

Effect of climate on physiological and quality parameters of kinnow mandarin under north western Himalayan region

ABSTRACT

Climatic factors are normally important in the development, yield and quality of fruits leading to commercial value. Field experiment was carried out to study the effect of weather parameter on physiological aspect and quality of Kinnow mandarin, which were drip-irrigated from initial year of planting. Results showed positive correlation of peel per cent, peels thickness and pulp percent of kinnow mandarin fruit with minimum temperature, Rainfall at K₄ stage while evaporation was the only climatic factor that showed positive correlation with peel per cent and pulp per cent of kinnow mandarin fruit at K₄ stage. Similarly maximum and minimum of both temperature at K₁ and K₃ stage along with relative humidity at K₁ stage positively favour the content of number of seed per kinnow mandarin fruit moreover evaporation also exhibited a positive effect on number of seed per kinnow mandarin fruit at K₂ and K₃ stage. Stock: Scion ratio were found positively influence by only evaporation at K₄ stage.

Comment [YS1]: were-replace by 'was'

Key words: Kinnow mandarin, Climate, Physiological, Quality

Introduction

Global climate change is the change in the statistical distribution of weather patterns that have far-reaching ecological, agricultural, and economic consequences. Climate on earth has changed many times during the existence of our planet, ranging from the ice ages to periods of warmth and has a dramatic effect on growth and productivity of various crops, there are various

environmental elements affect the life cycle of annual and perennial plants, like high temperature, heat-waves, drought, cool temperature and frost, rising carbon dioxide (CO₂) levels. Climate change represents a dangerous challenge for mankind, there need for an efficient strategy to guarantee adequate crop production for humanity.

Climate change and agriculture are interrelated processes and affect in many ways. Climate is interrelated with citrus quality and quantity (Dolkar *et al.*, 2017). Citrus fruits are one of the largest fruit crops in the world. Among the different commercially grown citrus fruits, cultivation of kinnow mandarin, a first generated hybrid of King Orange (♂) and Willow Leaf (♀) developed by Dr. H. B. Frost in 1915 in California (USA) has assumed most prized status among citrus fruit grower of North-Western regions of the India. Citrus is one of the main fruits all over the world, citrus can be grown in different climatic zones ranging from tropical, subtropical, arid and semi-arid areas, citrus grows properly in the range from 12.8 to 37°C, which considered the optimum temperature for citrus growth and fruiting, while, sever high temperature (above 44-45°C) stopped citrus growth completely. Low temperature considered the limiting factor for the geographical distribution of citrus, low temperature could stop metabolism activity, whereas, chilling and frost cause severe injuries and demolish the whole tree. Temperature fluctuation affects negatively growth, decreases total yield, and reduces fruit quality particularly when occurred during the maturity stage, also, there are negative effects of heatwaves on the production of different citrus varieties particularly seedless varieties like Navel orange, and some Mandarin and lemon cultivars. Moreover the climate of a particular region is a decisive factor to have quality fruit with marketable size (Dolkar *et al.*, 2018). Chelong and Sdoodee (2013) reported that decrease in rainfall and soil moisture of two areas viz., Yala and Pattani affected the fruit development, yield & quality and the quantity of shogun (*Citrus reticulata* Blanco) fruit

Comment [YS2]: Use comma after Moreover

was better in Pattani than in Yala based on fruit diameters, fruit weight, peel, juice and peel thickness whereas, the total soluble solids in Pattani were lower than in Yala. Furthermore, the color of the rind in Pattani was greener than that in Yala.

On another side, rising carbon dioxide has positive effects on the growth of citrus seedlings and trees productivity. Current forecast on ongoing increase in global average temperature and its effects on earth's climate system are expected to change climate in the classic regions of fruit tree cultivation. Restricted air exchange and concomitant increase in humidity may cause changes in plant development, growth and diseases incidence, which could have adverse effects on crop yield (Grange and Hand, 1987). Hence, the recent investigation was carried out to find out the impact of weather parameters on physiological aspect at different phenological stages and quality during fruit developmental stages of kinnow mandarin under sub-tropical foot-hill Himalayas conditions.

MATERIALS AND METHODS

Experimental site

The field experiment was conducted for two consecutive year 2014 and 2015 at Research Farm Chatha, Division of Fruit Science, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, India. The experimental orchard at Chatha is situated in the sub-tropical zone at latitude 32° 43' North, longitude of 74° 54' East and altitude 332 meters above mean sea level. Annual rainfall is about 1110 mm, out of which most of the rains are received during July to October. The mean annual maximum and minimum temperatures are 29.7 and 16.3 °C, respectively. Summer months are hot with temperature and humidity ranging from 23.5 to 35.5 °C and 53.0 to 73.5%, respectively. The winter months experience mild to severe cold conditions with an average temperature ranging from 6.5 to 21.7

°C. December is the coldest month, when minimum temperature touches to 4 °C. The highest temperature is recorded in the month of June (45 °C). Daily maximum and minimum values of temperature, evaporation rate rises from February onwards up to June drop during July to September with a slight peak in October and then drop progressively up to December.

Experimental design and treatments

The experiment was conducted on 08 year-old plants, uniformly growing and bearing habit trees of 'Kinnow' mandarin, which were drip-irrigated from initial year of planting. The experiment was laid out according to randomized block design, plant to plant spacing in a row and within the row was 5 m and 5 m, respectively. Three plants from each replication were selected randomly for periodic identification of phenological events. The stages were taken into consideration for purposes of identifying some critical stages required for this study. These stages were identified on the basis of external morphological characteristics of Kinnow mandarin which included (i) Pre-flowering stage (K₁), (ii) Flowering to first fruit set (K₂), (iii) First fruit set to maximum fruit set (K₃) and (iv) Maximum fruit set to fruit harvest (K₄).

Plant sampling and analysis

In the experiment, the phenophasewise correlation studies of growth, yield and quality with various parameters were carried out separately with the help of methodology described by Gomez and Gomez (1984) for the crop on first, second, third and four stages. The meteorological parameters included were maximum temperature (T_{max}), minimum temperature (T_{min}), maximum relative humidity (RH_{max}) and minimum relative humidity (RH_{min}), rainfall (R_f) and Evapotranspiration (E_v) whereas physiological aspect and quality parameters, viz. Peel thickness, no. of seed, peel per cent. The stock as well as scion girth thus measured was expressed as ratio.

For determining the pulp of fruit was cut into pieces and boiled in hot water for 15 minutes. Later, the seeds were separated by using ordinary sieve (< 20 mm) and then number of seeds per fruit were counted. The juice per cent, pulp per cent and peel per cent in fruits was determined according to Romero *et al.* (2006) where pulp and peel of fruit was manually separated and juice, pulp, peel per cent was estimated on weight basis with respect to the fruit weight. Whereas peel thickness of 10 randomly selected fruits from each treatment in each replication was recorded with the help of Digital Vernier's Caliper. The values were expressed in centimeters (cm).

Data analysis

The statistical correlation analysis of data was done using SPSS 16.0 software. The test of significance was done at $p < 0.01$, 0.05 and 0.005 level.

RESULTS AND DISCUSSION

Climate of crop cultivated region influence the physiological aspects of the crops and quality of the fruits, but its impact on crop is complex and is combined with other factors and hence, it become very difficult to single out any particular meteorological parameters for describing its influence. However, the emphasis was given on main climatic factors that influenced either individually or jointly the growth and quality of kinnow mandarin. These factors include maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity, rainfall, evaporation during both the crop growing seasons 2014 and 2015, which are depicted in Fig 1 and 2.

Effect of climatic factors on kinnow mandarin fruit

The data regarding the impact of climatic factor on the stock: scion ratio of kinnow mandarin fruit crops are presented in Table 1 which clearly showed that the stock: scion ratio were positively influence by rainfall at K₄ stage ($r = 0.87^{**}$), while negatively influence by climatic factor as maximum and minimum temperature at K₁ and K₃ stage ($r = -0.74^*$, -0.76^* and -0.75^* , -0.80^{**} , respectively), maximum and minimum relative humidity at K₁ stage ($r = -0.76^*$ and -0.77^* , respectively), maximum relative humidity at K₄ stage ($r = -0.78^*$ and -0.75^*) and evapo-transpiration at K₂ and K₃ stage ($r = -0.83^{**}$ and -0.83^{**} , respectively). These results are in consonance with the finding of Mounzer *et al.* (2008) who reported that in peach cv. “Flordastar” the maximal trunk growth rate being reached approximate 30 days after full bloom. Tree maintains a balance between the surface for water uptake in the root system and the surface for transpiration in the shoot system. This limitation of water absorption stops shoot growth and production (Borchert, 1973). High humidity reduced the transpiration and heavy rain during experiment time created excessive moisture conditions near root zone, which interfered in water uptake. High humidity reduced the transpiration and heavy rain during experiment time created excessive moisture conditions near root zone, which interfered in water uptake. These results are in accordance with the findings of Higuchi *et al.* (1999) that warmer temperature decreased Cherimoya trees shoot growth, while it increased at cool temperature

Number of seeds

Both maximum and minimum temperature and maximum relative humidity at K₁ stage ($r = 0.67^*$ each) positively favour the content of number of seeds per kinnow mandarin fruit. In addition to that, both maximum and minimum temperature at K₃ stage ($r = 0.68^*$ and 0.75^*), maximum and minimum relative humidity at K₄ and K₁ stage ($r = 0.69^*$ and 0.68^* , respectively) and evapo-transpiration at K₂ & K₃ stage ($r = 0.86^{**}$ and 0.79^*) also showed positive correlation

whereas, at K₄ stage the number of seeds per kinnow mandarin fruit were negatively influenced by minimum temperature, evapo-transpiration ($r = -0.82^{**}$ and -0.76^* , respectively) and rainfall at both K₃ and K₄ stage ($r = -0.79^*$ and -0.74^*). Higuchi *et al.* (1998) reported that warm temperature produced asymmetrical and small fruit containing a small number of seeds in cherimoya fruit, due to low-viability of pollen. While maximum temperature at K₄ stage, evapo-transpiration at K₁ stage and rainfall at K₄ stage did not show any correlation. Inverse relationship has been reported by Gucci *et al.* (2009) between cell size and water potential presumably due to the direct effect of turgor on cell expansion under low water availability

Juice per cent

Further the data indicated that maximum and minimum temperature at K₁ stage and K₃ stage ($r = 0.75^*$, 0.77^* and 0.71^* , 0.77^* , respectively) exerted positive impact on the juice per cent of kinnow mandarin. However, negatively favoured by minimum temperature at K₄ stage ($r = -0.73^*$) whereas, maximum and minimum relative humidity at K₁ stage ($r = 0.76^*$ and 0.77^* , respectively) maximum relative humidity at K₄ stage ($r = 0.75^*$) positively influenced the juice per cent in kinnow mandarin. Similarly, Reddy and Venkateswarlu (2015) observed that fruits grown in moist climate tend to have more juice than those grown in drier climate. Likewise, evapo-transpiration at K₂ and K₃ stage ($r = 0.84^{**}$ and 0.82^{**} , respectively) also exerted positive impact. While rainfall at K₃ and K₄ stage ($r = -0.73^*$ and -0.81^* , respectively) were negatively associated with juice content of kinnow mandarin.

Pulp per cent

Pulp per cent of kinnow mandarin were positively influenced by minimum temperature at K₄ stage ($r = 0.79^*$) and negatively influenced by both maximum and minimum temperature at K₁ and K₃ stage ($r = -0.70^*$, -0.72^* and -0.68^* , -0.74^* , respectively). Maximum and minimum

relative humidity at K₁ stage ($r = -0.72^*$ and -0.73^* , respectively) and as well as maximum relative humidity at K₄ stage ($r = -0.71^*$) showed negative correlation whereas, rainfall at K₃ and K₄ stage ($r = 0.76^*$ and 0.80^* , respectively) showed positive correlation with pulp per cent of kinnow mandarin. Evapo-transpiration at K₄ stage ($r = 0.73^*$) also showed positive correlation with pulp per cent, while K₂ and K₃ stage ($r = -0.85^{**}$ and -0.79^* , respectively) showed negative correlation with pulp per cent of kinnow mandarin.

Peel per cent

The peels per cent as influenced by different climatic factors are presented in Table 1. Among all the climatic factors, peel per cent of kinnow mandarin were positively influenced by minimum temperature at K₄ stage ($r = 0.77^*$) and negatively influenced at K₁ and K₃ stage by both maximum and minimum temperature ($r = -0.71^*$, -0.73^* and -0.71^* , -0.77^* , respectively). Similarly, maximum and minimum relative humidity also showed negative correlation with peel per cent at K₁ ($r = -0.73^*$ and -0.74^* , respectively) and maximum relative humidity at K₄ stage ($r = -0.71^*$) while, rainfall at K₃ and K₄ stage ($r = 0.75^*$ and 0.81^{**}) showed positive correlation with peel per cent of kinnow mandarin. Further, evapo-transpiration at K₄ stage ($r = 0.71^*$) also showed positive correlation with peel per cent, while K₂ and K₃ stage ($r = -0.86^{**}$ and -0.82^{**} , respectively) showed negative correlation with peel per cent of kinnow mandarin fruit crop. Chelong and Sdoodee (2013) reported that decrease in rainfall and soil moisture of two areas viz., Yala and Pattani affected the peel, juice and peel thickness of shogun (*Citrus reticulata* Blanco).

Peel Thickness

The perusal data presented in Table 1 revealed that peel thickness per cent in fruit of kinnow mandarin were positively influenced by minimum temperature at K₄ stage ($r = 0.67^*$

and 0.94***, respectively) and rainfall at K₃ and K₄ stage (r = 0.70* and 0.83*, respectively) and negatively influenced at K₁ and K₃ stage both by maximum and minimum temperature (r = -0.74*, -0.76* and -0.68*, -0.74*, respectively). Further, maximum and minimum relative humidity at K₁ stage (r = -0.75* and -0.77*, respectively) and maximum relative humidity at K₄ stage (r = -0.78* and -0.76*, respectively) also showed negative correlation with per cent peel thickness. In addition to that evapo-transpiration also exerted negative impact on per cent peel thickness at K₂ and K₃ stage (r = -0.83** and -0.78*, respectively). Similarly, Reddy and Venkateswarlu (2015) observed that fruits grown in moist climate tend to have thinner peel than those grown in drier climate.

CONCLUSION

On the basis of above study, it can be concluded that there was a strong relationship between weather parameters and quality of kinnow mandarin fruit crops. Further, the climate of a particular region is a decisive factor to have quality fruit with marketable size. Based on this study we can provide the optimum crop environment at different phenological stage of kinnow mandarin fruit crops by following proper crop management practices based on weather conditions for producing superior quality fruits having high market demand with more value

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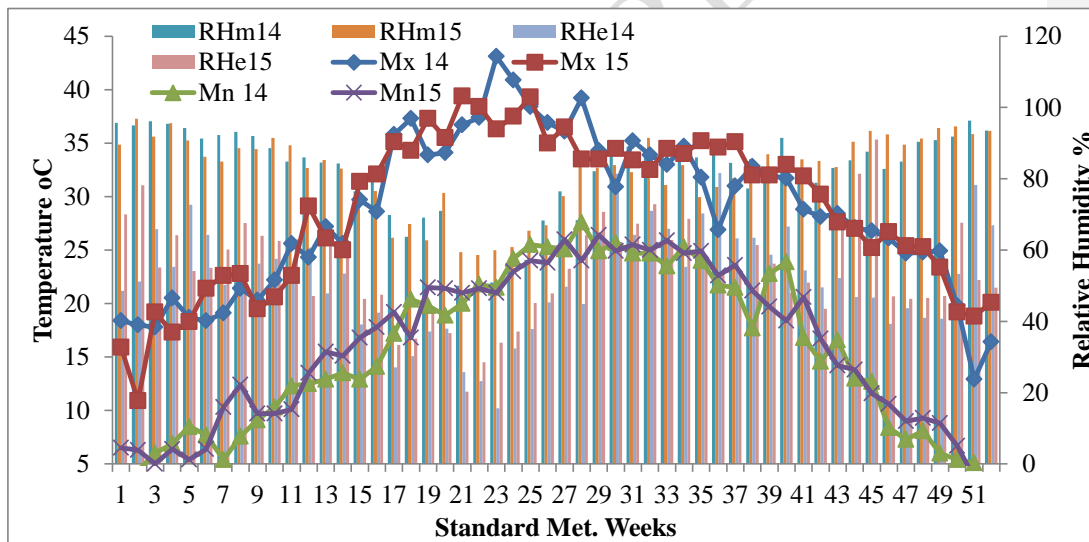


Fig. 1: Temperature and relative humidity recorded during the study period (2014 & 2015)

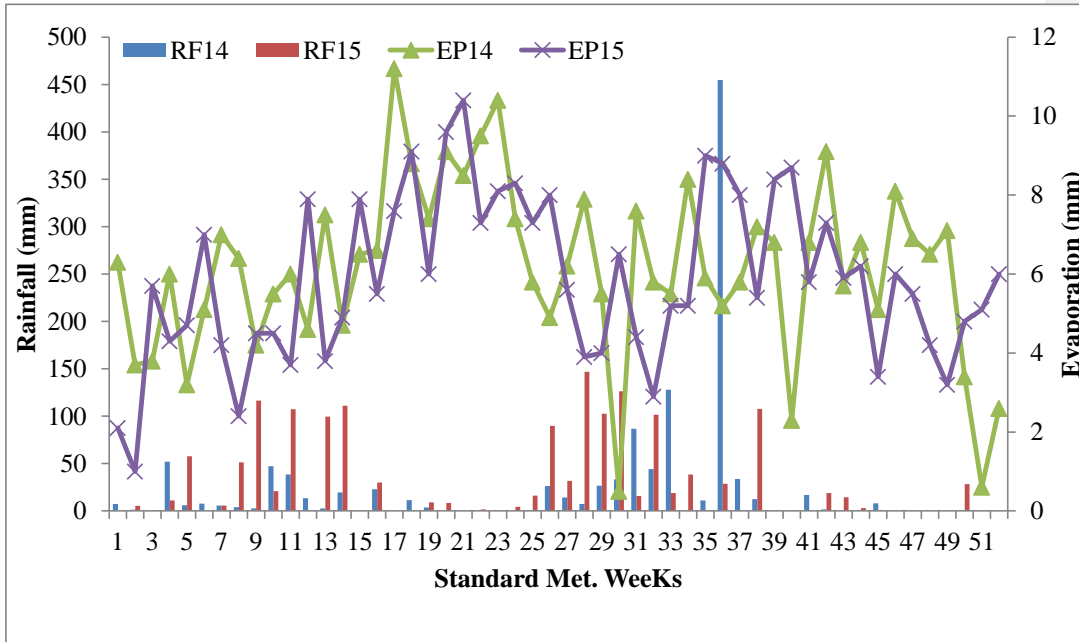


Fig. 2: Rainfall and evaporation recorded during the study period (2014 & 2015)

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Table1: Correlation between climatic factors and growth and quality at different stage of kinnow mandarin fruit crops during 2014

	St-G: Sc-G	No. Seed	Pulp %	Juice %	Peel %	Peel T
Max Temp K1	-0.74*	0.67*	-0.70*	0.75*	-0.71*	-0.74*
Max Temp K2	-0.15	0.24	-0.20	0.16	-0.21	-0.17
Max Temp K3	-0.75*	0.68*	-0.68*	0.71*	-0.71*	-0.68*
Max Temp K4	0.03	-0.22	0.19	-0.12	0.17	0.03
Min Temp K1	-0.76*	0.67*	-0.72*	0.77*	-0.73*	-0.76*
Min Temp K2	-0.48	0.57	-0.53	0.50	-0.54	-0.50
Min Temp K3	-0.80**	0.75*	-0.74*	0.77*	-0.77*	-0.74*
Min Temp K4	0.66	-0.82**	0.79*	-0.73*	0.77*	0.67*
Max RH K1	-0.76*	0.67*	-0.72*	0.76*	-0.73*	-0.75*
Max RH K2	0.25	-0.15	0.19	-0.23	0.18	0.22
Max RH K3	0.11	-0.10	0.09	-0.15	0.10	0.16
Max RH K4	-0.78*	0.69*	-0.71*	0.75*	-0.71*	-0.78*
Min RH K1	-0.77*	0.68*	-0.73*	0.77*	-0.74*	-0.77*
Min RH K2	0.20	-0.09	0.14	-0.19	0.13	0.18
Min RH K3	-0.18	0.02	-0.03	0.09	-0.07	-0.08
Min RH K4	-0.48	0.33	-0.35	0.40	-0.35	-0.45
Rain Fall K1	-0.58	0.49	-0.59	0.58	-0.58	-0.58
Rain Fall K2	0.39	-0.24	0.35	-0.36	0.35	0.37
Rain Fall K3	0.63	-0.79*	0.76*	-0.73*	0.75*	0.70*
Rain Fall K4	0.87**	-0.74*	0.80*	-0.81**	0.81**	0.83*
Epan K1	-0.64	0.63	-0.61	0.66	-0.60	-0.64
Epan K2	-0.83**	0.86**	-0.85**	0.84**	-0.86**	-0.83**
Epan K3	-0.83**	0.79*	-0.79*	0.82**	-0.82**	-0.78*
Epan K4	0.59	-0.76*	0.73*	-0.67	0.71*	0.60

Significant at $p < 0.01^*$, 0.05^{**} , 0.005^{***} level ;

K1: Pre-flowering stage, K2: Flowering to first fruit set , K3: First fruit set to maximum fruit set, K4: Maximum fruit set to fruit harvest; Max: maximum, Min: Minimum, Temp=Temperature, RH=Relative humidity, RF=Rainfall;