EFFECTS OF UNICONAZOLE ON THE FLOWERING OF 'TUONG DA XANH' MANGO (*MANGIFERA INDICA* L.) IN THE MEKONG DELTA, VIET NAM

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ABSTRACT

'Tuong Da Xanh' (TDX) is a mango cultivar (also known as 'Ba Mau' or 'Dai Loan') grown widely in the Mekong Delta, Viet Nam particularly in Gieng islet, Cho Moi district, An Giang province. Similar to other cultivars, off-season flowering of TDX is implemented by collar drenching of Paclobutrazol (PBZ) which is used as a flower bud initiation agent, followed by foliar application(s) of Thiourea or KNO_3 to induce flowering. However, PBZ residue has been reported to be able to remain for a long time in both soil and leaf. In addition, Thiourea has been long labelled as a carcinogen, thus banned from use in the USA and Australia. Therefore, it is of utmost importance to look for alternatives for these two chemicals. The aim of this study was to investigate the effects of Uniconazole (UCZ), as a replacement for PBZ, on the flowering of TDX mango. Results showed that UCZ applied either as collar drenching or foliar application is a good replacement for PBZ in terms of flowering rate and yield. Trees which were collar drenched with UCZ (1.0 g a.i. m^{-1} canopy diameter [c.d.]) followed by two sprays of KNO_3 (2.5% twice in one week) after 75 days, had flowering rates like those treated with PBZ 1.5 g a.i. m^{-1} c.d. Similarly, for foliar application, the flowering rates of trees sprayed with 1,000, 1,500, and 2,000 ppm UCZ followed by bud breaking treatment using KNO_3 (2.5%, twice in one week) after 75 days was not significantly different to that of those treated with PBZ 1.5 g a.i. m^{-1} c.d.

Keywords: bud break, Tuong da xanh (TDX) mango, paclobutrazol, uniconazole

1. INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most important fruit trees grown in many countries worldwide. According to the general statistics office of Viet Nam , mango growing area in Viet Nam is about 99,641.5 ha in 2018, primarily distributed in the Mekong Delta (MD), including An Giang, Dong Thap, Tien Giang, Vinh Long, and Hau Giang provinces. The most popular mango cultivars are 'Cat Hoa Loc' (Tien Giang and Dong Thap province) and 'Cat Chu' (Dong Thap province). Furthermore, mango cultivars originating from other countries, e.g. 'Nam Dok Mai' (Thailand), 'Keo' (Cambodia), and 'Tuong Da Xanh' (TDX) (originally from Taiwan) have also been grown in the MD. The latter is now one of the most favorite cultivars, originating from Taiwan where it is called 'Jin-Hwung'. It is reported to be one of the six most popular mango cultivars in Taiwan (Shu, 2010). 'TDX' mango can adapt well to the growing conditions of the MD as well providing high yields (Ve, 2011). Under good care, the cultivar starts to bear fruits from the second year with stable yield and no alternative bearing. An advantage of 'TDX' mango is its high fruit set rate despite low flowering rate. In addition, its fruits, suitable for consuming at unripen stage, are large in size with an average weight of 1.2-1.5 kg with thick, firm, crunchy fruit flesh.

[1] https://www.gso.gov.vn/Default.aspx?tabid=217

Various plant growth regulators and chemicals are used widely for off-season and year-round production of mango. Gibberellin (GA)-inhibitors, e.g. Paclobutrazol (PBZ), Uniconazole (UCZ), and Prohexadione-Ca, play an important role in the procedures of floral induction of not only mango but also many other fruit trees. Chemicals used for breaking bud dormancy, i.e. KNO_3, Thiourea, and NH_4NO_3 are also important for such procedures (Silva *et al*., 2013). Particularly, in the Mekong Delta, a floral induction procedure used for mango had been proposed by Hau (2013). Accordingly, PBZ (1-2 g a.i. m^{-1} canopy diameter [c.d.]) and Thiourea (0.3-0.5%) were the two key agents. The procedure has been applied widely in the Cao Lanh district - Dong Thap province (Hau *et al*., 2010), Cai Be district - Tien Giang province (Hau *et al*., 2014), and Chau Thanh A district - Hau Giang province (Hau *et al*., 2016). To date, PBZ has been the only GA-inhibitor used for mango flowering bud initiation in the MD. However, according to Litz (2009), PBZ has not been cleared for use in the USA. Similarly, Thiourea has been classified as a carcinogen (WHO, n.d.). While these two key agents are still utilized in some countries, e.g. Thailand, Indonesia and the Philippines, in the long term both PBZ and Thiourea will likely be withdrawn from usage in Viet Nam as a result of their notorious impacts on the environment as well as on human health. Thenceforth, it is of urgency to seek alternatives for the two mentioned chemicals. Krämer *et al*. (2007) reported that 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 'TDX', which is a popular mango cultivar in the MD. Besides, suitable UCZ dosages as well as concentrations and the times for floral induction after UCZ application would be determined.

2. MATERIALS AND METHODS

'TDX' mango trees at the age of 7-year-old were used in this study. These trees belong to commercial orchards located in the three communes of Cho Moi district, An Giang province, i.e. My Hiep, Binh Phuoc Xuan, and Tan My. After harvesting, the trees were pruned and fertilized to help recovery and concentrated flush. Urea and diammonium phosphate (DAP) (18-46-0) in 2:1 ratio, 1 kg/tree were applied to induce flushing. Subsequently, pesticides were used to protect new flushes from diseases and pests, i.e. anthracnose, thrips, bugs, and other insects, depending on the circumstances. After two completed flushes without damage, when young leaves turned reddish or yellowish (15-day-old), the trees were applied PBZ/UCZ by either collar drenching or foliar sprays. Dosages and concentrations of PBZ/UCZ were adjusted in accordance with the experimental treatments. Afterwards, depending on the treatments of times for bud break (45, 60, 75, and 90 days after PBZ/UCZ treatment - DAPUT), the trees were sprayed with KNO_3, 2.5% to induce bud break and flowering (Hau, 2008).

Experiments were arranged in completely randomized factorial design with two factors, i.e. dosages/concentrations of PBZ and UCZ, and times for bud break after PBZ/UCZ application. For the experiment to test UCZ in collar drenching, the first factor included the three doses of UCZ, i.e. 1.0, 1.5 and 2.0 g a.i. m^{-1} c.d. Similarly, in the other experiments using UCZ as foliar applications, the first factor comprised the three concentrations, *viz*. 1,000, 1,500 and 2,000 ppm. The positive control treatment, PBZ 1.5 g a.i. m^{-1} c.d., was proposed by Hau (2008) (Hau, 2008). The second factor consisted of the three times for floral induction with KNO_3 (2.5%), i.e. 60, 75, and 90 days after PBZ/UCZ applications (DAPUT). For the trial investigating the leaf age at the time of UCZ/PBZ application, the three concentrations of UCZ, *viz*. 1,000, 1,500 and 2,000 ppm were considered as the first factor; and the second one includes the three leaf ages, *viz*. 45, 60, and 75 days. Floral induction was implemented at 75 DAPUT with KNO_3 (2.5%). All treatments were repeated six times. Each replication equaled to one tree. The observed parameters included flowering and fruit set rate, yield, and fruit quality. Flowering rate was estimated by enumerating the number of vegetative and reproductive shoots appearing in a 1 m^2 frame. Average flowering rate was calculated from the 4 counts implemented evenly on the canopy. After emergence, 10 panicles per tree were labelled to determine the fruit set rate. Total fruit yield was obtained by weighing all fruits available on the tree. Yield of normal and seedless fruit was determined separately for each kind of fruit.

3. RESULTS

3.1. Uniconazole applied as collar drenching

3.1.1. Flowering rate

Results in Table 1 showed that the flowering rates observed at the three sites of experiment were relatively different. This could be linked to the different times of PBZ/UCZ treatment occurring in July, August, and September, which are the wettest months of the year in the MD. At site 1 (My Hiep commune), the flowering rates of PBZ/UCZ treatments were significantly different ($P<0.05$); meanwhile, those observed at sites 2 and 3, averaged at 29.3% and 45.7% respectively and were not significantly different among the PBZ/UCZ treatments. Particularly, at site 1, flowering rate of UCZ 2 g a.i. m^{-1} c.d. (61.6%) was significantly higher than that of the positive treatment - PBZ 1.5 g a.i. m^{-1} c.d. (41.0%); while those of treatments using lower UCZ doses (1 and 1.5 g a.i. m^{-1} c.d) showed no significant difference to that of the control. On the one hand, the effect of times of flowering induction treatment after PBZ/UCZ application were consistent throughout the three study sites. Accordingly, flowering rate was the highest (site 1: 82.7%; site 2: 47.5%; and site 3: 62.6%) when trees were induced for flowering at 75 days after PBZ/UCZ treatment DAPUT (days after PBZ and UCZ treatment). The flowering rates of 45 and 60 DAPUT treatment were mostly not different.

At sites 1 and 2, there was significant interaction ($P<0.05$) between the two experimental factors, i.e. PBZ/UCZ doses and times of floral induction. At site 1 (My Hiep commune), '45 DAPUT' and PBZ 1.5 g a.i. m^{-1} c.d. resulted in the lowest flowering rate (3.3%), significantly lower than these of the UCZ treatments with flowering rates varied from 31.0 – 44.5%. For 60 DAPUT, flowering rate reached to the highest level (68.2%) when trees were treated with UCZ 2.0 g a.i. m^{-1} c.d.; however those of the other two UCZ doses, viz. 1.0 and 1.5 g a.i. m^{-1} c.d., were low (37.5 and 34.8%, respectively) and not significantly different to that of PBZ (41.7%). It is noteworthy that, for 75 DAPUT, flowering rates of trees treated with either PBZ or any tested UCZ doses were high, from 77.9 – 90.0% with no significant difference. In short, these results suggested that for the trees treated with KNO3 2.5% to induce flowering at '75 DAPUT', either PBZ (1.5 g a.i. m^{-1} c.d.) or UCZ (1.0 – 2.0 g a.i. m^{-1} c.d.) application brought about high flowering rates.

3.1.2. Fruit set

Fruit set rate was significantly different among the treatments of both experimental factors. At all three sites of study, the highest fruit set was obtained with UCZ 1.0 g a.i. m^{-1} c.d., viz. 6.8% (site 1), 9.7% (site 2), and 6.8% (site 3). Similarly, for the times for floral induction, 45 DAPUT treatment resulted in the highest fruit set rate consistently at three places, i.e. 5.4% (site 1), 9.5% (site 2) and 6.6% (site 3).

The two investigated factors showed significant interaction at site 1 ($P<0.01$) and site 3 ($P<0.05$). At site 1, UCZ 1.0 g a.i. m^{-1} c.d. treatment combined with floral induction implemented at 45 DAPUT resulted in the highest fruit set rate (10.2%); in contrast, the lowest was observed when PBZ 1.5 g a.i. m-1 c.d. was used and subsequently induced flowering at 45 DAPUT (1.2%). At site

Table 1. Flowering rate (%), fruit set (%) and yield (kg/tree) of 'Tuong da xanh' mango under the effect of PBZ/UCZ and periods of flowering induction

Treatment	Site 1 (My Hiep commune)1					Site 2 (Tan My commune)2					Site 3 (Binh Phuoc Xuan commune)3				
	Flowering rate (%)	Fruit set (%)	NFe yield (kg/tree)	SFf yield (kg/tree)	TFg yield (kg/tree)	Flowering rate (%)	Fruit set (%)	NFe yield (kg/tree)	SFf yield (kg/tree)	TFg yield (kg/tree)	Flowering rate (%)	Fruit set (%)	NFe yield (kg/tree)	SFf yield (kg/tree)	TFg yield (kg/tree)
PBZ/UCZ doses (A)															
Controla	41.0b	3.3c	13.5b	12.0b	25.4b	24.5	7.9ab	7.2	4.6	11.8	43.6	5.1b	10.8	14.4	25.2
UCZ 1.0b	53.1ab	6.8a	12.6b	12.9ab	25.5b	28.6	9.7a	4.0	3.7	7.7	44.4	6.8a	10.8	16.8	27.5
UCZ 1.5c	53.8ab	5.2ab	18.4a	18.2ab	36.6a	36.5	6.9b	6.5	7.1	13.6	46.6	4.6b	8.7	19.5	28.2
UCZ 2.0d	61.6a	4.0b	14.5b	19.6a	34.1a	27.7	8.2ab	4.5	3.9	8.4	48.3	3.4c	11.2	20.5	31.8
Mean (A)	-	-	-	-	-	29.3	-	5.6	4.8	8.4	45.7	-	10.4	17.8	28.2
Times of flowering induction treatment (B) (days after PBZ/UCZ treatment)															
45 days	28.8c	5.4a	7.9a	17.1	25.0a	18.3b	9.5a	3.71	0.8c	4.5c	34.9b	6.6a	6.5b	19.5	26.1c
60 days	45.6b	5.2b	11.1b	13.5	24.6a	22.1b	9.1a	4.86	4.2b	9.1b	39.7b	5.6b	9.1b	14.8	23.8b
75 days	82.7a	3.9c	25.3c	16.3	41.6b	47.5a	6.0b	8.08	9.5a	17.6a	62.6a	2.8c	15.5a	19.1	34.6a
Mean (B)	-	-	-	15.7	-	-	-	5.6	-	-	-	-	-	17.8	-
F(A)	*	**	**	*	**	ns	*	ns	ns	ns	ns	*	ns	ns	ns
F(B)	**	**	**	ns	**	**	**	ns	**	**	*	*	*	ns	*
F (A*B)	*	**	*	*	*	ns	ns	ns	ns	ns	*	*	*	*	*

1Trees were treated with PBZ/UCZ on 4/7/2016; 2Trees were treated with PBZ/UCZ on 21/8/2016; 3Trees were treated with PBZ/UCZ on 11/9/2016
a Control: Paclobutrazol, 1.5 g a.i. m-1 canopy diameter; bUCZ 1.0: Uniconazole, 1.0 g a.i. m-1 canopy diameter; c UCZ 1.5:Uniconazole, 1.5 g a.i. m- canopy diameter; d UCZ 2.0:Uniconazole, 2.0 g a.i. m-1 canopy diameter; eNF yield: Normal-fruit yield; fSF yield: Seedless-fruit yield; gTF yield: Total-fruit yield.

Within one column, identical letters implied non-significant difference at $\alpha = 0.05$. ns: non-significant difference; **: significant difference/interaction at $P<0.01$

3, UCZ 1.0 g a.i. m^{-1} c.d. combined with floral induction at 45 DAPUT was again the treatment bringing about the highest fruit set rate.

3.1.3 Fruit yield

As compared with the other mango cultivars grown in the Mekong Delta, e.g. 'Cat Hoa Loc' and 'Cat Chu', fruit set characteristic of 'TDX' mango is relatively different. During the fruit set and development process, there is a certain ratio of seedless fruits. The size of seedless fruit was smaller than that of normal fruits. The size of normal and seedless fruits at maximum growth was 18,1 ± 0,5 cm length - 9.5 ± 0.5 cm width, and 9.5 ± 0.6 cm length – 5.5 ± 0.3 cm width, respectively (Hieu *et al.*, 2018).

Total fruit yield at sites 2 and 3 were at averages of 8.4 and 28.2 kg/tree, respectively. At site 1, total fruit yield of trees treated with PBZ/UCZ doses was significantly different ($P<0.01$). The highest yield was obtained with the UCZ 1.5 and 2.0 g a.i. m^{-1} c.d. treatment (34.1 - 36.1 kg/tree). For the treatments relating to the times of floral induction, 75 DAPUT brought about the highest yield 41.6 kg/tree, while those of the other two treatments (45 and 60 Days after bud initiation treatment - DABIT) were relatively low. The two factors showed significant interaction ($P<0.05$). The highest yield was obtained with PBZ and UCZ at the dose of 1.5 g a.i. m^{-1} c.d. (50.3 kg/tree), and subsequently implementing floral induction at 75 DABIT.

3.2. Foliar application

3.2.1. Concentrations of Uniconazole and times for floral induction

Results presented in Table 2 showed that when compared to the control treatment, foliar application of UCZ at all concentrations did not result in significant difference in terms of flowering rate varying from 47.5 to 59.4%. It is similar for the other parameters, i.e. fruit set (averagely 14.6%), fruit weight (941.1 g), number of fruits per tree (30.1), and yield (48.3 kg/tree). As for the treatments relating to the times of flowering induction after PBZ/UCZ application, 75 DAPUT predominated over the other two treatments (60 and 90 DAPUT) in most of the observed parameters. Flowering (74.2%) and fruit set (19.8%), and yield (48.3 kg/tree) of the 75 DAPUT treatment were significantly higher than those of the other two treatments.

3.2.2. Leaf age at the time of PBZ/UCZ application

Results in Table 3 reflected that the UCZ concentrations, 1,000 – 2,000 ppm showed no significant difference to the control treatment (PBZ 1.5 g a.i. m^{-1} c.d.) in terms of flowering, fruit set rate, and yield. Particularly, for the flowering rate, despite the significant difference observed at site 2 with the highest flowering rate changing from 51.8 – 56.3% (control, UCZ 1,000 ppm, and UCZ 2,000 ppm), the mean flowering rates at site 1 (56.2%) and 3 (58.3%) were not significantly different among the treatments. The latter results were consistent with those in the previous section for testing UCZ in foliar application (1,000 – 2,000 ppm) (Table 2). Similarly, although lower than the results of the previous trial, fruit set rates and fruit yield were not significantly different among the treatments at all three sites with averages from 1.8 – 3.2% for the fruit set rate, and 10.1 – 14.6 kg/tree for the total fruit yield. The effects of leaf ages at the time of UCZ/PBZ application, the three leaf ages (45, 60 and 75 days after emergence - DAM) generally did not show significant difference in flowering rate, fruit set and fruit yield. The only difference was observed on seedless fruit yield at site 2, with the highest yield of the 75 DAM treatment (7.9 kg/tree).

Table 2. Effect of Uniconazole concentrations and periods for floral induction with KNO3 (2.5%) on flowering and fruit set of 'Tuong da xanh' mango

Treatment	*Flowering (%)*	*Fruit set (%)*	*Fruit weight(g)*	*No. of fruits. tree-1*	*Yield (kg/tree)*
Paclobutrazol/Uniconazole (A)					
Control	59.4	16.1	936.2	25.2	23.6
U 1,000	47.5	13.8	944.8	32.0	31.5
U 1,500	51.5	14.1	937.6	31.0	29.8
U 2,000	52.3	14.5	945.7	32.0	31.7
Mean	52.7	14.6	941.1	30.1	29.2
Times of floral induction after PBZ/UCZ application (B)					
60 DAPUT	48.2b	13.0b	947.4	25b	23.3b
75 DAPUT	74.2a	19.8a	936.2	47a	48.3a
90 DAPUT	28.9c	9.7c	944.5	23b	21.4b
Mean	-	-	942.7		-
F(A)	ns	ns	ns	ns	ns
F(B)	**	**	ns	**	**
F(A*B)	ns	ns	ns	ns	ns

Control: Paclobutrazol 1.5 g a.i.m-1 canopy diameter; U 1,000: Uniconazole (UCZ) 1,000 ppm; U 1,500: UCZ 1,500 ppm; U 2,000: UCZ 2,000 ppm; DAPUT: Days after Paclobutrazol/Uniconazole treatments. Within one column, identical letters implied non-significant difference at α = 0.05 identified by Duncan multi range test; *: significant difference at α = 0.05; ns: non-significant difference.

Table 3. Flowering characteristics and yield of 'Tuong da xanh' mango under the influence of different concentrations of Uniconazole and leaf ages at the time of Uniconazole treatment

Treatment	Site 1 (My Hiep commune)1					Site 2 (Tan My commune)2					Site 3 (Binh Phuoc Xuan (commune)3				
	Flowering rate (%)	Fruit set (%)	NFe yield (kg/tree)	SFf yield (kg/tree)	TFg yield (kg/tree)	Flowering rate (%)	Fruit set (%)	NFe yield (kg/tree)	SFf yield (kg/tree)	TFg yield (kg/tree)	Flowering rate (%)	Fruit set (%)	NFe yield (kg/tree)	SFf yield (kg/tree)	TFg yield (kg/tree)
PBZ/UCZ doses (A)															
Controls	59.7	1.8	4.3	6.4	10.7	56.3a	2.2	4.6	6.9	11.5	55.8	6.6	6.7	6.9	13.6
U 1,000b	56.7	2.0	3.2	7.0	10.2	51.8a	2.2	3.5	6.4	9.8	58.0	2.1	9.2	5.7	14.8
U 1,500c	51.6	1.7	3.5	8.6	12.1	44.8b	2.2	1.9	6.5	8.4	61.3	2.2	7.0	7.4	14.4
U 2,000d	56.6	1.8	4.0	7.0	11.0	54.9a	2.2	4.1	6.5	10.6	57.9	2.0	7.6	8.0	15.6
Mean (A)	56.2	1.8	3.8	7.3	11.0	-	2.2	3.5	6.6	10.1	58.3	3.2	7.6	7.0	14.6
Times of flowering induction treatment (B) (days after PBZ/UCZ treatment)															
45 days	58.1	1.9	3.8	7.7	11.4	53.0	2.2	3.1	5.9b	9.0	60.2	5.1	8.5	5.8	14.3
60 days	54.8	1.8	3.2	6.6	9.8	52.2	2.2	3.8	5.9b	9.8	57.8	2.4	6.8	7.6	14.4
75 days	55.6	1.8	4.2	7.6	11.8	50.6	2.2	3.7	7.9a	11.5	56.6	2.2	7.6	7.6	14.2
Mean (B)	56.2	1.8	3.7	7.3	11.0	51.9	2.2	3.5	-	10.1	58.2	3.2	7.6	7.0	14.3
F(A)	ns	ns	ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns	ns	ns
F(B)	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
F (A*B)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

a Control: Paclobutrazol, 1.5 g a.i. m-1 canopy diameter; bU 1,000: Uniconazole, 1,000 ppm; c U 1,500: Uniconazole, 1,500 ppm; d U 2,000: Uniconazole, 2,000 ppm diameter; eNF yield: Normal-fruit yield; fSF yield: Seedless-fruit yield; gTF yield: Total-fruit yield.
Within one column, identical letters imply non-significant difference at α = 0.05. ns: non-significant difference; **: significant difference/interaction at P<0.01

4. DISCUSSION

The main aim of this study was to evaluate and determine the best dose and/or concentration of UCZ to replace PBZ, which is about to be banned from use in Viet Nam. The results obtained from the two separate trials to test the possibility of using UCZ as collar drenching or foliar application have confirmed that UCZ is a good replacement for PBZ. In regard to flowering rate, there was no significant difference between PBZ and UCZ applied by either collar drenching or foliar spray (Table 1, Table 2). As for the fruit set rate, despite the non-significant difference when UCZ was tested as foliar applications, collar drenching UCZ at 1.0 g a.i. m^{-1} c.d. resulted in the highest fruit set rate across the three experimental sites. Therefore, without considering fruit yield, which is governed by various factors, 1.0 g a.i. m^{-1} c.d. could be recommended when UCZ is applied by collar drenching. For foliar application, while there was no clear difference with regard to flowering rate, fruit set, yield and fruit quality, the lowest concentration of UCZ tested in this study, 1,000 ppm, is a good choice.

For the treatments relating to the times of floral induction after PBZ/UCZ application, the flowering rates of 75 DAPUT treatment in both trials (collar drenching and foliar application) were consistently higher than those of the other treatments. In the trial testing UCZ as collar drenching, the times for floral induction varied from 45 – 75 days after PBZ/UCZ application. Such intervals were increased to 90 days (ranging from 60 to 90 days) in the trial using UCZ as foliar sprays. However, the increase, from 75 to 90 days, even reduced the flowering rate enormously, from 74.2% (75 DAPUT) to 28.9% (90 DAPUT). Therefore, within the time frame of 45 to 90 days after PBZ/UCZ application, 75 days was determined to be the best interval to induce flowering using KNO3 2.5%, either when UCZ is applied as collar drenching or foliar application. These results suggest that flowering induction conducted on 'TDX' mango can be commenced from the 75th day after the application of either PBZ (1.5 g a.i. m^{-1} c.d.) or UCZ (1.0 – 2.0 g a.i. m^{-1} c.d.). Hau (2013) reported similar results showing that flowering induction with thiourea 0.5% on 'Cat Hoa Loc' mango conducted at 75 – 90 days after PBZ application led to high flowering rates. However, for 'Cat Chu mango', according to Hau and Dien (2009), floral induction with thiourea 0.5% implemented at the 60th day after collar drenching with PBZ 1.5 g a.i. m^{-1} c.d. resulted in higher flowering rate than that of the other two times, viz. 75 and 90 days after PBZ application. Therefore, the suitable times for floral induction after PBZ/UCZ application vary with the cultivars.

In the Mekong Delta, leaf age is an important factor to determine the time for PBZ application. However, the latter also changes depending on the cultivar. For 'Cat Hoa Loc' mango, leaf flushes turning gradually to light green, with soft and flexible lamella are suitable for PBZ application. For 'Chau Hang Vo', 'Buoi', and 'Thanh Ca' cultivars, the best time for PBZ application is when leaves turn to dark green, 4 to 5-month-old ~ 120 – 150 days (Hau, 2008). That means the leaf age of these cultivars must be older than that of 'cat Hoa Loc'. For 'Cat Hoa Loc' mangoes, Hau and Thuy (2008) conducted a study in which PBZ 1.0 g a.i. m^{-1} c.d. was applied at the leaf ages of 15, 30 and 60 day-old, followed by floral induction with thiourea (0.5%). It was reported that PBZ applications when leaves were at 15, 30, and 60 day-old brought about higher flowering rates than the untreated control treatment. Among the three leaf-age treatments, there was no significant difference in flowering rates observed before thiourea application with the highest flowering rate obtained with the 15-day-old leaf age (23.7%). However, the flowering rate recorded after thiourea application was not significantly different among the three leaf ages, varied from 53.8 (60-day-old) to 55.6% (15-day-old). In the present study, the flowering rate observed after floral induction with KNO_3 (2.5%) was similar, with no significant difference among the three leaf age (45. 60 and 75-day-old), varying from 50.6 to 60.2% (Table 3). In another trial of the present study investigating the effect of UCZ concentrations applied as foliar application and time for floral induction on flowering rate (Table 2), PBZ/UCZ was sprayed when leaf was 15-day-old. The mean flowering rate was 52.7%, varying from 47.5 to 59.4% (Table 4). Therefore, it is likely that the flowering rates obtained when PBZ/UCZ was applied on leaves at the age of 15 to 60-day-old were not different. Consequently, it is possible to commence PBZ/UCZ application as early as the leaf flushes reach to 15-day-old.

5. CONCLUSIONS

The results in this study suggested that for 'Tuong Da Xanh' mango, UCZ can totally be a good replacement for PBZ. For flowering rate, there was no clear or significant difference between PBZ and UCZ applied by either collar drenching or foliar spray. In addition, collar drenching UCZ at 1.0 g a.i. m^{-1} c.d. consistently resulted in the highest fruit set rate across the three experimental sites, thus it could be recommended for application on 'TDX'. For foliar application, while there was no clear difference about flowering rate, fruit set, yield and fruit quality, the lowest concentration of UCZ tested in this study (1,000 ppm) can be recommended. As for the time of floral induction undertaken with KNO_3 2.5% (two times in one week), the best time was 75 days after PBZ/UCZ application.

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