Effects of Calcium, Boron and Sorbitol on Pollination and Fruit Set in Mango cv. Namdokmai

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Keywords: boron, calcium, fruit set, mango, pollination, sorbitol

Abstract

The effects of calcium, boron and sorbitol on pollen germination in vitro, pollen tube growth on stigma and fruit set in mango cv. Namdokmai were investigated. Both commercial and technical grades of calcium nitrate and boric acid were used in this study, while only purified sorbitol was employed. All chemicals were sprayed onto 5-cm long mango inflorescences. When 50% of the flowers had bloomed, pollen was collected for in vitro observations (Brewbaker and Kwack agar medium). Pollen tube growth on the stigma was examined by the aniline blue fluorescence method, every 6-hours for 48 hours from 6 hours after hand pollination. Fruit set was examined every 3 days for 45 days after full bloom. The results showed that the applied chemicals had no effect on pollen germination or pollen tube growth. The percentage of pollen germination in all treatments was 44.52% to 54.16%, and pollen tubes took 24 to 30 hours to reach the stigma ends. Although, calcium, boron and sorbitol did not influence pollen germination and tube growth, they did induce more fruit set in this mango cultivar. Therefore, it is anticipated that these chemicals may exert other effects on the fruitset.

INTRODUCTION

Thailand is a country where the climate is suitable for cultivation of many varieties of tropical fruit trees. Mango (*Mangifera indica* L.) is one of the most important economic fruit crops. The total area planted to mango increased from 306,353 to 323,246 ha from 1993 to 1997 (Arthachinta, 1999). Most of the crop is sold as fresh fruit in the domestic market and the rest is exported as fresh and canned mangoes. From November to February, the weather in Thailand is cool, which induces flower bud differentiation. As a consequence, mango trees produce an abundance of flowers, which in some years results in good fruit set. As a result, the price of fruit is low during this period. Therefore, most growers prefer early and off-season fruit production.

To achieve early fruit production, mango must be forced to flower in September to October, which is during the rainy season. Pollination in this period is very poor, resulting in low fruit set. Hence, it is necessary to establish methods for improving pollination in mango in this season.

Brewbaker and Kwack (1964) reported that calcium and boron induced pollen germination in vitro. Also, calcium and boron have been found to induce best germination and fruit set in mango flowering in season (Jutamanee et al., 1998). The essential function of calcium was that it impaired membrane stabilization (Mengel and Kirkby, 1997). Boron deficiency resulted in low pollen viability, poor pollen germination and reduced pollen tube growth (Nyomora and Brown, 1997). Carbohydrate also plays an essential role in pollen tube growth. Deficiency in carbohydrate metabolism in the anther leads to abnormal pollen development in many plants (Bhadula and Sawhnev, 1989). Sorbitol is a carbohydrate that can be transported in many plants (Taiz and Zeiger, 1991). Boron is required for stigma receptivity and pollen tube extension by formation of boron-sorbitol complex that promotes absorption, translocation and metabolism of sugar in pollen and synthesis of pectin material for the cell wall of growing pollen tube (Nyomora and Brown, 1997; Vasil, 1964). When inflorescence growth is rapid, the flowers are unable to uptake adequate calcium and boron from the soil. Therefore, direct spray of these nutrients onto the inflorescences is practiced to help the plant obtain sufficient calcium and boron (Callan et al., 1978; Hanson, 1991).

The objective of this experiment was to study the effects of calcium, boron and sorbitol on pollination and fruit set in mango during the early flowering period, which occurs during the wet season.

MATERIALS AND METHODS

Two-year old mango trees cv. Namdokmai on Khaew rootstocks grown in 15-inch plastic pots with a canopy diameter of 1 m were used. Application of paclobutrazol and thiourea to induce early flowering in late September 1998 was used after Nartvaranant et al. (1999b). When the inflorescences reached about 5 cm in length, the commercial and technical grades of calcium nitrate and boric acid and fine sorbitol treatments were applied. Whole trees were sprayed until run off. One control treatment and six different combinations of calcium, boron and sorbitol as follows were tested.

1. Control (No chemical treatment)
2. Commercially prepared mixture of calcium nitrate (Ca 0.06%), boric acid (B 0.02%).
3. Commercially prepared mixture of calcium nitrate (Ca 0.06%), boric acid (B 0.02%) and 20% fine sorbitol.
4. Commercially prepared mixture of calcium nitrate (Ca 0.06%), boric acid (B 0.02%) and 40% fine sorbitol.
5. Laboratory mixture of calcium nitrate (Ca 0.06%) and boric acid (B 0.02%)
6. Laboratory mixture of calcium nitrate (Ca 0.06%), boric acid (B 0.02%) and sorbitol (20%).
7. Laboratory mixture of calcium nitrate (Ca 0.06%), boric acid (B 0.02%) and sorbitol (40%).

Each treatment was applied to 5 trees. One tree was used as one replication. When 50% of the flowers on the inflorescence bloomed, both male and hermaphrodite flowers were collected to examine pollen germination. However, growth of the pollen tube of hermaphrodite only was studied in vivo. Fruit set was observed after the flowers fully bloomed until fruits were 45 days old.

Pollen Germination

Germination of fifteen hermaphrodite and fifteen male flowers from each plant were examined. Pollen grains were germinated on modified Brewbaker and Kwacks with 30% sucrose at 25 °C, and their germination was determined after 6-hour incubation. Pollen that produced a germination tube longer in length than the diameter of the grain was considered germinated.

Pollen Tube Growth

When 50% of the flowers in the inflorescence bloomed, 24 hermaphrodite flowers from each plant were hand-pollinated with the pollen from male flowers on the same inflorescence. The pollinated flowers were then covered with plastic bags and sampled every 6 hours for 48 hours to study the in vivo pollen tube growth. The method for studying pollen tube growth through the style was that after Shivanna and Rangaswamy (1992) and is as follows. Pistils were excised, softened with 4N NaOH and stained with 0.1% decolorized aniline blue in order to see the callose deposits in the pollen tubes under fluorescence microscope. The length of pollen tubes that grew to the end of the style were calculated as percent of pollen tube length.

Fruit Setting

The healthiest inflorescence from each tree in each treatment was selected for the study of fruit setting. After full bloom, 30 hand-pollinated flowers from each inflorescence were marked. The selected inflorescences were covered with nylon net sac. The number of fruits per inflorescence was counted as fruit retention for 45 days.

Temperature and Relative Humidity Records

The average temperature and relative humidity recorded at the growing sites were 26.0 °C and 78%, respectively. The maximum temperature and relative humidity were 34.1 °C and 98%, whereas the minimum temperature and relative humidity were 23.7 °C and 57%, respectively.

RESULTS

Pollen Germination

Pollen germination in vitro for all treatments was found to be 44.52% - 54.16%. The mixture of calcium, boron and sorbitol slightly increased pollen germination, however this was not statistically significant (Fig. 1).

Pollen Tube Growth

Six and twelve hours after hand-pollination, pollen tube growth of mixed chemical treated flowers grew longer than non-treated ones (Table 1). However, by 24 hours, all pollen tubes of treated flowers reached the end of the style and by 36 hours all pollen tubes, including non-treated ones, reached the end of style.

Fruit Set

Table 2 shows that during 6 to 30 days after hand-pollination, the number of fruit set in all chemical treated trees was higher than that in non-treated ones. Furthermore, the best fruit set was obtained in trees treated with calcium-boron plus 40% sorbitol. However, 45 days after pollination, low fruit set was recorded in all treatments (data not shown).

DISCUSSION

The rates of in vitro pollen germination of early flowering mango were slightly higher than those of in-season flowering in the same cultivar (Jutamanee et al., 1999). Calcium and boron did not increase in vitro pollen germination, while calcium-boron with sorbitol induced pollen germination slightly, however not significantly. The data also showed that both commercially-prepared and laboratory-made mixtures of calcium and boron with 20 and 40% sorbitol enhanced pollen tube growth during the first 6 - 12 hours (Table 1). However, when examined at 24 hours, most pollen tubes reached the end of the style and after 36 hours pollen tubes in all treatments reached the end of style.

The data clearly showed that all chemical treatments increased fruit setting during the first 30 days, especially when calcium-boron with high concentration of sorbitol was applied (Fig. 2). Although pollination has been known to have a limiting effect on fruit set, these results indicate other factors may be influencing fruit set. In all treatments the pollen tubes reached the end of the style by 24 hours, however, in the chemically treated trees fruit set was better. The reason for this might be that boron and sorbitol enhanced the accumulation of carbohydrate in the flowering shoots and the carbohydrate was then utilized for the fruit set. The thinning of inflorescences in the cultivar Nam Dok Mai, also increased carbohydrate content resulting in the increase of fruit retention (Nartvaranant et al., 1999a). In addition, Isarangkool Na Ayutthaya (2000) showed that application of boron during flowering increased the carbohydrate content in shoots and fruit set of this cultivar. In this experiment, it was also observed that fruit set was low 30 days after full bloom. This may be party explained by the fact that calcium-boron with sorbitol were sprayed only once, while commercial growers always apply sorbitol weekly from full

Tables

Table 1. Effects of calcium, boron and sorbitol on pollen tube length in the style of stigma.

Treatment	Percent of pollen tube length at 6 hourly intervals (%)					
	6 h	12 h	18 h	24 h	30 h	36 h
Control	42.82 b[1]	64.92 y	78.84	92.00	95.00	100.00
Commercial Ca-B	66.54 ab	67.61 y	93.33	100.00	100.00	100.00
Commercial Ca-B+ 20% Sorbitol	72.00 a	87.44 x	95.00	100.00	100.00	100.00
Commercial Ca-B+ 40% Sorbitol	74.88 a	90.00 x	92.50	100.00	100.00	100.00
Lab. made Ca-B	52.41 b	61.91 y	93.33	100.00	100.00	100.00
Lab. made Ca-B+ 20% Sorbitol	78.31 a	92.50 x	100.00	100.00	100.00	100.00
Lab. made Ca-B + 40% Sorbitol	79.04 a	88.33 x	90.00	100.00	100.00	100.00

[1] Mean within the same parameter followed by similar letter are not significantly different at the 5% level according to Duncan*s Multiple Range Test

Table 2. Effects of calcium, boron and sorbitol on fruit set in mango cv. Nam Dok Mai.

Treatment	Percent of fruit set after full bloom (%)											
	6d	9d	12d	15d	18d	21d	24d	27d	30d	35d	40d	45d
Control	59.8	21.8	13.4	7.2	4.6	3.4	2.6	2.0	1.8	1.4	0.8	0.6
Commercial Ca-B	58.6	30.8	21.6	14.0	9.6	6.8	5.2	3.8	3.2	2.4	1.4	1.0
Commercial Ca-B + 20% Sorbitol	64.0	30.0	22.8	15.2	11.0	8.4	7.0	5.8	4.8	2.6	1:8	1.4
Commercial Ca-B + 40% Sorbitol	60.0	29.2	22.0	12.2	8.6	7.2	6.8	5.8	4.2	2.8	1.8	1.4
Lab. made Ca-B	52.2	28.0	20.8	12.8	8.0	6.8	5.2	4.6	3.6	2.6	1.6	1.2
Lab. made Ca-B + 20% Sorbitol	58.6	31.4	23.8	16.2	12.8	10.0	8.2	6.6	5.2	3.6	2.4	1.2
Lab. made Ca-B + 40% Sorbitol	55.0	31.4	22.6	15.6	12.6	9.0	6.2	5.2	3.6	2.8	2.4	2.0

Figures

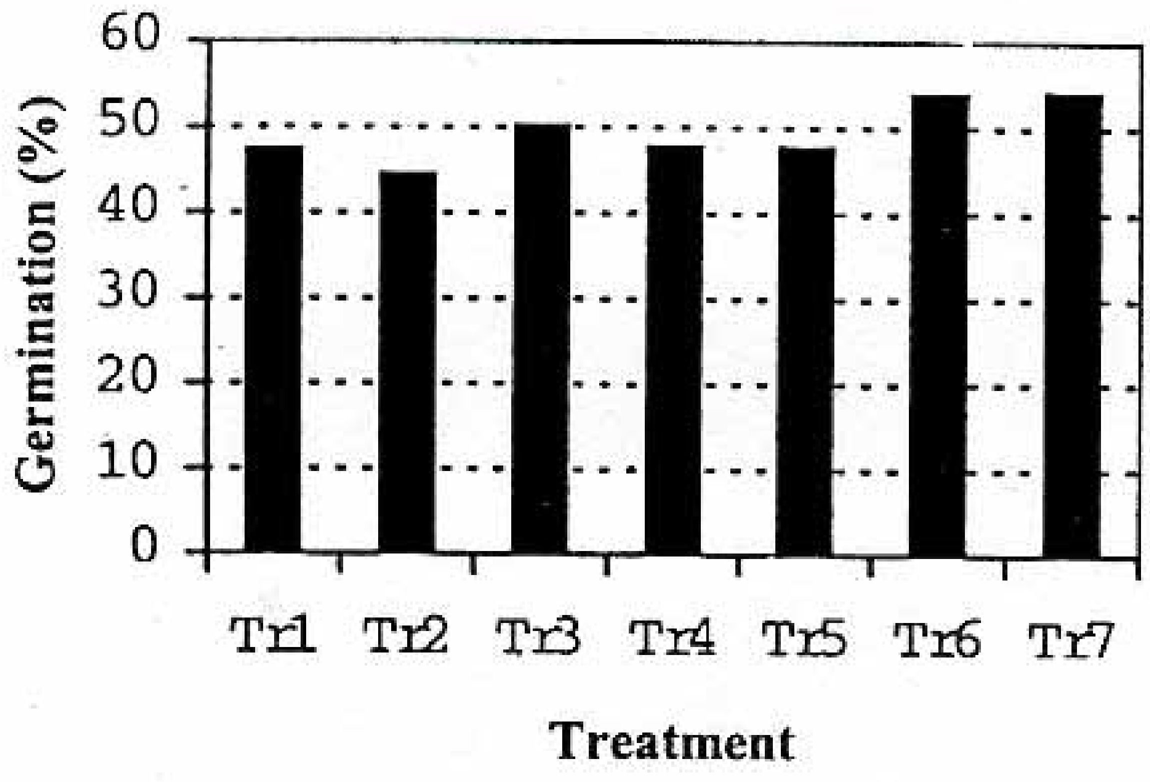

Fig. 1. Effects of calcium, boron and sorbitol on pollen germination in mango cv. Nam Dok Mai (Tr1 = control, Tr2 = commercial Ca-B, Tr3 = commercial Ca-B + 20% sorbitol, Tr4 = commercial Ca-B + 40% sorbitol, Tr5 = laboratory made Ca+B, Tr6 = lab. made Ca-B + 20% sorbitol, Tr7 = laboratory made Ca-B + 40% sorbitol).

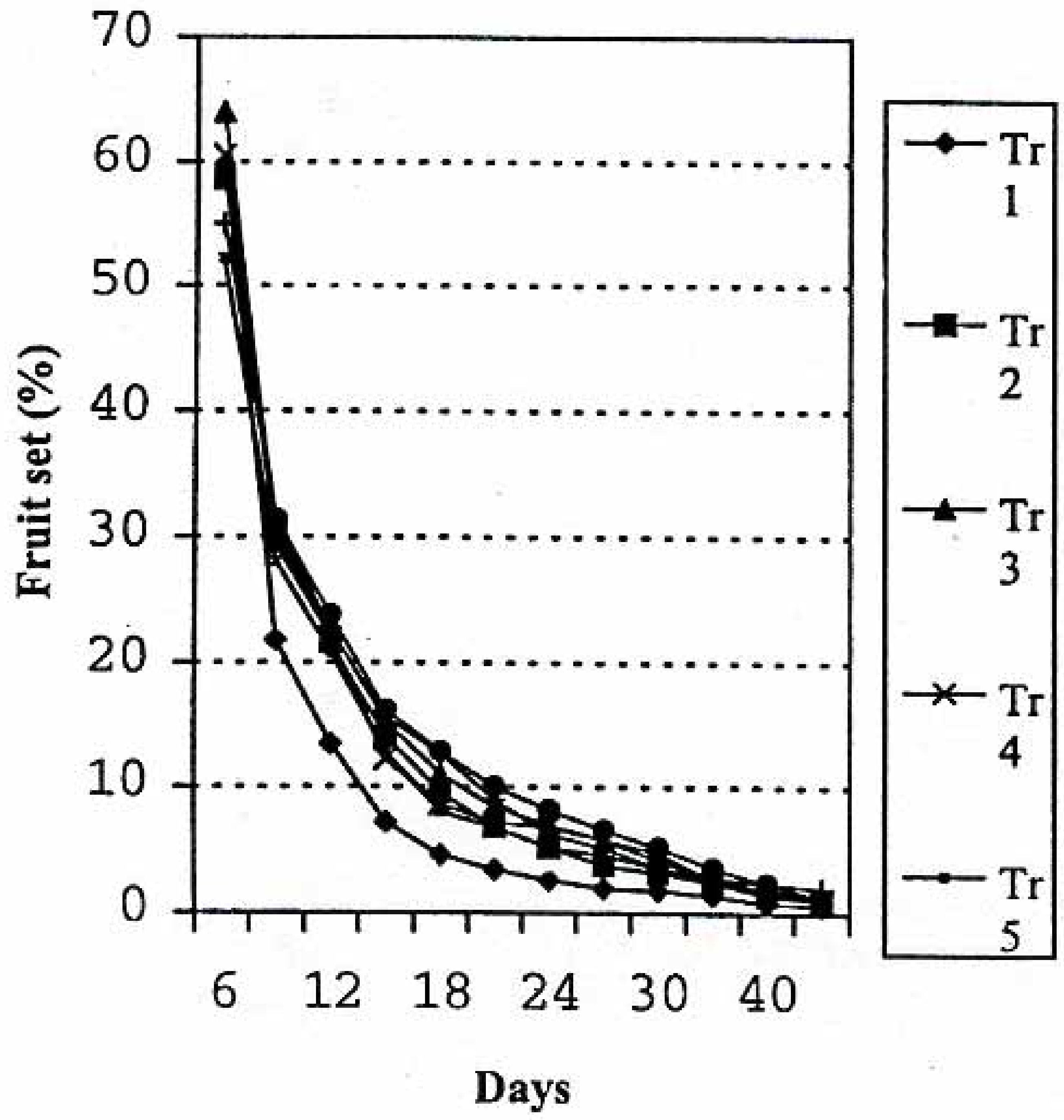

Fig. 2. Effects of calcium, boron and sorbitol on fruit set in mango cv. Nam Dok Mai. (Tr1 = control, Tr2 = commercial Ca-B, Tr3 = commercial Ca-B + 20% sorbitol Tr4 = commercial Ca-B + 40% sorbitol, Tr5 = laboratory made Ca+B, Tr6 = laboratory made Ca-B + 20% sorbitol, Tr7 = lab. made Ca-B + 40% sorbitol).

bloom to fruit maturity (40 days) to increase fruit retention.

CONCLUSIONS

1. Calcium, boron and sorbitol treatments had no effect on increasing pollen germination and pollen tube growth on stigma.
2. Calcium, boron and sorbitol treatments enhanced early fruit set.

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INCREASING FRUIT SET IN 'KHIEW SAWOEY' MANGO BY POLLINATION WITH OTHERS STAMEN.

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Keywords: pollination, pollen tube growth, fruit set, mango

Abstract

Fruit set in a commercial mango cultivar Khiew Sawoey was very low. The objective of this experiment was to propose method for increasing fruit set in this cultivar by pollination with others stamen. Pollens from cultivars Choke Anan and Mun Duen Kao were used for cross pollination. It was found cross pollination induced higher fruit set than self pollination. Cross pollination also gave the faster germination than self pollination and the pollen tubes of Choke Anan and Mun Duen Kao reached an ovule within 24 and 36 hours respectively. Self pollination was the slowest germination and it's tube reached an ovule within 42 hours. It was concluded that Khiew Sawoey mango need cross pollination for better pollen tube penetration, elongation and finally to complete fruit set.

INTRODUCTION

Thailand is a country where the origination of many cultivars of mango was appeared. Among these cultivars, Khiew Sawoey mango show the best favorite fruit but the fruit set is still poor. Fruit set in mango was successful by pollination and fertilization. Jutamanee (1999) found that low fruit set in Khiew Sawoey mango due to low pollen germination. Increasing fruit set in fruit crop by pollination using other cultivar pollens were achieved in many crop fruit such as durian () and .....

The objective of this study was to improve fruit set in Khiew Sawoey by cross pollination with other pollens that expressed strong fruit set behavior. We hypothesis that pollens from Choke Anan and Mun Duen Kao, the strong fruit set cultivars, would increase pollen tube growth and cause better fruit set in Khiew Sawoey mango.

MATERIALS AND METHODS

Two years old mango tree cv. Khiew Sawoey cultivated in 15 inch pots were employed. Emasculations were done before anther dehiscent when the plants were flowering. Choke Anan and Mun Duen Kao were used as difference pollens source and were hand pollinated on Khiew Sawoey stigma. Then, the pollinated flowers were covered with plastic bags and collected every 6 hour interval for altogether 48 hours for studying *in vivo* pollen tube growth under fluorescence microscope (Shivanna and Rangaswamy, 1992). The lengths of pollen tubes that grew to the end of the style were calculated as percent of pollen tube length. For fruit setting examine, hand-pollinated flowers by Choke Anan and Mun Duen Kao were marked. The number of fruits per inflorescence was counted as fruit retention for 15 days.

RESULTS AND DISCUSSION

The pollen tubes of Mun Duen Kao and Choke Anan reached the end of Khiew Sawoey style within 24 and 36 hours respectively while self pollination gave the slowest germination and it's tube reached an ovule within 42 hours. Cross pollination also induced higher fruit set than self pollination. Cross pollination by Choke Anan and Mun Duen Kao gave 44.00% and 36.00% fruit set at 15 day after pollination while only 13.33% was found in self pollination. The 42 hours pollen tubes reached an ovule as observed in self pollination caused lost efficiency of an ovule in fertilization because effective of fertilization was extremely reduced one day after blooming (Davenport and Nunez-Elisea, 1997). This phenomenal may be the important reason of poor fruit set occurred by self pollination in Khiew Sawoey cultivar.

CONCLUSIONS

Self pollination caused poor fruit set in Khiew Sawoey mango by the slowest pollen tube growth rate. However, improvement fruit set in this cultivar was achieved by pollinated with other stamen with induced higher pollen tube growth rate than self pollination.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Thailand research fund for financial support.

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