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Impact of meteorological parameters on growth and quality of peach (*Prunus persica*) cv Early Grande under subtropical condition

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ABSTRACT

Two years experiment was carried out to study the impact of climatic factors on growth and quality of low chilling peach [*Prunus persica* (L.) Batsch] cultivar, viz. Early Grande. The results reveal that plant volume of Early Grande was positively influenced by maximum and minimum temperature at P_1 stage. Minimum temperature at P_3 stage exerted positive impact on plant volume, while plant volume was negatively related to humidity at P_2 and P_3 stages. Shoot extension growth was also negatively influenced by relative humidity at P_3 stage. During second year, plant volume and shoot extension growth was positively related with temperature at different phenological stages, while relative humidity exerted negative impact on plant volume and shoot extension growth. The fruit diameter showed negative relation with temperature and positive relation with relative humidity at different phenological stage during first year, however reverse trend was observed during second year. Fruit weight was positively influenced by relative humidity during both the years at different phenological stages. Minimum relative humidity at P_1 stage was only factor which positively influenced TSS content during second year. Maximum and minimum relative humidity at P_1 stage positively favoured the acid content in fruit of Early Grande during second year. Lastly, sugar content in fruit of Early Grande was negatively influenced by maximum and minimum temperature, while positively favoured by maximum and minimum relative humidity at P_2 and P_3 stages during second year.

Key words: Climatic factors, Growth, Peach, Quality

The climate is most important factor that influences the growth and development of peach [*Prunus persica* (L.) Batsch] fruit which in turn has an effect on its yield. Climate affects the relative frequency of vegetative/flower bud and fruit shape in low chilling peach cultivars (Wert *et al*. 2007). According to Verma *et al*. (2009) most of the peach cultivars, are regional in their adaptation, performing well in one region and poorly in other and some of their qualitative characters are bound to change with respect of prevailing environmental condition. The major abiotic environmental challenges especially in low chill areas of the world where peaches are grown are: adaptation to low chilling accumulation; cold damage during bloom; high heat especially during bloom time; high heat during subsequent growth of the fruit and the tree. These factors affect productivity as well as fruit ripening time, size and quality (Byrne 2010). Temperature and relative humidity produce the strongest impact upon phenological phenomena. The response of the whole plant to temperature is the cumulative results of the specific effects of temperature on each part of the plant and the interactions among those tissues and organs. At the extremes, low or high temperature can cause tree death, while at intermediate temperature all physiological processes, especially in the reproductive organs, are affected (Ferree and Goldhamer 1990). The temperature increase also affects the photosynthesis, causes alternation in sugar, organic acids, firmness as well as post harvest quality of the fruit (Moretti *et al*. 2010). Current and forecast climatic change is expected to change the cultivation of deciduous fruit tree in the classic regions. Restricted air exchange and concomitant increase in humidity may cause changes in plant development, growth and disease incidence, which can have adverse effects on crop yield (Grange and Hand 1987). Hence, the present investigation was carried out to find out the impact of climatic factors on growth and quality of peach cv. Early Grande under sub-tropical conditions.

MATERIALS AND METHODS

The field experiment was conducted during spring-summer season of 2010 and 2011 at Research Orchard of Division of Fruit Science, SKUAST-J, Chatha on peach cultivar Early Grande. 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

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required for this study. These stages were identified on the basis of external morphological characteristics of peach which included (i) Period from budbreak to full bloom (P_1), (ii) period from full bloom to fruit maturity (P_2) and (iii) period from budbreak to fruit maturity (P_3). The phenophasewise correlation studies of growth 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 and third stages. The meteorological parameters included were maximum temperature (Max T), minimum temperature (Min T), maximum relative humidity (Max RH) and minimum relative humidity (Min RH), whereas growth and quality parameters, viz. plant volume, shoot extension growth, fruit diameter, fruit weight, total soluble solids, acid content and sugars. The plant volume was calculated as per the formula given below and suggested by Westwood *et al.* (1963).

$$V = 4/3\ \pi a^2 b$$

where 'a', represent radius of the crown of plant which was found by measuring the maximum spread in North-South and East-West direction adding these values and dividing the sum by 4. 'b', denotes height of the plant (m). The length of each shoot was measured at the beginning and end of growing season between the points of initiation of new growth to the extremity of the shoot tip and expressed in centimetres. The diameter of selected fruits was measured by using a digital vernier callipers. The fruits were weighed on electronic balance and mean weight per fruit was computed in grams. Total soluble solids (TSS) content of the juice were determined with the help of Erma-hand refractometer (0-32°Brix). Titratable acidity (%) in fresh fruits was determined by the method as suggested by AOAC (1990) and sugars were determined by the method as suggested by AOAC (1995). The statistical correlation analysis of data was made by SPSS 16.0 software at 5 per cent level of significance.

RESULTS AND DISCUSSION

Climate of particular region where crop is cultivated undoubtedly influence the growth, quality and yield, 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, quality and yield of peach. These factors include maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity of both the seasons 2009-10 and 2010-11, which are depicted in Fig 1 and 2.

The data pertaining to the effect of different climatic factors (temperature and relative humidity) at various growth levels were determined with different phenological stages of Early Grande cultivar of peach is presented in Table 1 and 2. It is evident from the data that plant volume of peach

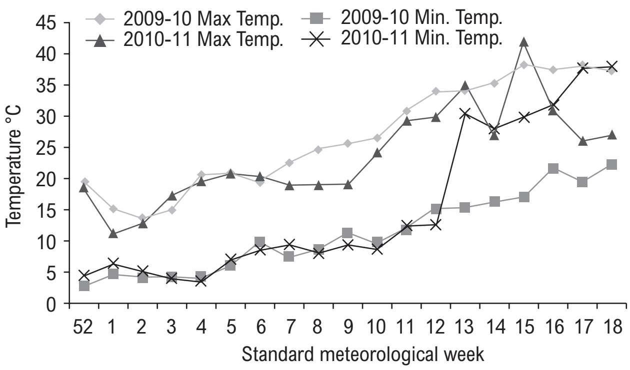

Fig 1 Maximum and minimum temperature during growth and development of Early Grande during 2009-10 and 2010-11

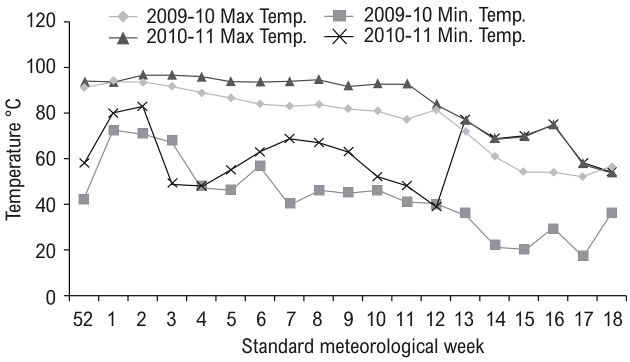

Fig 2 Maximum and minimum relative humidity during growth and development of Early Grande during 2009-10 and 2010-11

cultivar was significantly affected by weather factors. Maximum and minimum temperature at P_1 stage (r = 0.53** and 0.65**) and minimum temperature at P_3 stage (r = 0.63**) was positively correlated with plant volume of Early Grande. Similar observation was also made by Singh *et al.* (1999) who observed that olive canopy volume was significantly higher at location which represented relatively lower temperature at pre-bloom period. Further, plant volume of Early Grande showed negative relation with maximum and minimum relative humidity at P_2 and P_3 stage (r = -0.64**, –0.70** and r = –0.70**, –0.77**) during first year. During second year maximum and minimum temperature at P_1 and P_3 stage exerted positive impact (r = 0.61**, 0.73** and r = 0.76**, 0.80**) on plant volume of Early Grande. However, maximum relative humidity at P_1 stage was positively related with plant volume (r = 0.60**), whereas maximum and minimum relative humidity was negatively related to plants volume at P_2 and P_3 stage (r = –0.53**, –0.54** and r = –0.62**, –0.70**). Shoot extension growth was not influenced by temperature at any phenological stage, but maximum and minimum relative humidity at P_3 stage (r = –0.68** and –0.59**) negatively affected the shoot extension growth during first year. Minimum temperature during second year at P_1 and P_3 stage (r = 0.53** and 0.52**) positively favoured the shoot extension growth of Early Grande, however maximum and minimum relative humidity at P_3 stage (r = –0.63**

Table 1 Correlation between climatic factors and growth and quality of peach cv. Early Grande during 2010

	P_1mt	P_1mit	P_2mt	P_2mit	P_3mt	P_3mit	P_1mh	P_1mih	P_2mh	P_2mih	P_3mh	P_3mih	Pv	Seg	Fd	Fw	TSS	Ac	Su
P_1mt	1	0.98	–0.85	–0.64	0.61	0.66	0.91	0.65	–0.93	–0.93	–0.50	–0.67	**0.53****	0.25	**–0.62****	–0.31	**0.65****	0.50	0.19
P_1mit	0.98	1	–0.81	–0.56	0.64	0.75	0.81	0.49	–0.97	–0.97	–0.66	–0.80	**0.65****	0.36	**–0.63****	–0.45	**0.63****	0.40	0.19
P_2mt	–0.85	–0.81	1	0.92	–0.30	–0.25	–0.83	–0.65	0.84	0.81	0.46	0.54	–0.37	–0.40	0.28	0.21	**–0.63****	–0.42	–0.46
P_2mit	–0.64	–0.56	0.92	1	–0.08	0.11	–0.74	–0.70	0.56	0.54	0.17	0.23	–0.17	–0.26	–0.03	–0.05	–0.50	–0.35	**–0.64****
P_3mt	0.61	0.64	–0.30	–0.08	1	0.72	0.45	0.21	–0.55	–0.56	–0.39	–0.53	0.46	0.03	–0.32	–0.34	0.37	0.22	0.07
P_3mit	0.66	0.75	–0.25	0.11	0.72	1	0.36	–0.01	–0.72	–0.74	–0.70	–0.81	**0.63****	0.27	**–0.77****	–0.59	0.34	0.15	–0.28
P_1mh	0.91	0.81	–0.83	–0.74	0.45	0.36	1	0.91	–0.73	–0.72	–0.14	–0.32	0.24	0.03	–0.45	0.01	**0.61****	**0.61****	0.24
P_1mih	0.65	0.49	–0.65	–0.70	0.21	–0.01	0.91	1	–0.39	–0.37	0.27	0.11	–0.08	–0.20	–0.20	0.34	0.45	**0.61****	0.23
P_2mh	–0.93	–0.97	0.84	0.56	–0.55	–0.72	–0.73	–0.39	1	0.99	0.77	0.86	**–0.64****	–0.50	**0.62****	**0.52****	**–0.66****	–0.36	–0.13
P_2mih	–0.93	–0.97	0.81	0.54	–0.56	–0.74	–0.72	–0.37	0.99	1	0.78	0.88	**–0.70****	–0.50	**0.63****	**0.51****	**–0.67****	–0.36	–0.13
P_3mh	–0.50	–0.66	0.46	0.17	–0.39	–0.70	–0.14	0.27	0.77	0.78	1	0.96	**–0.70****	**–0.68****	0.47	**0.80****	–0.38	0.04	–0.03
P_3mih	–0.67	–0.80	0.54	0.23	–0.53	–0.81	–0.32	0.11	0.86	0.88	0.96	1	**–0.77****	**–0.59****	**0.58****	**0.74****	–0.47	–0.07	–0.05
Pv	0.53	0.65	–0.37	–0.17	0.46	0.63	0.24	–0.08	–0.64	–0.70	–0.70	–0.77	1	0.64	–0.33	–0.49	0.48	–0.17	0.15
Seg	0.25	0.36	–0.40	–0.26	0.03	0.27	0.03	–0.20	–0.50	–0.50	–0.68	–0.59	0.64	1	–0.06	–0.36	0.47	–0.35	0.17
Fd	–0.62	–0.63	0.28	–0.03	–0.32	–0.77	–0.45	–0.20	0.62	0.63	0.47	0.58	–0.33	–0.06	1	0.41	–0.26	–0.28	0.49
Fw	–0.31	–0.45	0.21	–0.05	–0.34	–0.59	0.01	0.34	0.52	0.51	0.80	0.74	–0.49	–0.36	0.41	1	0.03	0.19	–0.08
TSS	0.65	0.63	–0.63	–0.50	0.37	0.34	0.61	0.45	–0.66	–0.67	–0.38	–0.47	0.48	0.47	–0.26	0.03	1	0.48	0.11
Ac	0.50	0.40	–0.42	–0.35	0.22	0.15	0.61	0.61	–0.36	–0.36	0.04	–0.07	–0.17	–0.35	–0.28	0.19	0.48	1	–0.14
Su	0.19	0.19	–0.46	–0.64	0.07	–0.28	0.24	0.23	–0.13	–0.13	–0.03	–0.05	0.15	0.17	0.49	–0.08	0.11	–0.14	1

**Significant at 5% levels; P_1, bud break to full bloom; P_2, full bloom to fruit maturity; P_3, bud break to fruit maturity; m t, maximum temperature; mi t, minimum temperature; m h, maximum relative humidity; mi h, minimum relative humidity; Pv, plant volume; Seg, shoot extension growth; Fd, fruit diameter; Fw, fruit weight; TSS, total soluble solids; Ac, acid content; Su, sugars

Table 2 Correlation between climatic factors and growth and quality of peach cv. Early Grande during 2011

	P_1mt	P_1mit	P_2mt	P_2mit	P_3mt	P_3mit	P_1mh	P_1mih	P_2mh	P_2mih	P_3mh	P_3mih	Pv	Seg	Fd	Fw	TSS	Ac	Su
P_1mt	1	0.97	–0.33	–0.16	0.76	0.66	0.88	0.54	–0.61	–0.51	–0.38	–0.61	0.61**	0.39	0.60**	–0.05	0.48	0.62**	–0.31
P_1mi t	0.97	1	–0.18	0.00	0.83	0.77	0.85	0.51	–0.62	–0.54	–0.54	–0.73	0.73**	0.53**	0.62**	–0.27	0.37	0.53**	–0.49
P_2mt	–0.33	–0.18	1	0.97	0.30	0.43	–0.29	–0.48	0.05	–0.08	–0.61	–0.46	0.25	0.26	0.13	–0.54	–0.16	–0.55**	–0.55**
P_2mi t	–0.16	0.00	0.97	1	0.48	0.61	–0.14	–0.36	–0.12	–0.22	–0.73	–0.60	0.40	0.32	0.18	–0.64**	–0.17	–0.43	–0.72**
P_3mt	0.76	0.83	0.30	0.48	1	0.98	0.68	0.21	–0.64	–0.61	–0.76	–0.88	0.76**	0.43	0.64**	–0.44	0.31	0.27	–0.77**
P_3mit	0.66	0.77	0.43	0.61	0.98	1	0.58	0.16	–0.61	–0.59	–0.86	–0.92	0.80**	0.52**	0.59**	–0.61**	0.17	0.17	–0.87**
P_1mh	0.88	0.85	–0.29	–0.14	0.68	0.58	1	0.14	–0.85	–0.81	–0.30	–0.51	0.60**	0.35	0.61**	0.03	0.65**	0.73**	–0.29
P_1mih	0.54	0.51	–0.48	–0.36	0.21	0.16	0.14	1	0.18	0.35	0.01	–0.10	0.15	0.12	0.01	–0.03	–0.15	0.16	0.03
P_2mh	–0.61	–0.62	0.05	–0.12	–0.64	–0.61	–0.85	0.18	1	0.98	0.42	0.51	–0.53**	–0.26	–0.44	0.17	–0.42	–0.63**	0.51**
P_2mih	–0.51	–0.54	–0.08	–0.22	–0.61	–0.59	–0.81	0.35	0.98	1	0.44	0.51	–0.54**	–0.28	–0.48	0.18	–0.47	–0.55**	0.52**
P_3mh	–0.38	–0.54	–0.61	–0.73	–0.76	–0.86	–0.30	0.01	0.42	0.44	1	0.95	–0.62**	–0.63**	–0.49	0.74**	0.07	0.04	0.84**
P_3mih	–0.61	–0.73	–0.46	–0.60	–0.88	–0.92	–0.51	–0.10	0.51	0.51	0.95	1	–0.70**	–0.62**	–0.64**	0.59**	–0.14	–0.12	0.79**
Pv	0.61	0.73	0.25	0.40	0.76	0.80	0.60	0.15	–0.53	–0.54	–0.62	–0.70	1	0.73	0.39	–0.60	0.17	0.26	–0.70
Seg	0.39	0.53	0.26	0.32	0.43	0.52	0.35	0.12	–0.26	–0.28	–0.63	–0.62	0.73	1	0.25	–0.51	0.05	0.08	–0.44
Fd	0.60	0.62	0.13	0.18	0.64	0.59	0.61	0.01	–0.44	–0.48	–0.49	–0.64	0.39	0.25	1	–0.15	0.63	0.32	–0.42
Fw	–0.05	–0.27	–0.54	–0.64	–0.44	–0.61	0.03	–0.03	0.17	0.18	0.74	0.59	–0.60	–0.51	–0.15	1	0.49	0.20	0.85
TSS	0.48	0.37	–0.16	–0.17	0.31	0.17	0.65	–0.15	–0.42	–0.47	0.07	–0.14	0.17	0.05	0.63	0.49	1	0.47	0.14
Ac	0.62	0.53	–0.55	–0.43	0.27	0.17	0.73	0.16	–0.63	–0.55	0.04	–0.12	0.26	0.08	0.32	0.20	0.47	1	–0.07
Su	–0.31	–0.49	–0.55	–0.72	–0.77	–0.87	–0.29	0.03	0.51	0.52	0.84	0.79	–0.70	–0.44	–0.42	0.85	0.14	–0.07	1

Significant at 5% levels; P_1, bud break to full bloom; P_2, full bloom to fruit maturity; P_3, bud break to fruit maturity; m t, maximum temperature; mi t, minimum temperature; m h, maximum relative humidity; mi h, minimum relative humidity; Pv, plant volume; Seg, shoot extension growth; Fd, fruit diameter; Fw, fruit weight; TSS, total soluble solids; Ac, acid content; Su, sugars and –0.62) negatively influenced the shoot extension growth of Early Grande. Similarly, JingPing *et al*. (2005) stated that relative humidity had negative effects on branch length. Li *et al*. (2010) also reported that sweet cherry trees grew more vigorous in subtropical monsoon climate zone, but flower bud differentiation was delayed by high temperature and shoot growth was shorter than the plant grown in temperate climate zone due to the overgrowth caused by the high temperature.

Fruit diameter of Early Grande peach was negatively influenced by maximum and minimum temperature at P_1 stage (r = –0.62** and –0.63**) and minimum temperature at P_3 stage (r = –0.77**), decreased fruit size might be due to poor supply of resources to support the potential fruit growth rates associated with high rates of phenological development (Lopez *et al*. 2007), whereas maximum and minimum relative humidity at P_2 stage (r = 0.62** and 0.63**) and minimum relative humidity at P_3 stage (r = 0.58**) positively favoured fruit diameter during first year of study. However, maximum and minimum temperature at P_1 and P_3 stage (r = 0.60**, 0.62** and r = 0.64**, 0.59**) positively influenced diameter during second year, because low temperature during spring was an optimum factor for photosynthesis and affected fruit development resulting in high fruit size. While fruit diameter was positively related to maximum relative humidity at P_1 stage (r = 0.61**), similarly, JingPing *et al*. (2005) also reported that highest air temperature and relative humidity had positive relationship with the fruit size of guava, but minimum relative humidity at P_3 stage (r = –0.64**) exerted negative impact on fruit diameter of peach cv. Early Grande. Temperature did not show any significant relation with fruit weight of Early Grande peach, while maximum and minimum relative humidity at P_2 and P_3 stage (r = 0.52**, 0.51** and 0.80**, 0.74**) positively favoured the fruit weight during first year. During second year, fruit weight of Early Grande was negatively influenced by minimum temperature at P_2 and P_3 stage (r = –0.64** and –0.61**), however, maximum and minimum relative humidity at P_3 stage (r = 0.74** and 0.59**) exerted positive impact on fruit weight of Early Grande. Higher fruit weight could be due to the transport of water into fruits by root pressure, stimulated by high humidity at night (Bradfield and Guttridge 1984).

Total soluble solids content in fruits of Early Grande were positively favoured by maximum and minimum temperature at P_1 stage (r = 0.65** and 0.63**) and negatively affected by maximum temperature at P_2 stage (r = –0.63**). TSS content in fruits of Early Grande was positively related with maximum relative humidity at P_1 stage (r = 0.61**), while maximum and minimum relative humidity at P_2 stage (r = –0.66** and –0.67**) exerted negative impact on TSS content of fruit during first year. TSS content of fruit was only influenced by maximum relative humidity at P_2 stage (r = 0.65**) during second year. The results are in accordance with Mowat *et al*. (1997) who reported higher soluble solids content in persimmon cv. Fuyu fruit in a warm-subtropical region of Australia. Temperature didn't influence the acid content in fruits at any phenological stage during first year, but maximum and minimum relative humidity at P_1 stage (r = 0.61** and 0.61**) positively favoured the acid content in fruits. However, maximum temperature at P_2 stage (r = –0.55**) exerted negative impact on acid content in fruit during second year, while maximum and minimum temperature at P_1 stage (r = 0.62** and 0.53**) positively favoured the acid content of fruit. The acid content in fruit was positively affected by maximum relative humidity at P_1 stage (r = 0.73**), whereas maximum and minimum relative humidity at P_2 stage (r = –0.63** and –0.55**) negatively influenced the acid content in the fruit during second year. Minimum temperature at P_2 stage (r = –0.64**) was the only factor, which had exerted negative impact on the sugar content in the fruit, whereas during second year maximum and minimum temperature at P_2 and P_3 stage (r = –0.55**, –0.72** and –0.77**, –0.87**) negatively affected the sugar content in fruit. However maximum and minimum relative humidity at P_2 and P_3 stages (r = 0.51**, 0.52** and 0.84**, 0.79**) exerted positive impact on sugar exerted positive impact on sugar content in the fruits.

On the basis of above study, it can be concluded that there was a strong relationship between climatic factors and vegetative growth of Early Grande cultivar of peach. Further, the climate of a particular region is a decisive factor to have quality fruit with marketable size.

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