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Studies on the Relationships between Climatic Elements and the Yield of Mango in Yuching Area[1]

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Abstract : Mango tends to produce embryo-aborted fruits when grown under unfavorable climatic conditions in Yuching area. This study was aimed to investigate the influence of climatic elements during the flowering period on the frequency of seedless fruits and yield performance of mango. Experiments were conducted in 1993 and 1994 at Yuching area with 8-year old 'Irwin' mango trees. The seed aborted fruit percentage was counted 60 days after flowering, and the total sugar content of mango pulp was determined by a refractometer at harvest. The climatic data were recorded from 10 days before to 30 days after flowering, and their relationship with seedless fruit formation and yield was analyzed. Early flowering in January and early February resulted in high rate of seed aborted fruits and yield reduction. The cummulative temperature showed a significant negative correlation with the seed aborted fruit percentage and total sugar content. The cummulative precipitation showed a significant positive correlation whit both yield and total sugar content. The cummulative temperature and precipitation during the period of 30 days after flowing was more influential than those during the 10-day period before flowering in affecting the fruit characteristics.

Key words : Mango (*Mangifera indica*), Seed aborted fruit, Climatic elements.

INTRODUCTION

Mango (*Mangifera indica* L.) is a fruit crop of tropical origin. The cultivation area of mango in Taiwan totaled at 20,115 ha in 1992[(1)]. It is not uncommon that the yield of mango is unstable across years and locations which results in problems of the economic production of this important crop. The causes of yield instability are abundant fruiting in alternate years only[(3)] and the frequent occurrence of embryo-aborted fruits[(4)]. Mango trees grown in Yuching, located in the southern part of Taiwan and the main mango production area, produce many nubbins which lowers fruit yield to a very great extent[(4)]. Anatomical

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studies indicated that most of the nubbins were seedless fruits which abscised well in advance of harvestable maturity. Unfavorable the germination of pollens on the stigma could be impaired by low temperature[1], climatic conditions have been suggested as the main causes of nubbin occurrence.). Singh et al.[7] also reported that temperature alone was the most important single in affecting the growth of mango. Heavy rainfall was another deteriorating factor which lowers the fertilization function of the pollens[6]. Therefore, temperature and precipitaiton are the two major climatic elements affecting the percentage of seedless fruits as well as the yield of mango.

In view of this, experiments were conducted by this laboratory to investigate the possible influlence of climatic conditions during the 40-day period before and after flowering on the occurrence frequency of nubbins, and the yield and total sugar content of the mango fruits. Climatic elements of concern included cumulative temperature, sunshine hours, and precipitation. By understanding the relationship between these climatic elements and the fruiting characteristics, it is hoped that improvement measures could be recommended to reduce the yield loss caused by unfavorable climatic conditions.

MATERIALS AND METHODS

Experiments were conducted at the northern slope direction of Yuching area with an elevation of 110m. Eight-year old 'Irwin' mango cultivated at a planting density of 500 plants per ha was used as material. During the flowering period (January to April) in both 1993 and 1994, flowers were tagged at the day of blooming and the occurrence frequency of seed aborted fruits was measured 60 days later. At least 6 plants were investigated for each flowering-date sampling. Fruit yield was recorded during the harvest season in July or August. The climatic data on temperature, sunshine duration, and precipitation were recorded from 10 days before to 30 days after flowering. Their relationships to the percentage of seed aborted fruit formation, and yield and total sugar content of the fruit were analyzed.

The seed aborted fruits were distinguished from the seeded ones by visual examination and dimension measurements. The average fresh weight, length, and diameter of the normal fruits in this experiment were, respectively, 200g, 12cm, and 8.5cm. The respective values for seedaborted fruits were 40g, 5.5cm, and 4.5cm (Fig. 1). The fresh weight, length, and diameter of the stone (seed) of normal fruits were, respectively, 9.0g, 9.5cm, and 4.7cm. Those for the seed aborted fruits were 0.7g, 3.8cm, and 2.2cm (Fig. 2). Total sugar content of the mango pulp was determined by a refractometer.



Fig. 1. One seeded (left) and Two seed aborted (middle and right) fruits of Irwin mango at 80 DAF.



Fig. 2. Stones (seeds) taken from seeded (right) and seed aborted (left) Irwin mango fruits.

RESULTS AND DISCUSSION

The changes in climatic elements of 1993 and 1994 were illustrated in Fig. 3. Similar pattern of temperature change was observed between the two years. The temperature was low in early January, or initial flowering stage of mango, and increased gradually towards early April, or the end of flowering stage, and reached the maximum in July and August, or the harvest period. The minimum, maximum, and mean temperatures in early January were 14.4, 25.9, and 19.1°C respectively. The values in late April were, in order, 18.5, 28.0, and 23.7°C. The temperatures were slightly higher than those recorded from previous years, but were still lower than the optimum temperature (23.9—26.7°C) for the growth of mango[5]. Low temperature during this period might be the main cause of the formation of seed aborted fruits[1]. The minimum, maximum, and mean temperatures in July were, respectively, 24.5, 33.0, and 28.0°C, which were lower than the high-temperature limits of 42.2—43.3°C as suggested by Singh[6]. The temperatures between May and July were therefore considered appropriate for fruit growth in general. Whether the low temperature in the winter season, e.g., a mean of 18°C in December, was unfavorable to the differentiation and development of flower buds remained to be clarified.

Sunshine duration and precipitation peaked in July and August in both years (Fig. 3). The monthly mean sunshine duration was 173—243 hrs and that of precipitation was 335—1,199 mm. Althouth heavy rainfall has been suggested harmful to the fertilization by pollens [1], the rather low precipitation recorded from January to April, or the entire flowering period of mango, suggested that there was no over-precipitation stress on the fertilization of flowers.

The flowering of mango trees concentrated from January to March in both years as shown in Table 1. The entire flowering period, from January 6 to April 6, was divided into 10 stages with a 10-day interval. The results of Table 1 indicated that during the period of 10 days before and 30 days after flowering, cumulative temperature was the lowermost in late January and early February, and increased continuously towards early April. The pattern of changes in cumulative sunshine duration during the same period was rather erratic and ranged from 210.8 to 288.2 hrs in 1993 and 200.8 to 279.3 hrs in 1994. The cumulative precipitation was low during the entire flowering period, and the maximum values were only 38.5 mm in 1993 and 60.3mm in 1994.

Early flowering (from early January to early February) tended to produce higher frequencies of seedless fruits (66.2—84.6% in 1993 and 56.9—78.1% in 1994) as compared to late flowering (31.3—40.8% in 1993 and 40.5—46.7% in 1994). There was a tendency that fruit yield per plant was higher for those flowering between late January and mid-March, which ranged between 20.4 to 25.8kg in 1993 and 20.5 to 26.8kg in 1994. Similar trend in total sugar content of harvestable fruits was also observed. Late flowering (late March to early April) also resulted in low fruit yield and total sugar content (Table 1).

Further analysis of the data in Table 1 revealed that cumulative temperature during the period of 10 days before and 30 days after flowering was negatively correlated with the

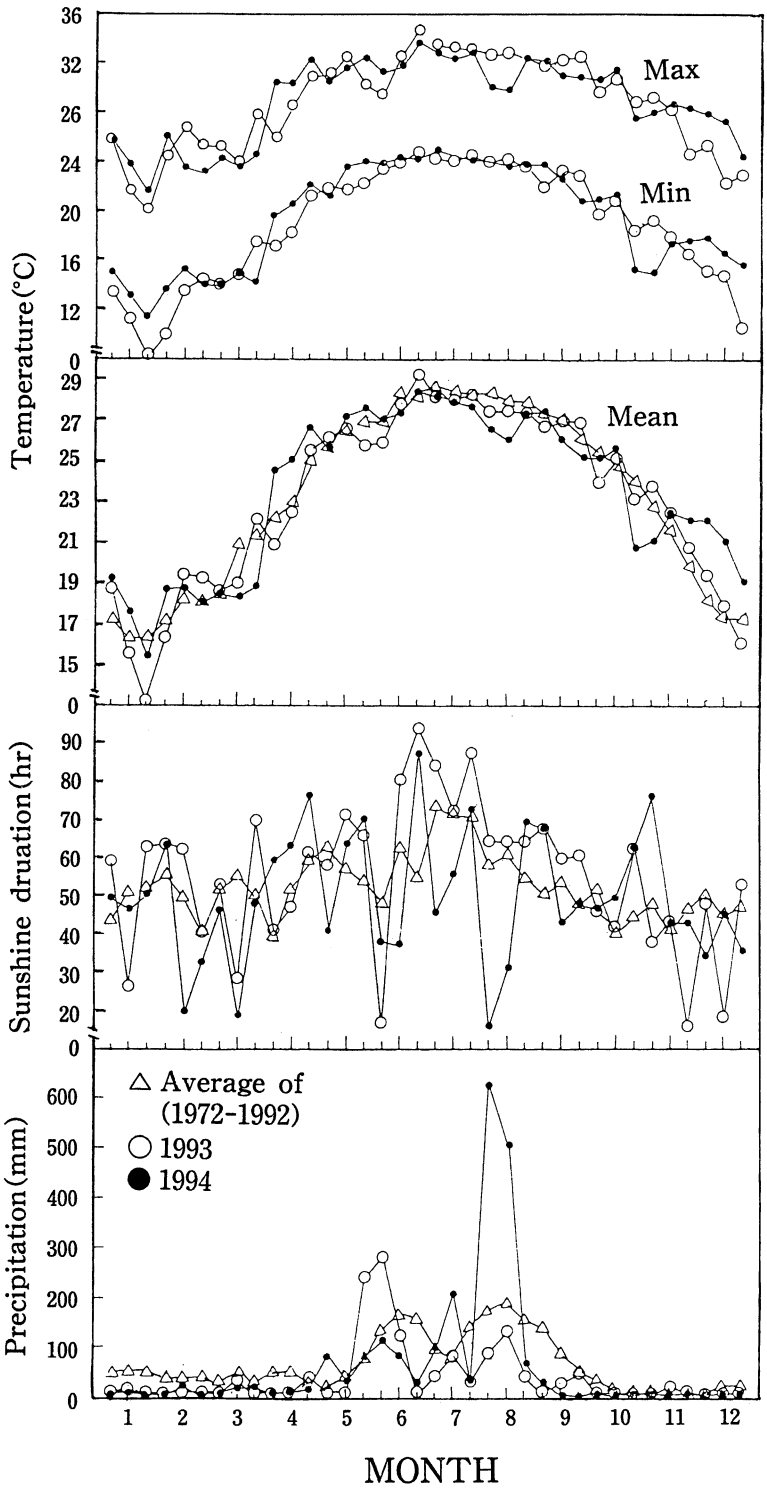


Fig. 3. Ten-day mean air temperature, sunshine duration, and precipitation recorded at Yuching area from 1993 to 1994.

Table 1. Relationship between the climatic elements (cumualtive values of 10 days before and 30 days after flowering) and the percentage of seedless fruit and yields of mango in different flowering stages.

Flowering time	Cumulative Temperature(°C)		Cumulative Sunshine hours		Cumulative Precipitation (mm)		Seedless	Fruit yield	Total sugar
(month/day)	10 days before flowering	30 days after flowering	10 days before flowering	30 days after flowering	10 days before flowering	30 days after flowering	fruit (%)	(kg/plant)	(Brix)
1993									
1/06	178.3	602.1	53.6	186.1	6.6	2.6	66.2	17.3	15.2
1/16	144.3	622.4	49.4	178.5	2.6	4.9	71.7	22.3	16.0
1/26	140.2	604.0	50.3	161.2	1.5	2.5	84.6	18.5	15.4
2/05	130.1	623.7	61.2	27.5	1.1	2.1	77.6	20.4	15.8
2/15	148.2	632.2	57.8	181.5	1.0	3.6	40.8	22.8	16.1
2/25	193.6	637.3	50.4	160.4	3.3	23.5	42.5	23.6	16.3
3/07	189.3	661.4	53.6	219.4	6.2	32.3	37.3	25.8	16.5
3/17	215.5	630.1	51.3	149.4	2.7	13.5	38.9	23.2	16.0
3/27	270.0	620.2	67.5	220.7	1.1	1.7	31.3	19.6	14.2
4/06	264.2	623.6	74.1	214.1	0.4	0.8	35.6	16.2	13.1
1994									
1/06	192.0	580.2	48.3	169.2	3.1	3.7	58.4	16.3	14.7
1/16	156.2	618.8	44.6	156.2	2.6	5.8	56.9	19.9	15.4
1/26	119.9	620.6	44.3	176.0	1.1	1.5	78.1	20.5	15.7
2/05	110.6	635.8	61.2	191.8	2.8	25.1	66.4	23.8	16.3
2/15	121.5	639.3	64.3	210.5	9.4	50.9	46.7	26.8	16.4
2/25	124.1	634.6	62.9	204.6	10.3	22.4	50.1	25.8	15.7
3/07	126.2	640.5	69.9	206.4	10.8	27.6	44.4	26.5	16.7
3/17	182.4	626.0	63.4	188.4	11.1	12.0	41.6	23.1	14.8
3/27	227.1	609.4	59.5	170.6	6.0	6.3	40.5	20.5	14.5
4/06	247.1	633.7	71.8	207.5	5.3	2.8	41.7	18.8	13.4

percentage of seed aborted fruit ($r=-0.7747$, $P>0.001$) and total sugar content ($r=-0.6145$, $P>0.005$). Cumulative precipitation during the same period was positively correlated with fruit yield ($r=0.8025$, $P>0.0001$) and total sugar content ($r=0.6084$, $P>0.005$). No relationship was found between cumulative sunshine hours and the fruit characteristics. On the other hand, yield per plant was positively correlated with total sugar contents of the harvested fruits (data not shown).

Detailed correlation analysis indicated that the climatic elements in the 10 days before flowering exhibited no significant impacts on the fruit characteristics, as the correlations were all non-significant (Table 2). It is possible that the climatic conditions during this 10-day period for all flowering stages listed in Table 1 might be adequate or not severe enough in terms of affecting the fertilization and fruit setting of the crop. However, cumulative temperature during the 30-day period after flowering was negatively correlated with the percentage of seed aborted fruits and positively correlated with both fruit yield and total sugar content. As for cumulative precipitation during the 30-day period after flowering, it was positively correlated with only the fruit yield (Table 2). In other words, the cumulative temperature during the 30-day period after flowering was more important than that during the 10-day period before flowering in affecting the fruit characteristics. The results of this experiment were not in full agreement with the report of Hsu[2] who stated that cumulative temperature over 800°C during the period of 40 days after flowering was unfavorable to fruit setting of mango. It is suggested that since mango is a species of tropical origin, the fruit setting and development of this crop prefer higher temperature, or at least within the temperature scope recorded in this experiment.

Table 2. Correlation coefficient between climatic elements and the fruit characteristics of mango in 1993 and 1994.

Item	Cumulative temperature (°C)		Cumulative precipitation (mm)	
	10 days before flowering	30 days before flowering	10 days before flowering	30 days before flowering
Seed sborted fruit (%)	−0.46	−0.61*	−0.21	−0.36
Fruit yield (kg/ha)	0.34	0.67*	0.39	0.93**
Total sugar (Brix)	0.26	0.65*	−0.17	0.55

*,** significant at 0.05 and 0.01 levels, respectively.

The cumulative precipitation from flower bud stage to young fruit stage in both 1993 and 1994 was 300 mm less than the average from previous years. As precipitation was positively correlated with fruit yield, it is worth to irrigate the crop during the dry season. In 1995, farmers were recommended to perform irrigation with automatic sprayers. Its effects on fruit setting and development, as well as yield, will be determined during the coming harvest season.

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玉井地區氣象因素與檬果產量關係之研究[1]

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摘 要

檬果生長於不良的氣候環境裡會發生胚夭折之果實。本研究之目的在觀察氣象因素對於檬果產量與無子果發生率之影響。在玉井地區1993及1994年以 8 年生愛文檬果爲材料進行試驗。開花前10天至開花後30天記錄氣象資料，並分析氣象因素與無子果形成及產量之關係。由試驗結果得知，於元月及 2 月初之早期開花者出現高無子果率及產量減低。開花前10天至開花後30天之積算溫度、積算雨量與無子果率及收穫期果實總糖含量各呈現顯著性之正、負相關。而開花後30天比開花前10天之積算溫度或積算雨量對於果實特性（無子果率、產量及總糖含量）之影響程度較大。

關鍵詞：無子果、氣象因素。

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