Chapter 5

Discussion

It is well known that potassium chlorate can induce flowering in longan. However, the mechanism of chlorate on longan flowering is still questionable. The most referable hypothesis for flowering is hormonal balances inside the plant. Therefore, there were many efforts to use plant growth regulators to promote flowering in many plants which were successful in some plants such as the use of paclobutrazole (a gibberellin inhibitor) to promote off-season flowering in mango. There were also many efforts to use plant growth regulators to promote flowering in longan but they were not successful until potassium chlorate was found to promote longan flowering, not only on season-flowering but also off-season flowering. Most of the researchers explained that the effect of potassium chlorate on longan flowering is based on the hormonal balances. After longan plants took up potassium chlorate, the auxins and gibberellins contents in shoots and leaves were decreased and the cytokinins and ethylene contents in shoots and leaves were increased. These explainations were supported by many reports (Hegele *et al*., 2004; Kiatsakun, 2004; Thoongkeaw, 2001; Wangsin, 2002). There was a report from Sinlaphasomboon (2007) which suggested that there was another pathway which promoted flowering of longan by potassium chlorate. He suggested that there were some signals/substances which were synthesized in longan leaves after treating with potassium chlorate and transported to the shoot during the longan flower induction process. In his study, he did not mention about the hormonal balances.

Cytokinins and gibberellins were the two famous hormones which related to flowering process in many plants. Thus the notable synthesis site of these two hormones is the root of the plant. Moonrat (2005) reported that longan plants which were derooted (got rid of the source of cytokinins and gibberellins) and treated with

potassium chlorate could flowering. This phenomenon did not do along well with hormonal balances hypothesis on flowering.

In the first study, many potassium chlorate concentrations were used to induce flowering of derooted air-layered longan cv. Daw. They revealed that the derooted longans could induce flowering by potassium chlorate at the concentrations of 300-500 ppm. The treated longans were flowered within 30-35 days. This result agreed with Moonrat (2005). However, at the high concentration treatments of 1,000-5,000 ppm, derooted longan developed the chlorate toxic symptoms followed by plant death. Solomonsson and Venesland (1972) reported that toxicity of chlorate depended upon the rate of its uptake by plant. Chlorate application to longan might also produce lethal effects such as severe leaf drop, shoot dry out, panicle dieback and finally the tree death (Li *et al.,* 2003) which were similar to the results in this experiment. Huang *et al.* (2006) and Manochai *et al.* (2005) also reported that cultivar, soil type, tree age and irrigation and fertilization practices could affect the chlorate for responses of the plant. In this experiment, the derooted longan showed more toxic symptoms than the rooted longan. It was also found that toxic symptoms could be observed in derooted trees which dipped in potassium chlorate for only one hour. It suggested that potassium can enter the plant xylem of derooted longan faster than the rooted ones. This should be caused by in rooted longan the chlorate must enter the plant xylem by the via of root and this was the slower absorption process than the direct absorption by xylem in derooted longan. Therefore, the derooted longans showed dehydration and leaf drop symptom within 7-10 DAT. For the derooted longans which were treated with potassium chlorate and then cultured in the nutrient solution, they did not flower but the longans died faster than those cultured in water. This should be the effect of bacterial growth in the nutrients solution which caused xylem blockage.

By the microtome sections of terminals buds, it was found that at 25 DAT, air-layered and derooted air-layered treated with $KClO_3$ could develop the floral buds. At 45 DAT the flowers was observed. This suggested that flower buds were developed at 25 DAT and used about 20 days before the flowering were observed. This results

somewhat agree with Manochai *et al*. (2005) who reported that the application of $KClO_3$ in November and December used about 26.3 and 39.5 DAT respectively for longan to flower. The delay of flowering should cause by the low temperature in December which could slow down the metabolism process in the plants.

Chlorophyll a, b and total chlorophyll changes were not significant differences. However the chlorophyll a, b and total chlorophyll contents in rooted longan seemed to be higher than derooted longan. This should be the effect of potassium chlorate which destroyed the chlorophyll (Pankasemsuk, 1999) and the derooted longan could absorb more chlorate than the rooted longans. Nutrient limitation also could be an accelerating factor to hasten the toxification process or increase the severity of toxic symptoms especially the leaf yellowing. Nitrogen which has a high correlation between the chlorophyll content and photosynthetic rate (Marini, 1986) should be the one that involved in this process because the assessment of photosynthetic pigments, and consequently their relationships, is an important indicator of senescence (Brown *et al*., 1991). In this experiment, the chlorophyll contents in derooted treatments (DR and DR+$KClO_3$) decreased but increased in rooted treatments (R and R+$KClO_3$). This suggested that deroot had affect on the chlorophyll contents. Chlorophyll loss was associated to environmental stress and the variation in total chlorophyll/carotenoids ratio may be a good indicator of stress in plants (Hendry and Price, 1993). Peterson *et al*. (1993) reported that there was a closed link between leaf chlorophyll concentration and leaf N content and the majority of leaf N was found in chlorophyll molecules. This also agreed with the results in this study which the leaf nitrogen contents of all treatments decreased similar to the decreasing of the chlorophyll contents.

. The carbohydrates; TNC, RS and TS, in all treatments decreased from 0 to 25 DAT and did not show a high significant evidence which related to the flower induction process. The carbohydrate and nitrogen (C:N) ratio is one of the hypotheses used to explain about flower induction of many plants in the past. Presently most plant physiologists believe that the C:N ratio is only the supporting factor in the flowering induction process (Pankasemsuk, 1999). This agrees with the result from this study which C:N ratio did not relate to the longan flower induction process by

potassium chlorate because there were no significant differences of C:N ratios among the flowering and non-flowering trees. Similar to pummelo which also found that leaf carbohydrate content could not account for the promotion effect of starches on flower induction and initiation, but their level at the time of flowering seemed to directly relate to the growth and yield (Yamanishi, 1995).

The total nitrogen (TN), phosphorus (P), potassium (K) and calcium (Ca) also did not show the prominent functions in longan flower induction process by potassium chlorate. The TN, nitrate and P contents tended to decrease throughout the studied period. This should be caused by the leaf aging and the lacking of nitrogen source due to the plants be cultured in the water which did not provide any nitrogen to the plants. The K contents in almost all treatment seemed to unchange. This should be caused by the lack of potassium source in the treatments and the senescence process. Leaf calcium contents of all treatments did not change but the shoot calcium contents in the treatment which treated with $KClO_3$ tended to decreased. However only DR+$KClO_3$ showed the significant decreasing percentage. This should be caused by the lack of calcium due to the lack of root and they were cultured in water and $KClO_3$ should also have some effect. However, in the R and DR treatment, the Ca contents of shoot unchanged. This longan trees were under the smaller degree of stress than the other treatments.

Nitrate reductase activities within each treatment tended to decrease gradually. This should be caused by the effect of potassium chlorate which it was reported that it could destroy the nitrate reductase even though it could induce nitrate reductate synthesis (Pankasemsuk, 1999). Another possible cause should be the lack of nitrate source because nitrate reductase is a substrate inducing enzyme. It means that plant will synthezis nitrate reductase after the plant has received some nitrate or the analog molecule such as the chlorate. In this study, longan plants did not receive any nitrate from the cultured water. Therefore, the nitrate reductases in all treatments were decreased.

Hormonal balance hypothesis is still the most trustable in explaining the flowering process in plants (Pankasemsuk,1999). Many researchers reported the

increasing of cytokinins and ethylene along with the reduction of auxins and gibberellins during the flowering process (Hegele *et al*., 2004; Kiatsakun, 2004; Srikasetsarakul, 2007; Thoongkeaw, 2001; Wangsin, 2002). However, there were some evidences which cannot explain by the hormonal balance hypothesis. This make some cues that there should be more than one pathways for flower induction. The results from this study showed that the IAA contents in leaves and shoots within each treatment decreased throughout the studied period except in control (R). This should be the positive effect for flower induction in the treatments.

For gibberellins contents, the results revealed that gibberellin-like substances contents were decreased throughout the studied period. This should be the effect of derooted (get rid of the gibberellins source) and potassium chlorate which destroyed the roots. The reduction of gibberellins-like substances should also be a positive factor for flower induction.

For cytokinins contents, the results revealed that cytokinin-like substances contents decreased throughout the studied period as same as IAA and gibberellin-like substances. This should be caused by derooting and the stress under water culture condition. The decreasing of cytokinin-like substances should be counted for the negative factor for flowering. However, gibberellins:cytokinins ratios also decreased. This factor might be counted for the positive factor for flower induction as well.

For ethylene contents, the results revealed that ethylene contents within each treatment seemed to unchange throughout the studied period, the ethylene contents in leaves and shoots of all treatments were very low. The ethylene content of leaves of all treatments were only 1.31-1.78 ppm. The ethylene content of shoots of all treatments were 1.38-1.87 ppm. These showed that the ethylene in leaves and shoots may not involve in this flower induction process.

The results also showed that only the longan which was treated with potassium chlorate ($R+KClO_3$ and $DR+KClO_3$) showed the formation of flower buds (25 DAT) while the treatments without potassium chlorate (R and DR) showed only vegetative buds. The results did not agree with the hormonal balances hypothesis because even

the R and DR showed the non-significant differences contents and/or ratios of the hormones they still could not develop any flower bud unlike the potassium chlorate treatments which showed the flower buds development at 25 DAT.

It could be inferred that they should be more than one pathway to induce flowering in longan and the root did not play the key role in longan flower induction by $KClO_3$. Longan flower induction by potassium chlorate may have more than one pathway. For this study, another pathway for inducing flowering of longan should not depend on the hormonal balances inside the plant. The results of this study agree with Sinlaphasomboon (2007) which reported that after treating the longan with potassium chlorate, the chlorate ion transported to the shoots and leaves via the xylem transportation. After that the leaves produce some flower induction substances or some signals for flower induction and transported to the shoots by phloem transportation which caused flower induction.