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Biotic and abiotic stress management in scientific cultivation of Mango (*Mangifera indica* L.) for sustainable yield and quality with environmental safety

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Abstract

The climate change scenarios predict pronounced modification of the climate in the coming decades. Climate change is therefore great concern agriculture will have to cope with in the coming century. Since a few decades, several research teams around the world carry out a huge work to model the future climatic change during the 21st century, based on several scenarios of greenhouse gas emission. We have to expect rise in average temperatures, in atmospheric CO₂ concentration, in soil salinity in some areas, and lower and more irregular rainfall. The climate variability and the frequency of extreme events have greatly affected the overall yield of mango in the country. Mango is one of the common fruit in most continents, particularly in Asia, Central and South America and Africa. Global production of mangoes is concentrated mainly in Asia and more precisely in India which produces an average of 15 million t (MT) a year. Mangoes are now growing in more than 100 countries of which more than 65 countries produce each more than 1,000 MT a year. There is wide gap between yield & profitability. It is due to poor management practices, biotic and abiotic stresses round the year particularly in flowering and fruiting period. Biotic factors like attack of red banded caterpillar, Madhua kit, powdery mildew, mango fruit fly attack. Abiotic stresses are high temperature in January, rain in November – December, high temperature followed by low temperature causes blackening of flowers, westerly wind in January month causes huge loss of flowers particularly early variety like Bombay, Jardalu, Gulabkhas. Rain in November December tends towards vegetative growth in place of flowering. Late flowering leads to delayed harvesting of fruits hits 300 crores of annual export market (The Hindu 2020). Working in Krishi Vigyan Kendra, Bhagalpur from 2009 to till date a keen observation is made on effect of climate change and indiscriminate management practices with no safeguard for environment. To combat the effect of biotic and abiotic factors study and observation revealed balance dose of fertilizer, proper management of insect and pest, suitable intercrop and use of wind break can be able to mitigate the problems. Farmers are able to harvest good quality of crops and fetch higher prices in the market.

Keywords: biotic and abiotic stress, environmental safety, cultivation of mango

Introduction

Mango is the most important crop grown all over the world. Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae. It is considered to be the most important commercially grown fruit crop in our country. Mango is often referred to as the king of fruits. India has the richest collection of mango cultivars. The mangoes that are grown in India consist of three major categories- early, mid and late mangoes. India ranks first with 18779000 tonnes production shares 40.46% of total production ^[1] (FAO 2016 N.J Thakor IMC-2018 Special Ad). India is the largest producer of in the world ^[5] (Trends in Middle East climate extreme indices from 1950 to 2003). As we compare the productivity from the developed countries India lies far behind. Study revealed that there is wide GAP between yield obtained and potential yield that is 1 to 1.5 quintal per plant. Mango is grown in 19637000 hectares ^[2] (AGRICULTURE - Statistical Year Book India 2017, Ministry of Agriculture, and Government of India.). Major growing states are Uttar Pradesh, Kerala, Tamil Nadu, Karnataka, Orissa and Bihar. The total area under mango cultivation is increasing day by day, as we can see that it was 2163 thousand hectare in year 2014-15, in 2015-16 2209 thousand

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hectares, which increased to 2263 thousand hectares by 2016-17. In respect of area it is not sizeable but its production is also quite sizable. Same as the production of mango in the year 2014-15 was 18527 Metric tonnes, in year 2015-16 it was 18643 Metric tonnes which leads to 19687 metric tonnes in year 2016-17^[2] (AGRICULTURE - Statistical Year Book India 2017, Ministry of Agriculture, Government of India). State wise contribution is Uttar Pradesh (23.72%), Andhra Pradesh (18.13%), Telangana (9.61%), Karnataka (9.46%), Bihar (7.28%), Gujarat (6.09%), Maharashtra (4.74%), Tamil Nadu (4.36%)^[16] (Anonymous, 2016). The working experience in Krishi Vigyan Kendra Sabour, Bhagalpur - 813210 from 2009 to till date area will increase remarkably under the orchard. This is due to easy maintenance and handsome return to the growers. Mango is grown from very ancient time. The Unripe mangos are used to prepare pickles, chutney, drinks, candies etc. Unripe mango are also cooked and made into a juice which is used against heatstroke. Ripe mangos are used to prepare juice, shake, candies and other preserves. So, cultivation of mango for quality yield with safe environmental effect is necessity of the day. Climatic change is basic reality of cultivation. It causes a sudden high and low temperature, unexpected rain, westerly winds, increase CO₂ concentration and lots of invisible change. This climatic changes adversely affecting the growth and productivity of mango plants. These climatic changes regulate the behaviour of biotic and abiotic factors that ultimately influence the production and quality of mango. Working in Krishi Vigyaan Kendra Sabour, Institute that deals with farmers, face the problems the farmers go through and deals how to mitigate with these problems in general. How we can increase the yield and quality, study the methods to make it profitable. Though, Krishi Vigyan Kendra is very small unit but it works in a wide array.

Present Scenario

The climatic changes are real. In the last ten years, this has turned into an observed reality. The major cause of this is because of the increase in the anthropogenic greenhouse gas concentration in our surroundings. Not only this, but industrialization has also led to an exponential increase in global climatic issues like soil erosion, global warming and overall deterioration in the quality of air. Industries that include chores like animal husbandry and factories have led to major concerning issues like over-grazing, deforestation and overall waste generation of an area. This doesn't stop here as can expect a rise in average temperatures, the overall atmospheric CO₂ concentration, the in soil salinity in a lot of areas and lower and more irregular rainfall. Not only this, many natural calamities are expected to rise too. Climate change is therefore a great concern for agriculture. Mango being one of the most widely cultivated and popular fruits in India, and especially in Bihar, have gone through some major changes in its production and cultivation. This owes to the drastic environmental changes in the last decade. Mango grown in Bihar constitutes the state's major fruit production fraction. The ones grown in the region are famous for their immense economic and nutritional values. Mango tree has got multiple uses. Mango leaves are fed to cattle in the shortage of fodder. The leaves are also used in numerous ceremonies in the Hindu rituals. Mango tree has a lot of medicinal properties as well. The wood of the mango tree is used for furniture making and also as fuel. Mangoes are rich sources of vitamin A and C. Mango pulp is laxative in nature and has unique nutritional value.

The fruit is very popular with the masses due to its wide range of adaptability, high nutritive value, richness in variety, delicious taste and excellent flavour. It is a rich source of vitamin A and C. The fruit is consumed raw or ripe. Good mango varieties contain 20% of total soluble sugars. The acid content of ripe desert fruit varies from 0.2 to 0.5% and protein content is about 1%.

Raw fruits of local varieties of mango trees are used for preparing various traditional products like raw slices in brine, amchur, pickle, murabba, chutney, panhe (sharabat) etc. Presently, the raw fruit of local varieties of mango are used for preparing pickle and raw slices in brine on commercial scale while fruits of Alphonso variety are used for squash in coastal western zone.

The wood is used as timber, and dried twigs are used for religious purposes. The mango kernel also contains about 8-10% good quality fat which can be used for saponification. Its starch is used in confectionery industry.

Mangoes are naturally accounted for one to wonder about the effect of climatic changes on the mango tree and about the reverberations on its production and cultivation. The absence of crop model for mango puts a stop to the forecast of the effects of climate change on mango tree development and production. They are then judged on the grounds of our current understanding on the impact of climatic variables on mango tree development and production. We narrate the supremacy of climatic variables on processes of agronomical significance for the mango tree: photosynthesis, vegetative and reproductive development, fruit quality.

We then scrutinise the climate changes forecasted for two areas of mango production and draw the feasible ramification for mango cultivation. At last, we suggest some research ways to adjust mango cultivation to climate change in the coming decades. The interest of developing a mango crop model is discussed.

Materials and Methods Used

Krishi Vigyan Kendra, Sabour, Bhagalpur is located in the Sabour block of Bhagalpur district. The block is geographically situated in the eastern part of Bihar. It is bestowed with rich soil of endo-gangatic plains rich in mineral and nutrients that are required for good horticultural crops. Mango is very important crop of Bhagalpur district grown in 88750 hectares of land. Proper growth and productivity related to climatic variables. In coming decades the climatic change scenarios predict pronounced modification in coming^[4] (IPCC, 2007). The effect of climatic change results in imbalance in the biotic and abiotic factors of agriculture that ultimately affect the yield and quality of produce. Particularly for those crops which is directly consumed by the consumer. To combat these stress farmers use indiscriminate insecticides, pesticides without any schedule. Some of them even spray fifteen days before the harvesting. This is most hazardous for health of humans and environment too. Mango is most widely cultivated crop in the world. So, this is a matter of great concern to study the effect of climatic changes that regulate the incidence of abiotic and biotic factors. This paper is harnessing the experience of working on farmers' field, exposure to the field orchard and farmers. Everyone tells their story that is unique in experience. This paper justifies the effects of change in scenario of cultivation, to what extent package and practices should be modified to fight against the effects of climatic changes. Before the application, every step should be justified whether it is good for humans and environment or not? To

study the impact of climatic change on mango that regulate the effects that comes as different stress like rise in temperature, rain in November, heavy infestation of insect and pest etc. These factors hinder the proper growth and development that ultimately influences the yield and quality of mango production. Outcome of these effects is low income to the farmers and poor market. To study these factors first we have considered the different stresses that influence the growth and yield of mango. These stresses are

1. Biotic stress: Madhua kit, Mealy bug attack, powdery mildew, shooty mould, scab, anthracnose etc
2. Abiotic stress: High temperature, low temperature, untimely rain, Westerly Winds.
3. Study the effects of control to these factors that is safe for environment or not.

The base of study is questionnaire that was provided to the farmers, exposure to the number of problems faced by them, visit to the farmers' orchard, farmers visiting Krishi Vigyan Kendra Sabour, Bhagalpur, management done by farmers round the year and prevailing recommendations. Effect of climate change seen more pronounced from the last ten years. But to study, we have considered three years from namely-2015-16, 2016-17 and 2017-18. During this period, unusual

behaviour of climate and effect was studied. There is need to develop model practices that is suitable in all situation. To study we have considered major factors of change.

Result and Discussion

Krishi Vigyan Kendra, Sabour, Bhagalpur lies in eastern part of Bihar. This district is blessed to have a variety of soils-from loam to sandy loam. Apart from that, abundance of labourers is also a plus point of the place. Therefore, a wide range of crops are grown over here. Most of the crops include paddy, wheat, oil and pulses. Not limiting to them, a wide range of Horticultural crops are also grown on a sizable scale. Being a Horticultural scientist well-being of horticultural crops is our prime concern, out of which, mango is very important because it is grown in large area of 88786 acres (Source: District Horticulture Office, Bhagalpur). Jardalu mango has nationwide fame. Randomly selected farmers were subjected to a questionnaire. Out of 100 farmers, 78 farmers asked about blackening of flowers of mangos. To understand the basic problems we have observed the temperature pattern prevailing in January, February for three consecutive years obtained from meteorological observatory of Krishi Vigyaan Kendra, Sabour was as follows:

Table 1: To understand the basic problems we have observed the temperature pattern prevailing in January, February for three consecutive years obtained from meteorological observatory of Krishi Vigyaan Kendra, Sabour was as follows:

Serial number	Year	Month	temperature	Month	temperature
01	2015-16	January	14.95 degree Celsius	February	15.2degree Celsius
02	2016-17	January	15.2 degree Celsius	February	18 degree Celsius
03	2017-18	January	12.5 degree Celsius	February	18.85 degree Celsius

We can observe that the pattern for three consecutive years from 2015 to 2018 for two months that is January and February and it is found that in year 2015-16 temperature was 15.2 degree Celsius that is optimum for flowering in mango^[10] (Geetha *et al.* 2016). Temperature below 15 degree Celsius induces flowering whereas temperature above 20 degree Celsius promotes vegetative growth^[6] (Nunez-Elisea and Davenport 1991, Nunz – Elisea *et al.* 1993). In shorten warm temperature shorten growth period of panicle, flowering duration and life span of individual flowers^[8] (Z.H. Shu, 1999).

This can be easily understood that how temperature is playing important role in flowering fruiting in mango. Abiotic stress brings so many biochemical changes. This is known fact that plant synthesis wide spectrum of secondary metabolites when herbivores injured the plants. Abiotic factors leads to a series of morphological, physiological, biochemical and molecular changes in plants that adversely affect the growth and productivity. This is a big researchable issue for all concerned people. Plant acclimation to the environmental stress is the process to adjust to a gradual change in the process in its plants allows the plants to maintain performance across a range of adverse environmental condition. Stress tolerance mechanism in mango are gaining attention because most agricultural regions are predicted to experience considerably more extreme environmental fluctuation due to global climate change. Slight change in temperature plants tends towards vegetative growth, delayed flowering, blackening of inflorescence are the effect of abiotic stress. Another important factor is arrival of westerly wind that burns the flowers of mango and cause huge loss to the farmers. Sometimes delayed flowering of early varieties faces heat strokes of westerly wind particularly early varieties like

Jardalu, Bombay, Gulabkhas. These rises in temperature also activate insects' pest attack on flowering orchard. Farmers have some recommendation that plant high density. Plantation of high density crop orchard is helpful in reducing the effects of heat waves/westerly wind. This is due to dense canopy of orchard and greenery effects of plants provide cooling effects. Many governments in countries like Hong Kong and Japan plant high density for beauty, greenery and for cooling effects. High density planting is not helpful in fighting against sudden heat stroke but also helpful in maintaining the orchard disease and insect free. For proper maintenances plants trained and pruned. During this training and pruning branches touch and overlap to each year are removed. Those branches are preferred to remove which is infected. This regular training and pruning of orchard helps in eradication of disease like anthracnose and powdery mildew. Hopper is also controlled easily. This is due to removal of source; enhance aeration and efficient spraying of chemicals. This type of research work was also conducted at Tamil Nadu Agricultural University. Farmers are also advised to plant suitable intercrop in their orchard after harvesting of fruits. In general trend it is found that after harvesting of fruit or in between the period of fruiting there is no management of to control the insect, pest and disease. There is no strategy to minimize the abiotic and biotic stresses/effects on the orchard. Beginning years we have started to collect the problems from the farmers whether they are coming to Krishi Vigyaan Kendra or we are visiting to the farmers' field attending chaupal, efficacy of existing problems, round year management feedback given by farmers. On the basis of these feedbacks plant intercrops in their orchard. This is very vast subject and there are different synergistic effects of different intercrops. Farmers who are planting turmeric in their orchard benefited in the sense that

this intercrop helpful in reducing termite attack. But it is helpful in boosting the yield of mango by controlling trunk eater, gummosis also provides extra income to the farmers (The Hindu, 2011) This is due to the turmeric roots exudates curcumin in rhizome presents in soil probably assist in disease suppression by reducing the activity and population of trunk borer larvae and soil borne pests and fungus. Turmeric Plantation as intercrop can find application in organic farming system, to control various soil borne pests and diseases in several fruits orchard ^[14] (K.Usha, Principal scientist of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi). Another important intercrops sown by some farmers are Dhaincha, Sanai, other pulses crop like moong lobia hemp, guara, senji etc in orchard. This replenish the soil with organic matter, keeps the weed in check, check the unnecessary growth of grubs and other harmful fungus (Krishi Sewa com 2019). Sowing of fibrous crop like hemp, sania, Green moong helps in maintaining the soil the soil moisture which helps in fight against heat stresses, provides nitrogen by fixing atmospheric nitrogen to the main crop that is mango.

Despite seasonal and regional variability general change of climatic change in tropics and sub –tropics are higher temperature, untimely rain, higher frequency of extreme weather condition such as scorching heat, drought, low temperature in flowering season. These abiotic factors adversely affect the physiology of mango plants. They also enhance the attack of different insects and pests. For example when low temperature and humid weather exist in the month of January increase the probability of powdery mildew incidence, delayed flowerings and adversely affect the pollination process ^[9] (Rajatiya *et al.*, 2018 International journal of pure and applied Bio science 6(3):597-607 2018) also revealed that low temperature and after monsoon rain delayed flowering in mango. Phenological response to low temperature and rainfall: A case study that climate sensitive crop like mango has impact on fruit bud differentiation, early and delayed flowering of mango, male female ratio (researchgate.com). An early flowering of under the tropics and sub – tropics may result in low fruit set because of abnormalities arising from low night temperature.

Conclusion

Mango is the most widely grown crop in the world. In India it is most important commercial grown by the farmers. So, it is a matter of concern for researchers and scientists working in Krishi Vigyan Kendra and the most important for the farmers that are the largest group who are responsible for the betterment of the crop. Study, exposure, problems analysis revealed that profound impact on highly sensitive mango crop. Phenological response to temperature and rainfall: a case study of mango also advocates the same pattern of mango. The climate change, abiotic stress is environmental errors which are mostly beyond of our control. It's not possible for us to have a control over the nature. But adaptation is something in which we have been excelling even when fire was not discovered. Consequences of these abiotic factors that comes as heavy infestation of insects, pest and diseases. To control these factors, we all spray random chemicals, without discrimination of time. Most of us do not give it second thought weather is it safe for environment and humans or not. This is something we need to change on an individual level. We should hear and manage your orchard safely. There goes a list of few steps that should be followed as concluded. These are as follows:

Step 1: First know the environment you stay in and every aspect of crop you are cultivating.

Step 2: Select upland for orcharding.

Step 3: Select Disease free plant and certified plant from guaranteed nursery.

Step 4: Establish orchard properly like layout, pit digging, treatment of pit etc

Step 5: Manage your orchard very meticulously up to ten years as per recommendation on the fertilizer

Step 6: Before starting the schedule of training pruning of orchard should be done. Cleaning of plants means remove all diseased parts and destroy them. Collect all affected fruits and destroy them. Spray a recommended insecticide properly. Way spraying should be proper. Purpose is that we have to destroy the population of insect and pest and check its circulation /population.

Step 7: This is the age of plant when it comes in peak fruiting. So, after fruit harvest manure it. A unit kilo gram Nitrogen, 750 gm Phosphorus and 1.5 kg Potash with 10 kg compost with every split doses can be used. This dose is sufficient for a one year old plant. In order to find the right amount of dosage for different plants, multiply with age of the plant with the manure used for a single unit. For new establishing orchard, three split doses first on onset of monsoon, second right after monsoon and third in February. If orchard is fruiting / productive, one should apply these manures first after harvesting 2/3rd of nitrogenous fertilizer, 2/3rd phosphatic fertilizer and 1/4th of potassic fertilizer. Second dose of the fertilizer should be applied in the month of September. The rest of potassic fertilizer can be applied when the mangos in the tree attain the size of a small potato.

Step 8: Intercrop your orchard with suitable inter crop.

Step 9: Always Plant WIND BREAK before orcharding.

Step 10: The final and the most important step is to observe your orchard/ plant from time to time. Follow recommendation properly and accurately. Be safe and keep your environment safe.

These inferences drawn on the basis of experience working in Krishi Vigyan Kendra, feedback provided by our farmers and researches in this regard.

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