ISSN: 2773-9376 (Print), 2773-9473 (Online)

JARST Journal of Applied Research on Science and Technology
Rajamangala University of Technology Thanyaburi

Effect of Paclobutrazol Concentrations and Foliar Application Times on Flowering of 'Mahachanok' Mango

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ARTICLE INFO

Article history:
Received: July 21, 2022
Revised: November 27, 2022
Accepted: November 29, 2022
Available online: December 26, 2022
DOI: 10.14456/jarst.2022.24

Keywords: flowering, foliar application, Mahachanok mango, paclobutrazol

ABSTRACT

Paclobutrazol (PBZ) is a growth regulator that has been widely used to stimulate mango flowering by soil drenching. This study aimed to investigate the suitable concentration of PBZ and the number of application times that can induce flowering by foliar application. The experimental design was Completely Randomized Design (CRD) with 10 treatments and 4 replications. 'Mahachanok' mango trees were used in this study. They received two and three PBZ foliar applications, applied at 15 days after pruning (DAP) with 1,000 2,000, 3,000 and 4,000 mg/L and repeated with PBZ 2,000 mg/L for the second time and third time at 30 and 45 DAP comparing to 2,000 mg/L of PBZ at 30 DAP and non-PBZ application as the control treatment. The results showed that PBZ foliar application stimulated earlier flowering and a higher percentage of flowering shoots than the control. The earliest flowering was presented when they got 1,000 mg/L at 15 days and repeated at 30 days with 2,000 mg/L of PBZ, flowered within 106.5 DAP and 72.5 % of new shoots flowering. Moreover, the length of mango panicles with PBZ treatments was significantly shorter than that of the control treatment. PBZ doses and the number of application times caused phytotoxic symptoms in vegetative shoots and inflorescences. However, there were found phytotoxic symptoms of shoots and panicles on the PBZ treatments at the rate of 2,000

ISSN: 2773-9376 (Print), 2773-9473 (Online)

mg/L and above, at the first foliar application (15 DAP). The phytotoxic symptoms on shoots and panicles occurred after mango trees received foliar application at 15 and 90 days, respectively.

INTRODUCTION

Mango is considered a commercially important tropical fruit crop in Thailand. The cultivation of mango trees is highly well-known among planters all across the country. This is because mangoes can be cultivated for a variety of consuming purposes. Various species of mangoes are grown for ripe fruit production, while others are used for fruit preservation and production, and they can be edible as fresh fruits like apple fruits. The annual production of mangoes plays an important role in the Thai economy. The well-known commercial cultivar is Mahachanok.

Mango flowering is a physiological process that starts fruit production [1] and it is the first of several events that set the stage for mango production each year. It also influences the quality and quantity of fruits [2]. Mango trees flower in response to the age of the last vegetative flush in tropical conditions. Synchronization of the vegetative tree canopies is a necessary first step in the flowering management program. Synchronization growth is best accomplished by tip pruning all of the stems on the tree [3]. The next step is to decide whether to use paclobutrazol (PBZ). PBZ has been used with considerable success to induce flowering in several fruit crops such as apple [4], pummelo [5], apricot [6] and mango [7]. PBZ inhibits gibberellin biosynthesis reduces vegetative growth and induces water-stress tolerance and increases total non-structural carbohydrates (TNC) [8]. PBZ has been widely marketed throughout the tropics to stimulate mango flowering. Soil application of PBZ has been found to be more responsive in regard to suppressing vegetative growth and enhancing the reproductive growth in mango [9]. Studies have shown that PBZ is needed to be applied annually to increase mango fruit yields [10]. In recent years, many reports showed that the application of PBZ by soil drenching produced an uneven distribution of the chemical throughout the plant, as noticed by the uneven size of the panicles in the lower versus the upper part of the tree. Overdose may cause undesirable effects such as stunting of flushes, panicle malformation, vegetative and root growth of mango was reduced [11]. In areas where PBZ is applied regularly, there may be a risk of environmental contamination due to its residues persisting in soil for a very long time [12]. In another experiment, but with the variety 'Namdokmai-sitong', the application was carried out 15 and 30 days after pruning with doses of 500, 1,000, 1,500 and 2,000 mg/L, which resulted in a decrease in vegetative growth and an improvement in the number of flowers and buds [7]. In this context, the objective of this work is to evaluate the effects of PBZ doses applied by foliar application and foliar application time on flowering of 'Mahachanok' mango.

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MATHERIALS AND METHODS

Experimental details

The experiment was carried out in the orchard of Tropical Fruit Research and Development Center, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom province, Thailand. Mango trees cv. Mahachanok aged 6 years were selected as samples. Tip pruning was used to stimulate new shoots from all the branches of the tree (Figure 1). PBZ application rate was 200 mL of PBZ per shoot. The trees were randomly selected, and their shoots were marked around the canopy of each tree. The trees were monitored for flowering after the foliar application of PBZ.

(a)

(b)

(c)

Figure 1 New flush at 15 days (a), 30 days (b) and 45 days (c) after pruning in ‘Mahachanok’ mango.

Experimental design and data analysis

This study employed the Completely Randomized Design (CRD) method. Ten shoots of a mango tree represented one replication. There were four replications with ten treatments conducted in this study, as shown in Table 1. The data were collected in terms of parameters, including the percentage of flowering shoots, the time duration from the stage of shoots pruning to the flower emergence stage, panicle length that was measured when 50% blooming, and phenological changes of shoots. The data were analyzed using analysis of variance, and the means were further calculated using Duncan’s New Multiple Range Test (DMRT) at $p \leq 0.05$.

Table 1 PBZ doses and the number of foliar application times in each treatment.

Treatment	PBZ (mg/L)		
	15 DAP	30 DAP	45 DAP
1 (control)	-	-	-
2	-	2,000	-
3	1,000	2,000	-

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Treatment	PBZ (mg/L)		
	15 DAP	30 DAP	45 DAP
4	2,000	2,000	-
5	3,000	2,000	-
6	4,000	2,000	-
7	1,000	2,000	2,000
8	2,000	2,000	2,000
9	3,000	2,000	2,000
10	4,000	2,000	2,000

RESULTS AND DISCUSSION

The study results showed that the foliar application of PBZ could induce a higher percentage of flowering shoots than the control trees. The mango trees received 1,000 mg/L at 15 days and the treatment was replicated at 30 days with 2,000 mg/L of PBZ. They obtained the highest percentage of flowering shoots of 72.5%. On the other hand, the control trees did not have any flowering shoots. Foliar application of PBZ could stimulate earlier flowering. There was a significant difference in time taken from shoot pruning to flower emergence of ‘Mahachanok’ mango. Trees treated with PBZ had a significantly earlier time to flowering than the control tree. Trees receiving 1,000 mg/L at 15 days and repeated at 30 days with 2,000 mg/L of PBZ had the earliest flowering at 106.5 days from shoot pruning (Table 2).

A significant difference was found on the length of panicles. The mango trees treated with PBZ had a significantly shorter panicle compared with the control. However, the higher concentration of PBZ gave a shorter panicle. Panicles from the trees receiving 2,000 mg/L of PBZ at 15 days and repeated at 30 days with 2,000 mg/L and repeated at 45 days with 2,000 mg/L of PBZ had the shortest panicle of 15.5 cm. The panicle length applied three times foliar application was shorter than that with twice times (Table 2). The acceptable panicle length was 30-35 cm.

The shoots receiving the PBZ application showed its effect by significantly decreasing the length of shoots and panicles (Table 2). In this study, the phytotoxic symptoms of shoots and panicles were found on the PBZ treatments at the rate of 2,000 mg/L and above at the first foliar application (15 DAP). The shoots receiving the PBZ at 4,000 mg/L at 15 DAP were stunted and panicle malformation was found (Figures 2 and 3). PBZ doses and the number of application times caused phytotoxic symptoms in vegetative shoots and inflorescence. The phytotoxic symptoms at shoots and panicles occurred after mango trees received foliar application for 15 and 90 days, respectively.

Pruning after harvest helped the emergence of floral buds, which gave rise to the new shoots. This produced more homogenous and strong buds for the next harvest. Subsequently, stems and shoots started to emerge at the same time [13]. PBZ, which is associated with climatic conditions and branch maturation, brings about conditions that are suitable for flowering. Furthermore, the combination of this product with nitrate sprays fosters floral initiation [3]. ‘Mahachanok’ mango trees are in the group of plants with intense vegetation capacity. Shoot tip pruning decreases the auxin synthesis at the apex of branches [14], causing the transport of assimilated cytokinin to the axillary buds of branches under flowering conditions, contributing to the formation of axillary inflorescences [15].

Table 2 Effect of PBZ on the percentage of flowering shoots, time to flowering and length of a panicle of 'Mahachanok' mango after foliar application of PBZ at a different rate.

Treatment	Flowering shoot (%)	Time to flowering (days)	Length of panicles (cm)
T1	0.00 g	172.75 a	42.13 a
T2	12.50 f	111.25 c	33.00 c
T3	72.50 a	106.50 d	37.75 b
T4	32.50 de	107.25 d	28.63 d
T5	37.50 cd	107.75 d	28.50 d
T6	55.00 b	107.50 d	16.28 f
T7	25.00 e	107.25 d	24.65 e
T8	45.00 bc	107.75 d	15.50 f
T9	40.00 cd	107.50 d	26.65 de
T10	7.50 fg	162.25 b	25.50 e
F-test	*	*	*
cv.(%)	22.28	1.26	4.81

Means in each column followed by the same letter (s) are not significantly different at the 5% level by DMRT.

* = significantly different at $p \leq 0.05$

In mango trees, PBZ is known as one of the widely used plant growth regulators. It is basically used to inhibit gibberellin synthesis, which subsequently induces the process of flowering and fruiting. As a consequence, the vegetative growth decreases, and reproductive organs and the yield potential increase. The stage of flowering is very significant since it is the first stage of attaining fruit. In the literature, a number of current studies have significantly indicated that the quantity of flowering contributes to yields, and the duration of time that flowers start growing is significantly influenced by the time of fruit maturity. It has been accepted that early flowering gives rise to early fruit maturity. However, Mango trees used as commercial varieties do not flower regularly each year. In general, flowering is also alternate, causing considerable variation in the time of fruit maturity. The induction of flowering will certainly guarantee higher yields and promising returns to the planter [16].

After PBZ is used with mango trees, the chemical is transported up through the shoots, and because of its anti-gibberellins properties, the synthesis of flowering inhibitors is blocked, which, subsequently, allowing the flower-promoting factors to work. In this study, the effectiveness of PBZ application was found in decreasing shoot length. This is because PBZ inhibits

ISSN: 2773-9376 (Print), 2773-9473 (Online)

gibberellin biosynthesis by preventing the step in the oxidation of ent-kaurene to ent-kaurenoic acid [17], inducing unelongated shoots, even though cell division still occurs. Triazole compounds are anti-gibberellic that could adjust the gibberellin levels in shoot buds. PBZ application could increase the number of flowering shoots because the vegetative growth is low, and the reserves in the tree are higher. Similar findings were also found in Silva *et al.*'s [18] study on mango cv. Kent. In 'Tommy Atkins' mango, triazole products foster a transformation from the vegetative phase to the flowering phase, a cultivar that is difficult to change the phases [3]. Similarly, resembled results are reported in apples [4]. Additionally, PBZ is also found that it could induce flowering in mango trees because vegetative growth was decreased. The involvement of gibberellin in mango was also reported by Yamashita *et al*. [19], who maintained that gibberellin acted as a flowering inhibitor. The use of PBZ could stimulate a higher percentage of flowering shoots than those of the control trees. The finding in this research was also supported by the study of Yeshitela *et al*. [8], who claimed that PBZ produced the highest number of flowers per panicle in mango trees. The trees that received PBZ of more than 2,000 mg/L by the foliar application were stunted, and panicle malformation was found, giving rise to the decrease in the physiological and biochemical characteristics of leaf tissues in terms of PBZ doses [20].

PBZ, a triazole derivative, has been effectively utilized to induce and manipulate flowering, fruiting and tree vigor in several perennial fruit crops. Nevertheless, the use of PBZ in mango is quite prevalent. Soil application of PBZ has been effective in promoting flowering and increasing yields in many fruit crops. However, conflicting reports on its impact on fruit quality parameters are observed. Apart from reducing gibberellin levels, PBZ increases cytokinin contents, root activities and C : N ratio, whereas its influence on nutrient uptake lacks consistency. In soil and water environments, PBZ has been described as an environmentally stable compound with a half-life of more than a year, under both aerobic and anaerobic conditions [21, 22]. However, the multiple foliar application of PBZ was effective in promoting uniform off-season flowering in mango trees, without detrimental side-effects on non-uniform growth retardation and flowering [23, 24].

(a) (b)

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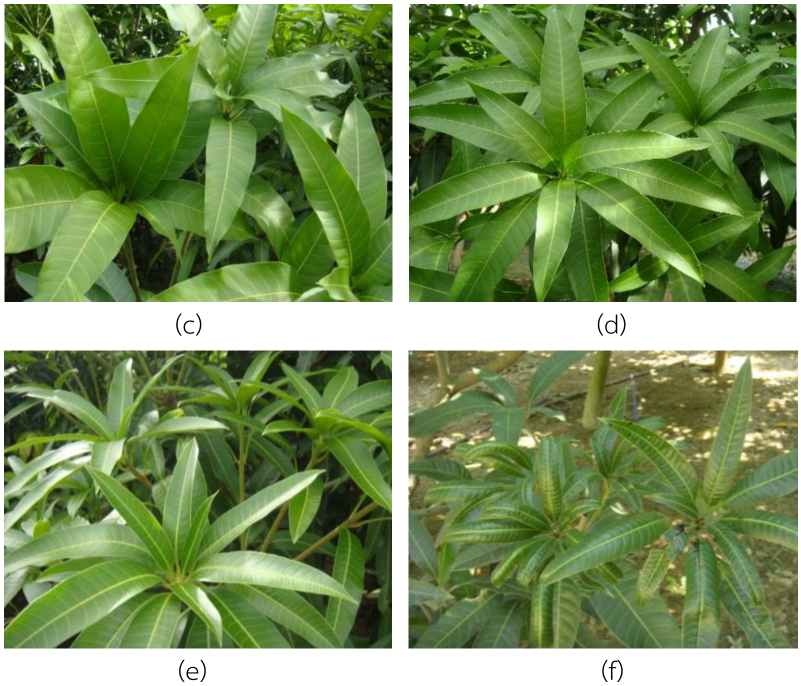
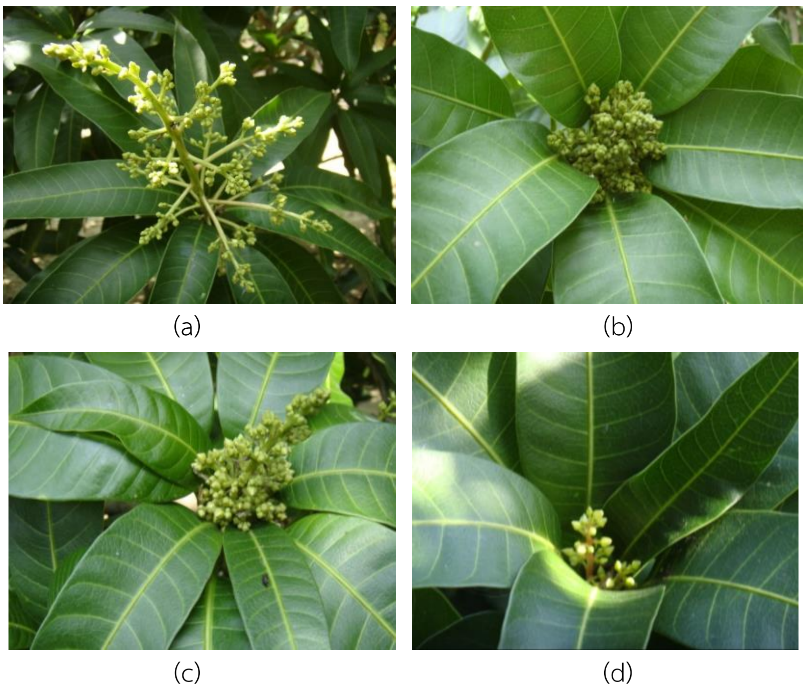


Figure 2 The normal 'Mahachanok' mango (a) and *p*hytotoxic symptoms of shoots after PBZ foliar application for 2,000 mg/L at 15, 30 and 45 DAP (b), 3,000 and 2,000 mg/L PBZ at 15 and 30 DAP, respectively (c), 3000 mg/L PBZ at 15 DAP and 2,000 mg/L PBZ at 30 and 45 DAP (d), 4,000 and 2,000 mg/L PBZ at 15 and 30 DAP, respectively (e), and 4,000 mg/L PBZ at 15 DAP and 2,000 mg/L PBZ at 30 DAP and 45 DAP (f)



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(e) (f)

Figure 3 The normal 'Mahachanok' mango (a) and phytotoxic symptoms of panicles after PBZ foliar application for 4,000 and 2,000 mg/L PBZ at 15 and 30 DAP, respectively (b), 2,000 mg/L PBZ at 15, 30 and 45 DAP (c), 2,000 mg/L PBZ at 15 and 30 DAP (d), 3,000 mg/L PBZ at 15 DAP and 2,000 mg/L PBZ at 30 DAP and 45 DAP, respectively (e), and 3,000 mg/L PBZ at 15 DAP and 2,000 mg/L PBZ at 30 DAP (f)

CONCLUSION

The PBZ applying as foliar application after pruning for mango trees cv. Mahachanok could induce earlier flowering, and it also increased the percentage of flowering shoots more than the non-sprayed trees. There was a significant difference in the time taken from shoot pruning to flower emergence of 'Mahachanok' mango. Trees with PBZ application have significantly affected faster flowering period than the non-sprayed trees. The earliest flowering was presented when they got 1,000 mg/L at 15 days and repeated at 30 days with 2,000 mg/L of PBZ. Moreover, the length of mango panicles with PBZ treatments was significantly shorter than with control treatment. However, the rate of PBZ use that negatively affected the phytotoxic symptoms of shoots and panicles was observed at more than 2,000 mg/L when first applied (15 DAP). Therefore, concentrations of PBZ and the number of foliar sprays could influence flowering period, panicle length and phytotoxic symptoms in mango trees cv. Mahachanok.

ACKNOWLEDGEMENT

This research was supported by a grant from the program Strategic Scholarships for Frontier Research Network from the Higher Education Commission, Thailand. The authors would like to thank the Department of Horticulture, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Thailand.

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