Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 9(6): 1710-1712
Received: 08-08-2020
Accepted: 09-10-2020

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Effect of climate change on major tropical and sub-tropical fruit crops

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Abstract

The climate of earth, although relatively stable for the past 10,000 years or so, has always been changing, mainly due to natural cause such as volcanic activity. But since the 1900s more rapid changes have taken place and these are thought to be mainly man-made. Climate change refers to a change in the state of the climate that can be identified by changes in the mean and variability of its properties and that persist for an extended period, typically decades. Climate change is becoming an observed reality, very likely due to the increase of anthropogenic greenhouse gas concentration. We have to expect rise in average temperatures, atmospheric CO_2 concentration, soil salinity in some areas and receiving erratic rainfall. Warm temperature increased the rate and percentages of anther dehiscence and fertilization in mango compared to cool temperatures. Night temperature more than 17 ^{0}C during flower induction period in December showed detrimental effect leading to poor flowering and ultimately affecting the crop yield.

Keywords: Climate change, temperature, rainfall and fruits

Introduction

Climate has always been changing, mainly due to natural causes such as volcanic activity, earthquakes *etc*. But since the 1900's more rapid changes have taken place and these are thought to be mainly man-made. According to IPCC, climate change refers to a change in the state of the climate that can be identified by changes in the mean and variability of its properties, and that persist for an extended period, typically decades. Since a few decades, several research teams around the world carried out a huge work to model the future climatic change during the 21st century, based on several scenarios of greenhouse gas emission (Meehl *et al*., 2007) [8]. The climate variability and the frequency of extreme events like scorching heat, heavy rainfall, drought and hurricane are also expected to rise.

Climate variables affecting fruit production under following heads:

Effect of solar radiation on fruit crops

- Light intensity influence the crop growth through photosynthesis.
- Production rate of photosynthates depends on compensation point and saturation point.
- Light intensity a minimum of 500 -1000 ft candles is required for effective rate of photosynthesis.
- Duration of light period influence time of flowering of many fruit crops.
- Quality of light affects the process of photosynthesis, assimilation of nutrients and dry matter distribution in fruit crop plants (PAR 0.40 - 0.70 micron).

Effect of temperature

- Chlorophyll synthesis and leaf area development.
- Activities of PGRs are high.
- Temperature greater influence germination, leaf initiation and flowering of all fruit crops.
- Seedling development is more rapid as temperature increases.
- High temperature leads to sunburn and sunscald (Burning of leaves and fruits, bark of trunk may splits in extreme case), metabolic disturbance (High rate of respiration results in stunted growth), heat and thermal injury (Bleaching of chlorophyll, necrosis of fruit tissue) and desiccation (wilting of leaves and new seedlings in tropics).

Effect of Humidity

- It directly influences water relations of fruit crops and indirectly influences leaf growth, photosynthesis, occurrence of disease and finally economic yield.
- It affects rate of evapotranspiration and water requirement of the fruit crops.
- High humidity favours leaf enlargement due to high turgor pressure.

- High humidity favours easy germination of fungal spores on plant leaves.

Effect of Precipitation
- It is the major source of soil moisture for crop growth in irrigated and dry land horticulture.
- Cell growth, cell wall and photosynthesis are adversely affected by the water stress.
- Stomatal closure due to water stress restricts CO_2.
- Respiration increases and sugar accumulates under moisture stress results in reduced crop yield.

Effect of Wind
- Direction and velocity have significant influence on fruit growth.
- Increases transpiration and photosynthesis.
- Hot wind accelerates the desiccation of crop.
- Alters the balance of hormones.
- Increases ethylene production and decreases GA_3 of roots and shoots.
- Hot dry winds causes reduction in plant height – due to cell can't attain full turgidity.
- Crop lodging, shedding of flower and fruit drop – major injury.

Table 1: Resistant rootstocks and varieties of fruit crops against biotic and abiotic stresses

Crop	Root stock	Trait
Mango	13-1, Kurakkan, Nileshwar dwarf, Bappakai	Salinity tolerant
Guava	*P. molle* × *P. guajava*	Wilt resistant rootstock
	P. cujavillis	Tolerant to drought, sodic soils
	Chinese guava (*P. friedrichsthalianum*)	Dwarfing, Nematode tolerant and wilt tolerant
Grape	Dogridge, 110R, SO-4	Drought, Salinity tolerant
Citrus	Rangpur lime	Drought, Phytophothora tolerant
	Cleopatra mandarin	Salinity tolerant
Sapota	Khirni	Drought tolerant
Anona	Arka Sahan	Drought tolerant
Ber	*Ziziphus nummularia*	Drought tolerant and dwarf stature
	Z. mauritiana var. Tikdi and *Z. mauritiana var.* Shukawani	Vigorous growth
Fig	*Ficus glomerata*	Nematode and salinity tolerant
	Deanna and Excel	Drought tolerant
Passion fruit	*P. edulis f. flavicarpa*	Fusarium collar rot, nematode toleran0t
Pomegranate	Ruby	Drought tolerant
Avocado	Duke	Phytophthora root rot

Review

Mango (*Mangifera indica* L., Family: Anacardiaceae)
Shu (1999) [14] conducted an experiment to study the effect of temperature on flowering biology and fertilization of mangoes of four cultivars Haden, Irwin, Keitt and Local. Warm temperature (31 ^{0}C/25 ^{0}C) hastened growth rate of panicles and flowers, shortened flowering duration and life span of individual flower as compared to 25 ^{0}C/ 19 ^{0}C. It also decreased number of hermaphrodite and male flowers. But warm temperature increased the rates and percentages of anther dehiscence and fertilization.
Parmar *et al.* (2012) [11] reported that temperature below 17 ^{0}C was considered optimum for flower induction, night temperature more than 17 ^{0}C prevailing during flower induction period in December seems to have detrimental effect leading to poor flowering and ultimately affecting crop yield in mango.
Kumar *et al.* (2014) [7] studied the correlation between weather and yield attributes of mango. They revealed that maximum temperature (32 ^{0}C), minimum temperature (20.3 ^{0}C), relative humidity (84.50%) and rainfall (130.00 mm) had highly significant and positive correlation with all flowering and fruiting parameters of both main and off season in Kanyakumari location.
Normand *et al.* (2015) [10] assessed climate change and its probable effects on mango production and cultivation. They predicted climate for the end of the 21st century, with respect to mean climate of last 20 years of the 20th century was warmer and wetter in south Asia conditions and drier and moderately warmer in Carribbean islands probably lead to lower floral induction.
Geetha *et al.* (2016) [5] studied varietal variations in temperature responses for hermaphrodite flower production and fruit set in mango. They reported that Langra and Amrapalli varieties showed higher proportion of hermaphrodite flowers. Fruit set was recorded highest during the month of March followed by February and was lowest in January; even though the hermaphrodite flower proportion was lowest in February indicating that the fruit set was influenced by both sex ratio as well as the temperature during flower anthesis.

Banana (*Musa paradisiaca* L., Family: Musaceae)
Patil *et al.* (2015) [12] assessed growth, variability in weather parameter, correlation in area, production and productivity of fruit crops. They reported that CGR was significant in case of productivity of banana and mango. There was negatively correlated in case of rainfall and minimum temperature with area, production and productivity. The positive correlation between production and maximum temperature with banana as well as mango and negative correlation with grape was noticed.
Badgujar (2016) [3] did correlation study on weather and growth parameters in banana. The study indicated that the rainfall, relative humidity and wind velocity had positive correlation with the bunch weight but negative correlation with temperature, evaporation and sunshine hours in banana.
Salau *et al.* (2016) [13] suggested that excessive rainfall and extremely high temperature reduced banana productivity, while production was less when rainfall and temperature were very low with poor humidity. The mean temperature of about 26 ^{0}C and average rainfall around 1891 mm with relative humidity of 77 % was lead to good annual banana production above 61,000 tonne in Ondo state, Nigeria.
Swati *et al.* (2019) [15] revealed that production and productivity of 4 major fruits (banana, mango, sapota and papaya) had moderate negative correlation with mean annual temperature *i.e.* > - 50 percent except the productivity of

banana whereas; it showed negative and non-significant correlation with total annual rainfall.

Pomegranate (*Punica granatum* L., Family: Punicaceae)

Hanim and Yildiz (2009) [6] examined the change of proline content in pomegranate cultivars namely Hicaz, Oguzeli and Devedisi in year 2007 and 2008. In year 2007, proline content of three cultivars were 30 mg l^{-1} while it was 93 mg l^{-1} in year 2008, indicating that climatic change affects proline accumulation in pomegranate fruits. In hot and dry areas, proline accumulation in fruits were increased.

Borochev *et al.* (2011) [4] reported that anthocyanin accumulation change was inversely proportional to season's temperature. Total anthocyanin content was higher in winter fruit compared to summer fruit. Fruit that ripened in early summer and during the winter were significantly smaller than late summer and autumn. Early summer fruit contained higher juice content and TA whereas, mid winter fruit contained highest level of total phenolics.

Pineapple (*Ananas comosus* L., Family: Bromeliaceae)

Williams *et al.* (2017) [16] a nalyzed correlation studies on pineapple production in Ghana. The results showed that minimum temperature during all growth stages had significant correlation with pineapple yield in Nsawam and Gomoa districts. Maximum temperature had significant correlation with vegetative, flowering stage and yield for Akatsi and Gomoa districts.

Litchi (*Litchi chinensis* L., Sapindaceae)

Menzel and Simpson (1991) [9] reported that high temperature increased the number of male flowers in as well as, decline in the proportion of female flowers in Tai so and Bengal cultivars of litchi. In cultivars, Kwai May Pink and Wai Chee, the proportion of female flowers was reduced only at 30/25 ^{0}C.

Sapota (*Manilkara achras* (Mill.) Fosberg, Family: Sapotaceae)

Arun and Azeez (2004) [2] conducted an experiment on declining yield in sapota in Dahanu areas of Maharashtra. They reported that the orchards have experienced around 50 % reduction in their annual yields during the past five years due to climate change.

Conclusions

Warm temperature increased the rate and percentages of anther dehiscence and fertilization in mango compared to cool temperatures. Night temperature more than 17 ^{0}C during flower induction period in December showed detrimental effect leading to poor flowering and ultimately affecting the crop yield in mango. Temperature, humidity and rainfall showed significant and positive correlation with all flowering and fruiting parameters of main and off season mango in Kanyakumari. Fruit set percent was greater during the month of March followed by February in mango. The rainfall, relative humidity and wind velocity had positive correlation with the bunch weight in banana but negative correlation with temperature, evaporation and sunshine hours. The positive correlation was noticed between production and maximum temperature banana and mango and negatively correlated with grape. The production and productivity banana, mango, sapota and papaya has negative correlation with mean annual temperature *i.e.* > 50 percent except productivity of banana whereas, non-significant and negative correlation with annual rainfall. Proline accumulation increases with increasing temperature in pomegranate. Anthocyanin content was higher in winter fruit as compared to summer fruit in pomegranate. The maximum and minimum temperature had significant correlation with yield and flowering in pineapple production in Ghana districts. High temperature increased the number of male flowers as well as decrease of female flowers in Tai So and Bengal cultivars in litchi. There was a 50 percent reduction in annual yield of sapota during the last 5 years in Dahanu areas due to climate change.

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