Impact of climate change on plantation crops

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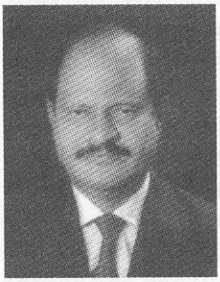

Climate change has emerged as a major challenge influencing agricultural production in the country. In recent times the pace of climate change has accelerated as a direct result of industrialization, deforestation, population growth, and various other anthropogenic activities. Climate change can also lead to increase in global temperature which will cause extreme weather events such as change in the amount and pattern of precipitation, glacier retreat leading to rise in sea level, changes in agricultural yields etc. resulting in major economic losses on one side and poverty on the other. As per IPCC reports, atmospheric concentration of CO_2 will further rise leading to increased temperatures. Unless corrective measures are taken, climate change is likely to become more rapid and have an adverse and extreme impact on life on earth. Thus it is important to study the adaptation capacity of plants which are scavengers of atmospheric CO_2 so as to choose suitable crops or cultivars which can thrive under such conditions.

Intensive agriculture and excessive use of external inputs have lead to the degradation and depletion of natural resources like soil, water and plant which in turn adversely affect the agricultural production and profitability. It is a known fact that crops and trees are natural carbon sinks and conservation agricultural practices help in carbon sequestration. The New Delhi declaration on conservation agriculture during February 2009 stressed the conservation of natural resources based on the three principles: minimum mechanical disturbance to the soil, permanent organic cover on the soil surface and a diversified sequence or association of crops.

Climate change and plantation crops

Plantation crops, being perennial in nature, have to face the impact of climate change even during a single generation or in a standing crop. Hence it is important that the impact of climate change is understood well. Plantation crops mainly coconut, rubber, tea, coffee, cashew, oil palm *etc.* are grown in ecologically sensitive areas such as coastal belts, hilly areas and areas with high rainfall and high humidity. All these crops are of high economic value contributing substantially to the agricultural exports at global and national levels. These are grown in large areas in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, West Bengal and Assam. The plantations provide sustenance to the millions of people. Weather variables such as rainfall, evapo-transpiration, temperature, solar radiation, sunshine hours, relative humidity and wind velocity influence the yield potential of these crops.

Impact of climate variables on coconut, arecanut and cocoa

Coconut palms, as rainfed crops, are exposed to drought of different intensities and durations in various parts of the

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country. Characterization of drought in different agro-climatic Zones in India viz; Western ghats high rainfall zone (Kidu-Karnataka), Western coastal area - hot sub-humid-per-humid (Kasaragod - Kerala; Ratnagiri - Maharashtra), hot semi arid (Arisikere - Karnataka) and Eastern coastal plains- hot sub-humid (Veppankulum- Tamil Nadu; Ambajipeta- Andhra Pradesh) indicated variations in length and number of dry spells in each zone bringing about the different intensities of drought. In view of long duration of 44 months between the initiation of inflorescence primordium and ultimate nut yield, with about 70% period of pre-fertilization and only 30% by fertilization/ post-fertilization phases, any fluctuations in dry spell occurring during important stages of floral/fruit development would reflect on nut yield and the impact can be seen from the year of drought till four years. 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.

The arecanut is grown under irrigated conditions and generally more than 50% of variation in yield is due to climatic differences. It is grown under different agro-climatic conditions. The most important climatic factors that influence the growth and development are altitude, relative humidity and rainfall. But extremes of temperature and wide diurnal variations are not conducive for healthy growth. A 12 year data of weather variables indicated that the yield is influenced by relative humidity, evaporation and rainfall.

Though cocoa is grown under wide climatic conditions, its yield potential is higher in arid tropics where the climate shows relatively little variation throughout the year, especially in terms of temperature, solar radiation and day length. In India it flourishes mainly under shade. The yield was significantly correlated with the number of rainy days in the previous year and, sunshine hours and maximum and minimum temperatures of the current year. Relative humidity, temperature, sunshine hours, rainfall and rainy days showed maximum correlation with yield during the five months lag period, coinciding with flowering period. Most of the cocoa growing areas lie below 300 m. However, cocoa can be grown successfully up to a height of 1100-1200 m provided the temperature is congenial during flower production. Cocoa can be grown within 20° of the equator. However, over *75%* of the world's cocoa lies within 8° of the equator.

Climate change studies in coconut

Studies conducted at CPCRI on impact of climate change on coconut indicated general warming trends in most of the coconut growing areas. Coconut productivity increased over past 50 years except recent declining trends in plains of Karnataka and Coimbatore district of Tamil Nadu due to consecutive droughts. In Coimbatore district the coconut productivity was reduced to the tune of about 3500 nuts/ha/year for 4 years. Loss due to 1996 cyclone in Andhra Pradesh was to the tune of 6200 nuts/ha/year in East Godavari district and by ~4100 nuts/ha/year in West Godavari district for 6 years. Impact assessment and climate change future projections in different scenarios indicated that plains of Karnataka, Eastern TN, coastal Andhra Pradesh, Pondicherry, West Bengal and Assam in decreasing order are found to be hot spots as per different HadCM3 model scenarios.

For the first time a coconut simulation model was developed. Using coconut simulation model, yields were simulated for 13 agro-climatic zones represented by 16 centres. These areas contribute over 90% to the coconut production. Simulations for yield projections were done for HadCM3 climate change storylines viz., A2a, B2a and A1F for 2020, 2050 and 2080 scenarios. Analysis based on coconut simulation model studies indicate that coconut productivity is projected to go up to 10% during 2020, 16% in 2050 and 36% in 2080 over current yields only due to climate change in west coast of India. However, in east coast yields are projected to decline by about 2% in 2020, 8% in 2050 and 31% in 2080. Spatial variations exist for these projections. Yields are projected to go up in Kerala, Tamil Nadu (if irrigation is continued to be provided), Karnataka, and Maharashtra while they are likely to decline in A P, Orissa, parts of Karnataka, T N and Gujarat. However, situations may vary if future irrigation sources are limited particularly in irrigated areas as in Tamil Nadu and Karnataka.

Response of elevated CO_2 and temperature on coconut, arecanut and cocoa

Effect of elevated CO_2 and temperature on coconut, arecanut and cocoa studied in open top chambers indicated that seedlings grown under elevated CO_2 had higher root dry matter, specific leaf area, chlorophyll a/b ratio, collar girth, shoot height, shoot dry matter and leaf area. Seedlings exposed to elevated temperature had high shoot height, root length, collar girth and root dry matter and volume as compared to the chamber control. The shoot and root dry matter in cocoa and arecanut seedlings was more in those exposed to elevated CO_2 over control chamber.

In coconut elevated CO_2 and temperature caused significant reduction in leaf stomatal density. However the reduction in stomatal density did not influence the net photosynthetic rate, indicating significant adaptation strategy by coconut to changing climate. Further, biochemical parameters indicated that the elevated CO_2 caused increased accumulation of proline in leaf tissue in spite of maintenance of high leaf water potentials. On the other hand, elevated temperature caused only a slight increase in proline concentration, despite the reduced leaf water potentials. These results suggest greater role for proline in coconut adaptation to high CO_2 concentrations. Observations on epicuticular wax, proline and scavenging enzymes such as super oxide dismutase, poly phenol oxidase, peroxidase and catalase clearly showed the response of coconut cultivars to different treatments.

Carbon sequestration and carbon stocks

The carbon sequestration in coconut above ground biomass varied from 15 to 35 CO_2/ha/year depending on cultivar, agro-climatic zone, soil type and management. Sequestered carbon stocked in to stem was in the range of 0.3 to 2.3 CO_2/ha/year. Standing C stocks in 16 year old coconut cultivars in different agro-climatic zones varied from 15 to 60 CO_2/ha/year. Annual carbon sequestration by coconut mono-plantation is higher in red sandy loam soils and lowest in littoral sandy soils. In areca - cocoa system the CO_2 sequestration ranged from 5.14 to 10.94 Mg/ha/year in arecanut sole plantations while in cocoa it ranged from 1.38 to 2.66 Mg/ ha/year. Hence, coconut, arecanut and cocoa can be strong candidates for carbon sequestration under Clean Development Mechanism.

Socio-economic analysis on impact of drought in Coconut growing area

It has been observed that more than two lakh palms died and about six lakh palms were severely/partially affected due to drought in Coimbatore and

Tumkur districts. Farmers who adopted soil moisture conservation practices or drip irrigation could reduce the drought impact and improve coconut yields. Hence soil moisture conservation is the only adaptive strategy to reduce the climate change impact on plantation crops.

Simulation models in plantation crops

Even though simulation model in perennial crop like cocoa has been reported, the model is not yet validated for Indian conditions and suitability for climate change studies. In coconut, simulation model has been developed based on the generic crop model InfoCrop that simulates various annual crops in tropical and subtropical regions. The InfoCrop-coconut model was calibrated and validated with data compiled from published studies comprising many physiological, agronomical and nutritional experiments conducted between 1978 and 2005 in diverse geographic locations throughout India. The treatments included various water and nutrient regimes and varieties of coconut. The genetic coefficients used for calibration and validation were generated from field experiments conducted during 1995-2005. Simulated trends in phenological development, total dry mass and its partitioning, and nut yield agreed closely with observed values. The model adequately simulated the effects of various factors like management practices, soil and nutritional factors on coconut growth, dry matter, partitioning and nut yields.

Carbon sequestration and high density multi species cropping system (HDMSCS)

Productivity of land can be increased by adopting high density cropping system. The principle of multistoried cropping is to use the basic production inputs such as light, water and nutrients to the maximum extent with minimum soil deterioration. This is attained by growing suitable crops having different canopy patterns and root systems. A variety of crops are grown in the interspaces of coconut and arecanut ranging from short season annuals to perennial tree species. Biomass production of various crops in a cropping system gives a rough indication of their compatibility. The beneficial changes in rhizosphere of the main crop and intercrops not only improve the soil micronutrients, but also result in increasing yields considerably besides helping in carbon sequestration. Utilization of land, airspace and inputs with maximum sustainable returns are the advantages of HDMSCS.

Conclusions and future thrust

Efforts are being made to understand the impact of climate change in all the plantation crops. No valid models are available for the exhaustive studies and hence studies are required to develop simulation models suitable for climate change studies. Plantation crops offer to be good candidates for carbon sequestration and carbon trade. Recent report of the Panel meeting of the plantation crop workers held at CPCRI, Kasaragod, on "Carbon sequestration in plantation crops and trading under Clean Development Mechanism" clearly showed that all the plantation crops with an estimated area of 4.764 m. ha in India, with cumulative CO_2 sequestration potential of 146.05 M. tonnes can reduce emissions effectively. However, currently under CDM, plantation crops are not included for carbon trade. Keeping future possibilities on inclusion of plantations for carbon trade, studies on carbon sequestration potential of plantation crops need to be intensified.