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Climate Change: Plantation Crops and Spices of Kerala

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CHALLENGES AND OPPORTUNITIES OF PLANTATION CROPS RESPONSE TO CLIMATE CHANGE: COCONUT PERSPECTIVE

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Agricultural production in most parts of the world will face less predictable weather conditions than mankind experienced during the last century. Weather extremes will become predominant. Coastal and hilly areas are believed to be more vulnerable to climate change compared to other terrestrial areas. Here in these tracts in addition to the projected high temperature and drought there is a serious threat of flooding and sea level rise which may affect the livelihood of millions of people. Plantation crops are the predominant cropping systems in coastal and hilly tracts. Unlike in seasonal crops the impact of weather aberrations will be having long standing ill effects as the crops are perennial in nature as a result the regions economy will be adversely affected.

Plantation crops mainly coconut, rubber, tea, coffee, oil palm, arecanut, cashew, cocoa are grown in ecologically sensitive areas such as coastal belts, hilly areas and areas with high rainfall and high humidity. Amongst these, coconut is the major crop grown in almost 2 m ha while others are grown in 0.5 m ha or less areas. Coconut is grown between 20° N and 20° S latitude. It can be grown even at 26° N latitude but the temperature is the main limitation. It requires an optimum temperature of 27+°C for its growth and development. It has a high water requirement from 40 to 120 liters per day depending on the growth stage. Hence, it is mostly grown in high rainfall areas of 150 to 250 cm. Since, it is humid tropical crop it grows well above 60% humidity with plenty of sunlight (120 hours/month). Any environmental aberration will affect the coconut production and the livelihood of millions of coconut growing families of the country.

Climate change will affect coconut plantation through higher temperatures, elevated CO_2 concentration, precipitation changes, increased weeds, pests, and disease pressure, and increased vulnerability of organic carbon pools. In general various approaches are used to mitigate risks associated with seasonal climate variability, such as shifting planting dates, changing crop varieties, and cultural practices. However, to adapt to the threats of climate change a perennial crop like coconut has certain challenges and at the same time it has few opportunities to face the risk of climate change and support the livelihood of millions of people. In this paper the challenges and opportunities of coconut response to climate change are discussed.

CHALLENGES

Drought

More than 60% of coconut cultivation is rainfed and over 50 to 60% yield loss is due to drought stress. Extensive work has been carried out at CPCRI to characterize the drought prone areas, to assess the impact and identify the critical stages. Coconut drought is characterized in different agro-climatic zones *viz.*, Western ghats high rainfall zone (Kidu-Karnataka), Western coastal area - hot sub-humid-per-humid (Kasaragod - Kerala; Ratnagiri - Maharastra), hot semi arid (Arisikere - Karnataka) and Eastern coastal plains- hot sub-humid (Veppankulum- Tamil Nadu; Ambajipeta- Andhra Pradesh). Weather data based characterization of drought and its intensity indicated variations in length and number of dry spells in each zone. Apart from this they also differed for rainfall, temperature regimes and light intensities, thus bringing about the different intensities of drought.

Drought affects coconut and the impact can be seen from the year of drought till four years. Since the inflorescence primordial initiation to nut maturity takes 44 months, any coincidence of drought with critical sensitive phases adversely affects the yields For the recovery also coconut takes at least three to four years. The impact of drought on nut yield can be seen in the following years with the maximum effect occurring about 13 months after the end of the drought. The effect of drought on nut yield was greatest between the eighth and twelfth month after the drought. The coconut palm experiences moisture stress when exposed to irradiation above 265 Wm^{-2}, temperature of 33°C and vapour pressure deficit of 26 m bar, aggravated by soil water deficit during the period. Annual rainfall and its distribution has greater influence on the nut production in coconut.

Over the years it was observed that dry spells are in increasing trends in Karnataka and Kerala whereas reducing trends in coastal AP and coastal MS. Coconut productivity increased over past 50 years except recent declining trends in maidan Karnataka and Coimbatore district (TN) due to consecutive droughts. Consecutive droughts in Coimbatore district (TN) reduced the coconut production by about 3 lakh nuts/year for 4 years; Productivity loss was to the tune of about 3500 nuts/ha/year; Loss due to 1996 cyclone in Konaseema (AP) was to the tune of 2200 lakh nuts/year in 6 years; Productivity was reduced by 6200 nuts/ha/year in E. Godavari district and by ~4100 nuts/ha/year in AP.

Temperature

High temperatures can lead to negative impacts such as added heat stress, especially in areas at low to mid-latitudes already at risk today, but they also may lead to positive impacts in currently cold-limited high-latitude regions. Warming trends are already noticed in most parts of the coconut growing areas of Karnataka, Kerala and Tamil Nadu. A mean annual temperature of 27°C with diurnal variation not exceeding 7°C is considered optimum for the coconut palms. The ideal mean annual temperature for coconut growing is usually considered to be in the region of 29°C (27 - 32°C), with abundant sunshine and a well-distributed annual rainfall. High temperature increases both photorespiration and the dark respiration and thus the total biomass production go down. Regression analysis indicated increase in T-min increased the leaf emergence rate: increase in T-max increased inflorescence emergence rate; pistillate flower production has curvilinear relationship with rainfall/month (150mm/month-opt), nut retention has curvilinear relationship with T-max (32°C-opt) and Tmin (20°C-opt). Frequent but short periods of temperature below 15°C result in abnormalities of fruit such as bicarpelate nuts and lack of pollination under North Indian conditions.

Elevated atmospheric CO_2 concentrations

In open top chamber (OTC) experiments it was observed that coconut seedling growth and biomass accumulation increases at 700 and 550 ppm CO_2 as against ambient CO_2 concentration of 380 ppm. C3 plants like coconut it may increase plant growth and yield and may improve plant water use efficiency. However, a number of factors such as pests, soil and water quality, adequate water supply, and crop-weed competition may severely limit the realization of any potential benefits.

Quality of coconut in relation to Climate change scenarios

Variation in MCFAs (medium chain fatty acids) in coconut oil grown at different agro-climatic zones was found maximum in nuts harvested during Jan, Oct and Jul and least in those harvested in April. Increase in storage temperature from 22°C to 45°C reduced oil percentage while it increased starch, carbohydrates and reducing sugars in copra. The reproductive development of coconut is more sensitive to climate change than vegetative processes. It would be advantageous for plants to exhibit greater reproductive survivability under moderately high temperatures and water stress conditions normally encountered during plant reproduction and processes leading to fruit set.

Weeds, pests and diseases

Weeds, pests and diseases under climate change have the potential to severely limit crop production. Whereas quantitative knowledge is lacking compared to other controllable climate and management variables, some anecdotal data show the proliferation of weed and pest species in response to recent warming trends of annual crops.

Vulnerability of organic carbon pools

Organic carbon pools have important repercussions for land sustainability and climate mitigation. Since, plantation crops are mainly grown in high rainfall areas the soil is highly eroded and poor in organic matter content. In addition to plant species responses to elevated CO_2, future changes in carbon stocks and net fluxes will critically depend on management practices such as Nitrogen (N) fertilization, irrigation, and tillage, in addition to plant species responses to elevated CO_2.

Difficulty in adopting the new technologies

To meet the projected demand of 22 billion nuts in 2025 from the present supply of around 15 billion nuts, need adaptation measures that are most likely to be effective in stabilizing yields grown under drought, flood and high temperature conditions in future climates. Some of the low cost adaptation measures evolved for annual crops like change in date of planting, adoption of biotic and abiotic stress tolerant varieties etc are difficult to adopt in perennial crops like coconut. Since it has long life span old varieties can not be replaced with the evolution of new tolerant varieties or hybrids.

OPPORTUNITIES

Simulation studies

A simulation model Infocrop-coconut was developed to simulate the growth and production of coconut under future climatic conditions. Simulation analysis indicates that under all storylines, coconut productivity is projected to go up by up to 10% during 2020, up to 16% in 2050 and up to 36% in 2080 over current yields only due to climate change. However, in east coast yield is projected to decline by about 2% in 2020, 8% in 2050 and 31% in 2080 scenario over current yields due to climate change. Yields are projected to go up in Kerala, Tamil Nadu, Karnataka, Maharastra while they are projected to decline in Andhra Pradesh, Orissa and Gujarat.

In order to validate the simulated results, an open top chamber facility was built at CPCRI, Kasaragod wherein the seedling growth of coconut, cocoa and arecanut was estimated under elevated CO_2 concentration and temperature.

Open top chamber (OTC) facility to validate model simulated data

In order to validate the model simulated data an open top chamber facility is created at CPCRI, Kasaragod. Coconut, arecanut and cocoa seedlings were exposed to elevated CO_2 and temperature and their effect was studied on growth, physiology and biochemical parameters of plant. It was observed that under elevated CO_2 coconut seedlings produced greater biomass and collar girth as a result of higher root dry mass, specific leaf area, chlorophyll a/b ratio. On the other hand with high temperature the specific leaf weight was low. Biochemical paprameters like starch, reducing sugar and amino acid content was high with elevated CO_2 while under high temperature plants had higher phenolic content.

Drought tolerant cultivars are identified

The physiological and biochemical parameters for screening coconut to drought tolerance have been standardized. The physiological parameters and their critical levels are stomatal resistance (9 s cm^{-1}), transpiration rate (2.5 ug cm^{-2} s^{-1}), leaf water potential (-1.2 MPa) and relative water content. The biochemical parameters used are lipid peroxidation, superoxide dismutase, peroxidase, catalase, polyphenol oxidase, acid phosphotase and nitrate reductase. Based on the above screening parameters the drought tolerant cultivars identified are west coast tall (WCT), Lacadive Ordinary (LO), Andaman ordinary (AO), WCT x COD and LO x GB.

Cultural practices, soil conservation and water management techniques are evolved to mange the drought

Apart from the identification of drought tolerant cultivars, the following soil, water and crop management techniques are perfected to manage the drought.

Soil management

- Mulching with coir dust, 50kg/palm
- Burial of husks in 3 or 4 layers
- Application of green manures and organic manures (FYM), 50 to 100 kg/palm
- Spreading dried coconut leaves and other organic residues (mulching effect)
- Addition of tank silt at 100 to 200 kg/palm (improves organic matter and water holding capacity)
- Spreading of 2 kg NaCl around the palm basin
- Organic agriculture to increase soil's water retention capacity

Soil conservation

- In sloppy lands, terracing the palm basins may be undertaken (interrupts run off water and enhances soil moisture)
- Rain water harvesting: *insitu (land configuration,* mulching etc.) and *ex situ (Ponds, micro water* harvesting structure *- jalkund etc).*
- Prepare bunds dividing the field into plots to prevent runoff of water. These measures would help in rainfed palms

Water management

- Bury two or three earthen pots/hollow bamboos and fill them with water (subsoil moistening)
- Drip irrigation: two or three drippers may have placed per palm – drippers to wet subsoil layer
- If adequate water is available, irrigate with 200 liters water/palm once in four days. Mulch with dry leaves
- Avoid flooding the basins. If water resources are good, save for future irrigation
- Effective recycling of waste water from back yards

Higher yield realization with the adoption of scientific technologies

Simulation analysis indicated that negative impacts of climate change can be overcome by adaptation strategies such as assured irrigation through drip system coupled with soil moisture conservation and by providing fertilizers/nutrients through organic and inorganic source in doses higher than those currently applied by the farmers. Such measures also maximize the positive impacts of climate change. Farmers who adopted soil moisture conservation practices or drip irrigation could reduce the drought impact on their plantations. In drought affected coconut gardens, farmers could grow short duration pulses, oil seeds and millets for their sustenance.

In Kerala, providing more fertilizers along with summer time irrigation coupled with soil moisture conservation could further improve the positive gains due to climate change by 7 to 21% in different scenarios. In Karnataka, West Bengal, Gujarat, Maharashtra and Orissa assured irrigation and providing more fertilizers could not only off-set the negative impacts but can result in higher yields.

In North-Eastern States, providing summer irrigation and even low dose of fertilizers can further improve (in the range of 10-33%) the positive impacts of climate change. Coconut plantations in islands, if managed scientifically by proper spacing, canopy management, summer irrigation and even with low dose of fertilizers, positive impacts of climate change can be improved by 2-25%.

Coconut is an excellent tree crop for climate change mitigation

- *Carbon sequestration and carbon stocks in coconut:*

Plantation crops has significant potential for offsetting and reducing the projected increases in green house 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 to 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 Kerala, Karnataka, Tamilnadu, and Andhra Pradesh is to the tune of 0.732 million tones of carbon every year. These values can dramatically go up if all other aspects of carbon sequestration are taken into consideration.

- *Coconut can check erosion and wind speed*

Probably coconut is the only crop next to mangroves grows well in coastal areas. It is the best suited crop for climate change situations as it can withstand temporary waterlogging 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.

However, adapting to future climate change might require farmers to use management practices and technologies that are beyond those existing today. Research must play proactive role to generate necessary responses and technologies that farmers will need to handle such future challenges.