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Prevailing Weather Condition Impact on Different Phenophases of Kinnow Mandarin (*Citrus nobilis* Lour * *Citrus deliciosa* Tenore)

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ABSTRACT

Experiment was conducted with the objective to cointified the impact on flowering, fruiting, fruit development and yield parameters of Kinnow mandarin at Hisar, Haryana condition. The experiment was carried out consecutively for four year (2011 to 2014) on 16-19 years old kinnow plants planted at 6×6 m spacing in a block of one hectare. Flowering density and fruit set percentage did not vary with the seasons, whereas, more June drop and less final fruit retention, yield & fruit weight was found in the late flowering years during study period. The early flower bearing years showed less June drop, more fruit weight and yield. During stage 1st (From the month April to May) the different weather parameters played the significant role from the flowering to fruiting. The maximum (T_{max}) and minimum temperature (T_{min}) and evaporation showed, the significant positive correlation with the diameter, fresh and dry weight and peel thickness, whereas the morning and evening relative humidity was significantly negative correlated with peel thickness and non-significantly negative correlation with diameter, fresh and dry weight of Kinnow mandarin citrus fruit. Significant variation in stage 1 to 3 from flower bud initiation to physiological maturity of fruit was found in respective year of study. The pooled correlation coefficient in the stage 1 with the T_{max}, T_{min}, BSS, evaporation, and rainfall positive and RHm, RHe negative correlated with the fruit diameter, Fresh weight (g), Dry weight (g) and Peel thickness (mm), stage 2 negative correlation with T_{max} and T_{min}, evaporation but RHm, RHe, and rain negatively correlated with peel thickness and positive correlated to RHm, RHe, and rainfall, stage 3 negative correlated.

Key words: *Orchard Kinnow fruiting, flowering, weather impact, correlation, optimum weather parameters*

INTRODUCTION

Citrus is the leading tree fruit crop of the world. It is grown in tropical and subtropical areas as a commercial crop in about 49 countries worldwide[13]. The Kinnow mandarin (*Citrus nobilis* x *Citrus deliciosa*) is a predominantly citrus fruit of Punjab and Haryana and mostly cultivated in the Haryana under the arid to semi arid agroclimatic region and ranks first with respect to area and production[12].

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Physiological disorders are widely recognized with Interaction of climate and mineral nutritional bound. In arid regions citrus trees are highly prone to heat injury or sun burn, drying of fruit and death of bark & slightly dis-colouration of fruit skin. High temperature and high intensity of solar radiation are two environmental factors causing injury to fruit and tree[10]. Roy and Goldschmidt[14] found that growth and development in citrus has several stages that are controlled by various internal and external factors in terms of time (temporal) and place (spatial). For instance, environmental conditions may influence some or advance stages related to flowering (blooming) and flower development and prevent natural process of these stages[9]. Besides, at higher mean temperatures, citrus flowers bloom sooner (within short period of time), fruit mature earlier, fruit size gets bigger and acidity level of fruit juice remains low. Deris *et al*[8]., found that the day (maximum temperature) and night (minimum) temperature fluctuations have make better fruit coloring and sugar accumulation. The phenological stages of citrus fruit tree, in fact refers to the relation between weather conditions and alternative biologic events. Various weather parameters or factors related to phenological stages directly/indirectly which is influenced by three internal factors (physiological, chemical and biological) that may differ from season to season due to difference in climatic conditions or agroclimatic regions. In citrus gardens management, some suggestions are usually proposed regarding a predefined calendar and generally for all areas that most of such areas does not have a suitable garden[6,11]. Citrus bud induction starts in the fall and usually completed early in January (low temperature) first stop growth and then promote induction of flower buds when hours of low temperatures accumulated below 20 °C. If the crop load is light, sufficient flower bud induction is be achieved when total accumulated hours of low temperatures exceed 800 hours below 20 °C[1]. Keeping in view the above facts, the present investigation was carried out with the objective to study the relationship of flowering, fruiting, fruit growth & development and yield with weather parameters at different stages (flower bud initiation to fruit maturity) at the Hisar condition.

MATERIAL AND METHODS

Experimental site, location and Climatic condition

Field experiment was conducted from 2011 to 2014 at experimental orchard, Department of Horticulture, CCS HAU, Hisar, Haryana situated at 29^0 10' N latitude, 75^0 46' E longitude and altitude of 215.2 meters. Soil of the experimental site was sandy loam. The location is categorized as semi-arid irrigated with annual rainfall of 450 mm and experiences maximum temperature of 47^0C during summer and minimum 0.0 or few days <0.0 during winter months. The maximum rainfall occurs in July-August with onset of south-west monsoon. The meteorological data used for the study was collected from Agrometeorological observatory situated at 0.5 km away from the kinnow orchard.

Experimental Technical/specification/ layout

One hectare kinnow orchard bearing 275 plants, aged 16 years old, planted at university recommended spacing of 6×6 m were selected for the study. Out of one hectare block five plants with uniform growth, health and yield were selected and four shoots/ plant of uniform diameter were tagged in all direction (North-South and East -West) for taking the observation on flowering parameters i.e. flower bud initiation, days taken to open flower, time and duration of flowering, flowering density, fruit set and yield parameters (fruit weight, retention and yield). In this study fruit growth and development period was divided into three stages as per the phenological events appeared in kinnow. Stage-1(April.-May): cell division stage; Stage-II (June –September): cell enlargement stage and stage-III (Oct.-December): maturity and ripening period. Data on peel thickness, fruit fresh weight, fruit dry weight and fruit diameter was collected from fruit set onwards

till harvesting of fruits from already selected five plants at 15 days intervals.

Data collection:

Flowering and yield parameters: Date of flower bud initiation was taken when 5% of flower buds across the block were visible. Days taken to open flower were counted between dates of flower bud initiation to opening of flower. Time of flowering was noticed between openings of first flower to last flower on each shoot and consequently duration of flowering was calculated. Flowering density was observed by dividing the number of flowers on shoot by the branch cross sectional area (cm^2 BCSA) of the respective shoot and expressed as number of flowers/cm^2 BCSA. Initial fruit set was observed by counting the number of actual fruit formed from total number of flowers per shoot and expressed in percentage. June drop (fruit) was observed by counting the number of dropped fruit on each shoot upto the first week of July and expressed in percentage on fruit set basis. Similarly, pre –harvest fruit drop was calculated by counting the number of fruit dropped from September onwards till harvest from each representative plant selected and expressed in percentage pre-harvest fruit drop on the basis of total fruit count on the plant. Consequently, final fruit retention was taken in account the total number of fruits harvested/ plant over the initial fruit set and expressed in percentage. Yield/ tree was recorded by weighing the harvested fruits and expressed as (Kg/tree). Average fruit weight was measured by taking the weight of ten fruits / plant and averaged.

Fruit growth and development parameters: During these three fruit growth stages (stages I, II & III) stages data was collected on fresh and dry fruit weight, fruit diameter and peel thickness. For the collection of data on fresh and dry weight and peel thickness two fruits per selected plant were harvested on each date of observation i.e. 15^{th} & 30^{th} of each month and their fresh weight was observed and then these fruits were cut at the equator into two equal halves and peel thickness was measured at the equatorial line to right angle at four places with the help of vernier caliper and averages. Then these fruits were cut into small pieces and dried in hot air oven by gradually increasing the temperature to 68^0C till the constant weight was achieved. Diameter of the developing fruits were measured by tagging 15 fruit/plant in month of April and diameters of these fruits were measured regularly on each date of observation in two direction opposite to each other with vernier calliper and averaged.

Statistical analysis

The fruit growth and development parameters like kinnow fruit diameter, dry matter, peel thickness, fresh weight (stage 1 to 3) were correlated with the meteorological parameters i.e. maximum temperature (T_{max}), minimum temperature (T_{min}), mean temperature (T_{mean}), bright sunshine hours (BSS), relative humidity morning (RHm), relative humidity morning (RHe), evaporation (EP) and rainfall (RF) in respective year (individual) and pooled.

RESULTS AND DISCUSSION

Flowering and yield: Flowering bud initiation started early (21 & 24^{th} February) during the year 2011 & 2013, respectively and delayed i.e. 4^{th} & 5^{th} March in the year 2012-2014, respectively (Table 1). Days taken to open flower were more (18 days) in the year 2011-2013, whereas, it took 15 days in the year 2012-2014. Similarly duration of flowering was longer (14-16 days) in the year 2011&13 as compared to 12 days in the year 2012 &14. Flowering density did not vary among the different years of study, but minimum (28.31) was found in the year 2012 and maximum (31.82) in the year 2011.

Initial fruit set, fruit drop, fruit retention and fruit weight are the parameters contributing the yield of the fruit plant. Great variation has been observed in June fruit drop and pre-harvest drop and fruit retention during the period of study. June drop varied between 53.60-69.7% and pre-harvest drop between 5.56-15.50%. Maximum June drop was observed in 2014 (69.7%) and minimum (53.60%) in 2011. Whereas, maximum pre-harvest drop (15.50%) was observed in year

2011 and minimum (5.56%) in year 2012. Maximum fruit retention (20.37%) was found in year 2011 and minimum (14.8%) in 2014. Fruit yield varied with the study years and maximum (122.53 kg/tree) was observed in 2013 and minimum (86.52 kg/tree) in 2012. Similarly, average fruit weight was maximum (178.14g) in year 2013 and minimum 153.48g in 2012.

It can be inferred from Table 1 that in the year 2011 & 13 early flower bud initiation is accompanied by the more days to open flower and longer flowering duration without influencing the flowering density and fruit set. This showed that early flowering results in more days available for flower development as temperature is optimum range 28-32°C, Tmax range 15.2°C to 43.2°C and average 34°C, Tmin range -1.5 to 32°C, Tmin average 16.8°C and congenial to agreeable suited in the last of February (Tmin range -1.3 to 14.6°C, Tmin average 7.5°C) and delayed bud initiation results in forced opening of flower due to increase in temperature with progress of time. But flowering density and fruit set is independent of flowering time and flower bud initiation.

There was more June drop during late flowering years 2012 & 2014, which may be due to poor flower development during these year and reduced period of flower formation which results in poor initial growth of the fruit. Whereas, in case of pre-harvest drop i.e. heavy June drop was accompanied by less pre-harvest drop and vice-versa. Fruit retention and yield was found more in the early flowering bearing years 2011 & 2013. This may be due to less June drop and more average fruit weight as evident from the present investigation. Late flowering results in less average fruit weight and this again confirm the hypothesis that late flowering results in poor ovary development as forced opening of flowers due to high temperature in late season. Hence fruit size may remain small in late bearing years as compared to years of timely/early bearing and flowering time in kinnow is the best indicator for yield prediction.

Table 1: Flowering and yield of Kinnow mandarin at Hisar (2011-14)

Sr #	Parameters	2011	2012	2013	2014
	Flowering & fruiting				
1	Time of flower bud initiation	21st Feb.	4th March	24th Feb.	5th March
2	Days taken to open flower	18 days	15 days	18 days	15 Days
3	Time of flowering	10/3 to 26/3	19/3 to 31/3	14/3 to 27/3	19/3 to 30/3
4	Duration of flowering	16 days	12 days	14 days	12 days
5	Flowering density (No./Cm^2 BCSA)	31.82	28.31	31.16	31.26
	Yield parameters				
1	Initial fruit set (%)	51.93	57.47	54.4	54.5%
2	June drop (%)	53.60	66.87	59.5	69.7
3	Pre-harvest fruit drop (Sept.-Dec.) (%)	15.50	5.56	12.38	9.6
4	Fruit retention (%)	20.37	17.96	19.54	14.8
5	Yield (Kg/tree)	114.63	86.52	122.53	98.6
6	Average fruit weight (g)	174.12	153.44	178.14	162.2

Fruit growth and development: Fruit diameter and fresh and dry weight was increased linearly, whereas, peel thickness was oscillating from May onwards till harvesting Table 1 & 2. Fruit diameter increased at faster rate up to August there after increase was comparatively slow up to harvest. Diameter is contributed about 36% during cell division stage and 37 % during cell elongation and 17% during the maturity stage of the final fruit diameter (73.75mm). Fresh and dry fruit weight increased continuously up to harvest. Fresh weight increased more rapidly from May onward to October contributing 83% of final fruit weight (174.39g) at harvest. October onward fruit weight increased at slow rate. Up

to stage I (April-May) fruit weight is contributed only 4.5% of the final fruit weight. Stage II contributed most increase in fruit weight. Dry weight increased linearly with slow increase rate in August and slightly more increase in dry weight in October and November. Altaf and Khan[2] found that diameter of kinnow fruit increased at faster rate up to August and then slowed down comparatively. After cessation of cell division, fruit cell differentiation takes place followed by a period of cell enlargement, enhances pulp growth resulting in large fruit size[3]. Bower[7] also observed that citrus has a sigmoid growth pattern. Peel thickness increased up to 30th May and was maximum (5.70mm), thereafter decreased continuously up to 15th October and was thinnest (2.53mm) and again there was increase in peel thickness till harvesting (3.70mm). The increase in peel thickness was due to increased cell division in ovary wall. Brain[5] reported increase in fruit size during stage I was mainly due to growth of peel and peel has 2/3rd of fruit radius at the end of stage I. The decrease in peel thickness during stage II is due to the pressure exerted by the expanding cells of the juice tissues as a result the peel cells gets stretched and thin. Augusti *et al*[4]., stated that growth of the pulp may also be attributed to cell expansion of the juice vesicles. Increase in peel thickness during stage III is due to disintegration of albedo tissue and enlargement of lenticels of flavedo and ultimately softening of the peel at maturity and ripening stage. Values of all the fruit growth and development parameters were observed less during the years 2012 & 14 say off years due to late flowering in years 2012 & 14, resulted in poor flower development and finally smaller fruit size compared to 2011 & 13.

Table 2: Fruit dry weight and peel thickness of Kinnow mandarin at 15 days interval from 1st May onwards at Hisar (2011-14)

Date of observations	Fruit dry weight (g)					Peel thickness (mm)				
	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled
1st May	-	0.4	0.5	0.3	0.36	-	-	4.1	3.0	3.55
15-May	2.0	0.7	1.7	1.0	1.35	6.1	4.4	5.9	5.0	5.35
30-May	2.7	2.1	2.	2.1	2.23	6.0	5.4	6.0	5.4	5.70
15-June	4.4	3.4	3.9	3.3	3.75	4.9	5.1	4.8	5.8	5.15
30-June	5.4	4.6	5.0	4.2	4.80	4.4	4.6	4.3	4.8	4.53
15-July	6.7	6.4	6.0	5.6	6.18	4.0	4.2	3.9	3.9	4.00
30-July	9.9	6.2	8.5	7.4	8.00	3.8	3.5	3.4	3.5	3.55
15-Aug.	9.4	7.3	8.8	7.8	8.33	3.3	3.1	3.2	3.1	3.18
30-Aug.	9.5	8.0	9.1	8.9	8.88	3.1	3.0	3.0	3.0	3.03
15-Sept.	9.6	8.7	10.2	9.5	9.50	2.7	2.7	2.9	2.9	2.80
30-Sept.	10.2	9.8	10.8	10.6	10.35	2.5	2.4	2.7	2.9	2.63
15-Oct.	11.1	10.4	11.6	10.6	10.93	2.2	2.5	2.5	2.9	2.53
30-Oct.	13.9	12.0	14.4	14.8	13.78	3.0	2.8	3.1	3.5	3.10
15-Nov.	14.7	13.7	16.0	15.3	14.93	3.4	3.1	3.3	3.7	3.38
30-Nov.	16.2	14.2	18.6	16.0	16.25	3.2	3.3	3.6	3.8	3.48
15-Dec.	17.2	14.9	18.7	16.1	16.73	3.4	3.4	3.7	3.9	3.60
30-Dec.	17.8	15.1	19.9	16.2	17.25	3.5	3.5	3.8	4.0	3.70

Table 3: Fruit diameter and fruit fresh weight of Kinnow mandarin at 15 days interval from 1st May onwards at Hisar (2011-14)

Date of observation	Fruit diameter (mm)					Fruit fresh weight (g)				
	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled
1st May	19.5	14.4	14.0	10.9	14.70	-	1.1	1.48	0.8	1.13
15-May	24.9	17.1	22.8	16.8	20.40	6.8	2.1	6.33	3.2	4.61
30-May	29.3	25.4	27.9	24.8	26.85	9.1	6.9	7.97	7.2	7.79
15-June	34.7	29.8	32.7	29.1	31.58	18.5	11.7	17.07	11.4	14.67
30-June	39.6	34.5	37.6	32.4	36.03	27.8	18.3	21.28	16.2	20.90
15-July	44.9	41.0	43.4	37.4	41.68	42.9	35.2	33.39	27.0	34.62
30-July	49.0	45.3	47.9	44.5	46.68	54.6	42.2	51.56	49.9	49.57
15-Aug.	54.2	50.5	53.0	48.3	51.50	79.3	64.3	68.16	48.6	65.09
30-Aug.	57.6	55.0	56.4	52.4	55.35	108.8	76.0	79.97	68.2	83.24
15-Sept.	62.7	58.1	58.1	55.6	58.63	111.8	87.6	94.74	83.3	94.36
30-Sept.	64.6	59.8	62.6	58.5	61.38	114.0	98.8	103.97	91.0	101.94
15-Oct.	66.3	60.8	66.0	60.2	63.33	137.2	100.5	125.62	93.7	114.26
30-Oct.	68.1	64.8	68.0	63.8	66.18	161.9	130.2	152.32	133.2	144.41
15-Nov.	72.4	67.3	74.2	66.2	70.03	177.8	138.6	180.36	151.4	162.04
30-Nov.	74.8	68.4	75.5	67.7	71.60	183.2	150.5	182.17	163.6	169.87
15-Dec.	76.5	70.4	76.0	69.2	73.03	187.1	154.1	186.78	167.2	173.80
30-Dec.	77.1	71.0	76.6	70.3	73.75	187.4	154.7	187.14	168.3	174.39

Correlation studies:

Stage 1 (April-May)

The maximum, minimum temperature and pan evaporation (PE) showed the significant positive correlation with the diameter, fresh and dry weight and peel thickness (Table 4). The morning and evening relative humidity showed significantly negative correlation with peel thickness and non-significantly negative correlation with diameter, fresh and dry weight. Minimum and maximum temperature was found positive significant with the fresh weight, diameter and dry weight of Kinnow. This might be due to favourable temperature for the photosynthesis activity and fast accumulation of carbohydrate resulted in more growth by cell division of peel tissues of Kinnow fruit during the first stage.

Stage II (June-September)

The maximum and minimum temperature and pan evaporation were significantly negative correlated with fruit diameter, fresh and dry weight and significantly positive correlation with the peel thickness. Whereas, morning and evening relative humidity had positive correlation with diameter, fresh and dry weight and significantly negative with peel thickness. During this stage fruit growth takes place due to cell enlargement of juice tissues which require more sink of photosynthates and water. During these month temperature remains higher than optimum which resulted in more energy utilized in respiration and secondly high temperature causes more transpiration rate which adversely affect the sink source and ultimately fruit growth. Similarly, lower rate of sink accumulation in juice tissue exert less pressure on peel tissues results in less stretching of peel results in thicker peel.

Stage III (October-December)

The maximum temperature and PE showed significantly negative correlation with

diameter, fresh and dry weight and peel thickness. Morning relative humidity showed positive correlation with diameter, fresh and dry weight and peel thickness. Whereas, evening relative humidity had non-significantly positive correlation with these parameters. During 3rd stage i.e. maturation and ripening processes takes place which require low temperature for colour and quality development. But when temperature is somewhat higher there is more vegetative flush (autumn season growth) at the cost of transferring of reserve photosynthates to the vegetative flush, hence slower growth. The negative correlation of peel thickness with temperature during this stage may be due to slower rate of disintegration of albedo tissue and softening of peel at higher temperature than normal temperature, resulted in thinner peel.

Correlation studies

The correlation was computed of respective year data with the weather parameters of individual year and pooled data set which is mention in the subsequent with positive and negative relationship were exited with T_{max} and T_{min}, relative humidity morning (RHm) and evening (RHe), bright sunshine hours (BSS), evaporation (EP) and rainfall (RF).

Table 4: Correlation of stage wise pooled data of kinnow fruit growth with weather parameter (2011-2014)

		T_{max} (°C)	**T_{min} (°C)**	RHm (%)	RHe (%)	BSS (hrs)	EP (mm)	RF (mm)
Stage 1	Fruit diameter (mm)	0.79	0.85	-0.54	-0.37	0.20	0.82	0.13
	Fruit fresh weight (g)	0.79	0.85	-0.55	-0.42	0.25	0.82	0.12
	Fruit dry weight (g)	0.78	0.86	-0.52	-0.36	0.25	0.82	0.14
	Peel thickness (mm)	0.90	0.88	-0.78	-0.68	0.27	0.91	0.04
Stage 2	Fruit diameter (mm)	-0.90	-0.60	0.87	0.74	-0.10	-0.85	0.32
	Fruit fresh weight (g)	-0.85	-0.65	0.80	0.67	-0.04	-0.80	0.27
	Fruit dry weight (g)	-0.84	-0.56	0.82	0.67	-0.05	-0.82	0.22
	Peel thickness (mm)	0.89	0.45	-0.86	-0.74	0.15	0.85	-0.30
Stage 3	Fruit diameter (mm)	-0.64	-0.68	0.73	0.21	-0.29	-0.76	-0.29
	Fruit fresh weight (g)	-0.62	-0.71	0.68	0.13	-0.29	-0.76	-0.32
	Fruit dry weight (g)	-0.71	-0.75	0.64	0.20	-0.30	-0.82	-0.26
	Peel thickness (mm)	-0.75	-0.73	0.49	0.29	-0.43	-0.76	-0.11

The pooled correlation coefficient in the stage 1 with the maximum (0.79 to 0.90) and minimum temperature (0.85 to 0.88), bright sunshine hours (0.20-0.27), evaporation (0.82 to 0.91) and rainfall (0.04 to 0.14) positive correlation and relative humidity morning (-0.52 to -0.68), and relative humidity evening (-0.37 t -0.68) negative correlation of fruit diameter, Fresh weight (g), Dry weight (g) and Peel thickness (mm). In the Stage 2 shows the negative correlation with maximum and minimum temperature, evaporation but RHm, RHe, and rain negatively correlated with peel thickness and positive correlation with RHm, RHe and rainfall. In case of Stage 3 negative correlation coefficient, shows in the Table 4.

The individual year correlation study was analyzed between Kinnow and weather variable from the day of initial flower to the fruit harvested. The correlation coefficient value was varies from negative to positive shown in the Table 4.0. The correlation coefficient of weather parameter of individual year for the diameter, fresh weight (g), dry weight (g) and peel thick were found positive (with the range of 0.01 to 0.89) but highest with the diameter-morning relative humidity in the 2013 and negative (with the range of -0.06 to -0.93) but highest with the dry weight (g)-pan evaporation (mm) in the 2013 and other respective parameters existing relationship with the weather parameters are shown in the

Table 5. Tmax were found the significant negative correlation with kinnow fruit diameter (mm), fruit weight (g). The individual year from 2011 to 2014 correlation were analyzed and results are reveal that the almost similar negative and positive correlation in the stage 1 to 3 but lower mixed positive and negative correlation were obtained with RHe (-0.06 to 0.75), BSS (-0.46 to 0.49) and rain (-44 to 0.14) fall shown in Table 5. The highest correlation was obtained with the maximum temperature and lowest with relative humidity evening or rainfall in all the respective years.

Table 5: Correlation study of Kinnow fruit growth with weather parameter in Individual year (from 2011-2014)

Year	Parameters	T_{max} (°C)	T_{min} (°C)	RHm (%)	RHe (%)	BSS (hrs)	EP (mm)	RF (mm)
2011	Diameter (mm)	-0.83	-0.64	0.83	0.09	-0.27	-0.87	-0.32
	Fresh fruit weight (g)	-0.87	-0.77	0.80	-0.06	-0.17	-0.91	-0.42
	Fruit dry weight (g)	-0.88	-0.74	0.80	-0.03	-0.28	-0.90	-0.44
	Peel thickness (mm)	0.56	0.32	-0.87	-0.42	0.10	0.74	0.11
2012	Diameter (mm)	-0.74	-0.56	0.83	0.49	-0.34	-0.76	-0.05
	Fruit fresh weight (g)	-0.87	-0.76	0.84	0.39	-0.29	-0.85	-0.18
	Fruit dry weight (g)	-0.82	-0.70	0.80	0.39	-0.33	-0.78	-0.18
	Peel thickness (mm)	0.51	0.31	-0.80	-0.51	0.11	0.73	-0.15
2013	Diameter (mm)	-0.84	-0.57	0.89	0.50	-0.29	-0.91	-0.02
	Fruit fresh weight (g)	-0.91	-0.77	0.80	0.29	-0.20	-0.93	-0.22
	Fruit dry weight (g)	-0.92	-0.74	0.83	0.36	-0.24	-0.93	-0.17
	Peel thickness (mm)	0.51	0.05	-0.86	-0.75	0.38	0.70	-0.33
2014	Diameter (mm)	-0.68	-0.55	0.81	0.35	-0.46	-0.80	-0.30
	Fruit fresh weight (g)	-0.83	-0.79	0.81	0.26	-0.47	-0.91	-0.38
	Fruit dry weight (g)	-0.77	-0.69	0.82	0.30	-0.48	-0.86	-0.36
	Peel thickness (mm)	0.23	0.01	-0.54	-0.37	0.15	0.44	0.14

The average peel thickness was observed 3.7 mm, maximum 6.1 mm and lowest 2.2 mm (Table 2). The pooled data of dry matter of respective years showed negative correlation with T_{max} (-0.80), T_{min} (-0.65), T_{mean} (-0.75) and BSS (-0.28) with dry matter, peel thickness and positive correlation with T_{max}, T_{min}, T_{mean}, EP and rainfall but negative correlated only with RHm and RHe. Fruit diameter and fresh weight were negatively correlated with the T_{max}, T_{min}, T_{mean}, EP and rainfall, and negative to RHm or RHe shows in Table 6.

Table 6: Pooled correlation of Kinnow fruit growth with weather parameter

Parameters	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	BSS (hr.)	RHm (%)	RHe (%)	EP (mm)	RF (mm)
Fruit dry weight (g)	-0.80	-0.65	-0.75	-0.28	0.21	0.03	-0.25	-0.07
Peel thickness (mm)	0.43	0.12	0.27	0.23	-0.16	-0.09	0.16	0.04
Fruit diameter (mm)	-0.73	-0.54	-0.66	-0.27	0.10	-	-0.14	-0.03
Fruit fresh weight (g)	-0.83	-0.72	-0.80	-0.21	0.16	0.02	-0.18	-0.02

CONCLUSIONS

The results of this study revealed that the suitability of weather condition in the different stages from first flower bud initiation to day of physiological maturity or harvesting of fruits of the kinnow fruits crop. Flowering density and fruit set percentage did not vary, whereas, more June drop and less final fruit retention, yield & fruit weight were found in the late flowering years during study period may be

categorized as off year (2012 and 2014). The early flower bearing years showed less June drop, more fruit weight and yield may be categorized as on year (2011 and 2013). So, the kinnow crop showed somewhat alternate bearing habit. Weather parameters played the significant positive and negative relationship with different growth parameters as well stages as phenological events. The maximum, minimum temperature and pan evaporation observed significant negative correlation in maturity and ripening stage with diameter, fresh weight, dry weight and peel thickness of kinnow fruit. Whereas, higher morning relative humidity showed positive significant influence to development of fruit such as diameter, fresh weight, dry weight and peel thickness.

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