed reasonably high pollen germination at 40°C while it was negligible in other dwarf variety like CGD, CRD and MYD. The existing genetic variability can be made use of to select or breed genotypes suitable for warmer areas or where there is the threat of high temperature event to happen under climate change.

DEVELOPING VARIETIES

Integration of Traits

At CPCRI, Kasaragod, germplasm lines are collected from different agro-climatic zones and maintained and evaluated at International gene bank at Kidu Karnataka and used to develop cultivars adapted to climate change.

Response of coconut seedling to high temperature; *(a)* control, *(b)* ambient + 3°C, *(c)* 550 ppm CO_2 + ambient + 3°C

There are all together 434 germplasm accessions and they have been evaluated for different biotic and abiotic stress characters. The tolerant traits are incorporated to get climate resilient varieties. Some of the drought tolerant varieties developed at CPCRI are Chandra Kalpa, Kalpatharu, Kera Keralam, Kalpa Mitra, Kalpa Dhenu, Kera Sankara and Chandra Laksha.

Devised Cropping/ Farming Systems

In coastal areas, where the rainfall is very high and the soil is poor in nutrients, the soil is sandy or laterite which has very low water holding capacity. Studies conducted at CPCRI and elsewhere indicated that coconut based farming system approach is the best adaptation strategy to overcome the effect of climate change. Appropriate, site specific cropping system management practices have been developed which help alleviate the effects of abiotic and biotic stresses on crop productivity and yield.

Cultural Practices

Intensifying yields sustainably on existing arable land uses land more efficiently with better soil management. Soil management techniques like mulching of basin with coir dust @50 kg/palm, burial of husks in 3 or 4 layers, application of green manures or organic manures (FYM) @ 50 to 100 kg/palm, spreading dried coconut leaves and other organic residues (mulching effect), addition of tank silt @ 100 to 200 kg/palm and organic agriculture to increase soil's water retention capacity are some of the ways to improve the productivity from unit land and reduce the climate change effect. Similarly, soil conservation measures viz. terracing the palm basins in sloppy lands to interrupt run off of water and to enhance soil moisture, rain water harvesting, *in situ* (land configuration, mulching etc.) and *ex situ* (Ponds, micro water harvesting structure -jalkund etc), bunding the field to prevent runoff of water. These measures would help in rainfed orchards.

With climate change, water supplies are expected to become threatened in certain regions of coconut cultivation, but water management strategies, such as drip irrigation, can conserve water and protect from water shortages. To achieve "more crop per drop", water management techniques like pitcher irrigation (bury two or three

Coconut Tree

Coconut is a tree which has no branches and grows straight vertically upwards providing more space under its canopy. Its leaves are such that it allows sun light to the crops grown under it. Between two coconut trees, fruit trees such as lime, lemon, guava, pomegranate, custard apple, cocoa, nutmeg, clove crops are planted at 15-20 ft distance. These are medium sized crops both in height as well as canopy and can easily fit in between two adjacent coconut trees. They can be planted simultaneously or after the coconuts are established. It takes 8-10 years for coconut trees to start yielding properly. Whereas a number of the above mentioned crops start yielding well within 3-5 years and last only 15-20 years. By that time the coconut will be in its peak yield stage and will be about 20 ft high. The intercrops may be replaced by any other crop including vegetables and grasses and another cycle of medium sized intercrops can be established. Coconut farming systems have dramatic powers to stabilize eroding farmland, especially sloping lands. Practices like using nitrogen fixing perennials, ploughing, and intensive livestock rotation have fantastic soil building abilities. Plantings of useful trees can protect coastlines from damage caused by increased storm activity.

earthen pots/hollow bamboos and fill them with water to moisten subsoil), drip irrigation (two or three drippers per palm to wet subsoil layer) or if adequate water is available irrigate with 200 litres water/palm once in four days and mulching the basin with dry leaves facilitate the retention of soil moisture and achieve the "more crop per drop".

Coconut: An Excellent Tree Crop

Plantation crops has significant potential for offsetting and reducing the projected increases in greenhouse gas (GHG) emissions and regarded as an important option for greenhouse gases mitigation. Above ground biomass in coconut varied from 15 CERs to 35 CERs depending on cultivar, agroclimatic zone, soil type and management. Annually sequestered carbon stocked in the stem in the range of 0.3 to 2.3 CERs. Standing C stocks in 16 year old coconut cultivars in different agro-climatic zones varied from 15 CERs to 60 CERs. Annual C sequestration by coconut plantation is higher in red sandy loam soils and lowest in littoral sandy soils. Simulation results indicated that the carbon sequestered and stored in stem in coconut plantation in four states viz. Kerala, Karnataka, Tamil Nadu, and Andhra Pradesh is to the tune of 0.732 million tonnes of carbon every year. These values can dramatically go up if all other aspects of carbon sequestration are taken into consideration.

Checking Erosion, Wind Speed and Salt Spray

Probably coconut is the only crop next to mangroves that grows well in coastal areas. It is the best suited crop for climate change situations as it can withstand temporary water logging conditions like floods and tides with special adaptability against strong winds, storms and cyclones. It has a fibrous root system spread over few meters which not only takes up water and nutrients and anchors the plant but also helps in checking the erosion in high rainfall areas. Coconut orchards also act as strong wind breaks and reduce storms and cyclones.

Salt spray is another phenomenon, generally occurs during the commencement of monsoon in west coast. Commencement of monsoon starts with gusty winds which brings tiny droplets of salt to the sea shore and adjoining areas and deposit on the plants. If there is no or low rainfall, it cause high salt injury and it may be fatal. Coconut is moderately tolerant to salt spray and hence it mitigates the salt spray effect on other sensitive crops in the sea shore.

SUMMARY

The existing scientific knowledge can address to adapt cropping systems to climate change in the short-term. However, uncertainties and limited predictability in long-term require an infrastructure that drives innovation and implements crop adaptation strategies in a sustainable manner. In particular, develop region-specific farming models that integrate genetic and management technology.The farm-level weather insurance may be another tool which should be seriously examined for the benefit of the farmers in the event of crop losses due to weather extremes.

For further interaction, please write to:
Dr K B Hebbar (Scientist), Central Plantation Crops Research Institute, Kasaragod, Kerala 672 104.