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# The effects of uniconazole dosages and suitable periods for bud break on the flowering of 'Dai Loan' mango (*Mangifera indica* L.) grown in Cho Moi district, An Giang province, 2016

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**ABSTRACT**

*This study was aimed to investigate the effect of Uniconazole (UCZ), as a replacement for Paclobutrazol (PBZ), on flowering of 'Dai Loan' mango cultivar, and to determine suitable UCZ dosages and the periods for bud break. Experiments were conducted on 7-year-old trees arranged in completely randomized factorial design with two factors, i.e. dosages of bud initiation agents and periods for bud break. The three dosages of UCZ included 1.0, 1.5 and 2.0 g a.i. $m^{-1}$ canopy diameter, and a positive control (PBZ at 1.5 g a.i. $m^{-1}$ canopy diameter). The second factor comprised three periods for bud break after bud initiation applications, viz. 45, 60, and 75 days (days after bud initiation treatment - DABIT). All treatments were replicated six times, each of which equalled to one tree. The results suggested that UCZ can definitely replace PBZ in regard to its effects on the flowering. Flowering ratio reached the highest, 85.5 - 90.0% when UCZ was applied at 1.5 - 2.0 g a.i. $m^{-1}$ canopy diameter and subsequently followed by bud break treatment with $KNO_3$ 2.5% at 75 DABIT. In addition, inflorescence length was not different between PBZ and UCZ dosages, while UCZ 1.5 and 2.0 g a.i. treatment brought about a high number of hermaphrodite flowers per inflorescence. Furthermore, the application of either PBZ or UCZ at 1.5 g a.i. $m^{-1}$ canopy diameter combined with bud breaking treatment at 75 DABIT, resulted in the highest yield, i.e. 40.8 and 50.3 kg/tree, respectively. As for the characteristics and quality of fruit, neither the two investigated factors caused significant impact.*

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## 1 INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important fruit trees grown worldwide. In Vietnam, mango growing area is about 56,600 ha, primarily distributed in the Mekong Delta, including Tien Giang, Vinh Long, Dong Thap, and Hau Giang (General Statistics Office, 2015). The most popular mango cultivars at these places are Cat Hoa Loc (Tien Giang), 'Cat Chu' (Dong Thap). Fruits of these cultivars are of high quality and exported to many countries (Australia, Japan) recently. In addition, there have been many other cultivars adopted from the other countries, e.g. 'Nam Dok Mai' (Thailand), 'Keo' (Cambodia), and 'Dai Loan' (Taiwan-China). The latter is now one of the most

favourite cultivars in the Mekong Delta, but there has not been any study relating to flowering induction conducted on the cultivar.

In order to induce off-season flowering and manipulate year-round production of mango, it requires the involvement of the chemicals and plant growth regulators. Firstly, the compounds used for flowering initiation included Paclobutrazol (PBZ), Uniconazole (UCZ), and Prohexadione-Ca which inhibit GA-like compounds synthesis. The chemicals utilized for bud break are $KNO_3$, Thiourea, and $NH_4NO_3$ (Silva *et al.*, 2009). In the Mekong Delta, the application of PBZ and Thiourea to induce flowering on mango was proposed by Tran Van Hau (2008), in which PBZ at 1 - 2 g a.i. $m^{-1}$ canopy diameter, and Thiourea at 0.5% were suitable for this purpose. In particular, that flowering induction procedure has been applied widely in Cao Lanh district - Dong Thap province (Hau *et al.*, 2010), Cai Be district - Tien Giang province (Tran Van Hau *et al.*, 2014), and Chau Thanh A district - Hau Giang province (Tran Van Hau *et al.*, 2016). Henceforth, the only compound used for flower bud initiation in the Mekong Delta has been PBZ. Meanwhile, until the time of this study, PBZ is not cleared to use in the USA (Litz, 2009). Similarly, Thiourea is not authorized to use in the USA and Australia due to its classification as a carcinogen (IPCS, 2017 access). Therefore, there is a concern that in the near future, both PBZ and Thiourea may be banned in Vietnam owing to its effects on the environment and human health. Consequently, it is important and urgent to study the alternative/ substitutive flowering induction procedure, using UCZ and $KNO_3$, to replace the current one employing PBZ and Thiourea. According to Krämer *et al.* (2007), UCZ is safe for the environment. Besides, early studies showed that UCZ can be very persistent in retarding plant growth without causing phytotoxicity (Davis *et al.*, 1988). Consequently, the aim of this study was to investigate the effect of UCZ, as a replacement for PBZ, on flowering of 'Dai Loan' mango. Besides, suitable UCZ dosages and the periods for bud break would be determined.

## 2 MATERIALS AND METHODS

### 2.1 Materials

The experiments were conducted on 'Dai Loan' mango trees at the age of 7 years; these were grown at My Hiep commune (Latitude: 10 28'57'' N Longitude: 105 28'38'' E), Cho Moi district, An Giang province. After harvest, the trees were pruned and fertilized to help recovery and concentrated flush. For flushing, Urea and DAP (18-46-0) in 2:1 ratio at 1 kg/tree were applied. Flushes after emerging were protected from pests, i.e. anthracnose, thrips, bugs, and other insects by foliar sprays of some agrochemicals (Cypermethrin, Abamectin, Carbendazim, Azoxystrobin) depending on the circumstances. When young leaves turned to reddish or yellowish (15 day-old), the trees were collar drenched with bud initiation agents, PBZ or UCZ, with dosages adjusted in accordance with the experimental treatments. Subsequently, depending on the treatments of periods for bud break (45, 60, and 75 days after bud initiation treatment - DABIT), the trees were sprayed with $KNO_3$ 2.5% to induced bud break and flowering (Tran Van Hau, 2008).

### 2.2 Methods

The experiments were arranged in completely randomized factorial design with two factors, i.e. dosages of bud initiation agent (PBZ and UCZ), and periods for bud break. The three dosages of UCZ included 1.0, 1.5 and 2.0 g a.i. $m^{-1}$ canopy diameter, and the positive control was the application of PBZ at 1.5 g a.i. $m^{-1}$ canopy diameter as recommended by Tran Van Hau (2008). The second factor consisted of the three periods for bud break after bud initiation applications, i.e. 45, 60, and 75 DABIT. All treatments were replicated six times, with each replication equalled to one tree. In total, 72 trees were employed in the present study.

After treated with PBZ/UCZ, and subsequently $KNO_3$, the trees were observed for parameters relating to the changes of some biochemical factors, flowering, fruit set, yield, and fruit quality. Total content (%) of carbon, sugar, starch, and content of GA-like compounds in leaves were observed for the biochemical changes in the leaves. The samples used for analysing these parameters included 5 shoots distributed evenly in the canopy. Shoots were collected before bud initiation and after bud break treatment. Total carbon content was determined by Loss on ignition - LOI method. Sugar in leaves was extracted and measured according to the protocol described by Dubois *et al.* (1956). Total starch content in leaves was obtained with the approach reported by Coombs *et al.* (1987). High pressure liquid chromatography (HPLC) was used to analyse the content of GA-like compounds in leaves at the Advanced Laboratory, Can Tho University.

For flowering, flowering ratio was estimated by enumerating the number of vegetative and reproductive shoots appearing in a 1 x 1 m frame. Average flowering ratios were taken from the 4 counts implemented evenly on the canopy. When the inflorescence emerged, 10 inflorescences were

labelled for further observations, viz. inflorescence length, percentage of hermaphrodite flower, fruit set and fruit abscission ratio. Fruit yield was obtained by counting and weighing all fruits available on the tree. Fruit quality parameters were based on sampling and analysing three fruits per tree. Fruits were collected at mature stage and induced ripening by incubating with $CaC_2$ at 2.5 g/kg fruit. Fruit quality parameters included $^oBrix$ and total acid (TA) of fruit flesh.

## 3 RESULTS AND DISCUSSION

### 3.1 Flowering ratio

The results in Table 1 showed that the flowering ratios of the treatments of agents used for inducing flower initiation were significantly different ($P<0.01$). It is noteworthy that the flowering ratios of the UCZ treatments, at all three concentrations (53.1 – 61.6%), were higher than those of the positive control, PBZ (41.0%). Similarly, the treatments of the periods for bud breaking showed significant difference ($P<0.01$), in which flowering ratio of the '75 DABIT' treatment was the highest (82.7%). There was significant interaction ($P<0.01$) between the two factors, i.e. agents inducing flowering bud initiation and periods for bud breaking. In case of '45 DABIT', PBZ application resulted in the lowest flowering ratio (3.3%), significantly lower than these of the UCZ treatments with flowering ratios varied from 31.0 - 44.5%. For '60 DABIT', flowering ratio reached the highest (68.2%) when the trees were treated with UCZ at 2.0 g a.i. $m^{-1}$ canopy diameter, while these of the other two concentrations of UCZ, viz. 1.0 and 1.5 g a.i. $m^{-1}$ canopy diameter were low (37.5 and 34.8%, respectively) and not significantly different to that of PBZ (41.7%). In particular, for '75 DABIT', the flowering ratios of all the treatments of flowering bud initiation agents were high, from 77.9 - 90.0%, and there was no significant difference between the flowering ratios of trees treated with PBZ (77.9%) and these treated with different UCZ concentrations (77.2 - 90.0%). These results were consistent with these reported by Hau *et al*. (2003), showing that flowering induction on 'Cat Hoa Loc' mango conducted at 75 - 90 days after treating with PBZ showed high flowering ratios. Generally, these results suggested that for the trees treated with $KNO_3$ for bud break at '75 DABIT', either PBZ (1.5 g a.i.) or UCZ (1.0 - 2.0 g a.i. $m^{-1}$ canopy diameter) application brought about high flowering ratios.

**Table 1: Flowering percent (%) of 'Dai Loan' mango under the effect of bud initiation agents and periods for bud breaking treatment**

| Periods for bud break treatment (B)* | Flower bud initiation agents (A)* | | | | Mean |
|---|---|---|---|---|---|
| | PBZ[a] | UCZ1[b] | UCZ1.5[c] | UCZ2[d] | |
| 45 DABIT[e] | 3.3 (5.8) | 44.5 (41.8) | 36.5 (36.6) | 31.0 (33.4) | 28.8 (29.4) |
| 60 DABIT[e] | 41.7 (40.0) | 37.5 (37.0) | 34.8 (35.7) | 68.2 (56.4) | 45.6 (42.2) |
| 75 DABIT[e] | 77.9 (63.2) | 77.2 (62.4) | 90.0 (71.7) | 85.5 (67.8) | 82.7 (66.3) |
| Mean | 41.0 (36.3) | 53.1 (47.0) | 53.8 (48.0) | 61.6 (52.5) | |
| F (A) = 5.07 **, $LSD_{0.05}$ = 8.8 | | | | | |
| F (B) = 50.17**, $LSD_{0.05}$ = 7.6 | | | | | |
| F(A) x (B) = 4.09 **, $LSD_{0.05}$ = 15.2 | | | | | |
| CV (%) = 23.0 | | | | | |

*[a] Paclobutrazol, 1.5 g a.i. $m^{-1}$ canopy diameter; [b] Uniconazole, 1.0 g a.i. $m^{-1}$ canopy diameter; [c] Uniconazole, 1.5 g a.i. $m^{-}$ canopy diameter; [d] Uniconazole, 2.0 g a.i. $m^{-1}$ canopy diameter; [e] DABIT: days after bud initiation treatment.*

*ns: non-significant difference; **: significant difference/interaction at P<0.01*

**Data were transformed into 'arcsin$\sqrt{x}$' prior to conducting ANOVA. Numbers presented in parentheses were calculated from transformed data*

Silva *et al.* (2009) conducted a study investigating the effect of foliar applications of UCZ (500, 1,000, and 1,500 mg/L) on the flowering of 'Kent' mango, with the collar drenching of PBZ (2.0 g a.i. $m^{-1}$ canopy diameter) as a control treatment. In that study, $NH_4NO_3$ 1.5% was sprayed 5 times, every week, to induce bud break; the period of application was 92 DABIT. In comparison to the flowering ratio of this study, which varied from 3.3 to 90.0%, these reported by Silva *et al.* (2009) were much lower, ranging from 0.5 to maximum 8% in all treatments, in which collar drenching with PBZ only resulted in 8% of flowering ratio. It is noticeable that the flowering ratios obtained with UCZ were also relatively low, only 2.5 - 5%. It is possible that the chemical used for bud breaking plays a crucial role in inducing flowering. According to Tran Van Hau (2008), on 'Cat Hoa Loc' and 'Cat Chu' mango, Thiourea 0.5% was shown to be very effective as for inducing flowering with the flowering ratios higher than 90%. In addition, the periods for bud break is another important factor to be considered. While

Silva *et al.* (2009) conducting bud breaking at 92 DABIT, on 'Hoa Loc' and 'Cat Chu' mango, Tran Van Hau (2008) suggested to induce flowering at 75 - 90 DABIT. According to Rademacher (1988), PBZ is best applied to the soil due to its low solubility, long residual activity and lack of efficient foliar uptake. Henceforth, the foliar application of UCZ instead of collar drenching can also be a reason for the low flowering ratio in the study of Silva *et al.* (2009). Núñez-Elisea and Davenport (1994) reported that PBZ and UCZ application advanced the bud break of containerized trees in controlled environment chambers, but cool temperatures were necessary to induce flowering.

### 3.2 Flower characteristics

There was no interaction between the two factors investigated in terms of inflorescence length, number of hermaphrodite flowers per inflorescence, and percentage of hermaphrodite flower. For the agents used to induce flower bud initiation, no significant difference was observed with regard to inflorescence length, and percentage of hermaphrodite flower. However, as considering the number of hermaphrodite flower per inflorescence, there was significant difference ($P<0.01$) among the treatments of agents used flower bud initiation. The highest number of hermaphrodite flower, 377.5 - 422.9 flowers per inflorescence, was observed with the treatment using UCZ at the concentration of 1.5 or 2 g a.i. $m^{-1}$ canopy diameter. At different periods for bud break treatment, significant difference was shown in connection with inflorescence length and number of hermaphrodite flower per inflorescence. For the treatment '75 DABIT', the highest levels of these two parameters (44.9 cm and 406.1 flowers/inflorescence, respectively) were recorded. On the one hand, concerning the percentage of hermaphrodite flower, no significant difference was observed in neither the two studied factors.

**Table 2: Inflorescence length (cm), number of hermaphrodite flowers per inflorescence, and percentage of hermaphrodite flower of 'Dai Loan' mango under the effect of bud initiation agents and periods for bud breaking treatment**

| Treatment | Inflorescence length (cm) | Number of hermaphrodite flowers per inflorescence | Percentage of hermaphrodite flower* |
|---|---|---|---|
| **Flower bud initiation agents (A)** | | | |
| PBZ – 1.5 g a.i. | 44.3 | 306.0 b | 6.7 |
| UCZ – 1.0 g a.i. | 39.6 | 271.6 c | 7.4 |
| UCZ – 1.5 g a.i. | 38.7 | 422.9 a | 6.3 |
| UCZ – 2.0 g a.i. | 40.0 | 377.5 ab | 8.2 |
| **Periods for bud break treatment (B)** | | | |
| 45 DABIT | 43.3 a | 324.3 b | 8.3 |
| 60 DABIT | 33.1 b | 293.7 b | 6.1 |
| 75 DABIT | 44.9 a | 406.1 a | 7.2 |
| **Mean** | **40.7** | **-** | **7.1** |
| F(A) | *ns* | ** | ns |
| F(B) | ** | ** | ns |
| F(A) x (B) | *ns* | *ns* | ns |
| CV (%) | 32.8 | 41.7 | 60.2 |

*Note: PBZ- Paclobutrazol, UCZ- Uniconazole, DABIT: days after bud initiation treatment. Within one column, different letters imply significant difference at P< 0.05 level as shown by LSD.*

*ns: non-significant difference; **: significant difference at P<0.01*

**Data were transformed into '√x' prior to conducting ANOVA.*

Goguey (1990) reported that the application of PBZ reduces the number of panicles, despite the increase of fruit set. In addition, it has been well documented that high levels of Triazole inhibit panicle elongation (Kulkarni, 1988; Winston, 1992; Davenport, 1994). Henceforth, inflorescences treated with Triazole are likely becoming compact, thus increasing the chance of being attacked by disease and insects (Winston, 1992). Davenport (1994) warned that the use of Triazole plant growth retardants for control of tree growth, flowering or yield must be done with considerable care since residual UCZ or PBZ applied as a soil drench is apparently retained. In the present study, the compactness of inflorescence may occur as the normal length of inflorescence of 'Dai Loan' mango is 52.1 ± 5.4 cm (Tran Van Hau, 2013), while these of the same variety treated with PBZ and UCZ ranged from 38.7 - 44.3 cm (Table 2), which are about 10 - 15 cm shorter than normal. In comparison to the other varieties, the inflorescence lengths of

'Cat Hoa Loc' and 'Falun' mango are 55.9 ± 1.3 cm, and 38.9 ± 5.1 cm respectively (Tran Van Hau, 2013). Similarly, the number of hermaphrodite flowers per inflorescence (271.6 - 422.9 flower) and percentage of hermaphrodite flower (6.3 - 8.2%) reported in this study were lower than those reported by Tran Van Hau (2013), viz. 1,746 ± 259 flowers and 19.1 ± 5.4%. These effects could be linked to the shorter inflorescence length owing to the application of PBZ/UCZ which resulted in the shorter panicles as reported by Kulkarni (1988).

### 3.3 Fruit set ratio

As considering the two factors separately, fruit set ratio was not significantly different among the treatments relating to periods for bud break, with fruit set ratio varied from 3.9 - 5.4% (Table 3). However, there was significant difference (P<0.01) among the treatments of agents used for flower bud initiation. The highest fruit set ratio (6.8%) was obtained with the UCZ 1.0 g a.i. $m^{-1}$ canopy diameter. That was higher than the fruit set ratio of the PBZ (3.3%) and UCZ 2.0 g a.i. treatment (4.0%). The two investigated factors showed significant interaction (P<0.01). Flower bud initiation induction with UCZ 1.0 g a.i. $m^{-1}$ canopy diameter in combination with bud breaking at 45 DABIT resulted in the highest fruit set ratio (10.2%). Meanwhile, the lowest fruit set ratio was observed when PBZ was used and subsequently bud breaking at 45 DABIT.

**Table 3: Fruit set percentage (%) of 'Dai Loan' mango under the effect of bud initiation agents and periods for bud breaking treatment**

| Periods for bud break treatment (B)* | Flower bud initiation agents (A)* | | | | Mean |
|---|---|---|---|---|---|
| | PBZ[a] | UCZ1[b] | UCZ1.5[c] | UCZ2[d] | |
| 45 DABIT[e] | 1.2 (3.6) | 10.2 (18.5) | 5.5 (13.5) | 4.7 (12.4) | 5.4 (12.0) |
| 60 DABIT[e] | 5.8 (13.8) | 6.2 (14.4) | 5.9 (13.9) | 3.1 (10.1) | 5.2 (13.1) |
| 75 DABIT[e] | 3.1 (10.1) | 4.0 (11.5) | 4.2 (11.7) | 4.3 (11.9) | 3.9 (11.3) |
| Mean | 3.3 (9.2) | 6.8 (14.8) | 5.2 (13.1) | 4.0 (11.5) | |
| F (A) = 12.8 **, $LSD_{0.05}$ = 1.9 | | | | | |
| F (B) = 2.4 ns | | | | | |
| F (A) x (B) = 9.8 **, $LSD_{0.05}$ = 3.3 | | | | | |
| CV (%) = 19.1 | | | | | |

*[a] Paclobutrazol, 1.5 g a.i. $m^{-1}$ canopy diameter; [b] Uniconazole, 1.0 g a.i. $m^{-1}$ canopy diameter; [c] Uniconazole, 1.5 g a.i. $m^{-}$ canopy diameter; [d] Uniconazole, 2.0 g a.i. $m^{-1}$ canopy diameter; [e] DABIT: days after bud initiation treatment*

*ns: non-significant difference; **: significant difference/interaction at P<0.01*

** Data were transformed into '√x' prior to conducting ANOVA. Numbers presented in parentheses were calculated from transformed data.*

### 3.4 Fruit yield

Fruit yield of trees treated with the agents used for induction of flower bud initiation were significantly different (P<0.01). The highest yield was obtained with the UCZ 1.5 g a.i. treatment (34.1 kg/tree), while the lowest yields were recorded on the PBZ (25.4 kg/tree) and UCZ 1.0 g a.i. (25.5 kg/tree) treatment (Table 4). For the treatments relating to the periods for bud break, '75 DABIT' treatment brought about the highest yield 41.6 kg/tree, while these of the other two treatments (45 and 60 DABIT) were relatively low, only 25.0 and 24.6 kg/tree, respectively. The two studied factors showed significant interaction (P<0.05), in which the highest yield was resulted with PBZ (40.8 kg/tree), UCZ 1.5 g a.i. (50.3 kg/tree), and subsequently implementing bud breaking at 75 DABIT. Meanwhile, the application of PBZ or UCZ 1.0 g a.i. coupled with bud breaking at 45 DABIT showed the lowest yield, viz. 14.7 and 17.4 kg/tree, respectively. It is clear that UCZ application at 1.5 and 2.0 g a.i. $m^{-1}$ canopy diameter brought about higher yield than PBZ application when bud breaking was conducted at 45 DABIT. However, for '60 DABIT' treatment, it was necessary to apply UCZ at 2.0 g a.i. $m^{-1}$ canopy diameter to obtain high yield; meanwhile, for '75DABIT' treatment, UCZ 1.5 g a.i. $m^{-1}$ canopy diameter was required.

**Table 4: Fruit yield (kg/tree) of 'Dai Loan' mango under the effect of bud initiation agents and periods for bud breaking treatment**

| Periods for bud break treatment (B) | Flower bud initiation agents (A) | | | | Mean |
|---|---|---|---|---|---|
| | PBZ[a] | UCZ1[b] | UCZ1.5[c] | UCZ2[d] | |
| 45 DABIT[e] | 14.7 | 17.4 | 33.1 | 34.7 | 25,0 |
| 60 DABIT[e] | 20.8 | 20.3 | 26.3 | 31.0 | 24,6 |
| 75 DABIT[e] | 40.8 | 38.9 | 50.3 | 36.5 | 41,6 |
| Mean | 25.4 | 25.5 | 36.6 | 34.1 | |
| F (A) = 28.1$^{**}$, $LSD_{0.05}$ = 6.1 | | | | | |
| F (B) = 7.5$^{**}$, $LSD_{0.05}$ = 5.3 | | | | | |
| F (A) x (B) = 2.6$^{*}$, $LSD_{0.05}$ = 10.1 | | | | | |
| CV (%) = 24.1 | | | | | |

*[a] Paclobutrazol, 1.5 g a.i. $m^{-1}$ canopy diameter; [b] Uniconazole, 1.0 g a.i. $m^{-1}$ canopy diameter; [c] Uniconazole, 1.5 g a.i. $m^{-}$ canopy diameter; [d] Uniconazole, 2.0 g a.i. $m^{-1}$ canopy diameter; [e] DABIT: days after bud initiation treatment*

*ns: non-significant difference; **: significant difference at P<0.01; *: significant difference/interaction at P<0.05*

### 3.5 Biochemical changes in leaves

For the three parameters evaluating biochemical changes in leaves, i.e. C/N ratio, total sugar, and starch content in leaves, there was no significant difference in the treatments of the two investigated factors (Table 5). In addition, no significant interaction occurred between the two factors. Generally, the average C/N was 35.0, varied from 34.0 to 35.9. As compared with 'Cat Hoa Loc' mango treated with PBZ at 1.5 g a.i. $m^{-1}$ canopy diameter, average C/N ratio was much lower, 23.6 (Tran Van Hau, 2008 and 2013). For sugar and starch content in leaves, the mean values were 0.75% and 0.86%, respectively (Table 5). In the case of 'Cat Hoa Loc' mango at the age of 10-year-old, one month after PBZ application, starch content in 60-day-old leaves of trees treated with PBZ reached the maximum level (1.17%), while these of the other leaf ages (15 and 30-day-old) were relatively stable (0.5 - 0.6%) (Tran Van Hau, 2013). The sugar content in leaves of 'Cat Hoa Loc' mango increased gradually and reached the highest level (2.2%) at 60 days after PBZ application, and subsequently decreased (Tran Van Hau, 2013). According to Tongumpai *et al.* (1989), starch content in leaves of 'Kiew Sawoey' mango start to increase when the content of GA-like compounds in leaves decreases to non-detectable. When the accumulation of starch accomplished, flower bud initiation will happen (Tongumpai *et al.*, 1989).

**Table 5: C/N ratio, total sugar and starch content in leaves of 'Dai Loan' mango under the effect of bud initiation agents and periods for bud breaking treatment**

| Treatment | C/N ratio | Total sugar content in leaves (%) | Total starch content in leaves (%) |
|---|---|---|---|
| **Flower bud initiation agents (A)** | | | |
| PBZ – 1.5 g a.i. | 34.1 | 0.77 | 0.87 |
| UCZ – 1.0 g a.i. | 35.9 | 0.70 | 0.85 |
| UCZ – 1.5 g a.i. | 34.1 | 0.78 | 0.86 |
| UCZ – 2.0 g a.i. | 35.9 | 0.75 | 0.87 |
| **Periods for bud break treatment (B)** | | | |
| 45 DABIT | 34.0 | 0.74 | 0.86 |
| 60 DABIT | 35.3 | 0.75 | 0.87 |
| 75 DABIT | 35.6 | 0.75 | 0.85 |
| **Mean** | **35.0** | **0.75** | **0.86** |
| F (A) | *ns* | *ns* | *ns* |
| F (B) | *ns* | *ns* | *ns* |
| F (A) x (B) | *ns* | *ns* | *ns* |
| CV (%) | 13.0 | 13.4 | 5.6 |

*Note: PBZ- Paclobutrazol, UCZ- Uniconazole, DABIT: days after bud initiation treatment.*

*ns: non-significant difference*

### 3.6 Content of GA-like compounds in leaves

Prior to the application of agents inducing flower bud initiation, content of GA-like compounds in leaves, changing from 1,468 - 2,149 mg/kg sample, was not significantly different among treatments. However, the application of these agents showed a

significant impact on the content of GA-like compounds. Leaf samples collected after inducing bud initiation displayed a clear reduction of the content of GA-like compounds, varying from 965.0 to 1,952.0 mg/kg sample (Table 6). Regarding the treatments relating to the periods for bud break, significant difference ($P<0.01$) was observed. The content of GA-like compounds was lowest (984.8 mg/kg sample) in leaves of the '60 DABIT' treatment, while these of the other two treatments, '45 DABIT' (1,464.3 mg/kg sample) and '75 DABIT' (1,251.5 mg/kg sample), were not significantly different. As the two studied factors showed significant interaction ($P<0.05$), it is notable that for PBZ treatment, the content of GA-like compounds in leaves did not change in correspondence with the periods for bud breaking, 45 - 75 DABIT. For all the UCZ treatments, at 60 DABIT, the content of GA-like compounds reduced significantly compared with these at 45 DABIT. At 75 DABIT, trees treated with UCZ at 2.0 g a.i. $m^{-1}$ canopy diameter showed the lowest content of GA-like compounds in leaves. Investigating the effect of PBZ on the content of endogenous GA-like compounds in leaves of 'Kiew-Savoey' mango, Tongumpai *et al.* (1996) concluded that flowering increases in concomitant with the reduction of endogenous GA content in shoots. In addition, trees treated with higher PBZ concentrations flowered earlier than those treated with lower PBZ concentrations. Accordingly, it is reasonable that the highest concentration of UCZ (2.0 g a.i. $m^{-1}$ canopy diameter) brought about the lowest concentration of GA-like compounds in leaves (777.0 mg/kg sample).

**Table 6: Content of GA-like compounds (mg/kg sample) in leaves of 'Dai Loan' mango after treated with flower bud initiation agents**

| Periods for bud break treatment (B) | Flower bud initiation agents (A) | | | | |
|---|---|---|---|---|---|
| | PBZ[a] | UCZ1[b] | UCZ1.5[c] | UCZ2[d] | Mean |
| 45 DABIT[e] | 1,047.0 | 965.0 | 1,929.0 | 1916.0 | 1,464.3 |
| 60 DABIT[e] | 1,042.0 | 969.0 | 968.0 | 960.0 | 984.8 |
| 75 DABIT[e] | 1,235.0 | 1,952.0 | 1,042.0 | 777.0 | 1,251.5 |
| Mean | 1,108.0 | 1,295.3 | 1,313.0 | 1217.7 | |
| F (A) = 0.79 $^{ns}$ | | | | | |
| F (B) = 4.46$^{*}$, $LSD_{0.05}$ = 386.3 | | | | | |
| F (A) x (B) = 3.31$^{*}$, $LSD_{0.05}$ = 770.8 | | | | | |
| CV (%) = 36.1 | | | | | |

*[a] Paclobutrazol, 1.5 g a.i. $m^{-1}$ canopy diameter; [b] Uniconazole, 1.0 g a.i. $m^{-1}$ canopy diameter; [c] Uniconazole, 1.5 g a.i. $m^{-}$ canopy diameter; [d] Uniconazole, 2.0 g a.i. $m^{-1}$ canopy diameter; [e] DABIT: days after bud initiation treatment*

*ns: non-significant difference; *: significant difference/interaction at $P<0.05$*

### 3.7 Characteristics and quality of fruits

The results in Table 7 showed that fruit characteristics and quality did not change under the effects of either agents used for inducing flower bud initiation or periods for bud breaking. The average fruit dimension was 19.7 cm in length, 9.9 cm in width, and 8.5 cm in thickness. The mean weights of fruit, edible part, and seed were 949.0, 778.8, and 84.3 g, respectively. For fruit quality, $^{o}$Brix values changed from 5.8 - 6.3, averagely 6.0, while the total acid values of fruit juice varied from 0.73 to 0.86 g/L with a mean of 0.8 g/L.

**Table 7: Characteristics and quality of fruit of 'Dai Loan' mango under the effect of bud initiation agents and periods for bud breaking treatment**

| Treatment | Fruit length (cm) | Fruit width (cm) | Fruit thickness (cm) | Fruit weight (g) | Weight of edible part (g) | Seed weight (g) | °Brix | Total acid (g/L) |
|---|---|---|---|---|---|---|---|---|
| **Flower bud initiation agents (A)** | | | | | | | | |
| PBZ – 1.5 g a.i. | 19.8 | 10.0 | 8.6 | 983.4 | 810.0 | 84.9 | 6.0 | 0.77 |
| UCZ – 1.0 g a.i. | 19.5 | 10.0 | 8.6 | 933.1 | 759.4 | 86.7 | 6.1 | 0.84 |
| UCZ – 1.5 g a.i. | 20.0 | 9.8 | 8.4 | 925.2 | 757.8 | 83.8 | 5.8 | 0.75 |
| UCZ – 2.0 g a.i. | 19.5 | 9.8 | 8.7 | 954.4 | 787.9 | 81.7 | 6.2 | 0.81 |
| **Periods for bud break treatment (B)** | | | | | | | | |
| 45 DABIT | 19.8 | 9.7 | 8.6 | 927.9 | 758.6 | 83.9 | 6.1 | 0.86 |
| 60 DABIT | 19.8 | 9.9 | 8.6 | 955.6 | 781.2 | 85.9 | 6.1 | 0.73 |
| 75 DABIT | 19.5 | 10.0 | 8.4 | 963.6 | 796.6 | 83.1 | 5.9 | 0.79 |
| **Mean** | **19.7** | **9.9** | **8.5** | **949.0** | **778.8** | **84.3** | **6.0** | **0.8** |
| F(A) | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |
| F(B) | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |
| F(A) x (B) | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* |
| CV (%) | 6.4 | 6.1 | 6.4 | 14.0 | 16.8 | 9.5 | 4.4 | 9.6 |

*Note: PBZ- Paclobutrazol, UCZ- Uniconazole, DABIT: days after bud initiation treatment*

*ns: non-significant difference*

## 4 CONCLUSION AND RECOMMENDATIONS

To sum up, the results in this study suggested that UCZ can totally be a good replacement for PBZ as considering its effects on the parameters relating to flowering. Flowering ratio was high when UCZ was applied at 1.5 - 2.0 g a.i. m canopy diameter and subsequently conducting bud break with $KNO_3$ 2.5% at 75 DABIT. In addition, in terms of flower characteristics, inflorescence length was not different between PBZ and UCZ dosages, while UCZ 1.5 and 2.0 g a.i. $m^{-1}$ canopy diameter treatment brought about higher number of hermaphrodite flowers per inflorescence than that caused by PBZ. In respect of fruit yield, the application of either PBZ or UCZ at 1.5 g a.i. $m^{-1}$ canopy diameter combined with bud breaking treatment at 75 DABIT, resulted in the highest yield. As for the characteristics and quality of fruit, neither the agents used for flower bud initiation and periods for bud break caused significant impact. Therefore, the application of UCZ at 1.5 - 2 g a.i. $m^{-1}$ canopy diameter to induce flower bud initiation, and then bud breaking with $KNO_3$ 2.5% at 75 DABIT are recommended to be applied on 'Dai Loan' mango. For the other mango varieties, to apply UCZ as a substitute for PBZ, more studies are needed to determine suitable dosage and periods for bud break treatment.

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