Section 6. Agricultural sciences

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MANAGEMENT OF FIELD AND HORTICULTURAL CROPS UNDER CHANGING CLIMATIC SCENARIO

Abstract. Low productivity in food grains, vegetable and fruit crops worldwide is the major cause of climate change. Increasing temperatures limits the water availability, flooding and salinity hamper the sustainable horticultural production. Changing climatic scenario leads to the crop failure, reduced production, poor quality produce and more incidences in pests and diseases makes food grain, vegetable and fruit production makes unprofitable. Droughts and soil salinity are major factors makes temperature worsening in horticultural production. Therefore, need arises to use appropriate climate resilient technologies and approaches to ward off various new insect pests, diseases and hitherto

unheard stresses and increase the productivity to feed the global population without compromising on the quality of the produce. A holistic climate resilient technologies consisting of mulching with crop residue management which helps in soil moisture conservation. Proper drainage due to heavy rains can be avoided by adoption of raised beds in vegetable crops. New genotypes tolerant to high temperature, droughts, salinity and conventional and non-conventional breeding techniques are essentially required to meet these challenges.

Keywords: Climate change, Climate resilient technologies, Field crops, Horticultural crops, Adaptation.

Introduction

Ensuring food security to Indian population in changing climatic scenario is the major concern and challenge to scientific community. At present crop simulation models are used to study the impact of climate change on agricultural production and food security. Simulation models help farmers to take appropriate decisions in farm management practices and alternative options to choose a particular farming system. Due to technological advances in India, the use of computer based simulation models by farmers, agri-professionals and policy makers is expected to increase and it is also witnessed in the past decade some work has been done on simulation models to understand the nature and change in production of various crops due to climate change. The current article focused on the impact of climate change on various field and horticultural crops and ways to mitigate these challenges through climate resilient technologies to boost higher food grain and horticultural production. Climate change is hampering agricultural growth and it was reported by Intergovernmental Panel on Climate Change (IPCC) that climate change is affecting the crop production in many regions of the world and the negative effects are more prominent in developing countries. Climate change has led to increase in carbon dioxide (CO_2) in atmosphere. Present day the concentration of carbon dioxide in earth's atmosphere is around 412 ppm and which has seen 47 percent increase from pre-industrial era. It is expected double by the end of this century (IPCC [5]).

Apart from the effect on the carbon dioxide, climate change has effect on multitude of factors

leading to erratic rainfall, higher average temperatures and water stress might which in turn have major implications for crop production in the tropical regions. Climate change is expected to increase the extreme weather conditions like increase in heat waves, cyclones which adversely affect agricultural activities leading to substantial reduction in agriculture production. It was reported by many researchers in India, that there is increased trend in surface temperature during the last century (Hingane et al., [8]; Srivastava et al., [20]; Rupa Kumar et al., [12]; De and Mukhopadhyay, [6]; Pant et al., [12]; Singh and Sontakke, 2002; Singh et al., [17]). Climate change is the alarming situation for agricultural production and food systems. Therefore, it is a time to support the farming community with technological approaches to transform the agricultural systems to support global food security to reduce poverty. (Sonja et al. [21]). To bring out the changes at global level, all the stakeholders at all levels need to work to mitigate the food security and climate change challenges. Farmers need to face the climate change challenges by intelligently adapting climate smart technologies for sustainable crop yields. Several advanced technologies and approaches have been developed by the scientific fraternity to increase agricultural production under varying climatic conditions and these should be adopted to obtain optimum production in changing climatic scenario. Efficient use of existing resources, use-and-re-use, safeguard of environment, societal safeguard, sustainability and long term development goals have the prime importance under these conditions. Participatory approach and on-site

demonstrations coupled with location specific technologies help farmers accept the present situations of climatic changes. The horticultural production systems suffer due to climate change affecting various issues like price fluctuations in fruits and vegetable crops. Also the declining fruit and vegetable production due to short growing period, will hamper the growth and development due to terminal heat stress and less availability of water. Variability in rainfall and less number of rainy days affects the rain-fed agriculture (Venkateswarlu and Shanker [22]). Climate-smart horticulture interventions which are highly location specific and knowledge based need to be employed to face the competitiveness in sustainable manner for improving horticultural production in the challenged environment (Malhotra and Srivastava [11], Malhotra [13]).

In India, there are two major crop growing seasons as far as climate is concern. The '*kharif*' crop growing season starts with June and goes up to September coincides with south-west monsoon. In *kharif* season crops like rice, maize, sugarcane, cotton, jute, groundnut, soybean and Bajra are grown based on the crop duration and harvested during the autumn (October–November) or winter (December–February) months. The southwest monsoon plays important role in *kharif* production which accounts for more than 50% (food-grain) and 65% of the oilseeds production in India. Monsoon rainfall variability affects large-scale droughts and floods in India, hampers food grain production (Parthasarathy and Pant [16]; Parthasarathy et al., 1992; Selvaraju, 2003; Kumar et al., [4]) in India and also on the economy (Gadgil et al., 1999 a; Kumar and Parikh [18]). After the summer monsoon, winter or '*rabi*' crop-growing season starts and continues up to early summer. Rainfall at the end of monsoon provides stored soil moisture and also helps for irrigation water for *rabi* crops. Therefore, summer monsoon is very important for both *kharif* and *rabi* seasons in India. Significant work on climate resilient practices in food-grain and horticultural crops

is done by Indian Council of Agricultural Research (ICAR) under National Innovations on Climate Resilient Agriculture (NICRA) network project which was started in the year 2011. The other organizations such as Consultative Group on International Agricultural Research (CGIAR) also started a program on Climate Change, Agriculture and Food Security (CCAFS) organization promoting adaptable resilient technologies in several countries including India. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has developed several climate-smart technologies. In spite, of having climate change challenges India stands second in vegetable and fruit production after China in the world and supports 17 per cent of the population with a land share of 2.4 per cent. Still we are facing the problem of food security. According to the UN report Right to Food, around 1 billion people sleep without food, and children suffer from malnutrition. Considering these facts, this chapter focuses on production challenges in food-grain, vegetables and fruits and ways to mitigate them with the adaptation appropriate climate resilient technologies.

1. Climate resilient technologies for Food grains

The adaptation strategies to overcome the adverse climate impacts includes the breeding of new varieties tolerant various kind of stresses such as moisture and heat, change in cultural practices of various crops, efficient water use practices, technologies of conservation agriculture, improved IPM practices, crop based insurance and use of traditional knowledge in practice among the farming community. There are several climate resilient technologies scientifically proved and tested by the National Innovations in Climate Resilient Agriculture (NICRA) are available for the farmers for adaptation.

1.1 Climate stresses tolerant varieties

NICRA screened large number of germplasm in rice and identified Nerica L44 and N22 cultivars which are resistant to heat and other stresses. These cultivars can serve as pre-breeding genetic resources

for breeding elite varieties. The use of improved genotypes will help in mitigating intermittent drought as well to save water in irrigated rice cultivation. NICRA screened two wild cultivars of tomato namely *L. peruvianum* and *L. pimpinellifolium* which are tolerance to temperature stress. The cultivars which are under cultivations viz., Pusa Sadabahar and TH-348 and two hybrids viz., DTH-9 and DTH 10 are also found tolerance to heat stress.

1.2 Water conservation

The several steps have been taken up by for water availability, renovation of water harvesting bodies and desilting and deepening of open wells through stakeholders' participation. Other water saving technologies are network of underground irrigation lines as drip, sprinkler, popup irrigation and use of rain-gun irrigation systems. Most advanced water saving technique is laser aid land levelling and efficient use of need based irrigation. Drip irrigation system also introduced for rice cultivation which helps in reduced GHGs emission and saves water.

1.3 Farm pond-rain water harvesting technology

It is an option to harvest rainwater to be used for irrigating the standing crops during water stress or to overcome with the terminal drought and pre sowing irrigation in rainfed areas. Farm ponds are helpful to recharge old open well, bore wells and injection wells for recharging ground water are taken up for enhancing farm level water storage.

1.4 Conservation agriculture technologies

Conservation agriculture helps in efficient use of resources provides economic benefits and minimizes unsupportive climatic stresses. Conservation agriculture is one of the soil and water conservation method adopted throughout the world. Conservation agriculture is a farming system in which soil is covered with various plant species for protection of soil and avoids soil tillage which helps to cultivate various plant species for improvement of soil conditions with reduced degradation and efficient use of water and nutrients. These conservation agriculture technologies or practices include direct sowing or

no tillage or minimum tillage, incorporation of plant residues in soil, cultivation of cover crops for annual or perennial crops. According to FAO to integrate farm income and soil health through CA (Conservation Agriculture) technologies must be focused on the concept of resource-saving agricultural production which includes achieve acceptable profits, high sustained production levels and conserve the environment. The conservation agriculture practices are applicable to all crops including food grains, horticulture and plantation crops. These technologies are more popular in maize, soyabean, rice and wheat.

1.5 Zero-tillage practice

Zero tillage practice helps farmers subject to farmers have to sow wheat immediate after harvesting of rice to void the threat of terminal heat. The zero tillage practice of rice-wheat system of north-west India can also be diversified in wheat and after harvesting of wheat crop summer mungbean and direct seeded rice can be practiced to enhance the income of farmer and also helpful to reduce the Green House Gases (GHGs) emission.

1.6 Improved nutrient management practices

In case of delayed monsoon, late sowing of direct seeded rice affects the yield reduction which can be compensated by timely application of Nitrogen to get higher yields and in case of delay in transplanting of rice due to delay in south-west monsoon can be compensated by using neem oil coated urea.

1.7 Integrated farming system:

Integration crop production along with livestock, backyard poultry, agro-forestry, fish culture etc., helps farmers to raise their income and livelihood.

2. Climate resilient technologies for horticultural crops (Vegetables)

2.1 Selection of location specific crop and cultivar

Crops suitable for rain-fed cultivation of vegetables are cowpea, drumstick, brinjal, cluster bean, okra, dolichos bean, lima bean, chilli. Among them vegetable crops, legume vegetables are most suitable for contingency crop-planning in the event of delay in monsoon. Selection of cultivars with good root

system and ability to recoup during the stress and short duration.

2.2 Production of seedlings using improved method

Use of Protray grown seedling using cocopeat instead of using soil under shadenet cover. Bio-fertilizer or bio-pesticides can be used for uniform disease free seedlings at nursery. These seedlings will establish quickly and has less damaged root system during transplanting and sustain better during biotic and abiotic stresses specially in water stress.

2.3 Crop residues to enhance soil organic matter

Incorporation of plant residues in soil and application of farm yard manure helps to improve the status of soil organic matter, soil structure, water holding capacity of constant efforts must be made to improve the soil organic carbon. Incorporation of crop residues and farmyard manure to soil improves the organic matter status, improves soil structure and soil moisture storage capacity. Organic matter in soil can be improved by opting alley cropping system, incorporation of green manure crops in the soil, crop rotation and agroforestry. For cultivation of vegetable crops proper organic matter needs to be maintained in the soil for faster growth of vegetable crops as the crops as short duration.

2.4 Foliar application micro nutrients

Timely application during water stress and drought of K and Ca is helpful for better growth and enhancement of yield in vegetables crops is essential. Due to foliar application the nutrients will be quickly absorb in plants which helps in overall development of the crop.

2.5 Water Resource Conservation

2.5.1 Micro irrigation

Drip irrigation system in vegetables is better than the traditional irrigation method for better quality of produce and also saves water around 30–50 per cent based on the crop season also helps to irrigate more area with the available water. Drip irrigation also helps in efficient use of fertilizers, weed control and saves manpower. The efficient use of water can be

achieved by using drip irrigation as the water drops will drop in the root zone area only. Drip irrigation have its own advantages such as faster growth and development of plants with higher yields in fruit crops. Drip irrigation easily adopted in chilli, brinjal, cauliflower and okra with paired row planting which is in practice by using one drip lateral in two crop rows. A considerable saving in water, increased growth, development and yields of fruits and vegetables and control of weeds, saving in labour under drip irrigation are the added advantages. Drip irrigation can be adopted in fruit crops and also to all vegetable crops including closed spaced crops like onions and beans. The saving in water is to the tune of 30–50% depending on the crop and season. Generally inline drip laterals having emitting point spaced at 30 cm distance and emitting at the rate of 2 LPH is selected for vegetable crops. In crops like chilli, brinjal, cauliflower and okra paired row planting is practiced and one drip lateral is used for two crop rows.

2.5.2 Sprinkler irrigation system

The cost of laying of micro sprinkler irrigation system is less than the drip irrigation system, this method can be used in almost all fruit and vegetable crops depending on the availability of water and soil structure. It helps in summer to reduce the micro climate temperature and increases humidity which helps to vigorous growth to boost the higher production. By using micro sprinklers 20–30 percent water can be save.

2.5.3 Water saving method under limited water resources

Alternate furrow irrigation method is more popular. This type of method can be easily adopted even by making wide spread furrows in various crops such as capsicum, tomato, okra and cauliflower by irrigating alternate-furrows which helps to save 35–40 per cent of water.

2.5.4 Moisture conservation and soil conservation techniques

Tillage, mulching, zero tillage, contour cultivation, contour strip cropping, multi-cropping systems,

the practices for *in-situ* soil moisture conservation. The mechanical method for soil and moisture conservation are contour bench terracing, bunding, graded bunding, vertical mulching etc. to be adopted in drylands. The other practise to stop the runoff water is harvesting of rain water and recycling. The areas with rainfall around 500–800 mm are suitable for rain water harvesting. In farm ponds 10–50% of the runoff water can be collected and it will be used for life saving irrigation during water stress conditions in various crops.

2.5.5 Mulching in Vegetable Production

In this method soil is covered with plant residues or with plastic sheets which helps for water conservation and also helps to control weeds. Mulching is used in all fruit crops and vegetable crops by using crop residues as well as by using organic matter. Very recently plastic mulches are commonly used due to its advantages in efficient moisture conservation, weed control and ant to maintain soil structure. In vegetable crops a 30-micron thick polyethylene with width of 1 to 2 m is used. Raised bed system is used for laying the mulching sheets.

2.6 Wind breaks, hedges and intercropping

Tall growing trees to be planted along with the border of field to avoid the strong winds and adverse effect such as dry spell and high temperature. In orchards vegetable crops can be grown as intercrop during summer.

2.7 Protected cultivation of vegetables

Vegetable production can be taken under protected condition in peri-urban areas where climate is not favourable round the year that to in open fields. Under protective cultivation biotic and abiotic constraints will be avoided. Commonly suitable material protective structure are green houses, plastic or net house, tunnels, polyhouses etc. Simple structure as rain-shelter covered with polyethylene sheet also helps in producing crops by avoiding the excessive rainfall. The production is adversely affected in the vegetable crops *viz.*, tomato, onion and melons due to heavy rainfall and difficult to man-

age fungal foliar diseases and also difficult to manage due to improper aeration in soil, poor drainage facility and flower drop in crops. Net houses and shade nets are the better options to cope up with the heat waves of summer. It helps to reduce the high temperature and creates the microclimate and improves the humidity. By using shade net or net house the production can be enhanced in tomato, French beans and capsicum.

2.8 Management of leaf miner and mites during high temperature stress

By spraying neem soap 4 grams / liter or triazophos at the rate 1.5 ml / l of water leaf miners can be controlled and to manage mites, Abanectin 0.5 ml/l and to control Aphids may be observed in case of beans. Neem soap (1.0%) or kernel extract (4.00%) are also useful in control of leaf minor and mites.

3. Climate resilient technologies for horticultural crops (orchards)

3.1 Abiotic stress tolerance varieties

Inclusion of varieties tolerance to abiotic stress in orchards *viz.*, Pomogranate (Ruby hybrid), Annona (Arka Sahan hybrid), Fig selection (Deanna and Excel) are the drought tolerant cultivars to be included in the cropping system. Dogris (Vitis champine) also promising cultivar for crop growth, yield and also suitable for seeded and seedless grapes with drought tolerant and sustains in saline soil.

3.2 Water management in orchard

Application of water in root zone area in water is very important for proper growth to boost higher yields it helps to save water, timely irrigation and quantity of water plays an important role. Shifting from traditional method of irrigation with channels can be replaced with drip irrigation or micro spray for effective and efficient use of water.

3.3 High-density planting in orchards

In lighter soils row spacing 10 m. and line spacing 5 m. is good to accommodate more number of trees to get the higher yields and it is possible with the recent technologies of high density planting. Same thing is applicable in heavy clay soils row spacing

may be 10 m. and line spacing is 8 m. subject to selection of less vigorous varieties in case of mango.

3.4 Agri-horti-silviculture and canopy management

Cultivation of legume-based pastures and leguminous crops are beneficial for orchards to add more fertilizers or fertilizers can be avoided to cut down the cost of cultivation and helpful for the farmers to get an extra income from the same land. Managing tree canopy helps to harvest good quality fruits.

3.5 Soil organic matter

Application of organic matter in various forms in orchard such as animal manures, wood chips mulches, deep rooting ground covers, leguminous pastures helps to maintain good soil structure and drainage. Enhances water holding capacity, good root health, nutrient cycling and good organic carbon levels.

3.6 Integrated pests and disease management

Use of suitable planting methods such as crop rotation in orchard crops between rows, planting of resistant plant varieties, use of pest-free rootstock. These methods are very useful and in terms of cost

reduction and lower risk to human health as well as environment.

4. Conclusions

The ever-increasing global population has put burden on the agricultural production system. The ways to increase the productivity of these crops using various means needs to be explored as there is less scope for area expansion. Climate change has further put burden on the crops as it is expected to increase the various biotic and abiotic stresses on crops making crop production systems suffer further. We need to use appropriate climate resilient technologies and approaches to ward off various new insect pests, diseases and hitherto unheard stresses and increase the productivity to feed the global population without compromising on the quality of the produce. A holistic climate resilient technologies consisting of conventional and modern approaches including climate resilient varieties, water conservation strategies and biomolecules for the management of emerging pests needs to be employed to get the optimum yields under changing climate.

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