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Research Paper

Climate Change And Its Impact On Orchid Productivity

Science

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ABSTRACT

Orchids are the most complex, advanced and successful family of flowers on the planet. Epiphytic orchids usually grow on tree trunks or branches and survive through nutrients from decaying organic matter that accumulates around the root zone and on their leaves and are usually distributed in tropical areas. Terrestrial orchids are originated from temperate regions and can tolerate adverse climatic conditions. Climate change due to global warming interacts with habitat loss and fragmentation, introduced and invasive species and population growths and many ecosystems are likely to undergo severe modification. In Asia, climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development. Semi-arid vegetation will tend to be replaced by arid vegetation. Levels of precipitation are likely to change radically in many areas of the world. Increasing temperature may result in vegetational zones gradually moving vertically up mountain sides, both permitting tropical species to subtropical areas, subtropical species to temperate areas and eliminating the species in the highest zones. Epiphytic orchids may be affected in various ways by changes in the availability of light, nutrients and moisture. Climate change is major threat to pollination services and there is a need to conserve plant communities in which orchids live. The combination of higher temperatures and lower rainfall may make forests more susceptible to fire and it may lead to extinction of local species. Majority of orchid species are capable of tolerating dry storage for many decades when stored at -20oC. Liquid nitrogen storage may produce further extensions of life spans of orchid seeds. Living collections are recently underutilized as a conservation tool and there is a need to do more to induce members of the wider orchid community.

Introduction

The global population is expected to rise by about 9 billion in 2050. Food, shelter, energy, employment, health care etc. have to depend upon the bio-resources of the Planet Earth. This un-certainty is due to climate change, agriculture pattern, urbanization etc. which are closely linked with biodiversity, economy and the welfare of the humanity. In 2050, 1.6 billion people of our country should have adequate, nutritious, safe and healthy food and adequate fibre within the available natural resources.

Major challenges that we have come across are

- Climate change due to rise in temperature, erratic precipitation and sea level rise
- Greenhouse gas emission
- Fragmented ecosystems
- Loss in biodiversity
- Trade and competitiveness

Before the early 1800's, the atmosphere contains about 290 ppm CO_2, in 1995 it was 360 ppm and according to World Organization CO_2 reached 379 ppm in 2006 . It is estimated that CO_2 will increase to 800 ppm by the end of this century and bring serious consequences to plants. 1°C increase in temperature may reduce yields of major food crops by 3-7%.. It is predicted that greater losses will occur at prolonged higher temperatures. A projected loss of 10-40% is expected in crop production by 2100.

Impact of Climate Change (Mitchell and Tanner, 2006)

Agriculture

- Shifts in food growing areas
- Changes in crop yields
- Increased irrigation demands
- Increased crop pests and diseases in warmer areas

Water resources

- Changes in water supply
- Decrease in water quality
- Increased drought
- Increased flooding

Forests

- Changes in forest compositions and locations
- Disappearance of some forests
- Increased fires from drying of forest trees and grasses
- Loss of wild habitat and species

Biodiversity

- Extinction of some animal and plant species
- Loss of habitats
- Disruption of aquatic life

Weather Extremes

- Prolonged heat waves and droughts
- Increased flooding
- More intense hurricanes, typhoons, tornadoes and violent storms

Sea Levels and Coastal Areas

- Rising sea levels
- Flooding of low lying islands and coastal cities
- Flooding of coastal estuaries, wetlands and coral reefs
- Beach erosion
- Disruption of coastal fisheries
- Contamination of coastal aquifers with salt water

Human Population

- Increased deaths
- More environmental refugees
- Increased migration

Human Health

- Increased deaths from heat and epidemic diseases
- Disruption of food and water supplies
- Spread of tropical diseases to temperate areas
- Increased water pollution from coastal flooding

Actions

Community-centred development projects can be incorporated for adaptation to climate change through the following activities:

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- Monitor species and the amount of vegetation to assess the impacts of climate change. Asking community members to report on invasive species and changes in growing patterns has been shown to effectively promote climate change awareness.
- Seasonal climate change projections can be reviewed during workshops with farmers, and decisions can be taken on responses.
- Keep an updated climate change scenario on file and refer to this at each stage to make sure activities are not increasing vulnerability to climate change. The scenarios can also be used as an advocacy tool.
- Participatory appraisal techniques can be used to assess the impacts of climate variability and change in livelihoods and production. Simple cost/benefit analysis of different adaptation options can also be included.
- Fire management techniques and training need to be considered.
- Early warning systems are especially relevant for agriculture. Regional and local seasonal predictions are currently in use and being developed using weather forecasting tools.
- Developmental Agencies need to raise awareness among partners and make their programmes more resilient to climate change impacts.
- Development NGOs will need to plan their adaptation activities carefully to ensure consistent poverty reduction policies, plans and program. This may require strategic assessment of the role of adaptation in their program, as well as supporting mainstreaming in developing countries.
- They can link climate change to other related areas such as disaster risk management and sustainable development.
- Vulnerable groups must work on climate change adaptation from the starting point of current variability. Integrating the impacts of future changes into vulnerability reduction remains a significant challenge at policy and strategic levels, as well as in communities and households.
- To develop GHG Inventory Management System (GHG-IMS) through Black Carbon Research Initiative-National Carbonaceous Aerosols Programme (BCRI-NCAP), Long-term Ecological Research Observatory (LTERO) for climate change, Co-ordinated studies (CS) in the North-Eastern Region on Climate Change (NECC) (CS-NECC) and Climate Change Assessment Studies (CCAS).
- In order to ensure sustainable management of biodiversity vis-a-vis climate change, adaptation is the key aspect in terms of chalking out a future strategy like to identify and conserve biodiversity components that are especially sensitive to climate change; preserve intact habitats so as to facilitate the long-term adaptation of biodiversity; improve our understanding of the climate change – biodiversity linkages, and fully integrate biodiversity considerations into climate change mitigation and adaptation plans.
- India needs to undertake the following at various scales (global, regional, national and local) with increased intensity to promote sustainable management, conservation and enhancement of sinks and reservoir; take climate change consideration into account to minimizing adverse effects on the economy and on the quality of environment promote and cooperate scientific research, education training and public awareness, exchange scientific information.

Challenges

Biodiversity and Conservation

Nearly 12.5 % of the global vascular flora facing extinction and therefore, conservation of rare and threatened plants are of international importance. Two third of orchid species are epiphytes and lithophytes, with terrestrial species comprising the remaining third almost half of the extinct species as per IUCN, 1999. In India, 250 species are under the threat of various categories

- Conservation of biota in fragmented landscapes, protecting and increasing the habitat, improving habitat quality, increasing connectivity, managing disturbance processes in the wider landscape, planning for the long term, and learning from conservation actions undertaken.
- To maintain the tropical biodiversity, there is no substitute for primary forests, there is a need to increase the forest area under protected area network.
- The value and importance of indigenous peoples' and local communities' customary sustainable use and traditional knowledge in conserving and upholding biodiversity, land- and seascapes, and protected areas should be acknowledged. Incentives may be needed to entice people to participate in conservation and recovery programs.
- Implementation of community-based projects on biodiversity conservation provides opportunities to actively engage and involve local and indigenous people.
- There is an urgent need to develop Biodiversity Profile of India so that we have adequate knowledge on existing species, ecosystem and genetic resources and threats to them in order to monitor and report on biodiversity (e.g., extinction rates, biodiversity loss). The main causes for a lack of knowledge on biodiversity loss include limited number of scientific experts, national indicators, research, finance and available technology and lack of biodiversity specific educational program.
- More biosphere reserves, sanctuaries and germplasm banks need to be established.
- Promoting education and awareness about plant diversity conservation and sustainable utilization and biodiversity conservation at the local level to be encouraged.
- An integrated orchid conservation approach including conservation genetics, mycorrhizal associations, pollinators interactions, *in- situ* conservations (Biosphere Reserves, National Parks, Sacred Grooves, Gene Sanctuary and Individual Trees) and *ex situ* conservations (Field Gene Banks, Botanical Garden, Herbal Garden, *In- vitro*-conservation, Cryopreservation and DNA Bank) will be taken up.

Genetic Improvement

- Genera and species wise cataloguing of all germplasm collection using IPGRI descriptors.
- The rich diversity of orchids in the country requires a strong concepted Network Approach mode. The NRC for Orchids have to work on a network mode and also to work as an National Active Germplasm site with the various active centres working on specific group of orchids. In view of the IPR regulations, it is the paramount importance to protect our germplasm using modern tools of bar coding. A network project involving groups with identical interest between universities and ICAR. These germplasm should be conserved with the duplicate sets grown in at least two locations, properly catalogued and characterized with national number obtained from NBPGR avoiding duplication. Cryopreservation to conserve germplasm can be taken up in collaboration with NBPGR.
- At present, orchid trade is solely based on the hybrids derived from varietals, interspecies and inter-generic crosses. Building up a strong crop improvement programme based on sound breeding methodologies that will yield into development of hybrids/varieties of internationally acceptable quality traits. It is essential to develop own hybrids suitable for varied agroclimate for our country fulfilling the basic requirements of market demands.
- Evaluation of newly evolved genotypes to suit specific agro-ecological conditions
- Locating sources of resistance for biotic an abiotic stresses using conventional and biotechnological tools and developing varieties with high yield, quality and specific traits.

Frontier Science Technologies

- It is essential to use the available hybrids and segregating populations to develop Association mapping. Hence the facilities available at IIHR and NRCO may be used to develop genome assistant or marker assistant selections.
- The lead obtained in GIS with the help of facilities of ISSR for *Cymbidium* to cover other species which aid in location specific as well as species specific survey effective.
- Characterization of rhizosphere microbial community structure and effect of engineered nanoparticles on microorganisms in the rhizosphere and phyllosphere.
- Commercialization of orchids through bioreactors covering micropropagation technology to industry in network mode.

Management of Natural Resources

- Cost effective agro-climatic management through optimization of a number of factors like light, temperature, humidity, water, air, growing media and nutrition for quality flower production. The standardization of growing media using cheap and indigenous materials such as leaf ferns, leaf moulds, green moss etc. may be explored and this must be used in consonance with cropping system to develop an orchid based farming systems.

- Development and popularization of cost effective agricultural practices (INM/IPM) for increasing productivity.

- Quantification of water use efficiency and water requirements in orchids based on growth habit.

- Carbon sequestration potential in orchid based cropping systems.

Post harvest and Value Addition

- Development of location specific complete protocols starting from pre-harvest, harvesting, post-harvest techniques upto domestic and international markets for each genera of commercial orchids.
- Developing a comprehensive approach on value added products from wild orchids including species trade, drying, flower arrangements, herbal medicines, edible products and other aesthetic and aromatic products.
- Bio-prospecting using bioinformatics tools

Bio-risk Management

- Surveillance, identification and characterization of new invasive insects pests and pathogens
- Pest-risk analysis
- Development of rapid and reliable diagnostics kits against pests and pathogens including invasive species
- Management alert and control of new invasive insect pests and pathogens

Policies

- Commercialization of the new upgraded technologies
- Genetic finger printing of rare, endangered and threatened species and their registration
- Finger printing and registration of newly released varieties or hybrids
- Patenting technologies related to orchids
- Confirmation and Documentation of ITK's

Transfer of Technology

- Constraint analysis and impact assessment of new technologies
- Production of quality planting materials , distribution and commercialization
- Large scale demonstration of proven technologies through training and FLD's
- Establishing agro-technology information centre like ITMU, AKMU
- Participatory planting material production of commercial orchids

Impact Assessment

Climate change due to global warming interacts with habitat loss and fragmentation, introduced and invasive species and population growths and many ecosystems are likely to undergo severe modification. In Asia, climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development. Semi-arid vegetation will tend to be replaced by arid vegetation. Levels of precipitation are likely to change radically in many areas of the world. Increasing temperature may result in vegetational zones gradually moving vertically up mountain sides, both permitting tropical species to subtropical areas, subtropical species to temperate areas and eliminating the species in the highest zones (Liu *et al*, 2010).

Epiphytic orchids may be affected in various ways by changes in the availability of light, nutrients and moisture. Climate change is major threat to pollination services and there is a need to conserve plant communities in which orchids live. The combination of higher temperatures and lower rainfall may make forests more susceptible to fire and it may lead to extinction of local species. During 1984, World Orchid Conference held in Miami, it was proposed that the orchid community should start banking orchid seed as an insurance against possible losses of species from their habitats in the wild. Majority of orchid species are capable of tolerating dry storage for many decades when stored at -20°C. Liquid nitrogen storage may produce further extensions of life spans of orchid seeds. Living collections are recently underutilized as a conservation tool and there is a need to do more to induce members of the wider orchid community (De, *et al*, 2012).

A number of strategies can be followed up for conservation, multiplication, production, improvement and protection of valuable orchid species and varieties (Table.1)

Table.1

Strategies for conservation, multiplication, production, improvement and protection of orchids (De, et al, 2013)

Goal	Approach	Performance Measure
Conservation of genetic resources	Integrated orchid conservation approach including GIS survey and remote sensing	· Conservation genetics with molecular methods and phylogenetic studies · Epiphytic (70%) and terrestrial (20%) mycorrhizal associations with analysis of DNA sequences · All Pollinators interactions with population genetics and phylogenetic analysis of orchids and pollinators · In-situ conservations (Biosphere Reserves, National Parks, Sacred Grooves, Gene Sanctuary and Individual Trees) of all available species) · Ex- situ conservations (Field gene banks, Botanical garden, Herbal Garden, In vitro-conservation, Cryopreservation and DNA conservation) of more than 100 species

Evaluation, valuation and improvement of genetic resources effectively to meet the challenges of biotic and biotic stresses to sustain the impact of climate change in addition to quality	Character specific collection of exotic and indigenous germplasm, locating resistance source and evolving high yielding and disease resistant lines through selection, mutation, inter-generic and inter-specific crosses, polyploidy breeding and biotechnological tools for orchid improvement	· Specific collection of 850 indigenous germplasm from NEH region, 288 species of North Western Himalayas, 379 species of Peninsular India and 115 species of Andaman and Nicobar Islands. Exotic germplasm from Thailand, Britain, Singapore, Australia, Hawaii, New Zealand will be attempted to enrich basic genetic materials. · Genera and species wise cataloguing of all 1350 germplasm of India collections using IPGRI descriptors. · Identification of genes contributing resistance to biotic and abiotic stress factors and quality characteristics of major 10 commercial orchid genera. · Improvement of Cymbidium to develop hybrids or varieties with less pre-blooming period and resistance to viruses. · Varietal evaluation of newly developed genotypes of commercial orchid genera to suit specific agro-ecological conditions. · Development of highly adaptive and tolerant genotypes to mitigate climate change and water stress · Genetic engineering and transformation for early flowering and extending shelf-life in commercial orchids · Development of Bar codes for germplasm identification at species level.
Increasing productivity of orchids through quality planting materials production and protected cultivation	Targeting the production levels by propagating and distributing quality planting materials of improved hybrids for effective spread	· Production of nucleus planting materials through mass multiplication using standardized protocols of commercial orchids at least one lakh per anuum. · Standardization of protocols for mass multiplication of endangered, rare and threatened orchid species · Participatory quality planting material production of commercial orchids in collaboration with line departments · Developing technologies suitable for protected cultivation of disease free planting materials
Developing efficient system for management of climatic factors and nutrients to get maximum production and developing an effective model	Generation of eco-region specific technologies based on maximum productivity of available natural resources	· Cost effective nutrient and agro-climatic management through optimization for quality flower production · Development and popularization of cost effective agricultural practices (INM/IPM) of 10 commercial orchid genera for increasing productivity · Quantification of water use efficiency and water requirements in orchids · Carbon sequestration potential in orchid based cropping systems · Development of at least two to five profitable orchid based cropping systems with other high value flower crops. · Reducing pre-blooming period of Cymbidium orchids from five to two years using effective management practices for higher income.
Management of biotic stress to reduce production losses by developing diagnostics, forecasting models, bio-control systems and effective management strategies	Identification of new and effective bio-molecules for management of biotic stresses coupled with development of innovative diagnostic techniques for rapid, accurate and cost effective detection of high impact pests and diseases.	· Surveillance, identification and characterization of new invasive pests and pathogens, pest risk analysis · Characterization of rhizosphere microbial community structure and effect of engineered nanoparticles on microorganisms in the rhizosphere and non-rhizosphere · Development of rapid and reliable diagnostics against pests and pathogens including invasive species · Management of new invasive insect pests and pathogens
Post-harvest and value addition	Development of post-harvest technologies to improve product quality and value addition , chemo profiling and identification of new flavour / bioactive principles.	· Development of pre-harvest, harvest and post-harvest technologies of major commercially grown orchids for specific target groups like domestic and export market and hybrid/variety specific technologies. · Development of packaging for marketing of commercially important fresh and dried produce using locally available materials. · Development of orchid based technologies for dry flowers and floral arrangement. · Use of orchid waste for production of phytochemicals including pigments, food, feed, herbal medicines and essential oils. · Patenting technologies related to species

Effective TOT to the target groups	Participatory approach for effective transfer of technologies to empower stakeholders, analyzing feed-back for further refinement	· Identification of various clusters of production, selection of beneficiaries and impart training and technical inputs in order to produce orchids of international standards · Large scale demonstration of proven technologies through FLD's and technology dissemination using advanced tools · Upgradation of Knowledge, Know How techniques, Managerial Skills and Self employment among extension functionaries, farmers, school drop outs, young man and women generations by organizing Kisan Mela, exhibition, Brainstorming session, need based and focused Training Programme, Demonstration, Model training Courses etc. · Inter –institutional collaboration to facilitate popularization of effective technologies · Commercialization of technologies and patenting · Documentation of ITK's

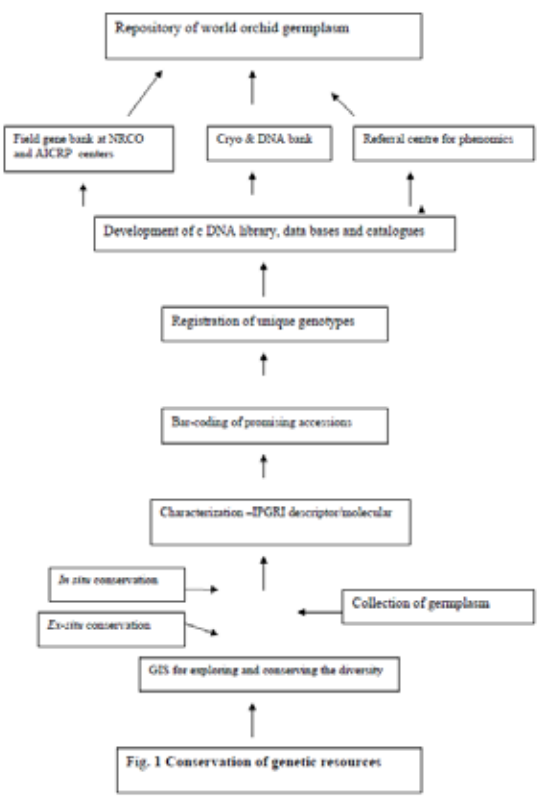

Fig. 1 Conservation of genetic resources

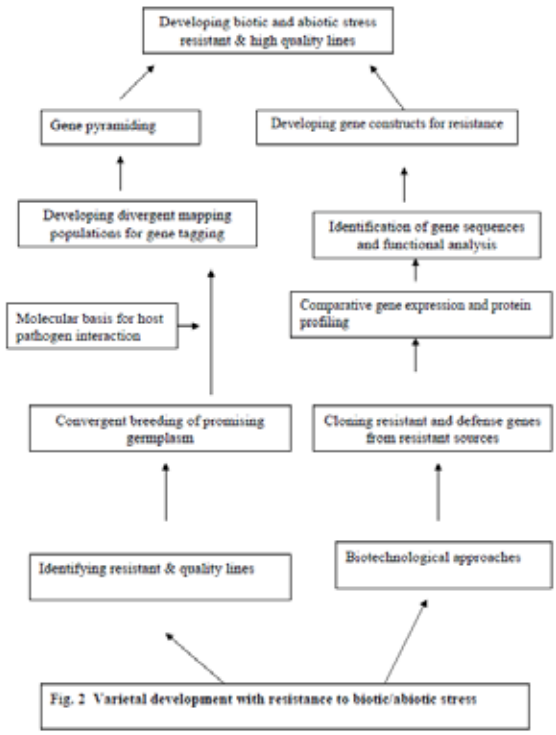

Fig. 2 Varietal development with resistance to biotic/abiotic stress

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