FLOWER INDUCTION, GROWTH, YIELD AND QUALITY OF MANGO (*Mangiferaindica* L.) AS AFFECTED BY DIFFERENT APPLICATION TIMES OF SELECTED CHEMICALS cv. SEIN TA LONE

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Athesis presented by

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The thesis attached hereto, entitled **"**Flower induction, growth, yield and quality of mango (*Mangifera indica* L.) as affected by different application times of selected chemicals cv. Sein Ta Lone**"** was prepared under the direction of the chairperson of the candidate supervisory committee and has been approved by all members of that committee and board of examiners as a requirement for the degree of **Doctor of Philosophy**.

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This thesis represents the original works of the author, except where otherwise stated. It has not been submitted previously for a degree at this or any other university.

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FLOWER INDUCTION, GROWTH, YIELD AND QUALITY OF MANGO (*Mangifera indica* L.) AS AFFECTED BY DIFFERENT APPLICATION TIMES OF SELECTED CHEMICALS cv. SEIN TA LONE

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ABSTRACT

Three experiments were conducted at Horticulture Section, DAR, in 2009-2010 and 2010-2011 for early flowering and harvesting, synchronization and yield increasing.

Experiments I and II were carried out to assess the effects of Paclobutrazol (PBZ) and different times of 3 %KNO_3 application on flower induction, growth, yield and quality. Two factors factorial arrangement in RCB with three replications was used. Two levels of PBZ (0.10 and 0.15 g aim^{-1} of canopy) were used as factor (A) and five different times of 3 % KNO_3 sprays (10,12,14,16 and 18 weeks after PBZ application) and two controls (water spraying and no spraying at all) were used as factor (B).The results of experiment 1 showed that either PBZ concentrations did not influence on number of inflorescences and number of fruits. However, both PBZ levels along with 3 % KNO_3 spraying at 18 weeks after PBZ application (WAP) gave not only the highest number of inflorescences and fruit yield but also 5 days earlier harvesting than the rest of the treatments. Spraying of 3%KNO_3 at 10 WAP, 12 WAP, Control 1 and 2 indicated the less inflorescences and yield compared to other treatments.

Experiment II was conducted during 2010-2011 at the same location and trees. But the rate of 0.15 g ai m^{-1} of canopy was increased to 0.20 g ai m^{-1} of canopy. The results indicated that number inflorescences, fruit yield, growth and fruit quality were not affected by not only PBZ levels but also floral induction treatments with 3 % KNO_3 sprays. However, the both doses of PBZ incorporated with 3 % KNO_3 spraying at 18 WAP gave the more number of fruits during early harvesting period.

Experiment III was done during 2010-2011 to evaluate with and without urea based on leaf N content and different times of 0.7 % thiourea spraying for flower induction, growth, yield and quality of mango. With and without urea application was used as a factor (A) and five different times of 0.7 % thiourea spraying (10,12,14,16 and 18 WAP) and two controls were regarded as factor (B). Without urea application rendered the 30 days earlier flowering than urea application but no significant difference in yield. Both with and without urea application combined with 0.7 % thiourea spraying at 14 WAP produced inflorescences 10 days earlier than 10,12,16 and 18 WAP and 20 days earlier than Control 1 and 2. As a result of earliness of flowering, 14 WAP showed 9 days ahead of harvesting than 16 WAP, 16 days ahead of 10, 12 and 18 WAP and 22 days ahead of Control 1 and 2. However, 18 WAP could be seen as the highest number of inflorescences and fruit yield and the best in synchronization of flowering and harvesting.

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CHAPTER I

GENERAL INTRODUCTION

The mango (*Mangifera indica* L.) belongs to the family Anacardiaceae and often referred to as 'King of fruits' for its high quality, palatability, adaptability in the tropical world (Krishna and Singh 2007). Mango is a popular fruit crop cultivated in more than 100 countries and grown commercially from the equator to the subtropical limits of the northern and southern hemispheres. This span includes tropical climate zone in which minimum temperatures rarely go below 18ºC through subtropical zone, which typically experiences minimum temperatures of 5-10ºC during winter (Jordan 2001).

According to Juliano (1937), who indicated that there were two main centres of domestication of mango, 'one in India with monoembryonic mangoes, the other in the Saigon area, Indonesia and the Philippines with polyembryonic mangoes'. However, Thailand and Myanmar, recognized by (Valmayor 1962), were the homes of polyembryonic mangoes. Notwithstanding, the origin of polyembryonic mangoes is probably better placed in Myanmar, and possibly the eastern part of Assam.

Being a country of the mangoes' origin, Myanmar possesses at least two hundred varieties (Hirano *et al*. 2008) in which Sein Ta Lone is the most popular one due to its attractive fragrance and specific taste. The skin colour is yellow. The pulp is pale yellow and has no fibre. Fruit has two beaks, one pointed with another perceptible beak bellow and also long lasting quality.

Among the fruits, maximum area is used for mango cultivation (93890 ha) that produces 524654 MT with a productivity of 6.88MT/ha in 2012-2013 from the harvesting areas of 76313ha. Mango is the most important fruit grown in Myanmar contributing about 27.12% in the total fruit production of the country (DAP 2013).

Sein Ta Lone is commercially the most popular variety due to its typical sugar acid blend, taste, attractive colour and pleasant flavor. In recent years, plantation of Sein Ta Lone mango in the tropical and sub-tropical regions of Myanmar has increased rapidly because of a high level of consumers demand for both the fruit on domestic and export markets. Ministry of Agriculture and Irrigation (MOAI) currently laid down the establishment of two special Sein Ta Lone mango zones alongside the Yangon-Mandalay union express way. Zone one is situated in Ottayathiyi and

Dehkinathiri townships and zone two is located in Yemethin township where prevailing climate having a distinct wet and dry and cool condition good enough for flowering morphogenesis for mango cultivation. Production of mango, therefore, will be further increased on the horizon.

The flowering time of Sein Ta Lone is from the beginning of January to the end of January in the middle parts of Myanmar. However, flowering may occur during February - March in Shan State. Thus, Sein Ta Lone fruits are available in late April to May in Middle Myanmar and during July in Shan State.

According to area expansions especially with sole emphasis on Sein Ta Lone mango alone in Myanmar indicates that production gluts during the main season, especially during May, cause the price of the fruit to fall. To overcome this marketing problem, a package technology to produce fruit in early or late season is required.

Off season production is of high economy because of market driven orientation. It is becoming an attractive strategy for farm producers in countries like Thailand, Parkistan and Austrilia. Off season production could increase fruit availability periods for domestic and export markets as well as improved livelihood of mango growers. In Thailand, the price of off-season mango is two to threefold that of in-season mango (Tongumpai *et al*. 1991a). Consequently, methods for off-season production not only enhance higher income for growers but also provide significant amounts of fruits for social demand.

Most mango growers are interested in managing the flowering time of orchards in order to obtain early harvest that can give the highest profit. Sein Ta Lone cultivar takes about four months to fruit maturity from flowering, hence, the normal January flowering period in middle parts of Myanmar and February-March flowering period in Shan State must be shifted forward to November-December in order to accomplish harvest during March-April. Davenport (2007) reported that mango prices are highest during March and April in today's markets in the northern hemisphere.

Induction refers to commitment of buds to evoke a particular shoot type, i.e., vegetative shoot (vegetative induction), generative shoot (floral induction), mixed shoot (combined vegetative-floral induction) (Davenport and Nunez-Elisea 1997). Cold temperature (around 15˚C) plays a major role in flower induction of mango trees (Naphrom *et al*. 2003).

Davenport (2007) reported that flowering was not an important issue for commercially produced mangoes in subtropical climate. It was explained by Whiley and Schaffer (1997), that beneficial stress in mango was the improved synchrony and reliability of flowering in subtropical climates due to cool winter temperature. Flowering in tropical latitudes, however, was an important issue, both for dependable flowering and for manipulation of the timing of flowering to take advantage of market opportunities.

Although floral initiation occurs after leaves have expanded and attained a dark-green colour, it is not clear what ages they become competent for floral induction. Sein Ta Lone variety does not flower regularly year after year. Flowering is also staggered, leading to considerable variation in fruit maturity. The induction of regular, early and uniform flowering will undoubtedly ensure higher yields and better returns to the grower.

Early flower induction and early fruit production with the manipulation of chemicals accompanied with restricted amount of nitrogen fertilizer application in Sein Ta Lone mango have not been so far determined in Myanmar. Therefore, the experiments were carried out to examine the following objective.

Overall Objective

To assess the effects of selected chemicals on Sein Ta Lone mango for reproductive morphogenesis.

CHAPTER II
REVIEW OF THE LITERATURE

2.1 Physiology of Mango Flowering

Two major differences exist between tropical and temperate deciduous horticultural trees with respect to floral initiation. Firstly, tropical species such as mango initiate flowers in response to an environmental stimulus, while temperate deciduous species, such as apple, initiate flowers autonomously. Secondly, temperate deciduous horticultural trees undergo a period of dormancy between floral initiation and anthesis, while in tropical species, including mango, floral development is continuous from floral induction to anthesis (Wilkie *et al*. 2008).

Mango flowering was an important physiological event that sets the start of fruit production. Mango vegetative shoots were monopodial and exhibited periodic extension or 'flushing' prior to formation of the apical panicle (Singh 1960; Verheij 1986). Dormant buds were non-differentiated (Reece *et al*. 1949; Singh 1960; Scholefield *et al*. 1986); therefore, upon initiating growth, all buds could potentially display vegetative or floral morphogenesis (Reece *et al*. 1946).

Mango trees flower in response to the age of the last vegetative flush in tropical conditions. In contrast, cool inductive temperatures induce flowering under subtropical conditions. Mango flowering could be manipulated in order to obtain out-of-season fruits and improve mango productivity (Ramíreza and Davenport 2010).

2.2 Influence of Environment on Mango Shoots Development

Davenport and Nun˜ez-Elisea (1997) defined that extension and lateral growth of mango stems occurred in periodic flushes of elongating shoots forming the terminal intercalary units of branches. Stems were here defined as non- growing, dormant vegetative structures that remained in rest most of the year, whereas shoots were actively growing vegetative or reproductive structures that were evoked from apical or lateral buds of these stems. Growth of individual shoots lasted only about 2weeks, forming 10 to 20 leaves before returning to a dormant or resting state that lasted two months to nearly a year, depending on the age of the tree and environmental conditions. Once elongation was completed, these shoots formed the terminal

intercalary unit of resting stems.

Mango trees produce basically three types of shoots as a consequence of cell division. Vegetative shoots bear only leaves. Generative shoots produce inflorescences and mixed shoots produce both leaves and inflorescences within the same nodes (Davenport 2007, 2009).

Growth of mango and other tropical trees was not continuous (Verheij 1986; and Davenport 1993, 2000, 2003). Apical buds spent most of the time in rest. Growth occurred as intermittent, ephemeral flushes of shoots from apical or lateral buds (Naik and Rao 1943; Singh 1958).

2.3 Vegetative and Reproductive Development Influenced by Environment

Mango trees require new vegetative growth in order to produce fruit each year (Bally 2009). Schaffer *et al*. (1994) reported that mango flowering was more likely to be problematic in tropical climates, where a dry period appeared to be the main flowering trigger, than in the subtropics, where winter cold was the main environmental cue.

Tropical climates were conducive to year-round vegetative growth of perennial tropical fruit crops, but flowering and fruit set were usually seasonal. Flowering from one season to next was unreliable, because the environmental signals for flower initiation were often inconsistent, subtle or poorly defined (Nagao and Nishina 1993).

Growth of mango trees was ephemeral. Periodic initiation of vegetative or reproductive shoots occurred from resting buds of terminal stems in several flushes per year (Davenport and Nu´nez-Elisea 1997). In the subtropics, the ambient temperature was the primary regulator of vegetative or reproductive induction at the time of shoot initiation. Vegetatively induced flushes of growth occur during warm spring, summer, and early fall months (Davenport *et al*. 2006).

Vegetative flushes of growth typically occur one to several times per year on individual stems. Under subtropical conditions, vegetative growth flushes occur during warm temperatures, around 25 ºC or higher (Núnez-Eliséa *et al*. 1996).

Growth and development of mangoes were determined by climate. In subtropical conditions with well-defined seasons, growth of mango canopy was typically synchronous with a time-gap between vegetative, rest and reproductive stages (Davenport 2009).

In contrast, under tropical conditions, the growth of mango was asynchronous sometimes displaying flowers, fruits and resting stems at the same time in different portions of the tree canopy (Verheij 1986; and Goguey 1997).

2.3.1 The role of temperature in mango floral morphogenesis

Studies in mango revealed existence of floral stimulus, which was continuously synthesized in mango leaves during exposure to cool, inductive temperature (Devanport and Nunez-Elisea 1990, Devanport and Nunez-Elisea 1992). Whiley *et al*. (1989) found that eight out of ten mango cultivars flowered at a day/night temperature regime of 15/10° C, and only one of the cultivars flowered at 20/15°C, while the other nine cultivars grew vegetative. Shu and Sheen (1987) found that 100% of 'Haden' mangoes flowered at 19/13°C, 60% at 25/19°C and 0% at 31/25°C. Interestingly, four cultivars that flowered at 30/20°C in the work of Sukhvibal *et al*. (2000) failed to flower at 20/15°C in the work of Whiley *et al*. (1989).

Some experiments confirmed by (Davenport 1990; Davenport and Nuñez-Elisea 1997) in mango, lichee and citrus found that when a plant of any of these species was exposed to warm temperatures (30° C day/25° C night) at the time of shoot initiation, the resulting shoot growth was purely vegetative. If it was instead maintained in cool conditions (18° C day/10° C night), it produced generative shoots. If placed in either of the two temperatures without clipping or tip pruning, initiation of bud break took several months to occur but the outcome was the same

Flowering in response to exposure to cold temperatures, –1° C to 10° C, for extended periods was termed vernalization (Simpson and Dean 2002). Unlike other plants requiring vernalization for floral induction, although cool temperatures induce mango flowering under subtropical and upper latitude tropical conditions, the age of the last flush is the key event that governs flowering in the warm tropical condition as evidenced by experiments conducted in Colombia on "Keitt" and "Tommy Atkins" mango trees (Ramírez and Davenport 2010).

There was evidence for a phloem mobile floral stimulus (florigen) in mango. Kulkarni (1986, 1988a, 1991) examined mango flowering by cross-grafting cultivars with different inductive requirements. While the rootstock was under inductive conditions it could promote flowering in the defoliated scion under conditions non-inductive for the scion cultivar, so long as the rootstock had leaves. However, when

leaves remained on the scion, flowering was inhibited and subsequent growth was vegetative. Similarly, juvenile mango plants had the ability to flower after grafting to a mature plant so long as the juvenile plant was defoliated and the adult plant had leaves (Singh 1959), indicating that signals from the leaves of the adult plant promoted flowering and could overcome juvenility, while leaves from juvenile plants inhibited flowering. In separate studies, when branches were girdled and decapitated, the growth from auxiliary buds was floral if leaves were allowed to remain on the plant for more than 4 days under inductive conditions (Reece *et al*. 1946, 1949). From these observations, it could be concluded that floral stimulus in mango were transient, graft transmissible, and generated by the leaves.

Floral or vegetative induction occurs when shoots are initiated. Resting buds of plants that are exposed to cool temperatures (18° C day/10° C night) for more than 3 weeks and then transferred to a warm temperature (30° C day/25° C night) before initiation, produce only vegetative shoots (Núñez-Elisea *et al.* 1996).

Two distinctly separate events must happen for flowering or vegetative growth to occur in mango. The resting bud must first initiate growth. Initiation is referred to here as the onset of rapid shoot development (bud break) regardless of the type of shoot evoked. Coincident with shoot initiation, induction occurs based on the conditions present at the time of initiation. Induction here refers to the temporary commitment of buds to evoke a particular shoot type, i.e., vegetative shoot, generative shoot or mixed shoot (Davenport 2000).

Induction controlling the type of shoots that were evoked up on initiation appeared to be governed by interaction of temperature regulated florigenic promoter (FP) and an age dependent vegetative promoter (VP) (Davenport and Núnez-Eliséa 1997; Davenport 2000).

At the time of shoot initiation, floral and vegetative inductive responses could be effectively explained by the ratio of FP and VP (Davenport 2000, 2007, 2009). He postulated that high FP/VP ratios when shoot initiation occurred might be conducive to induction of generative shoots, where as low ratios might be conductive to induction of vegetative shoots, and at intermediate levels, mixed shoots were induced. FP appears to be up-regulated during exposure to cool temperatures below18° C in subtropical conditions ; however, there appears to be a basal level present at all times regardless of temperature in order to regulate flowering during warm temperature conditions of the tropics (Davenport 2000).

2.4 Stimulating Mango Flowering with Practices and Chemicals

2.4.1 Girdling

Girdling (the removal of a ring of phloem) was a common horticultural practice used to manipulate tree growth and development, and fruit growth, in a variety of fruit species. Its most immediate effect was to stop the basipetal movement of assimilates through the phloem, which resulted in an accumulation of carbohydrates above the girdle (Roper and Williams 1989).

Girdling has been suggested as a way to improve earliness and intensity of flowering in mango reviewed by Pandey (1989). He stated that mango flowering could be stimulated by trunk or branch girdling. Hegele *et al.* (2004) explained that tree response was dependent on the width of the girdle. Narrow cuts resulted in either a short-term or no response; whereas, girdles that were too wide could kill trees if they did not close within a reasonable time. Girdling cuts phloem transport, starves roots of photoassimilates and interrupts auxin transport to roots. In this regard, Davenport (2009) postulated that these were detrimental to root development and could alter the bud cytokinin : auxin ratio due to reduced cytokinin translocation from roots. This resulted in delayed shoot initiation, which could impact the level of the age-dependent, putative VP when shoot initiation occurs. The delay in flushing, therefore, enhances flowering. A number of authors indicated that trunk girdling of mango trees to promote flowering was inconsistently effective (Gaskins 1963; Winston and Wright 1986) and could be detrimental to trees, especially if done in subsequent years. It has been shown to increase flowering in the ‘off’ year of alternate-bearing cultivars; however, it either has no effect or is only marginally beneficial in the ‘on’ year (Rath and Das 1979; Rameshwar 1989).

2.4.2 Water stress

In the absence of cool temperatures, mango trees in the tropics may flower in response to irrigation or rain following periods of water stress lasting 6–12 weeks or more (Pongsomboon 1991).Water stress affects turgor in plant cells and, consequently, influences bud growth in fruit trees. In some fruit crops, notably Citrus, water stress has the ability to induce floral morphogenesis, with floral bud growth initiating upon rewatering (Southwick and Davenport 1986).

Davenport (1992) and Schaffer *et al*. (1994) noted that the primary impact of water stress on mango was to prevent vegetative flushing during the stress period. The accumulating age of stems was greater in water-stressed trees than in trees maintained in under well watered conditions which could vegetatively flush more frequently.

This delay in flushing might provide more time for accumulation of a putative FP (Schaffer *et al.* 1994) or reduction in the level of a putative VP (Davenport and Núñez-Elisea 1997; Davenport 2000).

It was found that exogenously applied cytokinins stimulate shoots initiation of mango (Chen 1987; Nuñez-Elisea *et al*.1990). Water stress inhibits shoot initiation by its direct impact on cell division and elongation possibly by interfering with translocation of cytokinins from roots. There was little evidence that water stress was directly involved in inductive processes. During water stress, roots continued to grow and produced cytokinins (Itai *et al.* 1968; Wu *et al.* 1994). It could be clarified that reduced xylem flux due to limited soil hydration, and transpiration due to increased stomatal resistance during water stress might reduce the amount of cytokinins reaching stems thereby inhibiting the shoots initiation.

The water stress experiments on mango flowering conducted by Ntifiez-Elisea and Davenport (1995), who illustrated that in warm temperatures (mean minimum temperatures about 20°C), water stress delayed shoot extension, but did not induce floral morphogenesis. In cool temperatures (mean minimum temperatures about 15°C), floral buds were initiated regardless of water stress. Thus, floral morphogenesis was induced by chilling temperatures. In contrast to water stress delaying the development of vegetative buds, the growth of floral buds was stimulated by water stress. Low temperatures thus promoted floral induction of mango, whereas water stress promoted growth of florally induced buds. Overwatering, on the other hand, could result in luxury use of water, creating excessive vegetative growth and thereby intensifying the tendency toward biennial bearing (Núñez-Elisea and Davenport 1994)

2.4.3 Smudging and ethylene

As early as in (1923), Gonzales demonstrated that smudging showed effective to obtain earlier and increased flowering of ‘Carabao’ and ‘Pico’ mango in the Philippines. Smudging had been done continuously for several days and was stopped

if flower buds did not appear within two weeks. The process might be repeated 1-2 months later, but result was uncertain. Later, ethylene had been identified as the active agent responsible for flowering during smudging (Dutcher 1972). The ethylene generating agent, ethephon, applied at 125-200 ppm, could induce flowering of 'Carabao' mango in the Philippines within six weeks after treatment (Dutcher 1972).

Ethephon has also been successful in India for increasing flowering of 'Langra and Deshehari' during 'off' years (Chacko *et al*.1972 and Chanda and Pal 1986) and for inducing earlier production in juvenile plants (Chacho *et al*. 1974). Contrary to these results, Pal *et al.* (1979) indicated that ethephon was effective after five consecutive years of treatment. In addition, Send *et al.* (1973) reported an increase in flowering during "on" years but failed to stimulate flowering during "off" years by ethephon application.

2.4.4 Potassium nitrate (KNO_3)

The first evidence of potassium nitrate that could induce flowering of mango trees was also from the Philippines. Flowering was observed within seven days after treatment and was effective on shoots that were between 4.5 and 8.5 months old when treated (Barba 1974, Bueno and Valmayor 1974).

Since then, potassium nitrate was recommended in the Philippines for inducing uniform flowering and for the production of off-season fruits in the 'Pico' and 'Carabao' cultivars (Madamba 1978).

In addition, potassium nitrate applications just prior to and at the flowering stage promote flowering, increase fruit set and fruit retention (Oosthuyse 1997; Rojas and Leal 1997; Sergent *et al.* 1997; Saleh and El-Monem 2003). In the low and mid-latitude tropics, potassium nitrate was used to stimulate out-of-season flowering; however, this effect was lost in higher latitudes (Davenport and Núñez- Elisea ,1997). Protacio (2000), indicated that the KNO_3 effect on flowering was primarily due to N stimulation rather than K and he postulated that potassium nitrate overcomes the inhibitory effects of gibberellic acid (GA_3) on starch accumulation by elevating the N concentrations over the N threshold to synchronize bud break from apices with an existing floral initial.

On the other hand, Bondad and Linsangan (1989) suggested that one effect of KNO_3 was to trigger formation of nitrate reductase, an adaptive enzyme that appears in plants when nitrate was present and led to the synthesis of amino acids.

Contrary to the above assumption, the flower promoting effect of potassium nitrate sprays seems to be mediated through the dormancy-breaking property of the chemical. It was used to induce off-season flowering and for synchronous flowering instead of transformation of vegetative buds to reproductive one (Kulkarni 2004).

2.4.5 Thiourea

The chemicals which are now used commercially for breaking dormancy in various places are mineral oil, potassium nitrate (KNO_3), thiourea and cyanamide. All of these chemicals are inexpensive, can effectively break the true dormancy of buds, and improve the production of deciduous fruit trees in warm locations (Chang and Sung 2000).

Thiourea, a sulf hydral compound (NH2-CS-NH2), known for breaking dormancy and stimulating germination, has been reported to significantly improve growth, yield and water use efficiency of wheat (Sahu and Singh 1995) and also promote for rapid dormancy breaking, rapid emergence, increasing minituber number per plant and increasing tuber yield in potato minituber production (Germchi *et al.* 2011).

An experiment of efficacy of thiourea on terminal bud break of two mango cultivars- Nam Dok Mai and Khiew Sawoey conducted by Tongumpai *et al.* (1997), indicated that all concentrations utilized in an experiment, 0.5%, 1% and 1.5% thiourea, induced 100% bud break between 14 and 16 days after treatment in both cultivars.

Davenport (2007, 2009) defined that shoot initiation in mango, i.e .initiation of bud break, had to occur before induction determined the type of shoot to be evoked in those buds. They were different physiological events that led to the formation of reproductive, vegetative or mixed shoots.

2.4.6 Growth retardants

The balance between a growth promoter and a growth inhibitor might be required for flowering of mango. It has been generally accepted that gibberellins enhance

vegetative growth and inhibit flowering of mango (Tomer 1984; Chacko 1986; Chen 1987).

There was a general agreement on the principle that a growth check of sufficient duration was necessary for synchronous floral induction in mango (Vander meulen *et al*. 1971). Wolstenholme and Hofmeyer (1985) reported that vegetative growth and fruiting in mango trees were largely antagonistic and that excessive vegetative growth, especially in absence of a dry period, was likely to cause poor yields.

In this regard, plant growth retardants are used to improve long term reliability such as reducing tree growth, to stimulate early or more intense flowering, especially in the 'off' year of alternate-bearing cultivars (Davenport and Núñez-Elisea 1997).

Growth retardants are in three main classes: (i) the gibberellin transport inhibitor, daminozide (N-dimethylamino-succinamicacid), known as Alar or B-Nine; (ii) the onium type, chloremquat chloride(2-chloroethyl trimethylammonium chloride), known as cycocel and CCC; and (iii) the steroid-synthesis-inhibiting triazoles, for example PBZ (PP-333), known as Cultar®, and uniconazole, known as XE-1019 or Sumagic (Rademacher 2000). The latter two classes of compounds inhibit ent-kaurenesynthetase, an enzyme in the gibberellin synthesis pathway (Dalziel and Lawrence 1984).

2.4.6.1 Paclobutrazol (PBZ)

Among various retardant PGRs, PBZ [(2RS,3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl) pentan-3-ol] has been found to be particularly effective described by a number of authors (Burondkar and Gunjate 1993, Kurian and Iyer 1993). PBZ was taken up through roots and transported primarily in the xylem through the stems and accumulated in leaves (Sterrett 1985) and fruit if applied to the soil (Wang *et al*.1986)

PBZ was a potent inhibitor of gibberellin biosynthesis (Hedden and Graebe 1985) and could be applied as an overall spray, as a soil drench or by way of trunk painting; better results have been achieved when used as a soil drench, either in the root zone or the collar region of the tree. It was a broad-spectrum growth retardant and reportedly effective in inducing flowering in apple and pear (Williams and

Edgerton 1983) and mango (Tongumpai; *et al.*1991a) and reducing stem elongation in apple (Steffens and Wang 1985); citrus (Aron *et al*. 1985) and peach (Erez 1984).

One of the main roles of GA in trees was the stimulation of cell elongation. When gibberellin production was inhibited, cell division still occured, but the new cells did not elongate. The result was shoots with the same numbers of leaves and internodes compressed into a shorter length. For many years this was considered to be the sole response of trees to treatment with paclobutrazol. However, research has demonstrated that blocking a portion of the terpenoid pathway causes shunting of the accumulated intermediary compounds above the blockage. The consequence was an increase in the production of the hormone abscisic acid and the chlorophyll component phytyl, both beneficial to tree growth and health (Rademacher 2000).

PBZ could promote flowering in two ways: it could speed up and increase the synthesis of the floral stimulus in an inductive cycle, or, it could plausibly affect the ratio between flower promoting and flower inhibiting factors (Kulkarni 1988b). He also explained that in young grafted mango trees, the shortage of a promoting factor (because of fewer leaves) favoured the inhibitor, and PBZ could reduce the amount of inhibitor and thereby shifting the balance in favour of flower promotion. Similarly, in the case of bearing trees, increased flowering and earliness were noticed in the treated trees. It did this by altering sink strength in a plant, which resulted in more assimilates being partitioned to reproductive growth, formation of flower buds, formation of fruit and fruit growth (Lever 1986).

Presently, the use of PBZ in fruit trees has been banned in various countries, PBZ is still used in several countries to tackle the problem of alternate bearing of mango trees and to shift fruit harvest to economic niche periods of increase demand. PBZ used in many other mango growing countries for such a situation, they concern over its residue on soil and fruits because of its nature of mainly translocation via xylem and persistence in the soil. Persistence of PBZ in the soil may result in contamination of nearby water bodies, thus presenting a possible hazard to human and animal health, and could also influence soil microbial activity with further effect on biodiversity (Neidhart *et al*. 2006).

The former maximum residue levels of the Codex Alimentarius for PBZ (0.5mg $kg^{-1}$for apples, 0.05 mg $kg^{-1}$for stone fruits) have been revoked (FAO 2005). In the European Union, presently tolerated maximum residue levels of PBZ were 0.05 mg $kg^{-1}$for any other plant foodstuffs than apples described by Neidhart *et al*. (2006).

Residues of PBZ have been reported in literatures indicated that risk of intolerable PBZ residues were found in edible mesocarp (Neidhart *et al*. 2006, Sharma *et al*. 2007). However, the risk of PBZ accumulation in the soil became evident and high rate of application in the recent past resulted in higher residues (Neidhart *et al*. 2006). He also suggested that research in alternative strategies for flower induction of mango might be intensified.

2.4.7 The role of nitrogen on floral morphogenesis and fruit quality

There is no doubt that among nutrients, nitrogen has the great influence on growth and development of plants by providing essential components for production of branches, leaves and fruits. An essential ingredient of chlorophyll, proteins, growth hormones and enzymes, nitrogen is a building block for fruit production. Phosphorous is more closely associated with prolific root growth, production of strong stems, good fruit set, and timely ripening (Samara and Arora 1997). Moreover, N has a major effect on mango tree vigor stimulating both vegetative and floral growth (Bally 2009).

N could cause increased fruit set and retention (Oosthuyse 1997) and fruit weight and yield (Reddy *et al*. 2003). High N application rates that stimulate yield increases could also have negative effects on fruit quality (Bally 2009). Bally (2007) also reported a negative relationship between N and fruit colour cited by Bally (2009), demonstrating that high leaf N concentrations reduced the percentage of yellow skin in ripe fruit, reduced the lightness and chroma (vividness) of the yellow colour, the percentage of skin covered with blush and the intensity of the blush colour.

There was a general agreement on the principle that a growth check of sufficient duration was necessary for synchronous floral induction in mango (Vander meulen *et al*. 1971). It was also agreed that vegetative growth and fruiting in mango trees were largely antagonistic and that excessive vegetative growth, especially in absence of a dry period, was likely to cause poor yields (Wolstenholme & Hofmeyer 1985).

Therefore, mango trees with high leaf N levels rarely flower in the tropics. Lack of flowering was always due to frequent vegetative flushes of growth, especially during the rainy season. Mango trees must have leaf N levels of 1.1 to 1.4% at the time of synchronization pruning in order to suppress frequent flushes of vegetative growth (Davenport 2003). Similarly, high N in soils leads to high N levels in leaves resulting in frequent vegetative flushes that lead to poor flowering (Davenport 2009).

An experiment conducted by Li *et al.* (2001) on flowering and production of Lichee in Florida demonstrated that flowering and yield significantly decreased as N fertilizing increased.

Flowering of three fruit species such as mango, lichee and citrus had somewhat varied, but similarities in response to environmental cues suggested that many of the findings of one species could be applicable to the others (Davenport 2000).

CHAPTER III

EXPERIMENT 1: Effects of Two Levels of PBZ and 3% KNO_3 Spraying on Floral Induction, Growth, Yield and Quality of Sein Ta Lone Mango

3.1 Introduction

Production of Sein Ta Lone mango during the peak season leads to low prices. Early fruit production can fetch higher prices than in-season fruits. Early fruit can also gain high quality in their appearance and free from insect and disease infection. Because, early fruit harvesting period may be far or at least a little ahead of normal harvesting period during which uncertainty of rain may commonly occur. This situation is favorable for occurrences of fruit fly and anthracnose disease that reduce the fruit quality. Therefore early fruit production technique should be sought after to increase grower's benefit as well as consumer's fruit availability.

The major constraint of early fruit production of Sein Ta Lone mango was that the factors which determined switching from vegetative to reproductive mode of mango was poorly understood, although a period of low temperature (<18˚C) during the pre-flowering period was thought to be involved (Davenport and Núñez-Elisea 1997). In middle Myanmar, most mango cultivars including STL flower during the winter months. It can be assumed that the flowering of STL mango is governed by not only low temperature but also short photoperiod. Ntifiez-Elisea and Davenport (1995), however, clearly illustrated that cold temperature rather than a short photoperiod caused floral induction of mango.

In addition, it was commonly accepted that opportunities for flowering of mango were maximized as the terminal shoots became more mature (Scholefield *et al*. 1986). In the absence of cool temperatures, the ability to flower was directly correlated with the age of the terminal intercalary unit in tropical climates (Davenport 2000)

The critical component regulating floral induction of mangoes in the tropics was the age of the last flush (Núñez- Elisea and Davenport 1995). So synchronization of the vegetative growth of mango tree canopies was a necessary first step in the flowering management program.

Available evidences suggested that nitrate compounds and thiourea could be used to induce new flush in mango. Uniform leaf flushing could be achieved by spraying 0.5 % thiourea (Tongumpai *et.al*. 1997).

The older the age of the last vegetative flush (terminal intercalary unit), the more likely it is to flower when the next flush occur. Thus, successful floral management in the tropics requires discouraging initiation of shoots before the resting stems have reached sufficient maturity to induce flowering shoots (Davenport 2007).

Davenport (2007) also stated that stems must be in rest for sufficient time; generally about four to five months depending on cultivars to be induced to flower in absence of chilling temperature. In this regard, Paclobutrazol (PBZ) was very useful not only to restrict the vegetative growth during the resting period but also to promote the flowering of mango. Because PBZ inhibited the biosynthesis of gibberellins which was a hormone not only associated with the production of new vegetative growth but also suppressed the flowering of mango (Tongumpai *et.al*. 1991b). Kulkarni *et.al*. (1988b) postulated that PBZ moves up through the roots into shoots and, due to its anti–gibberellins properties, blocks the synthesis of flowering inhibitor thereby allowing the flowering promotion factors to work.

To date, beneficial effects of PBZ to get the regular bearing from biannual bearing habit and to advance in harvesting time of mango, PBZ is utilized in several other mango growing countries. According to behaviour of persistence in the soil and sole xylem mobile action of PBZ, an accumulation of PBZ to the soil and fruit are concerned in term of food safety and ecological impact.

In addition, there are some detrimental effect on subsequent growth and normal development of mango tree after application of PBZ elucidated by Davenport (1993), who stated that although fruit set and yield were increased, the PBZ produced compress panicle which did not dry out well and could develop powdery mildew and anthracnose even after a light dew. Another problem was that even when 1g ai of PBZ was applied to the tree as a soil drench, the tree was severely stunted after over six years when main branches were pruned. He also observed that recommendation used in Thailand of 1.5 to 2 g ai of PBZ /tree/year to stimulate more uniform flowering eventually resulted in such a kind of damage when those trees were pruned for some reason.

With regard to the above mentioned advantages and disadvantages of using PBZ in the mango, the experiment attempted to the development of an alternative management strategy for flower induction of mango by regulation with a little amount of PBZ (0.10 and 0.15 g ai m^{-1}) together with 1% thiourea for shoot induction and 3%KNO_3 for flower induction was laid down to investigate the consolidating efficacy, of those chemicals on vegetative and reproductive morphogenesis, flowering intensity, harvesting fruit percent from the total inflorescences, fruit yield and quality of Sein Ta Lone mango.

Objectives

(1) to induce early flowering and fruiting

(2) to manipulate flower synchronization in normal season

3.2 Materials and Methods

3.2.1 Area and season

The experiment was carried out at the Horticulture section, Department of Agricultural Research (DAR), Yezin as a preliminary study and began on June 15, 2009 to the end of May 2010.

3.2.2 Plant materials

Uniform 3-year-old Sein Ta Lone mango plants having almost equal number of branches and plant height were used for the experiment including 42 Sein Ta Lone mango trees.

3.2.3 Care and management of experimental trees

Onset of the study, all the experimental plants were measured in tern of height and canopy diameter. Then, pruning work (thinning out of water shoots and diseased and pest-infected twigs) was done on every experimental plant. To maintain mango plant healthy, spraying of insecticide and fungicide were carried out at each time of new flush of vegetative or reproductive one.

3.2.4 Materials used

For all the experiments, 10% PBZ and 99 % Thiourea imported from thailand were used. Multi K used in these experiments was manufactured by Haifa Chemicals,

Ltd as a KNO_3 consisting of Nitrogen (N) 13 %, Potassium oxide (K_2O) 46 % and Potassium (K) 38 %.

3.2.5 Treatments and experimental design

The experiment was a two factor factorial combination in a Randomized Complete Block design with three replications. In the factorial set, all the experimental plants were sprayed with 1% Thiourea on June 15, 2009 to induce new shoots. Then the trees were assigned under two different dosages of PBZ (0.1 g ai m^{-1} and 0.15 g ai m^{-1} of canopy diameter) which were applied as a soil drench on July 15, 2009 (1 month after spraying of Thiourea). Two and a half months after PBZ application, each randomly assigned plant from every replicate was sprayed with 3% KNO_3 at two weeks intervals to induce vegetative or reproductive shoots. Different spraying times of 3 % KNO_3 were considered as the flower induction treatments. KNO_3 3 % spraying was done at the following schedules-10 week after PBZ application (10 WAP), 12 WAP, 14 WAP, 16 WAP and 18 WAP, Control 1 and Control 2.The Control 1 comprised of 1% thiourea spraying for new flushing and two levels of PBZ application but with water only at 18 WAP. Control 2 (no application of thiourea, PBZ and KNO_3) was considered an additional treatment.

1% Thiourea spray for new flushing

PBZ application

3% KNO_3 spray for floral induction

0.7% Thiourea spray for floral induction

Plate 1 Selected chemicals applications for new flushing and floral induction

Factor (A) Two doses of PBZ application

(1): 0.10 g ai m^{-1} of canopy diameter

(2): 0.15 g ai m^{-1} of canopy diameter

Before application of two levels of PBZ, all the experimental trees except control 2 were sprayed with 0.1 % thiourea to induce uniform flushing.

.**Factor (B)** Different times of flower induction with 3% KNO_3 spraying

(1) 10 WAP
(2) 12 WAP
(3) 14 WAP
(4) 16 WAP
(5) 18 WAP
(6) Water spraying at 18 WAP (Control 1)
(7) No spray at all (Control 2)

3.2.6 Data collection, observation and calculation

(a) Growth pattern

The length (cm) of the first new shoots in each plant after 1% thiourea spraying for uniform flushing and the length (cm) of second new shoots coming after the two levels of PBZ application were measured to access growth of the plant.

The length (cm) of randomly selected inflorescences at the full bloom stage was also measured.

Canopy surface area (m) of each tree both the onset and at the end of season was also recorded.

(b) Flowering data

The visible inflorescences occurrence of generative shoots (GS) and mixed shoots (MS) after 3%KNO_3 spraying for flower induction were recorded. Number of GS and MS were counted at ten days intervals onwards till full bloom. The total numbers of inflorescences per tree were deliberated at each time of counting date from GS and MS. The flowering intensity percent was also calculated from existing shoots.

(c) Fruit yield and quality

The harvested fruit percent from the total inflorescences were also deliberated. Total number and weight of fruits (kg) per tree were also recorded. Fruits were harvested when skin colour change from mature green to pale.

The date to first harvest and last harvest were also calculated based on two levels of PBZ application done on 15 July 2009.

The fruit quality was determined in the following characteristics – fruit dimension (cm) (length, width and thickness), weight (g) and Brix % from random sample of seven fruits from each tree.

3.2.7 Statistical analysis

All the data were subjected to analysis of variance by using Statistix version-8. Comparisons of means were performed using Least Significant Difference (LSD) at 5% level.

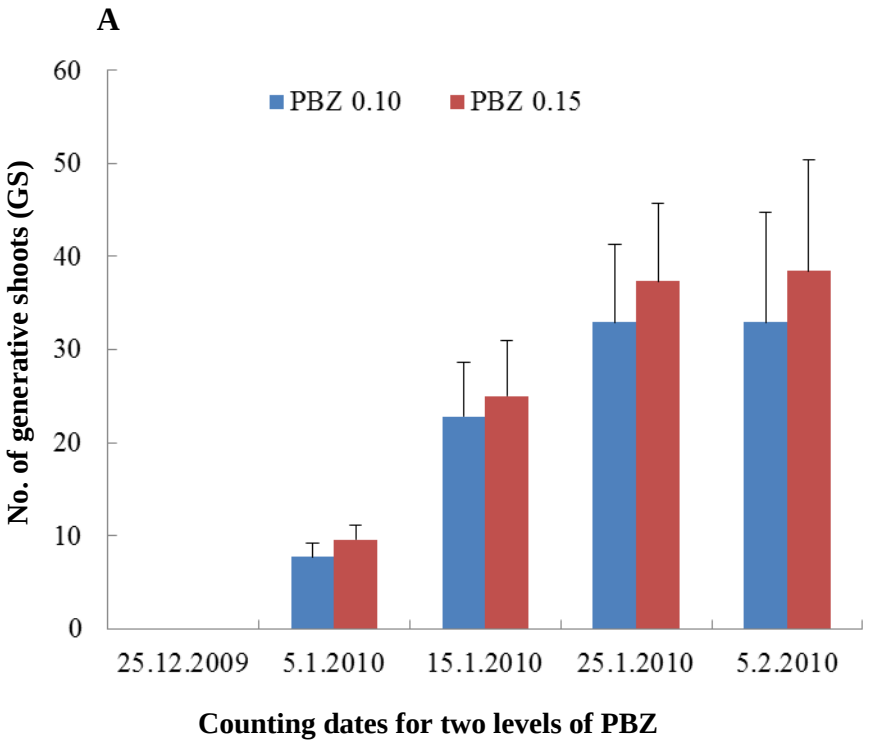
3.3 Results

3.3.1 The number of GS

The number of GS were not significantly different from one another in each time of counting date by using two levels of PBZ 0.10 and 0.15 g ai m^{-1} of canopy diameter (Figure 3.1 A). On the other hand, two weeks interval spraying with 3% KNO_3 for floral induction started from October 1, 2009 (10 WAP onwards to 18 WAP), results indicated that It was also found that 18 WAP gave the higher number of visible GS than other treatments during the early counting dates. However, total numbers of GS were not significantly differently from those of Control 1, 14 WAP and 16 WAP (Figure 3.1 B).

3.3.2 The number of MS

The number of MS on each counting date and total number of MS were not statistically different from one another by two levels of PBZ 0.10 and 0.15 g ai m^{-1} of canopy diameter (Figure 3.2 A). However, MS were observed more advanced noticeably on December 25, 2009 (Figure 3.1 B) than GS, which were seen beginning on January 5, 2010 (Figure 3.2 B). In addition, the results of flower induction with 3 % KNO_3 showed that the highest numbers of MS were observed in the 18 WAP and the lowest number were perceived in control 2 in each counting date (Figure 3.2 B).



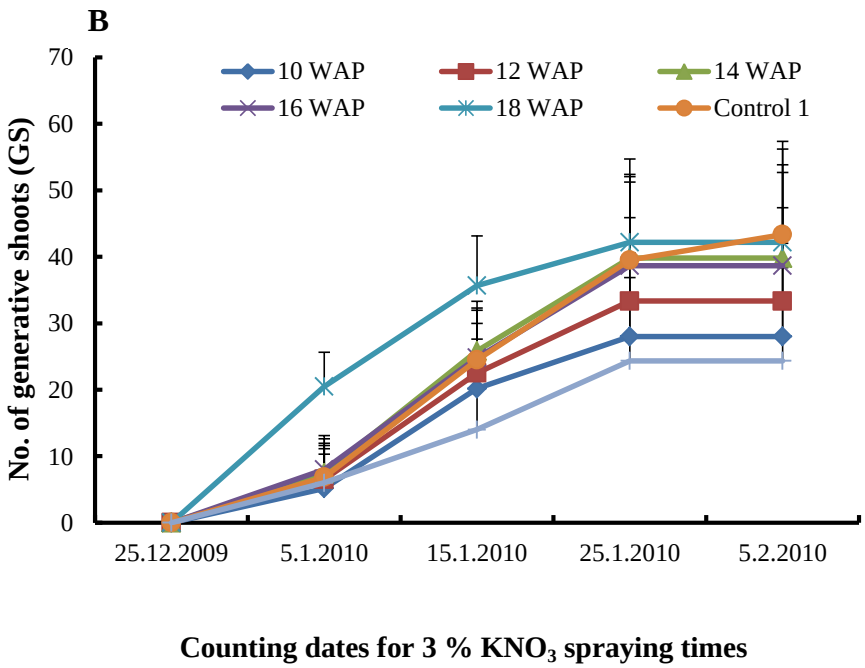


Figure 3.1 Number. of visible GS as affected by two levels of PBZ (A) and different times of 3%KNO_3 spraying (B)

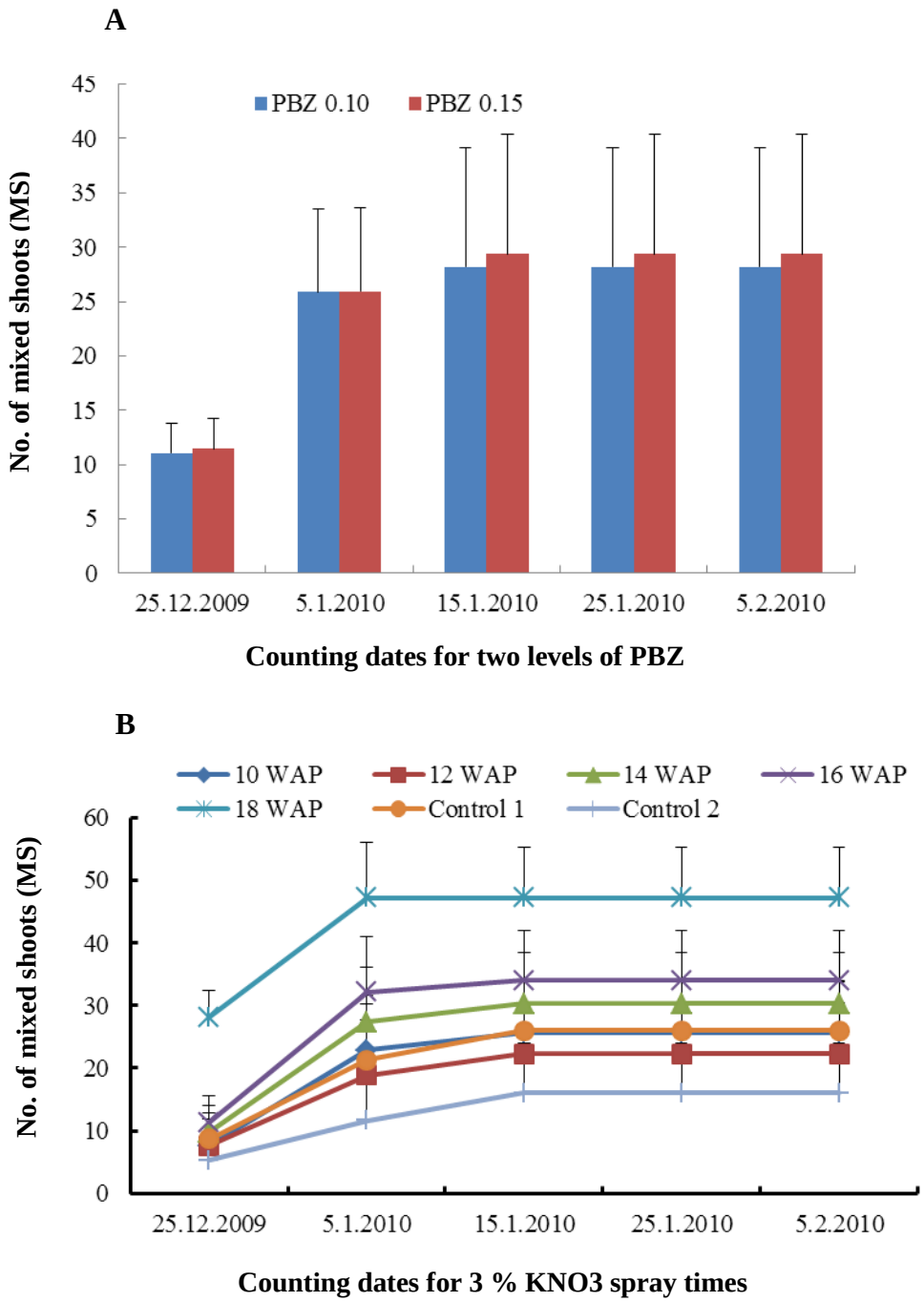


Figure 3.2 Number of visible MS as affected by two levels of PBZ (A) and different times of 3% KNO_3 spraying (B)

3.3.3 Number of inflorescences

With two levels of PBZ application, 0.1 and 0.15 g ai m^{-1} of canopy, there was no significant difference in number of inflorescences at each counting date and so was in total number of inflorescences at the end of floral organogenesis period (Figure 3.3 A).

However, the results of floral induction treatments showed that 18 WAP presented not only the earliest flowering but also the highest numbers of inflorescences and the lowest number of inflorescences were given by Control 2, followed by 10 WAP and 12 WAP (Figure 3.3 B).

Control (no flushing)

Uniform flushing after thiourea application

Shy and asynchronous inflorescences from Control 2

Profuse and synchronous inflorescences from 18 WAP

Plate 2 Effect of selected chemicals on new flushing and flowering of Sein Ta Lone mango

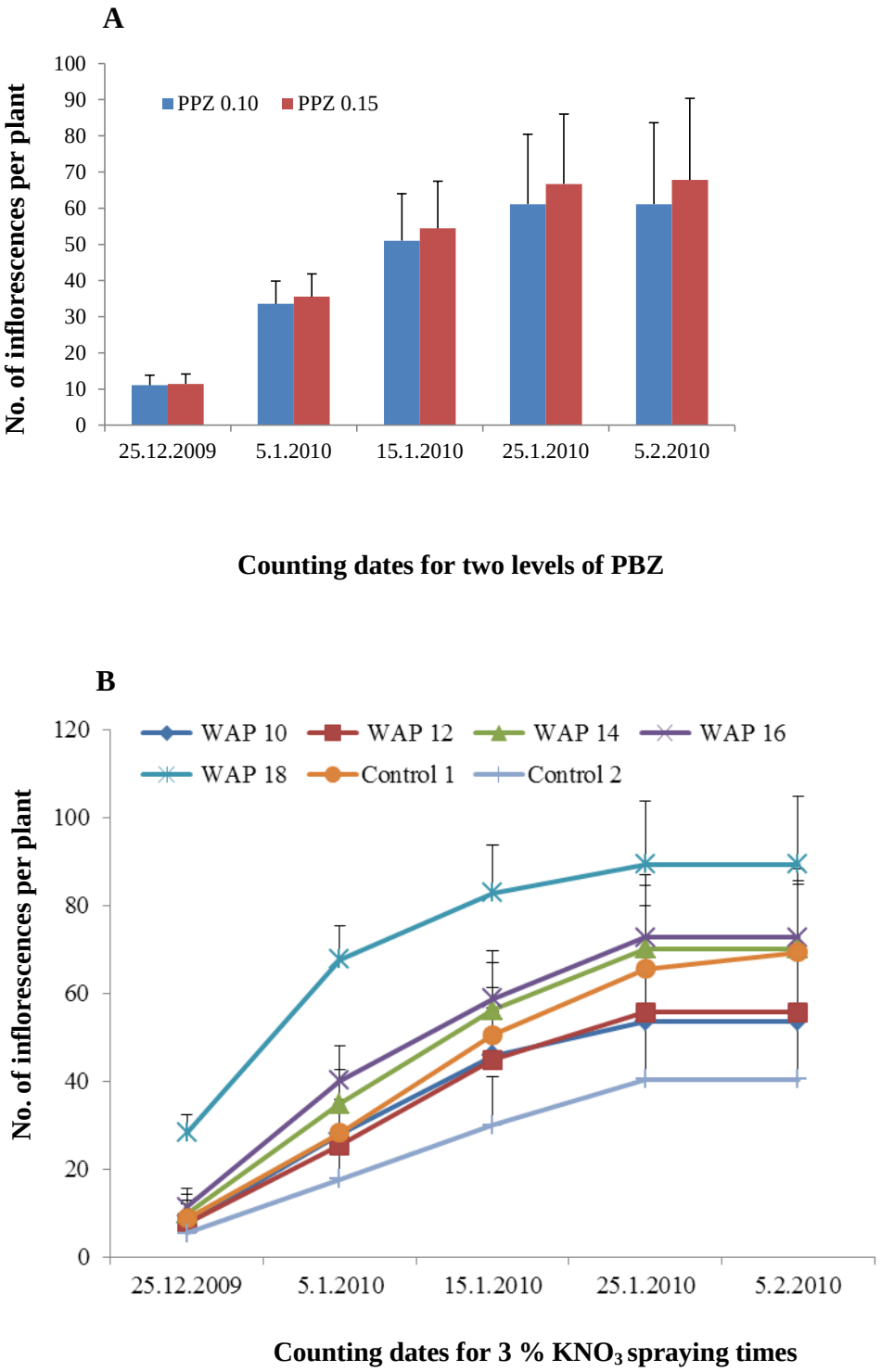


Figure 3.3 Number of inflorescences as affected by two levels of PBZ (A) and different times of 3% KNO_3 spraying (B)

3.3.4 First shoot length (FSL), second shoot length (SSL) and inflorescence length (IL)

Between two levels of PBZ application, 0.15 g ai m^{-1} gave the more length in both FSL and SSL than 0.10 g ai m^{-1} application but no differences were exhibited in IL (Table 1). Among the floral induction treatments, the results demonstrated that the longest FSL was observed in the Control 2, significantly different from other treatments. SSL was also the longest in Control 2, significantly longer than 10 WAP, followed by Control 1 and 16 WAP. The length of IL was not affected by floral induction treatments (Table 3.1).

Table 3.1 New shoot length and inflorescence length as affected by different dosages of PBZ and application time of KNO_3

Factors	First shoot length (cm)	Second shoot length (cm)	Inflorescence length (cm)
Levels of PBZ (g ai m^{-1})			
PBZ 0.10	15.91 b	14.57 b	37.74
PBZ 0.15	18.91 a	18.61 a	39.01
$LSD_{(0.05)}$	2.63	0.91	7.14
Application times of 3% KNO_3			
10 WAP	16.12 b	15.18 c	38.65
12 WAP	17.38 b	16.68 abc	36.97
14 WAP	16.55 b	16.75 abc	37.84
16 WAP	16.70 b	15.90 bc	37.60
18 WAP	17.57 b	17.68 ab	38.97
Control 1	17.12 b	15.75 bc	37.88
Control 2	20.42 a	18.17 a	40.70
$LSD_{(0.05)}$	2.39	2.02	3.57
F- test (A)	*	**	ns
(B)	*	*	ns
(A*B)	ns	*	ns
Cv%	11.51	10.2	7.81

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

3.3.5 Flowering intensity % and harvested fruit % from total inflorescences

Flowering intensity % and harvested fruit % from total inflorescences were not statistically different between applications of PBZ 0.10 and 0.15 g ai m^{-1} of canopy diameter. Despite no different evidence from the two levels of PBZ, floral induction treatments had proved that the highest flowering intensity (71.22 %) in 18 WAP was also significantly higher than those of other treatments. The lowest flowering intensity (36.34 %) was illustrated in Control 2, followed by 10 WAP (44.01 %) and 12 WAP (44.22 %) respectively but there were no significant differences in these three treatments. However, harvested fruit % from total inflorescences was not statistically different from each other (Table 3.2).

Table 3.2 Flower intensity % and harvested fruit % from total inflorescences as affected by different dosages of PBZ and 3% KNO_3 spraying

Factors	Flower intensity %	Harvested fruit % from total inflorescences
Levels of PBZ (g ai m^{-1})		
PBZ 0.10	49.48	64.37
PBZ 0.15	53.91	65.42
$LSD_{(0.05)}$	20.93	2.88
Application times of 3% KNO_3		
10 WAP	44.01 cd	65.36
12 WAP	44.22 cd	64.97
14 WAP	51.98 bc	67.20
16 WAP	58.42 ab	65.49
18 WAP	71.22 a	66.97
Control 1	55.71 bc	64.65
Control 2	36.34 d	59.11
$LSD_{(0.05)}$	13.12	7.75
F- test (A)	ns	ns
(B)	**	ns
(A *B)	ns	ns
CV%	21.28	10.02

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

3.3.6 Yield (number of fruits and weight) at each harvest date and total number of fruits and weight (kg)

There were not significant differences in the number of harvested fruits from each harvesting date and total number of fruits by applications of PBZ 0.10 and 0.15 g ai m^{-1} of canopy diameter (Table 3.3). The results of different times of 3% KNO_3 application for floral induction indicated that 7.5 fruits per plant were harvested only from 18 WAP at first harvest. At the second harvest time, fruits were harvested from all the treatments among which 18 WAP gave the highest number of fruits (25.5 fruit /tree) and also were statistically higher compared to others treatments and the lowest number of fruits were observed in Control 2 (4.67 fruits/tree), followed by Control 1 (9.5 fruits/tree), 10 WAP (10.83 fruits/tree) and 12 WAP (11.67 fruits/tree) respectively. The fruits harvested from third harvest time were 21.17 fruits/tree from 18 WAP and 21.50 fruits/tree from 14 WAP and the numbers were only significantly higher than those from Control 2 (10.33 fruits/tree) and 12 WAP (15.65 fruits/tree). The numbers of fruits harvested from each treatment were not significantly different from each other at fourth harvest. At the last harvesting time, 9 fruits/tree were harvested only from Control 2 and the rest of the treatments were terminated in the previous harvesting time. Total number of harvested fruits from each treatment indicated that 18 WAP gave the highest number of fruits (60.33 fruits/tree) and the lowest number of fruits was harvested from Control 2 (25 fruits/tree), followed by 10 WAP (34.67fruits/tree) and 12 WAP (35.83 fruits/tree) respectively (Table 3.3).

Fruit yield in terms of weight (kg/tree) has a similar trend with fruit numbers. The results of total fruit weight demonstrated that 18 WAP gave the highest (18.01 kg/tree) and Control 2 the lowest (7.92 kg/tree), followed by 10 WAP (11 kg/tree) and 12 WAP (11.28 kg/tree) respectively (Table 3.4).

Table 3.3 Number of fruits at different harvesting times and total fruit number by different dosages of PBZ and 3% KNO_3 spraying

Factors	Harvested fruit no./plant					
	1st (29.4.10)	2nd (3.5.10)	3rd (9.5.10)	4th (14.5.10)	5th (20.5.10)	Total
Levels of PBZ (g ai m^{-1})						
PBZ 0.10	0.81	14.29	15.38	7.90	1.10	39.48
PBZ 0.15	1.33	13.76	19.71	8.76	1.48	45.05
$LSD_{(0.05)}$	0.89	1.14	9.34	1.98	3.06	13.96
Application times of 3% KNO_3						
10 WAP	0.00 b	10.83 c	16.33 ab	7.50	0.00 b	34.67cd
12 WAP	0.00 b	11.67 c	15.67 b	8.50	0.00 b	35.83cd
14 WAP	0.00 b	16.33 b	21.50 a	9.83	0.00 b	47.67b
16 WAP	0.00 b	19.67 b	20.67 ab	7.17	0.00 b	47.50b
18 WAP	7.50 a	25.50 a	21.17 a	6.17	0.00 b	60.33a
Control 1	0.00 b	9.50 c	17.17 ab	9.17	9.00 a	44.83bc
Control 2	0.00 b	4.67 d	10.33 c	10.00	0.00 b	25.00d
$LSD_{(0.05)}$	1.18	4.04	5.26	3.81	2.38	11.23
F- test (A)	ns	ns	ns	ns	ns	ns
(B)	**	**	**	ns	**	**
(A *B)	*	ns	ns	ns	ns	ns
CV %	92.22	24.16	25.17	38.38	155.09	22.31

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

Table 3.4 Fruit weight at different harvesting times and total fruit weight by different dosages of PBZ and 3% KNO_3 spraying

Factors	Harvested fruit weight (kg/plant)					
	1st (29.4.10)	2nd (3.5.10)	3rd (9.5.10)	4th (14.5.10)	5th (20.5.10)	Total
Levels of PBZ (g ai m^{-1})						
PBZ 0.10	0.28	4.17	4.79	2.47	0.33	12.25
PBZ 0.15	0.39	4.37	6.09	2.69	0.41	13.76
$LSD_{(0.05)}$	0.26	0.35	2.55	0.ab59	0.90	3.66
Application times of 3% KNO_3						
10 WAP	0.00 b	3.41 c	5.23 ab	2.36	0.00 b	11.00 cd
12 WAP	0.00 b	3.65 c	4.95 b	2.68	0.00 b	11.28 c
14 WAP	0.00 b	4.93 b	6.64 a	3.02	0.00 b	14.59 b
16 WAP	0.00 b	5.93 b	6.33 ab	2.27	0.00 b	14.53 b
18 WAP	2.35 a	7.50 a	6.31 ab	1.85	0.00 b	18.01 a
Control 1	0.00 b	2.94 c	5.33 ab	2.80	2.60 a	13.67 bc
Control 2	0.00 b	1.54 d	3.26 c	3.12	0.00 b	7.92 d
$LSD_{(0.05)}$	0.28	1.15	1.55	1.11	0.73	3.13
F- test (A)	ns	ns	ns	ns	ns	ns
(B)	**	**	**	ns	**	**
(A *B)	*	ns	ns	ns	ns	ns
CV %	68.99	22.50	23.94	36.10	164.01	20.22

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

3.3.7 Days to first and last harvest

It could be clearly seen that the fruits were harvested after 280 days after application of PBZ 0.15 g ai m^{-1} of canopy diameter and after 288 days after application of PBZ 0.10 g ai m^{-1} of canopy diameter. In view of different floral induction treatments with 3% KNO_3, the fruits were harvested after 288 days after PBZ application in 18 WAP. However, the fruits were got after 292 days after PBZ application in other treatments (Table 3.5).

The days to last harvest at two PBZ levels were 309 days after PBZ application. However, the days to last harvest from different floral induction treatments, the

harvest could be done after 309 days after PBZ application from Control 1 but it was after 303 days after PBZ application in other treatments (Table 3.5).

Table 3.5 Days to first and last harvest from two levels of PBZ and 3% KNO_3 spraying

Factors	Days to	
	First Harvest	Last Harvest
Levels of PBZ (g ai m^{-1})		
PBZ 0.10	288	309
PBZ 0.15	280	309
Different times of 3 % KNO_3 spraying		
10 WAP	292	303
12 WAP	292	303
14 WAP	292	303
16 WAP	292	303
18 WAP	288	303
Control 1	292	309
Control 2	292	303

3.3.8 Fruit quality

There were not significant differences in fruit length, width, thickness, weight and Brix % between 0.10 and 0.15 g ai m^{-1} PBZ application. In addition, fruit length and width were not affected by different times of floral induction with 3% KNO_3 spraying. Significant differences were observed in fruit thickness, weight and Brix% by different times of floral induction treatments. It was found to be fruit thickness (7.26 cm) at 10 WAP, (7.25 cm) in Control 2, (7.18 cm) at 12 WAP and (7.18 cm) in Control 1. The fruits of 10 WAP, Control 2, 12 WAP and Control 1 showed statistically thicker fruit than those of 18 WAP (6.98 cm) and 16 WAP (7.03 cm). In terms of fruit weight, the heavier fruits were obtained in 12 WAP (329.17 g), Control 2 (322.5 g), 10 WAP (321.67 g) and Control 1 (314.17 g) compared to those of 18 WAP (295 g) and 16 WAP (302.08 g). Moreover, the highest Brix % was observed in

Control 2 and 18 WAP (19.4 % each), which were significantly higher compared to Control 1 (18.92 %) and 16 WAP (18.95 %), respectively (Table 3.6).

Table 3.6 Fruit length, width, thickness, weight and brix % as affected by different dosages of PBZ and 3% KNO_3 spraying

Factors	Fruit				
	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Brix (%)
Levels of PBZ (g ai m^{-1})					
PBZ 0.10	10.05	7.87	7.21	320.36	19.16
PBZ 0.15	10.19	7.74	7.07	306.79	19.18
LSD (0.05)	0.96	0.40	0.15	21.79	0.31
Application times of KNO_3					
10 WAP	10.37	7.90	7.26 a	321.67 ab	19.28 ab
12 WAP	10.37	7.82	7.18 abc	329.17 a	19.20 abc
14 WAP	10.19	7.82	7.09 bcd	310.42 bcd	19.05 bc
16 WAP	10.14	7.70	7.03 cd	302.08 cd	18.95 c
18 WAP	9.86	7.78	6.98 d	295.00 d	19.40 a
Control 1	9.37b	7.67	7.18 abc	314.17 abc	18.92 c
Control 2	10.56	7.94	7.25 ab	322.50 ab	19.40 a
LSD (0.05)	0.99	0.22	0.16	17.14	0.29
F- test (A)	ns	ns	ns	ns	ns
(B)	ns	ns	**	**	**
(A *B)	ns	ns	ns	ns	ns
CV%	8.28	2.37	1.89	4.59	1.29

Means followed by different letters in the same column are significantly different by LSD test at 5 % level.

3.3.9 Harvest dates as affected by two levels of PBZ and application times of 3% KNO_3

The harvest dates were not affected by two levels of PBZ application. On the other hand, the different times of floral induction with 3 % KNO_3, spraying the fruits from 18 WAP were five days earlier than those of the rest of the treatments. However, Control 1 and Control 2 gave the fruits four days later than other treatments at final harvest date (Figure 3.4).

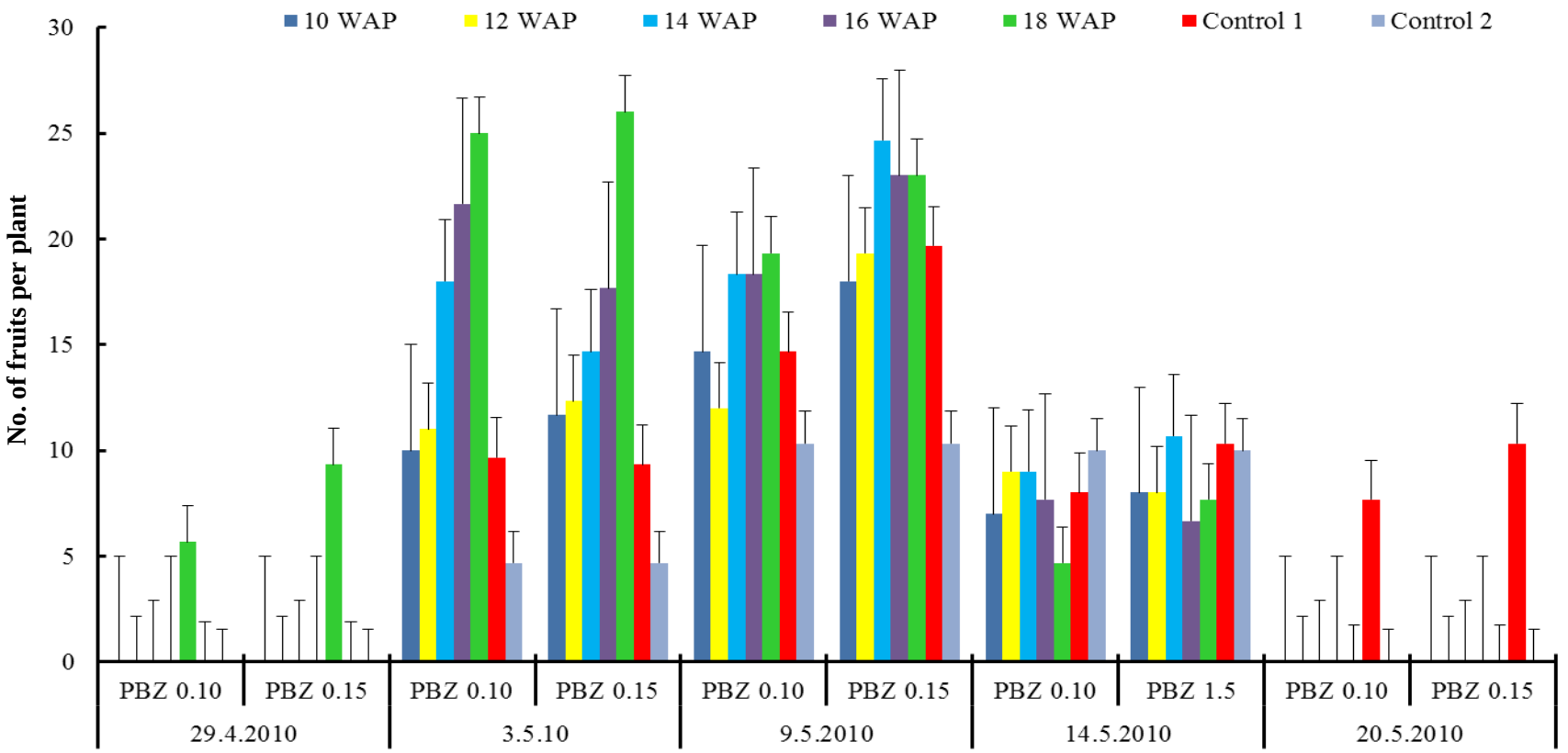


Figure 3.4 Number of fruits at different harvest date as affected by two levels of PBZ and application times of 3% KNO_3

3.4 Discussion

The flowering mechanism in Mango (*Mangifera indica* L.) is still poorly understood, although it clearly depends on environmental factors to bring about the transition from vegetative growth to reproductive growth (Davenport and Nunez-Elisea 1997). The results of this study indicated that numbers of GS and MS were not affeted by using PBZ 0.10 and 0.15 g ai m^{-1} of canopy. However, MS were observed ten days earlier than GS. It was explained by Joubert *et al*. (1993) who explained that MS normally developed when the daily mean temperature during the induction period exceeded 15˚C. Based on the theory and experiments, Davenport (2009), also deduced that floral or vegetative induction was possibly governed by the interactive ratio of a florigenic promoter (FP), which was up-regulated in low temperature to an age-regulated vegetative promoter (VP) in leaves at the time of shoot initiation. High FP:VP ratios would be conducive to induction of GS, while low ratios conducive to vegetative shoots and intermediate ratios conducive to MS. The night temperature was above 15˚C at the times of last application with 3 % KNO_3 at 18 WAP (Appendix 1). And this was in line with the finding of Joubert *et al*. (1993).

However, in different times of floral induction with 3 % KNO_3, the number of MS at 18 WAP were higher compared to other treatments throughout data collection period and the number of GS were also higher than other treatments especially during early counting dates of visible panicle emergence. It could be assumed that floral induction with 3 % KNO_3 at 18 WAP produced not only the more profuse GS and MS but also earlier occurrence of GS and MS in earlier parts of normal flowering season which would have impact on early fruit harvest.

Similarly, the numbers of inflorescences were not affected by application of PBZ 0.10 and 0.15 g ai m^{-1} of canopy diameter. The last floral induction at 18 WAP showed the earliest and the highest numbers of inflorescences because the inflorescence numbers were derived from combination of GS and MS. The results of early and profuse flowering at 18 WAP from this study could be elaborated that after the last time of floral induction with KNO_3, temperature dropped to 15˚C from the last week of December, 2009 and first week of January, 2010, which was favorable for mango flowering. Moreover, existing shoots of experimental trees at 18 WAP could be mature enough to produce panicles and effect of PBZ also could reduce the

amount of endogenous gibberellin levels to some extent because there was a difference in that Control 1 was sprayed with only water and 18 WAP with 3% KNO_3. The earliness and number of inflorescences were significantly lower in Control 1 compared to 18 WAP. The results of this study also accord with the finding of Rossetto and Bortoletto (2004). They found that PBZ, applied in the soil followed by sprays of Ethephon or KNO_3 90 days after PBZ, was effective for flower induction and harvest anticipation.

In contrast, the lowest numbers of inflorescences were obtained in Control 2, followed by 10 WAP and 12 WAP. The lack of success in achieving early flowering and intense flowering by spraying with 3% KNO_3 at 10 WAP and 12 WAP could be due to the presence of shoots not mature enough to induce flowers. KNO_3 3 % spraying at 10 WAP and 12 WAP produced new vegetative shoots instead of flowering ones during last week of October and first week of November, 2009. These vegetative shoots became about two months old during last week of December, 2009 and the end of January, 2010. This time is normal flowering period for Sein Ta Lone mango in Yezin area. The favourable night temperature of 15˚C for mango flowering lasted only two weeks in the normal flowering times (Appendix 1). The duration of cool night temperature was not long enough to change to reproductive shoots from previous shoots induced by 10 WAP and 12 WAP. The results of this study agreed with Whiley *et al*. (1991), who suggested that at least 17 weeks were required vegetative shoots to be maintained at 15˚ C day/ 10˚ C night for initiation of reproductive shoots. Núñez-Elisea *et al*. (1996) inferred that resting buds of mango trees that were exposed to cool temperatures (18˚ day/10˚ C night) for more than 3 weeks and then transferred to a warm temperature (30˚ C day/25˚ C night) before initiation, produced only vegetative shoots. The lack of inflorescences given by Control 2 could be due to untimely and sporadic vegetative shoots produced by experimental trees during the rainy season thereby reducing the number of inflorescences.

Although inflorescence length was not affected by PBS dosages and 3%KNO_3 sprays, the longer FSL and SSL was observed in PBZ 0.15 g ai m^{-1} of canopy. The longest FSL observed in Control 2 could be the facts that after the application of 1 % thiourea for shoot flushing, all of floral induction treatments apart from Control 2 produced almost a hundred percent new vegetative shoots from existing ones. These

uniform vegetative shoots would be competent for photo assimilation and nutrient reverse resulted in shorter length compared to Control 2. The interaction of levels of PBZ and floral induction treatments was significant in second shoot length.

The percent flower intensity and harvested fruit from total inflorescences were not influenced by levels of PBZ applications. However, the highest percent in 18 WAP and the lowest percent in Control 2 were observed and it could be directly involved in number of inflorescences produced by each treatment. Harvested fruit percent from total inflorescences was not affected by floral induction treatments therefore the higher the flower intensity percent, more number of harvested fruits could be expected.

Although number of fruits from each harvest date and total number of fruits were not affected by PBZ doses, significant effects of floral induction were seen. The highest total number of fruits were harvested from 18 WAP. Moreover, at the first harvest time, 18 WAP gave 7.5 fruits/plant but other treatments gave no fruit at all. At the second harvest time, 18 WAP also gave the highest numbers of 25.5 fruits/plant compared to other treatments. This could be due to the highest numbers and the earliest occurrence of inflorescences particularly during early parts of normal flowering period in 18 WAP. It could reflect both early harvesting and the highest total number of fruits. According to direct relationship between total number of fruits and total fruits weight, the highest total fruit weight was obtained from 18 WAP (18.01 kg/tree) and the lowest in Control 2 (7.92 kg/tree).

It was indicated that the trees applied with PBZ 0.15 g ai m^{-1} canopy were the eight days earlier harvesting than those applied with PBZ 0.10 g ai m^{-1} of canopy. The more dose of PBZ application seemed to be achieving early harvesting of fruits. Among the floral induction treatments with 3 % KNO_3 spraying, the fruit harvested from 18 WAP was five days earlier than other treatments in days to first harvest. In contrast, the fruit harvested from Control 1 was six days later than the other treatments in the days to last harvest.

Fruit quality in terms of fruit dimension, weight and Brix % was not influenced by PBZ rates. However, fruit thickness (cm), weight (g) and Brix % were affected by floral induction treatments. The thinnest (6.96 cm) and smallest fruits (295 g) were given by 18 WAP and the thickest fruit (7.26 cm) was obtained from 10 WAP and the

biggest fruit (329.57 g) was observed in 12 WAP. The smaller fruits given by 18 WAP could be due to difference number of fruits harvested from each treatment because 18 WAP gave nearly twofold than 10 WAP and 12 WAP and more than twofold than Control 2. As a result of heavier fruit load in 18 WAP, the smaller fruits were observed in it. Although significant difference Brix % was found, the lowest Brix % observed in 18 WAP was also acceptable.

3.5 Conclusion

Either PBZ dose used in the study did not influence on the date of occurrence of visible GS, MS and inflorescences, number of inflorescences and fruits and fruit weight. However, both PBZ doses (0.10 and 0.15 g ai m^{-1}) of canopy diameter along with 3 % KNO_3 spraying at 18 WAP produced the earlier inflorescences and harvesting than other treatments. Moreover, 18 WAP gave the highest number of inflorescences and fruit yield including number of fruits and weight (kg/plant). The early harvesting and more yield in terms of number of fruits and weight (kg/plant) given by 18 WAP were beneficial for mango growers to achieve good market price and more income.

CHAPTER IV

EXPERIMENT 2: Effects of Two Levels of PBZ and 3% KNO_3 Spraying on Floral Induction, Growth, Yield and Quality of Sein Ta Lone Mango

4.1 Introduction

The experiment attempted to the development of an alternative management strategy for flower induction of mango by regulation with a little amount of PBZ (0.1 and 0.2 g ai m^{-1}) together with 1% Thiourea for shoot induction and 3%KNO_3 for flower induction was laid down to investigate the consolidating efficacy of those chemicals on vegetative and reproductive morphogenesis, flowering intensity, harvesting fruit percent from the total inflorescences, fruit yield and quality of Sein Ta Lone mango.

Objectives

(1) to induce early flowering and fruiting

(2) to manipulate flower synchronization in normal season

4.2. Materials and Methods

4.2.1 Area and season

The experiment was carried out at the Horticulture section, Department of Agricultural Research (DAR), Yezin, as a second time study and began on June 15, 2010 and ended in May 2011.

4.2.2 Plant materials

Uniform 4-year-old Sein Ta Lone mango trees having almost equal number of branches and plant height were used for experiment in which 42 Sein Ta Lone mango trees were included.

4.2.3 Treatments and experimental design

The experiment was carried out as second time on the same site and plant materials existed in previous year and began in June 15, 2010 and ended in May 2011.

In a factorial set where PBZ 0.2 g ai m^{-1} of canopy diameter was used as a soil drench instead of 0.15 g ai m^{-1} of canopy in previous year. Another dose was 0.10 g ai m^{-1} the same as in the first experiment. There was also the same date of spraying of 1% thiourea on June 15, 2010 to induce new shoots before soil drenching of PBZ that was applied to each of experimental tree except Control 2 on July 15, 2010 to discourage vegetative during resting periods. Different spraying times of 3 % KNO_3 were considered as the flower induction treatments. KNO_3 3 % spraying was done at the following schedules-10 week after PBZ application (10 WAP), 12 WAP, 14 WAP, 16 WAP and 18 WAP, Control 1 and Control 2.The Control 1 comprised of 1% thiourea spraying for new flushing and two levels of PBZ application but with water spray only at 18 WAP. Control 2 (no application of thiourea, PBZ and KNO_3) was considered an additional treatment.

Factor (A) Two doses of PBZ application

(1) 0.1 g ai m^{-1} of canopy diameter

(2) 0.2 g ai m^{-1} of canopy diameter

Before application of two levels of PBZ, all the experimental plants except Control 2 plants were sprayed with 1 % thiourea to induce uniform flushing.

Factor (B) Different flower induction times with 3% KNO_3 spraying

(1) 10 WAP

(2) 12 WAP

(3) 14 WAP

(4) 16 WAP

(5) 18 WAP

(6) Water spraying at 18 WAP (Control 1)

(7) No spraying at all (Control 2)

4.2.4 Data collection, calculation and statistical analysis

Data collection, calculation and statistical analysis were performed the same as in experiment 1 (Chapter III).

4.3 Results

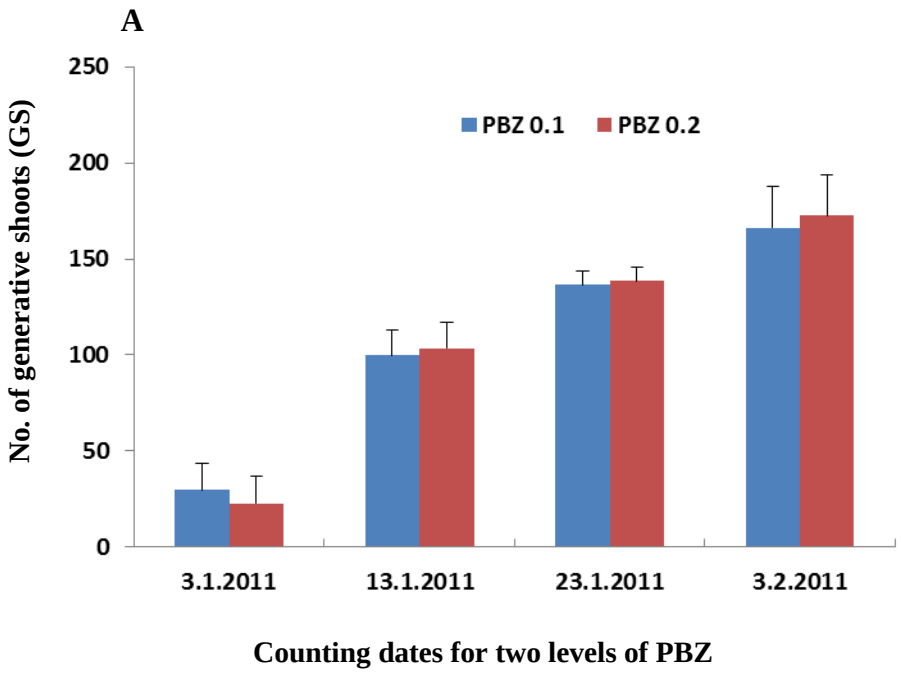
4.3.1 The number of GS

The numbers of GS were not significantly different from one another in each time of counting date by using two levels of PBZ 0.1 and 0.2 g ai m^{-1} of canopy diameter. In addition, total numbers of GS and the date of visible GS were not affected by two levels of PBZ used in the study (Figure 4.1A).

Although total number of GS were not significantly different from each other among the flower induction treatments with 3 % KNO_3, the highest number of GS were obtained from 18 WAP during the first to third counting dates. The lowest number of GS were observed in Control 2 during the first to third counting date (Figure 4.1B).

4.3.2 The number of MS

Similarly, the number of MS at each counting date, total number of MS and the date of visible MS were also not significantly different not only between two levels of PBZ but also at different times of 3 % KNO_3 spraying for flower induction (Figure 4.2AB).



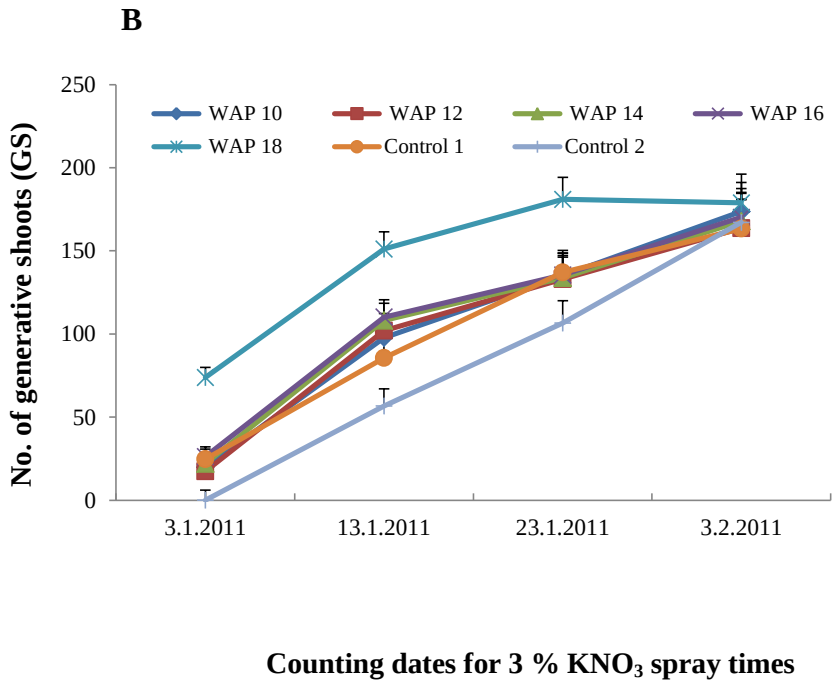
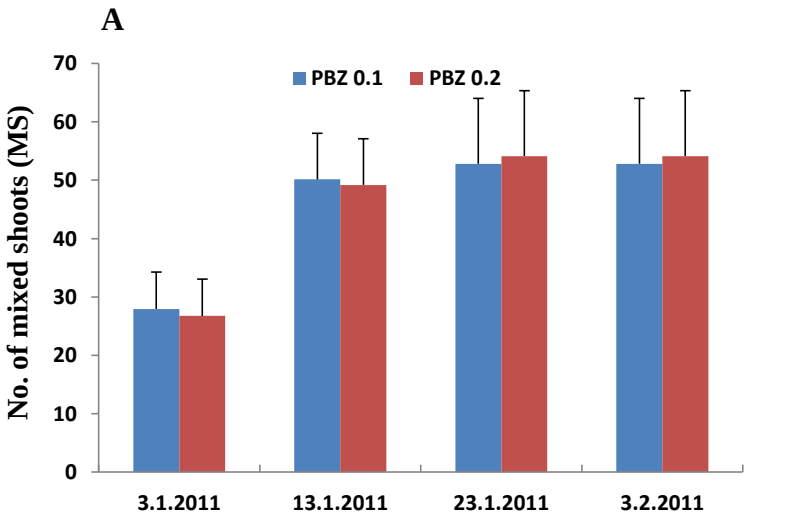


Figure 4.1 Number of visible GS as affected by two levels of PBZ (A) and different times of 3% KNO_3 spraying (B)



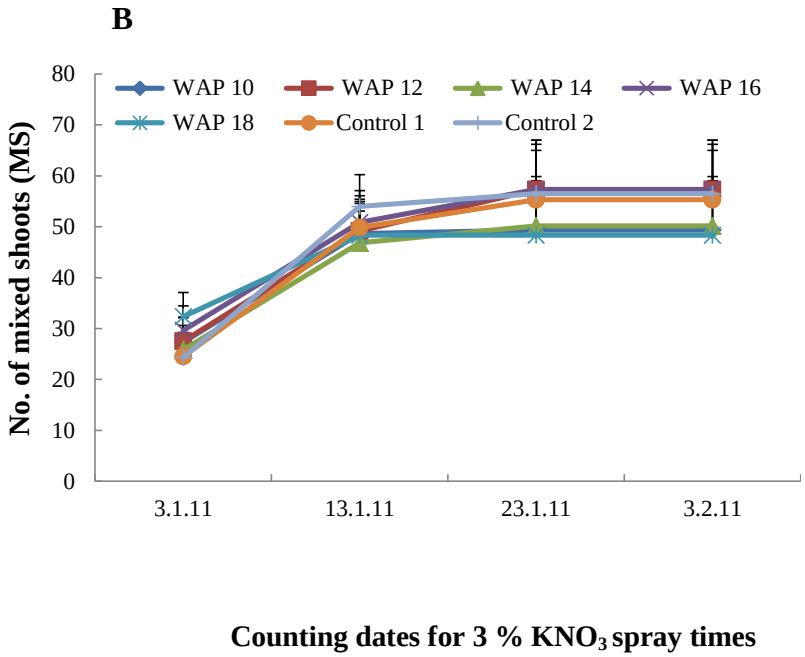
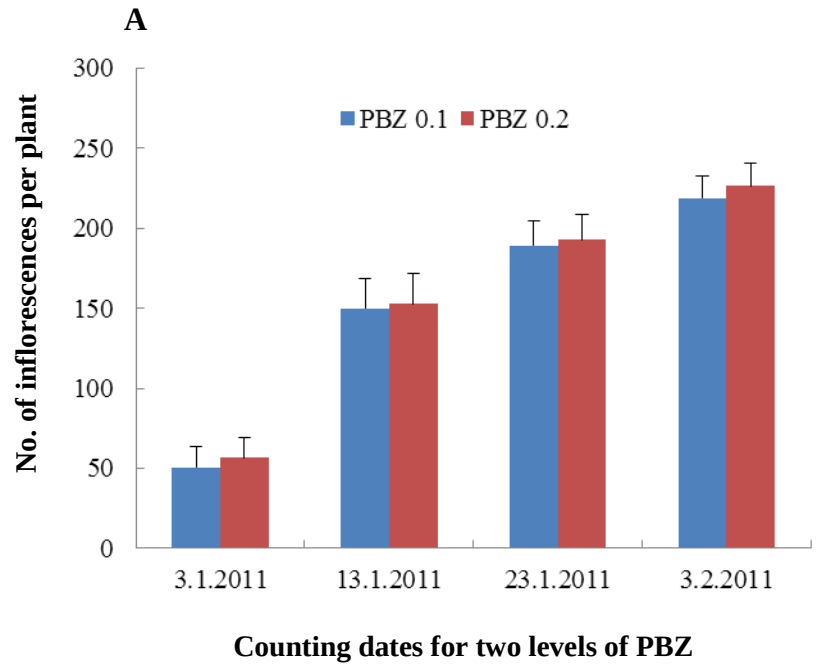


Figure 4.2 Number of visible MS as affected by two levels of PBZ (A) and different times of 3% KNO_3 spraying (B)

4.3.3 The number of inflorescences

In two levels of PBZ application 0.1 and 0.2 g ai m^{-1}, there were no significant differences in number of inflorescences at each counting date and also in total number of inflorescences at the end of the period of floral organogenesis. (Figure 4.3A).

The number of inflorescences were not significantly different from each other among the floral induction treatments at final counting date on February 3, 2011. However, 18 WAP presented the highest numbers of inflorescences starting counting date on January 3, 2011. The numbers of inflorescences from 18 WAP reached its peak on January 23, 2011and the rest of the treatments illustrated that the peak inflorescences numbers were observed on 3 February, 2011 (Figure 4.3B).



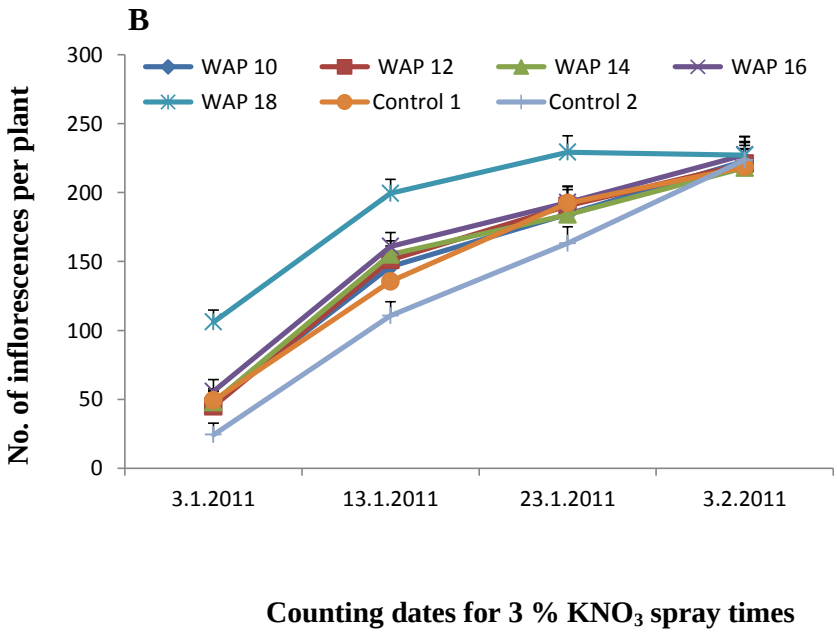


Figure 4.3 Number of inflorescences as affected by two levels of PBZ (A) and different times of 3% KNO_3 spraying (B)

4.3.4 First shoot length (FSL), second shoot length (SSL) and inflorescences length (IL)

FSL, SSL and IL were not affected by two levels of PBZ application, 0.1 and 0.2 g ai m^{-1} of canopy diameter. The results demonstrated that IL was not also affected by different times of the floral induction treatments with 3% KNO_3. However, the longest FSL was observed in Control 2 (19.4 cm) and the shortest FSL was given by 10 WAP. SSL was not significantly different from each other among the floral induction treatments (Table 4.1).

Table 4.1 New shoot length and inflorescence length as affected by different dosages of PBZ and different times of KNO_3 spraying

Factors	First shoot length (cm)	Second shoot length (cm)	Inflorescence. length (cm)
Levels of PBZ (g ai m^{-1})			
PBZ 0.1	17.37	18.07	37.55
PBZ 0.2	17.46	18.74	40.17
$LSD_{(0.05)}$	3.49	5.79	6.54
Application times of 3% KNO_3			
10 WAP	15.39 c	17.58	39.35
12 WAP	17.65 b	20.83	37.33
14 WAP	17.54 b	19.58	38.20
16 WAP	16.64 bc	16.75	39.07
18 WAP	17.93 ab	18.33	39.35
Control 1	17.32 b	17.83	38.53
Control 2	19.40 a	17.92	40.18
$LSD_{(0.05)}$	1.47	3.65	3.17
F- test (A)	ns	ns	ns
(B)	**	ns	ns
(A *B)	*	ns	ns
CV%	7.09	16.64	6.84

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

4.3.5 Flowering intensity % and harvested fruit % from total inflorescences

Flowering intensity % and harvested fruit % from total inflorescences were not statistically different neither by the application of PBZ 0.1 and 0.2 g ai m^{-1} of canopy diameter nor different times of 3% KNO_3 spraying for floral induction (Table 4.2).

Table 4.2 Flower intensity % and harvested fruit % from total inflorescences as affected by different dosages of PBZ and 3% KNO_3 spraying

Factors	Flower intensity %	Harvested fruit % from total inflorescences
Levels of PBZ (g ai m^{-1})		
PBZ 0.1	95.03	22.78
PBZ 0.2	95.33	22.63
$LSD_{(0.05)}$	1.84	4.62
Application times of 3% KNO_3		
10 WAP	94.54	22.66
12 WAP	94.93	23.14
14 WAP	95.99	23.85
16 WAP	95.55	20.60
18 WAP	95.38	22.69
Control 1	95.59	23.71
Control 2	94 25	22.31
$LSD_{(0.05)}$	1.99	5.42
F- test (A)	ns	ns
(B)	ns	ns
(A *B)	ns	ns
CV%	1.75	20.01

4.3.6 The yield (number of fruits and weight) at each harvest date and total number of fruits and weight (kg/plant)

There were not significant differences in the number of harvested fruits from each time of harvesting and total number of fruits by application of PBZ 0.1 and 0.2 g ai m^{-1} of canopy diameter (Table 4.3).

The numbers of total fruits were also not affected by different times of 3% KNO_3 spraying for floral induction. However, the height number of fruits was harvested at first harvesting date (May 3, 2011) from 18 WAP (20.65 fruits/plant), which was significantly higher than those of other treatments and the lowest number of fruits was harvested from Control 2 (6.33 fruits/plant) followed by Control 1 (9.33 fruits/plant). There was no significant difference among the treatments at second harvesting date (May 13, 2011). At third harvesting date (May 18, 2011), 14 WAP gave the highest number of fruits (19.67 fruits/plant), which was significantly higher than those of 12 WAP (11.77 fruits/tree), Control 2 (12 fruits/plant) and 18 WAP (12.33 fruits/tree). The number of fruits harvested at fourth harvest time were only from Control 2 (11.33 fruits/plant), Control 1 (10.55 fruits/plant), 10 WAP (8.83 fruits/plant) and 12 WAP (7 fruits/plant) respectively (Table 4.3).

Fruit yield from the perspective of weight basis (kg/tree) had a similar trend with the fruit numbers. The results of total fruit weight was not affected by two levels of PBZ 0.1 and 0.2 g ai m^{-1} application and different times of floral induction with 3 % KNO_3 spraying (Table 4.4).

Table 4.3 Number of fruits at different harvesting times and total fruit number by different dosages of PBZ and 3% KNO_3 spraying

Factors	No. of harvested fruit/plant				
	1st (2.5.11)	2nd (13.5.11)	3rd (18.5.11)	4th (22.5.11)	Total
Levels of PBZ (g ai m^{-1})					
PBZ 0.1	13.29	16.24	14.19	5.14	49.38
PBZ 0.2	12.52	18.52	14.86	5.62	51.24
$LSD_{(0.05)}$	5.42	6.51	6.44	0.89	6.28
Application times of 3% KNO_3					
10 WAP	12.00 cd	16.67	14.67 ab	8.83 ab	49.33
12 WAP	13.17 bc	17.83	11.17 b	7.00 b	50.83
14 WAP	13.33 bc	18.17	19.67 a	0.00 c	51.83
16 WAP	15.50 b	13.67	16.00 ab	0.00 c	46.83
18 WAP	20.67 a	20.17	12.33 b	0.00 c	51.50
Control 1	9.33 de	14.17	15.83 ab	10.50 a	51.83
Control 2	6.33 e	21.00	12.00 b	11.33 a	50.00
$LSD_{(0.05)}$	3.12	7.17	5.50	3.11	11.01
F- test (A)	ns	ns	ns	ns	ns
(B)	**	ns	*	**	ns
(A *B)	ns	ns	ns	ns	ns
CV %	20.26	34.61	31.80	48.50	11.36

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

Table 4.4 Fruit weight at different harvesting times and total fruit weight. by application of different dosages of PBZ and 3% KNO_3 spraying

Factors	Harvested fruit weight (kg/plant)				
	1st (2.5.11)	2nd (13.5.11)	3rd (18.5.11)	4th (22.5.11)	Total
Level of PBZ (g ai m^{-1})					
PBZ 0.1	4.00	4.89	4.25	1.57	14.71
PBZ 0.2	3.70	5.44	4.44	1.70	15.28
$LSD_{(0.05)}$	1.76	1.95	1.96	0.29	2.82
Application times of 3% KNO_3					
10 WAP	3.61 cd	5.01	4.42 ab	2.71 ab	15.75
12 WAP	3.90 bc	5.54	3.26 b	2.12 b	14.81
14 WAP	4.00 bc	5.38	5.86 a	0.00 c	15.24
16 WAP	4.58 b	4.14	4.82 ab	0.00 c	13.54
18 WAP	6.15 a	5.95	3.72 b	0.00 c	15.82
Control 1	2.84 de	4.11	4.75 ab	3.17 a	14.87
Control 2	1.90 e	6.02	3.59 b	3.43 a	14.94
$LSD_{(0.05)}$	0.99	1.99	1.59	0.92	4.00
F- test (A)	ns	ns	ns	ns	ns
(B)	**	ns	*	**	ns
(A *B)	ns	ns	ns	ns	ns
CV %	21.10	32.35	30.65	47.36	16.81

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

4.3.7 Days to first and last harvest

Days to first harvest and last harvest were 290 days and 310 days after PBZ application between the two levels of PBZ 0.1 and 0.2 g ai m^{-1}, respectively. It can be seen that the different floral induction treatments with 3% KNO_3, the fruits harvested from all the treatments were after 290 days after PBZ application (Table 4.5).

However, the days to last harvest from different floral induction treatments indicated that the fruits were harvested after 306 days after PBZ application from 18 WAP, 16 WAP and 14 WAP but 310 days from other treatments after PBZ application (Table 4.5).

Table 4.5 Days to first and last harvest from different dosages of PBZ and 3% KNO_3 spraying

Factors	Days to	
	First Harvest	Last Harvest
Level of PBZ (g ai m^{-1})		
PBZ 0.1	290	310
PBZ 0.2	290	310
Application times of 3% KNO_3		
10 WAP	290	310
12 WAP	290	310
14 WAP	290	306
16 WAP	290	306
18 WAP	290	306
Control 1	290	310
Control 2	290	310

4.3.8 Fruit Quality

There were no significant differences in fruit length, width, thickness and Brix% between 0.1 and 0.2 g ai m^{-1} of PBZ applications. However, the fruits harvested from the plants applied with 0.2 g ai m^{-1} of PBZ were heavier (304.5 g) than those (294.18 g) from the plants applied with 0.1 g ai m^{-1} of PBZ (Table 4.6).

All the variables collected for quality perspective were not statistically different from each other among the different times of floral induction with 3% KNO_3 spraying (Table 4.6).

Table 4.6 Fruit length, width, thickness, weight and brix % as affected by different dosages of PBZ and 3% KNO_3 spraying

Factors	Fruit				
	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Brix (%)
Levels of PBZ (g ai m^{-1})					
PBZ 0.1	10.20	7.87	7.06	294.18 b	19.91
PBZ 0.2	10.34	7.86	7.13	304.50 a	19.86
$LSD_{(0.05)}$	0.29	0.05	0.10	8.02	1.31
Application times of KNO_3					
10 WAP	10.14a	7.93	7.08	300.13	19.42
12 WAP	10.16	7.86	7.10	301.50	19.50
14 WAP	10.25	7.96	7.05	293.88	20.50
16 WAP	10.33	7.76	7.19	302.37	20.83
18 WAP	10.34	7.88	7.09	302.50	19.25
Control 1	10.35	7.73	7.04	297.50	20.67
Control 2	10.35	7.93	7.13	297.50	19.00
$LSD_{(0.05)}$	0.32	0.20	0.12	10.83	1.55
F- test (A)	ns	ns	ns	*	ns
(B)	ns	ns	ns	ns	ns
(A *B)	ns	ns	ns	ns	ns
CV%	3.03	2.45	1.68	3.57	6.54

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

4.3.9 Harvest dates as affected by two levels of PBZ and application times of 3% KNO_3

At the first harvesting date on May 3, 2011, the fruits were obtained from both two levels of PBZ application and all the different times of floral induction with 3% KNO_3. Similarly, at the last harvest date on May 22, 2011, the fruits were got from two levels of PBZ application. However, as for the different times of floral induction with 3 % KNO_3, fruits were harvested only from 10 WAP, 12 WAP, Control 1 and Control 2 (Figure 4.4).

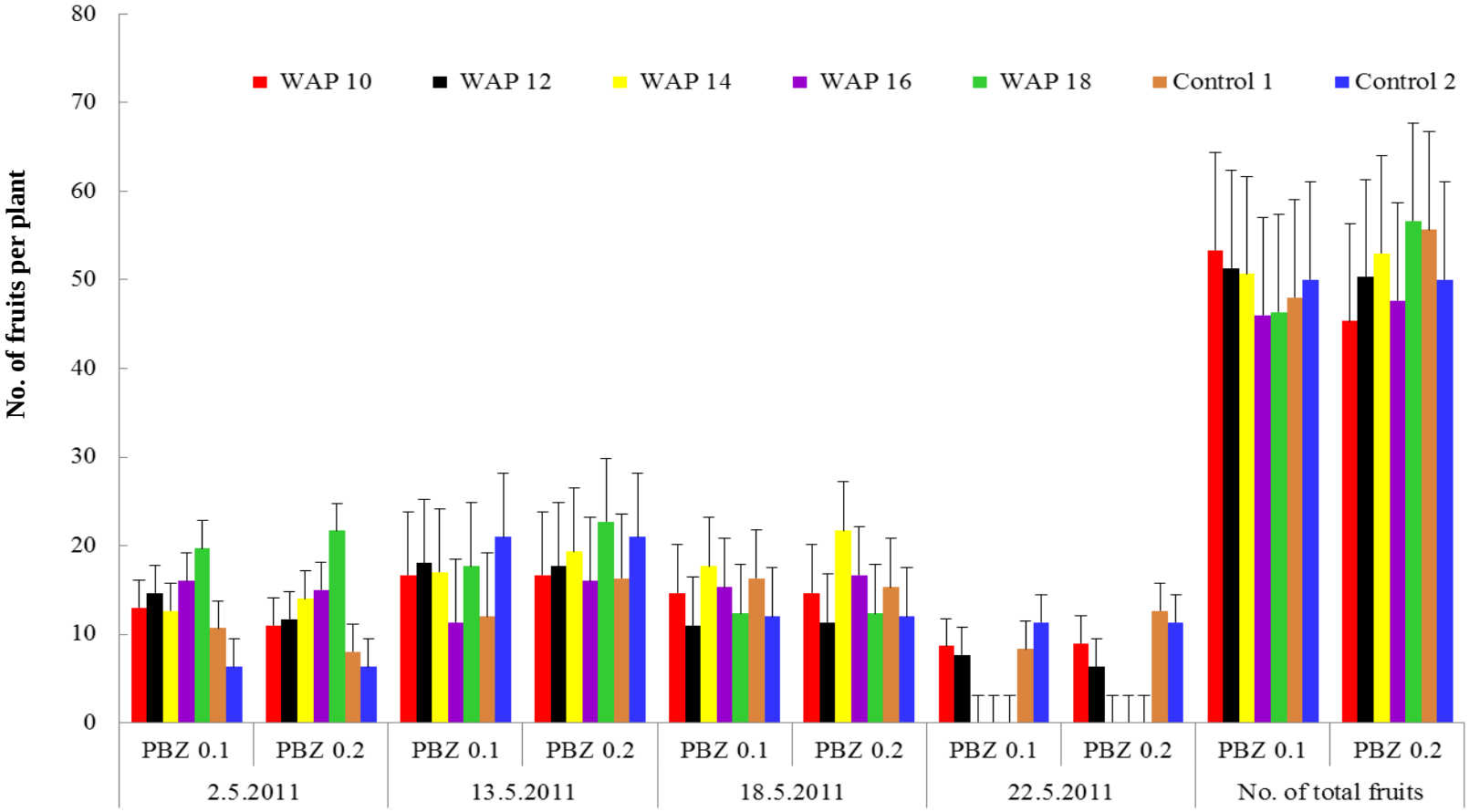


Figure 4.4 Number of fruits at different harvest date as affected by two levels of PBZ and application times of 3% KNO_3

4.4 Discussion

The results of this experiment demonstrated that the variables collected for number of GS, MS and inflorescences, total numbers of fruits and weight (kg/plant), days to first harvest, fruit quality in terms of dimension and Brix %, flower intensity % and harvested fruit % from total inflorescences were not influenced by not only PBZ rates but also different times of flower induction with 3 % KNO_3 spraying. Both PBZ rates integrated with 3% KNO_3 spraying at 18 WAP could be overcome the alternate bearing of STL mango. The trees from Control 2 produced new shoots soon after postharvest pruning as a result of previous less crop load compared to 18 WAP thereafter allowing the accumulation of starch reserves for next season. In addition, temperature 15˚C around or below lasted during the third week of December, 2010 to the end of January, 2011 (Appendix 2). This situation enhanced the flower bud formation for Control 2 trees resulting in profuse flowering and good yield.

Floral induction treatments with 3 % KNO_3 sprays, 10, 12, 14 and 16 WAP also indicated the intense flowering and good yields in this season. The evidences of these treatments could be the facts that dormant buds existed on those trees even after 3 % KNO_3 spraying were still dormant and underwent the normal flowering season thereby promoting flowering and good yield.

4.5 Conclusion

The number of inflorescences and yield were not influenced by both doses of PBZ and floral induction treatments with 3 % KNO_3 sprays. However, 18 WAP from floral induction treatments gave the more number of fruits during the early harvest dates. The early harvesting particularly during early parts of normal season was beneficial for mango growers to get quality fruits and good selling price because the early harvesting especially early parts of normal harvesting period was an ahead of rain pouring which commonly occurs later parts of normal harvesting period. This situation is favourable for occurrences of fruit fly and anthracnose disease that reduce the fruit quality.

CHAPTER V

EXPERITMENT 3: Effects of With and Without Urea and Different Application Times of 0.7 % Thiourea on Flower Induction, Growth, Yield and Quality of Sein Ta Lone Mango

5.1 Introduction

High nitrogen levels, especially under well-watered conditions, are conducive to initiation of frequent vegetative flushes (Davenport 2007), who suggested that it was critical to maintain annual leaf nitrogen levels sufficiently low to discourage unwanted flushes of vegetative growth in the months approaching the desired flowering date.

According to the facts mentioned above, some questions arose:

- How much does it take to produce reproductive shoots from vegetative shoot in Sein Ta Lone mango?
- Does application of PBZ actually shorten resting periods?
- Which time is the best for floral induction of Sein Ta Lone mango for spraying with 0.7% thiourea after the PBZ application?
- Does it possible to stimulate the out of season flowering of Sein Ta Lone mango by using PBZ combined with thiourea and limited amount of urea?

With regard to such questions, the experiments attempted to develop an alternative management strategy that can substitute the dependence upon environmental signal (low temperature) for flower initiation of mango by regulation with some chemicals plus restricted amount of urea on trees which were indicating only lower levels of leaf N content. This information was beneficial for development of technological package of future off- season mango fruit production in Myanmar.

Objectives

(1) to induce early flowering and fruiting

(2) to manipulate flower synchronization in normal season

(3) to assess restricted amount of urea application combined with selected chemicals on early flowering of Sein Ta Lone mango

5.2 Materials and Methods

5.2.1 Area and season

The experiment was carried out at the guest house's mango orchard, Department of Agricultural Research (DAR), Yezin, from June 15, 2010 to the end of May 2011.

5.2.2 Plant materials

Fifty two (four-year-old) Sein Ta Lone mango trees having almost equal number of branches and plant height were selected as experimental plants.

5.2.3 Treatments and experimental design

The experiment was a two factor factorial combination in a Randomized Complete Block design with four replications. Firstly, ten leaves from different positions and directions of individual tree from entire experimental trees were taken to evaluate leaf nitrogen content. Experimental trees were divided in to two groups based on the leaf N content. In the factorial set, separate set of 24 trees were assigned for two different dosages of fertilizer. One set that has more than 1.1 % N in leaf were applied with 600 g of (U:Tsp:Pot-2:1:1)/plant for bud forcing . Another set having less than 1.1 % N in leaf were applied with 300 g of (U:Tsp:Pot-0:1:1)/plant in order to avoid possible second flush.

All the experimental trees were sprayed with 0.7% thiourea to induce new shoots on June 15, 2010 and PBZ was also be used as a soil drench to protect frequent occurrence of new flush on July 15, 2010. However, application rate of PBZ was varied depending on tree size and dose for each tree was calculated according to the following formula described by Blaikie *et al.* (2004).

dose PBZ= canopy size (m) x 1.25

where canopy size was defined as the average of tree height (m) and maximum canopy diameter (m).

Two and a half months after PBZ application, randomly assigned plant from each replicate was sprayed with 0.7 % thiourea to induce floral morphogenesis. These different times of 0.7 % thiourea spraying were considered flower induction treatments. Spraying 0.7 % thiourea at two weeks intervals for floral induction were

as follow: 10 week after PBZ application (10 WAP), 12 WAP, 14 WAP, 16 WAP and 18 WAP, Control 1 and Control 2. The Control 1 consisted of spraying 0.7 % thiourea for new flushing and PBZ application but with water spray only at 18 WAP. However, Control 2 (no application of thiourea, PBZ and thiourea) was considered an additional treatment.

Factor (A) Two dosages of urea rate based on leaf N content

(1) 600 g of (Urea:Triple super phosphate:Potash 2:1:1)/tree that has more than 1.1 % leaf N content.

(2) 300g of (Urea: Triple super phosphate :Potash 0:1:1)/tree indicating less than 1.1 % leaf N content.

Factor (B) Different times of flower induction with spraying 0.7% thiourea

(1) 10 WAP

(2) 12 WAP

(3) 14 WAP

(4) 16 WAP

(5) 18 WAP

(6) Water spraying at 18 WAP (Control 1)

(7) No spraying at all (Control 2)

5.2.4 Data collection, calculation and statistical analysis

Data collection, calculation and statistical analysis were performed as the same in experiment 1 and 2 (Chapter III and IV).

5.3 Results

5.3.1 The number of GS

The number of GS were significantly higher in treatment without urea than did in urea application at each time of counting date. In addition, the visible date of GS was observed earlier in treatment without urea than in that with urea application (Figure 5.1A).

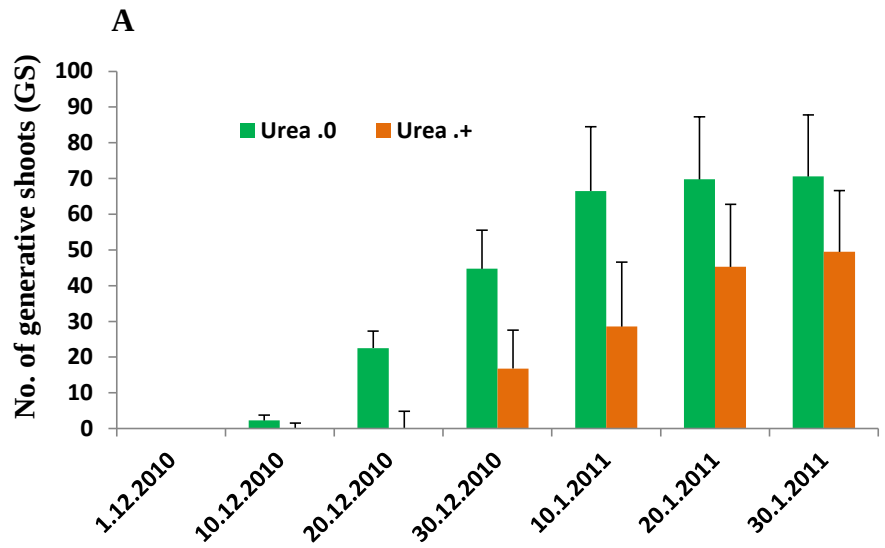
The results of the floral induction treatments with 0.7% thiourea sprays demonstrated that statistically higher number of GS were seen in 18 WAP from third counting date of December 20, 2010 to last counting date of January 31, 2011. The least numbers of GS were got in Control 2, followed by Control 1, and 10 WAP. (Figure 5.1B).

5.3.2 The numbers of MS

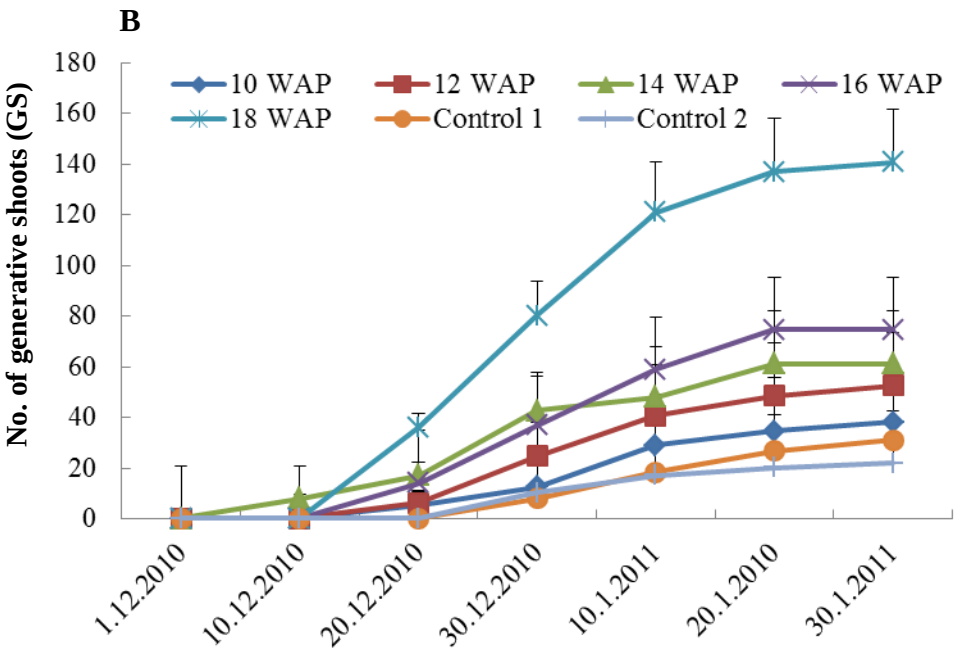
The results between with and without urea applications exhibited that the number of MS at each counting date and total number of MS in without urea were statistically higher than those with urea application. Moreover, the date of visible MS was seen more advanced in without urea than urea application (Figure 5.2A)

The visible date of MS (December 1, 2010) was more advanced than GS (December 10, 2010) even within treatment without urea application (Figure 5.1A), (Figure 5.2A).

The results of different times of 0.7 % thiourea spraying for flower induction indicated that 14 WAP gave the highest number of MS. However, the least number of MS were seen in 18 WAP. In addition, 14 WAP showed the earliest MS compared to rest of the treatments (Figure 5.2B).

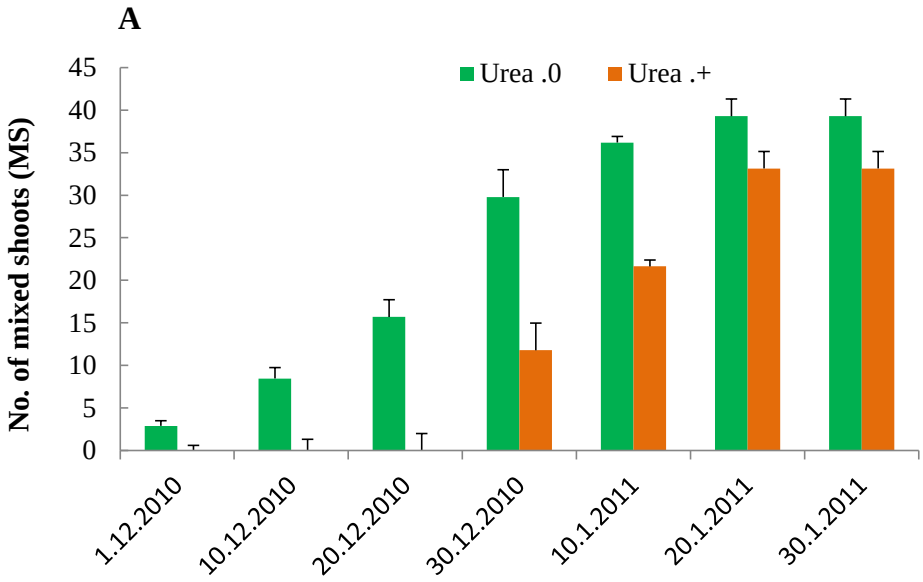


Counting dates for two levels of PBZ



Counting dates for 3 % KNO_3 sprayng times

Figure 5.1 Number of visible GS as affected by with and without urea (A) and different times of 0.7 % thiourea spraying (B)



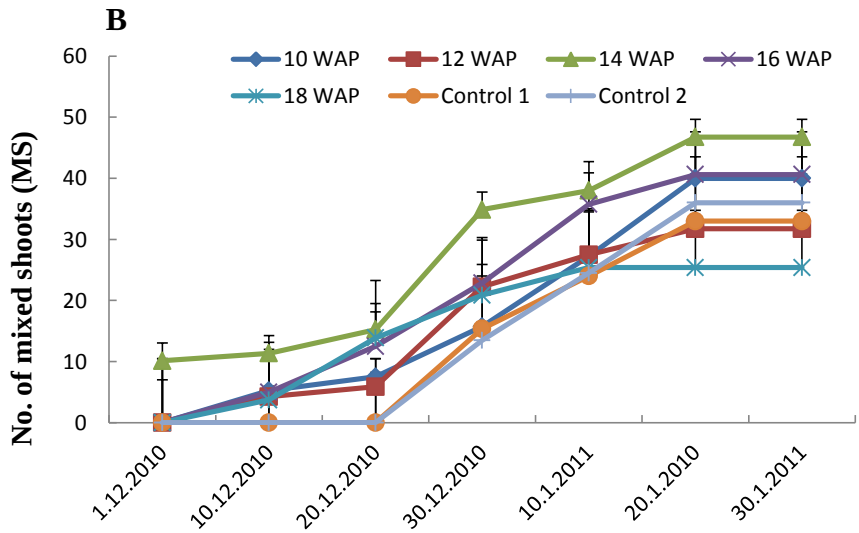


Figure 5.2 Number of visible MS as affected by with and without urea (A) and different times of 0.7% thiourea spraying (B)

5.3.3 The Number of inflorescences

Between with and without urea application, the number of inflorescences at each counting date and also total number of inflorescences at the end of the period of floral organogenesis were significantly higher in without urea than urea application. Moreover, without urea application gave 1 month earlier floral organogenesis occurrence compared to urea application (Figure 5.3A).

Among the flower induction treatments with 0.7 % thiourea spraying, 18 WAP presented the highest numbers of inflorescences and also significantly higher than those of other treatments starting from third counting date (December 20, 2010) to last counting date (January 31, 2011). The least numbers of inflorescences were observed in Control 2, followed by Control 1, 10 WAP and 12 WAP (Figure 5.3B).

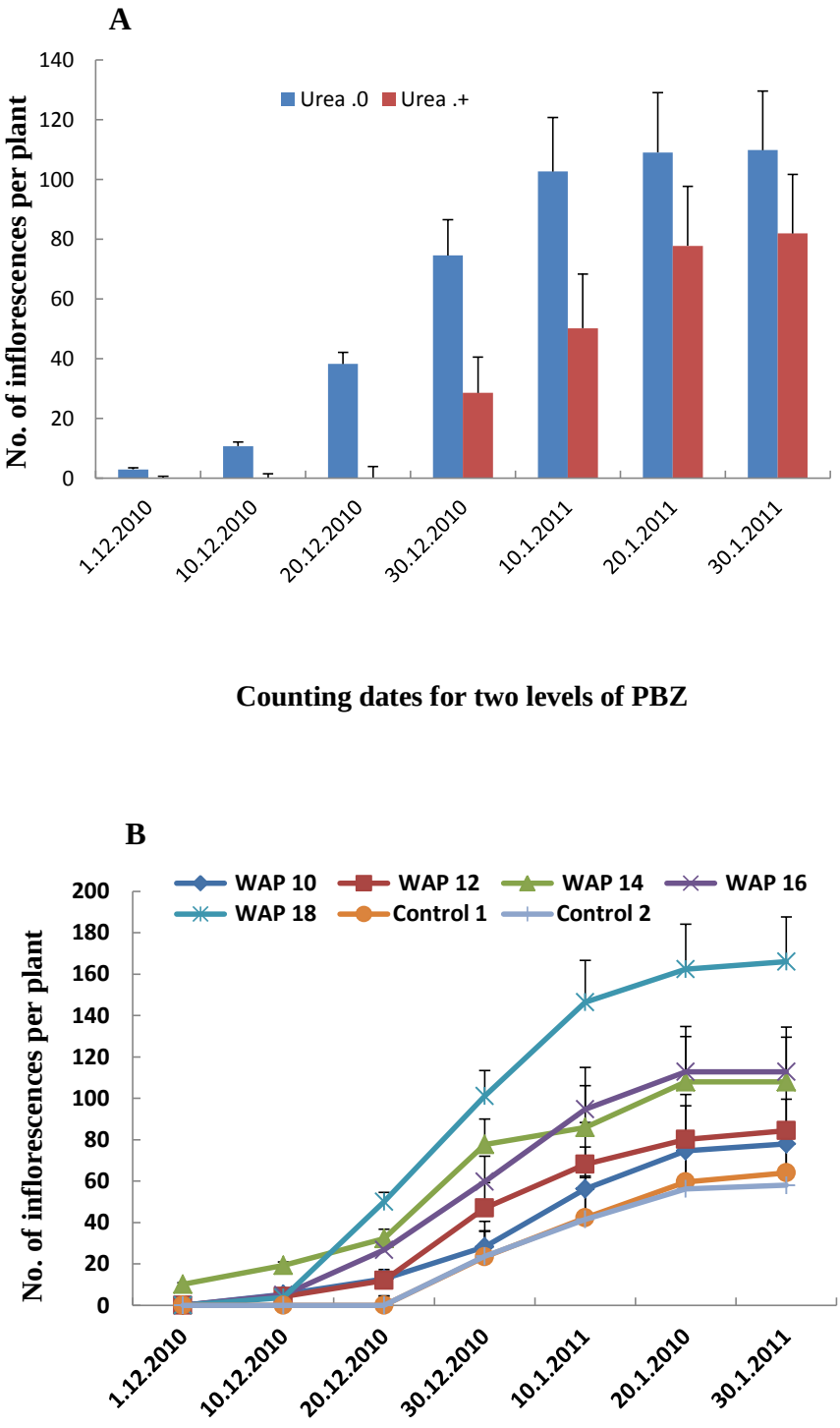


Figure 5.3 Number of inflorescences as affected by with and without urea (A) and different times of 0.7 % thiourea spraing

5.3.4 First shoot length (FSL), second shoot length (SSL) and inflorescence length (IL)

IL was not affected neither by with and without urea applications nor different times of 0.7 % thiourea spraying. However, FSL and SSL were shorter in without urea application than urea application (Table 5.1).

Among the floral induction treatments with 0.7 % thiourea, the longest FSL was observed in Control 2 (20.01 cm), which was also significantly longer than the rest of the treatments. SSL were not significantly from each other among the floral induction treatments (Table 5.1).

Table 5.1 New shoot length and inflorescence length as affected by application of with and without urea and time of 0.7 % thiourea application

Factors	First Shoot Length (cm)	Second Shoot Length (cm)	Inflorescence Length (cm)
Levels of Urea			
Urea: 0	15.82 b	14.72 b	37.50
Urea: +	18.65 a	18.60 a	38.52
$LSD_{(0.05)}$	1.48	0.68	3.81
Different spraying times of 0.7% Thiourea			
10 WAP	15.85 b	15.99	38.93
12 WAP	17.05 b	16.63	36.51
14 WAP	16.99 b	16.48	37.11
16 WAP	16.58 b	16.28	37.38
18 WAP	17.29 b	16.99	37.95
Control 1	16.86 b	16.43	37.48
Control 2	20.01 a	17.86	40.73
$LSD_{(0.05)}$	2.01	1.95	2.74
F- test (A)	**	**	ns
(B)	**	ns	ns
(A *B)	ns	*	ns
CV%	11.53	11.56	7.1

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

5.3.5 Flowering intensity % and harvested fruit % from total inflorescences

The more and significantly higher flower intensity of was observed in without urea fertilization (46.12 %) than in urea application (36.11 %). On the contrary, the harvested fruit % from total inflorescences were significantly higher in urea application (71.27 %) than without urea (58.85 %) (Table 5.2).

Among the different times of floral induction with 0.7% thiourea, 18 WAP indicated the highest flowering intensity (68.39 %), which was significantly higher than other treatments. The lowest flowering intensity was observed in Control 1 (28.31 %), followed by Control 2 (29.24 %), 10 WAP (33.09 %) and 12 WAP (35.09 %) (Table 5.2).

Table 5.2 Flower intensity % and harvested fruit % from total inflorescences as affected by with and without urea and application times of 0.7 % thiourea spraying

Factors	Flower intensity %	Harvested fruit % from total inflorescences
Levels of Urea		
Urea: 0	46.12 a	58.85 b
Urea: +	36.11 b	71.27 a
$LSD_{(0.05)}$	4.23	5.28
Different spraying times of 0.7% Thiourea		
10 WAP	33.37 cd	67.94 abc
12 WAP	35.09 c	63.49 bc
14 WAP	45.63 b	60.26 cd
16 WAP	47.61 b	63.00 bc
18 WAP	68.39 a	54.51 d
Control 1	28.31 d	70.96 ab
Control 2	29.42 cd	75.26 a
$LSD_{(0.05)}$	5.69	7.99
F- test (A)	**	**
(B)	**	**
(A *B)	**	ns
CV%	13.65	12.11

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

5.3.6 The yield (number of fruits and weight) at each harvest date and total number of fruits and weight (kg/tree)

There was no significant difference form one another in total number of fruits with the application of with and without urea. The fruit numbers harvested from each date were significant between with and without urea applications. The number of 1.82 fruits and 6 fruits were obtained only in the first and second harvest dates by application of without urea. At third harvesting date, without urea application gave more significant numbers (13.29 fruits/tree) than (2.14 fruits/tree) with urea application. However, at later harvesting times of fifth, sixth and seventh, more number of fruits were significantly harvested from urea application (Table 5.3).

Total number of fruits was significantly different from each other among the different times of floral induction with 0.7 % thiourea. The highest total fruit numbers was obtained from 18 WAP (82.5 fruits/tree) significantly higher than other treatments. The least number of total fruits were given by Control 1 (46 fruits/tree), followed by Control 2 (50.25 fruits/tree), 12 WAP (51.88 fruits/tree) and 10 WAP (53.63 fruits/tree), which were not significantly different from each other (Table 5.3). At the first harvesting date, only 14 WAP gave 6.83 fruits/tree. At second harvesting date, 10.5 fruits/tree and 9.5 fruits/tree were harvested from 14 WAP and 16 WAP, respectively (Table 5.3).

Starting from third to fifth harvesting times, maximum numbers of fruits were harvested from 18 WAP and it was also significantly higher than other treatments (Table 5.3).

At the sixth harvesting time, maximum numbers of fruit were given by Control 1 (17.5 fruits/plant), followed by 10 WAP (14.25 fruits/plant), 12 WAP (13.38 fruits/plant) and Control 2 (12.75 fruits/plant), which were not significantly different from each other (Table 5.3).

At last harvesting date, Control 2 indicated the largest in fruit numbers (10.75 fruits/plant), followed by Control 1 (4.75 fruits/plant), 10 WAP (3.63 fruits/plant) and 12 WAP (1.5 fruits/plant), respectively. The fruit harvesting of treatments of 14 WAP, 16 WAP and 18 WAP were terminated at sixth harvest time (Table 5.3).

Fruit yield from the perspective of weight basis (kg/tree) had a similar trend in the fruit yield in terms of fruit numbers. The results demonstrated that the largest amount of total fruit weight was observed in 18 WAP (23.68 kg/tree) and the least amount of total fruit weight could be seen in Control 1 (13.8 kg/tree) (Table 5.4).

Table 5.3 Number of fruits and total fruit no. at different harvesting dates by application of with and without urea and different times of 0.7 % thiourea spraying

Factors	Number of harvested fruits							
	1st (11.4.11)	2nd (20.4.11)	3rd (27.4.11)	4th (3.5.11)	5th (8.5.11)	6th (12.5.11)	7th (19.5.11)	Total
Levels of Urea								
Urea: 0	1.82 a	6.00 a	13.29 a	17.00 a	13.71b	5.57 b	2.18 b	59.57 a
Urea: +	0.00 b	0.00 b	2.14 b	16.96 a	18.18 a	17.96 a	3.71 a	58.96 a
LSD (0.05)	0.43	1.88	2.44	4.43	3.67	2.63	0.99	5.29
Different times of 0.7% Thiourea spraying								
10 WAP	0.00 b	0.00 b	6.63 c	15.00 cd	14.13 b	14.25 ab	3.63 b	53.63 cd
12 WAP	0.00 b	0.00 b	4.25 c	20.13 bc	12.63 b	13.38 abc	1.50 c	51.88 d
14 WAP	6.38 a	11.50 a	7.38 c	12.00 d	17.00 b	9.00 cd	0.00 c	63.25 bc
16 WAP	0.00 b	9.50 a	11.00 b	20.50 b	16.75 b	9.63 bcd	0.00 c	67.38 b
18 WAP	0.00 b	0.00 b	24.75 a	27.75 a	24.13 a	5.88 d	0.00 c	82.50 a
Control 1	0.00 b	0.00 b	0.00 d	12.75 d	11.00 b	17.50 a	4.75 b	46.00 d
Control 2	0.00 b	0.00 b	0.00 d	10.75 d	16.00 b	12.75 abc	10.75 a	50.25 d
LSD (0.05)	0.51	2.68	3.55	5.28	6.35	4.84	1.75	10.10
F- test (A)	**	**	**	ns	*	**	*	ns
(B)	**	**	**	**	**	**	**	**
(A *B)	**	**	**	ns	**	**	**	**
CV %	55.55	87.94	45.44	30.66	39.24	40.54	58.55	16.80

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

Table 5.4 Fruit weight. at different harvesting dates and total fruit weight. by with and without urea and application times of 0.7 % thiourea spraying

Factors	Harvested fruit weight (kg/plant)							
	1st (11.4.11)	2nd (20.4.11)	3rd (27.4.11)	4th (3.5.11)	5th (8.5.11)	6th (12.5.11)	7th (19.5.11)	Total
Levels of Urea								
Urea: 0	0.51 a	1.71 a	3.66 a	4.87 a	3.98 b	1.65 b	0.66 b	17.04 a
Urea: +	0.00 b	0.00 b	0.66 b	5.73 a	4.98 a	5.49 a	1.14 a	18.00 a
LSD (0.05)	0.11	0.53	0.65	1.99	0.78	0.86	0.33	1.82
Different times of 0.7% Thiourea spraying								
10 WAP	0.00 b	0.00 b	1.85 c	4.44 bcd	4.20 bcd	4.21 ab	1.10 b	15.80 cd
12 WAP	0.00 b	0.00 b	1.18 c	5.91 b	3.68 bcd	4.15 abc	0.45 c	15.37 d
14 WAP	1.80 a	3.38 a	1.97 c	5.71 bc	3.08 d	2.69 cd	0.00 c	18.62 bc
16 WAP	0.00 b	2.60 a	3.16 b	5.96 ab	4.13 b	2.91 bcd	0.00 c	19.76 b
18 WAP	0.00 b	0.00 b	6.97 a	7.84 a	7.02 a	1.84 d	0.00 c	23.68 a
Control 1	0.00 b	0.00 b	0.00 d	3.84 cd	3.34 cd	5.24 a	1.39 b	13.80 d
Control 2	0.00 b	0.00 b	0.00 d	3.38 d	4.92 bc	3.95 abc	3.35 a	15.60 d
LSD (0.05)	1.13	0.93	0.99	1.93	1.71	1.47	0.54	2.97
F- test (A)	**	**	**	ns	*	**	*	ns
(B)	**	**	**	**	**	**	**	**
(A *B)	**	**	**	**	**	**	**	*
CV%	48.19	106.93	45.24	35.92	37.71	40.53	59.72	16.71

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

5.3.7 Days to first and last harvest

Days to first harvest of with and without urea application were 292 days and 270 days after PBZ application respectively. However, days to last harvest was 308 days after PBZ application the same between with and without urea application (Table 5.5)

The days to first harvest of different floral induction times with 0.7 % thiourea indicated that the earliest fruits were harvested in 14 WAP (270 days after PBZ application), followed by 16 WAP (279 days after PBZ application), 18 , 10 and 12 WAP (286 days after PBZ application) and Control 1 and 2 (292 days after PBZ application). Days to last harvest were 301 days after PBZ application in 14, 16 and 18 WAP and 308 days in 10 and 12 WAP and Control 1 and 2 (Table 5.5).

Table 5.5 Days to first and last harvest by with and without urea and different times of 0.7% thiourea spraying

Factors	Days to	
	First Harvest	Last Harvest
Levels of Urea		
Urea: 0	270	308
Urea: +	292	308
Different times of 0.7% Thiourea spraying		
10 WAP	286	308
12 WAP	286	308
14 WAP	270	301
16 WAP	279	301
18 WAP	286	301
Control 1	292	308
Control 2	292	308

5.3.8 Fruit quality

There was no significant difference in fruit length, width and Brix% between with and without urea application. However, the fruits harvested from the tree applied with urea showed more fruit thickness and weight (7.1 cm and 302.29 g) than the those of the fruit (7 cm and 286.29 g) got from the trees applied with without urea (Table 5.6).

According to the different times of floral induction with 0.7 % thiourea spraying, there was no significant difference in fruit length and Brix % among the treatments. However, more fruit width, thickness and weight were observed in Control 2 (Table 5.6).

5.3.9 Harvest dates as affected by with and without urea and different times of 0.7 % thiourea spraying

According to with and without urea application, the results exhibited that the plants applied with without urea gave much earlier harvest in first, second and third harvesting times while no fruits were obtained from the plants given with urea application (Figure 5.4).

Among the different times of 0.7 % thiourea spraying for flower induction, the earliest fruits were harvested from 14 WAP, 9 days earlier than 16 WAP , 16 days earlier than 10, 12 and 18 WAP and 22 days earlier than Control 1 and 2 even within treatment without urea application. However, the latest fruits were observed in 10 and 12 WAP and Control 1 and 2 at final harvest date of May 19, 2011 (Figure 5.4).

Table 5.6 Fruit length, width, thickness, weight and brix% as affected by with and without urea and application times of 0.7 % thiourea spraying

Factors	Fruit				
	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)	Brix (%)
Levels of Urea					
Urea: 0	10.04	7.83	7.00 b	286.29 b	19.08
Urea: +	10.22	7.84	7.10 a	302.29 a	19.19
$LSD_{(0.05)}$	0.28	0.08	0.09	9.95	0.31
Different times of 0.7% Thiourea spraying					
10 WAP	10.24	8.00 a	7.13 ab	310.50 ab	19.24
12 WAP	10.26	7.93 ab	7.13 ab	306.25 ab	19.26
14 WAP	10.07	7.79 abc	6.95 b	282.50 bc	18.78
16 WAP	9.92	7.70 bc	7.00 b	278.13 c	19.04
18 WAP	10.07	7.78 abc	7.00 b	287.50 bc	19.34
Control 1	10.05	7.64 c	7.00 b	283.88 abc	18.99
Control 2	10.29	8.01 a	7.20 a	311.25 a	19.30
$LSD_{(0.05)}$	0.47	0.27	0.19	28.06	0.42
F- test					
(A)	ns	ns	*	*	ns
(B)	ns	*	*	*	ns
(A *B)	ns	ns	ns	ns	ns
CV%	4.59	3.45	2.67	9.40	2.21

Means followed by different letters in the same column are significantly different by LSD test at 5% level.

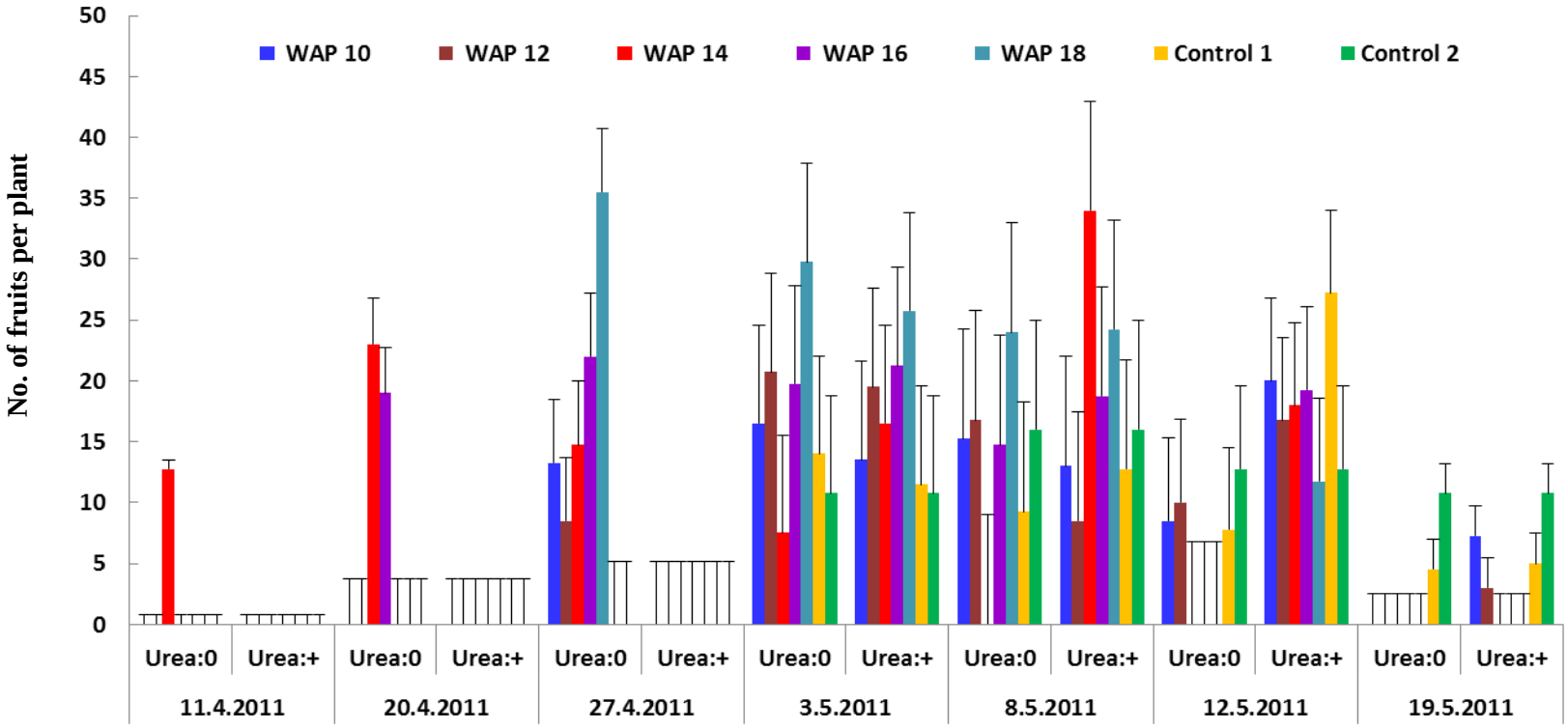


Figure 5.4 Number of fruits per plant at different harvest date as affected by with and without urea and different times of 0.7% thiourea spraying

5.4 Discussion

Flowering in perennial trees such as mango is not well understood because of a gamut of poorly justified reasons, such as structural complexity, intra tree interaction, multiplicity of factors affecting flowering and a wide array of techniques being used to manipulate flowering (Kulkarni 2004). The results of this experiment indicated that significantly more numbers of GS and MS were observed in without urea than urea application. It could be antagonistic effects of between vegetative and reproductive growth. (Davenport 2007) warned that high nitrogen levels, especially under well-watered condition, were conducive to initiation of frequent vegetative flushes that lead to lower flowering. In addition, the MS was noticed earlier than GS. This was due to the night temperature was above 15°C at the time of last application with 0.7 thiourea at 18 WAP (Appendix 2). And this was in accord with the finding of Joubert *et al*. (1993). He stated that MS normally developed when the daily mean temperature during the induction period exceeded 15° C.

In different times of floral induction with 0.7 % thiourea, the numbers of MS at 14 WAP were observed higher compared to other treatments but during early parts of counting dates differences were not much on later parts of counting dates. However, the number of GS were seen to be highest numbers in 18 WAP. But 14 WAP produced the GS more earlier than 18 WAP. It could be assume that floral induction with 0.7 % thiourea at 18 WAP indicated the more profuse GS and 14 WAP produced the earliest and more number of MS.

The more number of inflorescences were seen in without urea compared to urea application. In addition, without urea indicated early flowering especially at early counting dates of December 1, 10 and 20, 2010 during which urea application gave no inflorescences at all. The earliness of inflorescence occurrence could be due to combination effects of without urea and PBZ application. As a result of this condition, the buds in the tree treated without urea and PBZ were forced to be quiescent for some time while some of the buds on the trees of Control 2 and urea application burst into vegetative shoots before the normal flowering period resulting in poor flowering. The results of this study partially agree with results of six years experiment conducted by Torres *et al*. (2004), who suggested that the N fertilized tree had lower yield and mango trees grown in medium fertile soil might keep a high long productivity without N fertilization.

With regard to floral induction treatments with 0.7 % thiourea, the highest fruit numbers were given by 18 WAP and lowest in Control 2. However, the earliest formation of inflorescences was observed in 14 WAP. The early flowering by 14 WAP could be due to the fact that quiescent buds existed on trees could come into flowering. Here, PBZ used in this experiment could also take part in an important role. The application of PBZ caused an early reduction of endogenous GA levels within the shoots causing them to mature earlier (Yeshitela 2004). Protacio and Quinto (2009), concluded that low GA levels resulted in accumulation of total non-structural carbohydrates, primarily starch, in the leaves and buds. These series of events eventually led to the formation of floral initials. According to the facts mentioned above, floral induction with 0.7 % thiourea at 14 WAP showed earliest flowering that could be seen on December 1, 2010 as a visible panicle. However, the number of inflorescences given by 14 WAP was significantly lower compared to that by 18 WAP. It was probable that due to floral induction with 0.7 % thiourea at 14 WAP experimental trees produced not only inflorescences but also vegetative shoots that led failing to flower in normal period. The highest numbers of inflorescences were observed in 18 WAP. This result was the same trend observed in experiment 1. This result was in line with the finding of Perez-Barraza *et al.* (2000), who found that later spraying dates (close to the normal period of flowering) with NH_4NO_3 or KNO_3 to the ‘Manila’ mango resulted in advanced and profuse flowering.

`Although inflorescence length was not affected by with and without urea application and floral induction treatment, the longer FSL and SSL were observed in urea application. It could be noted that urea application enhanced vegetative growth. In addition, the longest first shoot length observed in Control 2. It could be feasible that new vegetative shoot induced by 0.7 % thiourea would be competent for photo assimilation and nutrient. As a results of this competency, shorter FSL was observed in other treatments compared to Control 2. The SSL was not affected by floral induction treatments.

The more percent of flower intensity was seen in without urea application. According to significant interaction, this result could be influenced by combination effects of PBZ, floral induction treatments and without urea application. In contrast, more harvested fruit percent from total inflorescences was observed in urea application that could replenish carbohydrates consumed during fruit growth and

retention. The lack of harvested fruits percent from total inflorescences in without urea application could be not enough N reserves. This was in line with the finding of Singh (1987), who explained that there are 100,000 flowers and each flower contains to 10 µg of N, then each time a tree flowers, it loses 1 kg of N. Therefore the tree needs to have adequate N reserves for subsequent fruit formation.

The highest flower intensity percent in 18 WAP and the lowest in Control 2 were observed and it could be directly involved in numbers of inflorescences produced by each treatment. On the contrary, harvested fruit percent from total inflorescences was affected by floral induction treatments whereas the highest percent was seen in Control 2 and the lowest in 18 WAP (Table 5.2).

Total number of fruits was not influenced by with and without urea application. However, the number of harvested fruits from each harvesting date except 4th harvesting time was affected by with and without urea application. The earlier and more number of fruits were harvested from without urea application during first, second and third harvesting times. On the contrary, more number of fruits were obtained from urea application at later harvesting times of the fifth, sixth and seventh. The results of this study indicated that without urea application gave earlier fruit harvesting than urea application. Significant interaction was observed at each time of harvesting date except fourth harvesting time. The earliness fruits obtained from without urea application were also involved by PBZ and floral induction treatments.

Total number of fruits affected by floral induction treatment with 0.7 % thiourea sprays illustrated that the highest numbers of fruits were obtained in 18 WAP and lowest in Control 2. As a result of earlier flowering gained by 14 WAP, the fruits harvested from first harvesting date were obtained only from 14 WAP, which was 9 days earlier than 16 WAP, 16 days earlier than 10, 12 and 18 WAP, and 22 days earlier than Control 1 and 2. The fruits harvested from 18 WAP were 6 days earlier than Control 1 and 2. In addition, 18 WAP gave the more fruits in early parts of normal season. The early harvesting and more fruit numbers harvested from 18 WAP, especially early part of normal harvesting period, were beneficial for mango growers to achieve good market price. At the final harvest, the fruits were harvested only from 10 WAP, 12 WAP, Control 1 and 2, which were 7 days later than other treatments. According to direct relationship between total number of fruits and total fruits weight,

the highest total fruit weight was obtained from 18 WAP (23.68 kg/tree) and the lowest in Control 1 (13.8 kg/tree).

The results indicated that the tree without urea application showed the 22 days earlier than the tree applied by urea. Among the floral induction treatments with 0.7% thiourea spraying, the fruits harvested from 14 WAP were 9 days earlier than 16 WAP, 16 days earlier than 10, 12 and 18 WAP and 22 days earlier than Control 1 and 2 for days to first harvest. The fruit harvested from 10, 12, Control 1 and 2 were 7 days later than the other treatments in days to last harvest (Figure 5.4).

The result demonstrated that Brix % was not affected neither by with and without urea application nor different spraying times of 0.7 % thiourea. However, bigger fruits in terms of fruit weight were obtained from urea application. In different floral induction treatments with 0.7 % thiourea, the heaviest fruit weight was given by Control 2 (311.25 g), followed by 10 WAP (310.5 g), 12 WAP (306.25 g) respectively. The heavier fruits obtained from these three treatments could be shy bearing of these treatments.

5.5 Conclusion

Between with and without urea application, the treatment with without urea produced the earlier inflorescences than that of urea application resulting in more advanced harvesting. In addition, without urea gave the more number of inflorescences and flower intensity percent than urea application but not significant difference in yield in terms of number of fruits and weight (kg/plant). The plant with without urea applications incorporated with PBZ and 0.7 % thiourea spraying at 14 WAP gave the earliest in flowering and harvesting. Spraying of 0.7 % thiourea at 16 WAP was the second earliest in flowering and harvesting. The early harvesting opportunity given by 14 WAP and 16 WAP from without urea application was useful for mango growers to get good selling price. However, the yield in terms of number of fruits and weight (kg/plant) obtained from 14 WAP and 16 WAP was significantly lower compared to 18 WAP. In addition, 18 WAP gave not only the highest in yield including number of fruits and weight (kg/plant) but also earlier harvesting than 10 WAP, 12 WAP, Control 1 and 2. This earlier harvesting especially early parts of normal harvesting period was also beneficial for mango growers for achieving good market price.

CHAPTER VI.

GENERAL DISCUSSION AND CONCLUSION

6.1 General Discussion

The results of three experiment demonstrated that 1 % thiourea used in experiment 1 and 2 for new vegetative flush had shown that treated trees produced almost hundred per cent new shoots from existing shoots. However, burning symptom on the leaves was observed and defoliation of these infected leaves was also seen. However, 0.7 % thiourea used in experiment 3 was also effective in producing uniform leaf flushes without detrimental effects such as leaf burn and defoliation.

Two levels of PBZ used in experiment 1 and 2 exhibited that there was no significant effect on advanced flowering and profuse flowering in Sein Ta Lone mango. PBZ 0.10, 0.15 and 0.20 g ai m^{-1} of canopy diameter used in the experiments showed no sign of detrimental effects on inflorescence length, first shoot length and second shoot length. However, both levels of PBZ incorporated with floral induction with 3 % KNO_3 at 18 WAP in either experiment gave the intense flowering and good fruit yield and advanced flowering, especially early parts of normal season. As a result, 18 WAP showed 4 days earlier harvest than other treatments and more numbers of fruits could be harvested in early parts of normal season. This evidence was also beneficial for growers to get more income. The fruit obtained from 18 WAP were smaller compared to 10, 12, Control 1 and 2 as a result of high fruit load and retention. Further study of nutritionally balanced fertilization, especially during flowering and fruiting, should be investigated. The effects of 3 % KNO_3 used for forced flowering in the experiments were not consistent. However, 0.7 % thiourea used in experiment 3 was an effective induction agent both for uniform flushing and flowering without injury to the leaves of Sein Ta Lone mango.

6.2 General Conclusion

PBZ doses (0.10 and 0.15 g ai m^{-1}) in experiment 1 and (0.1 and 0.2 g ai m^{-1}) in experiment along with 3 % KNO_3 spraying at 18 WAP produced the earlier inflorescences and harvesting than other treatments.

Moreover, 18 WAP gave the highest number of inflorescences and fruit yield including number of fruits and weight (kg/plant). The early harvesting and more yield in terms of number of fruits and weight (kg/plant) given by 18 WAP were beneficial for mango growers to achieve good market price and more income.

Harvest date and yield in terms of number of fruits and weight (kg/plant) were not affected by two levels of PBZ and different times of 3 % KNO_3 spraying in experiment 2.

Treatment with without urea applications incorporated with PBZ and 0.7 % thiourea spraying at 14 WAP gave the earliest in flowering and harvesting. And spraying of 0.7 % thiourea at 16 WAP was the second earliest in flowering and harvesting. The early harvesting opportunity given by 14 WAP and 16 WAP was useful for mango growers to get good selling price. However, the yield in terms of number of fruits and weight (kg/plant) obtained from 14 WAP and 16 WAP was significantly lower compared to 18 WAP. Among the floral induction treatment with 0.7 % thiourea, 18 WAP gave not only the highest in yield including number of fruits and weight (kg/plant) but also earlier harvesting than 10 WAP, 12 WAP, Control 1 and 2. This earlier harvesting especially early parts of normal harvesting period was also beneficial for mango growers for achieving good market price.

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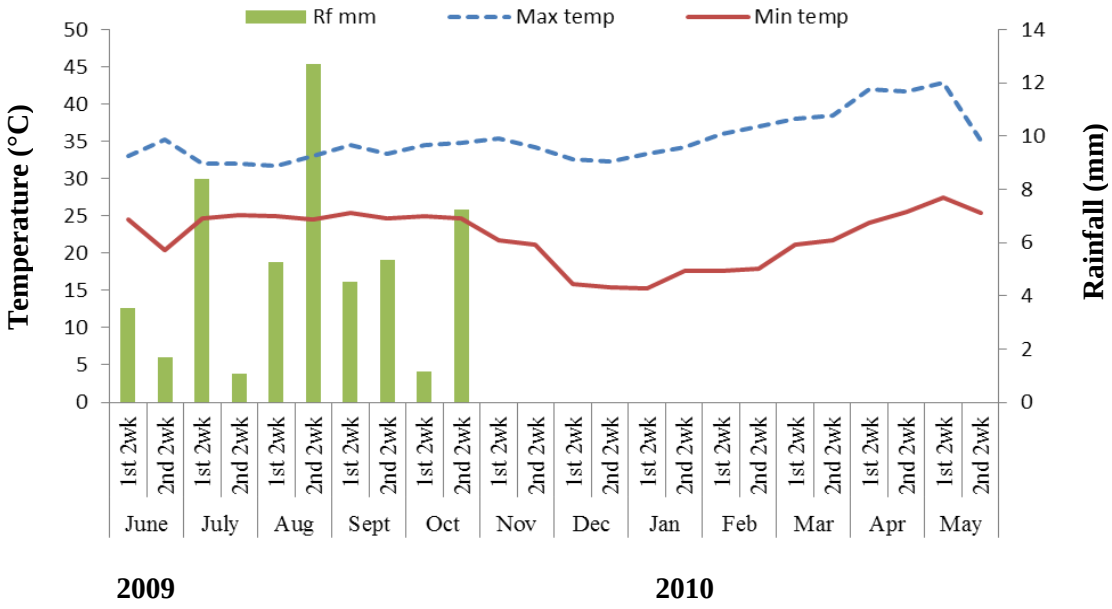
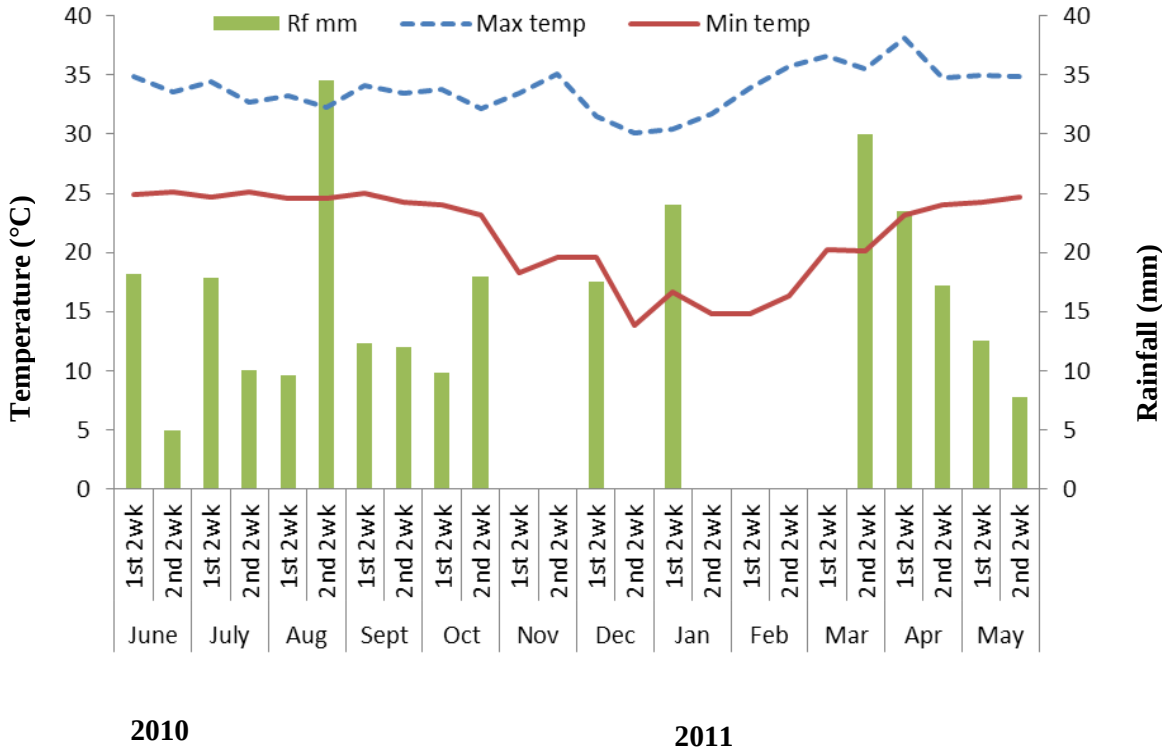
APPENDICES



Appendix 1 Average maximum and minimum temperature (˚C) and fortnightly rainfall (mm) at Yezin area, during experiment periods of 2009-2010.



Appendix 2 Average maximum and minimum temperature (℃) and fortnightly rainfall (mm) at Yezin area, during experimental periods of 2010-2011