http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 9 (4): 717-722, 2006
ISSN 1028-8880

Effect of Chemical Paclobutrazol on Fruit Development, Quality and Fruit Yield of Kaew Mango (*Mangifera indica* L.) in Northeast Thailand

Chutichudet Benjawan, P. Chutichudat, K. Boontiang and T. Chanaboon
Department of Agricultural Technology, Faculty of Technology,
Mahasarakham University, Mahasarakham Province 44000, Thailand

Abstract: This investigation was carried out during a period of October 2004 to June 2005 at Chaiyaphum Province, Northeast Thailand to search for more information on the effect of chemical Paclobutrazol (PBZ) on flower and fruit development, quality and fruit yield of Kaew mango (*Mangifera indica* L.). A completely randomized design with four replications was used. Five rates of Paclobutrazol were used, i.e., 0, 1,000; 3,000; 5,000 and 7,000 ppm/plant. The experiment consisted of two sets of treatments, i.e., T_1 –T_5 represent the first set and T_6-T_{10} for the second set. The results showed that PBZ had no significant effect in extending number of days from flower initiation up to full bloom. PBZ also had no significant effect in delaying fruit maturity age but fruit sets were significantly increased with PBZ rates applied. PBZ had a highly significant effect on fruit length but significantly decreased fruit thickness. Fruit yields were significantly increased with PBZ application. The best application rate of PBZ was found with T_7 (1,000 ppm/plant) with an extended flower raceme length of 5 cm. This treatment gave the highest mango edible fruit yield of 48,281.25 kg ha^{-1}.

Key words: Chemical Paclobutrazol, fruit dropping, harvesting age, fruit quality, fruit yields

INTRODUCTION

Mango (*Mangifera indica* L.) is one of many important orchard fruit trees in the tropics, particularly in Thailand. The cultivation of mango trees is highly popular among growers in all regions of the country, since there are lots of mango varieties being cultivated for different consuming purposes depending on variety some of them are grown for ripe fruit production and others are used for pickled fruits and edible fresh fruits like apple fruits, its annual production of fruits plays an important role in the Thai economy. The land area being used for growing mango trees in Thailand reached a figure of 332,220 ha and out of this figure about 20% have been used for the growth of Kaew variety (Anonymous, 2005). The need to grow Kaew variety has been increasingly with time due to its high demand for fruits in markets both domestic and overseas apart from its simplicity in growing, since Kaew mango could thrive on well under drought conditions and its annual production could be relatively high (Radanachaless *et al*., 2000). Kaew mango fruits have played its significant role in food industries in Thailand. There are many products being processed through many food manufacturers such as salted mango fruits, pickled mango fruits, oven-dried crispy mango slices and many other food preservations.

Northeast Thailand is a region located on high lands with an elevation of approximately 200 m above sea level for most plain areas but up to 800-1,300 m for mesa mountain of Phukradueng (high mountain with a large flat area). This region is geographically suitable for many orchard plantations apart from the establishment of many pasture lands for livestock production (Suksri, 1999). The high demand for more mango fruit production for domestic and overseas consumption has encouraged scientists to carry out more research investigation in order to produce adequate amount of mango fruits for the high demand of the markets. Thus different methods in stimulating matured mango trees to flower were carried out such as the research of Feungchan (1995). He reported that the training of branches of mango trees to spread out for more radiant energy interception from the sun gave significantly greater amounts of flowers and mango production than without. With another study carried out in Northeast Thailand on the application of chemical Paclobutrazol, Feungchan *et al*. (1991) reported that the application of Paclobutrazol at a rate of 20 cc/plant to the soil at the mango trunk above ground level together with chemical fertilizers gave significantly greater number of flowers and mango fruits than without. Other researchers have stated that by nature, number of fruits/raceme of mango plants could be relatively low due

Corresponding Author: Ms Benjawan Chutichudet, Department of Agricultural Technology, Faculty of Technology, Mahasarakham University, Mahasarakham 44000, Thailand

to small amount of fertilized flowers as a result of environmental conditions and internal mechanisms within the mango plants (Khader *et al*., 1988; Schaffer *et al*., 1994; Krisanapook *et al*., 2000; Negi, 2000). Some researchers have stated that there is always a competition for assimilates among fruits within a raceme of mango, thus a number of small fruits dropped off at its early stage of development (Ram, 1992; Davenport and Nunez-Elisea, 1997). Growers of mango plantations in Thailand have always accustomed to problems on unfertilized flowers, dropping off of fruits at its early stage of development and the inconsistency in annual flowering of mango trees, i.e. mango trees bearing its fruits in between years. Thus these encourage scientists to carry out more experiments on such problems in order to provide adequate information for growers of mango plants. Chemical Paclobutrazol (PBZ), a growth regulator is known to have played its significant role in delaying growth in plants by its inhibition on the synthesis of Gibberrellin (Rademacher 1995; Nartvaranant *et al*., 2000; Bally *et al*., 2000) thus PBZ application could probably lengthen both flowering and fruit filling up periods in mango plants in order to provide adequate assimilates for fruit development of mango plants. Therefore, there is an urgent need to investigate further in order to attain maximum outputs of the annual production of mango trees. It is of important value to carry out experiment on the effect of different spraying rates of chemical Paclobutrazol to different flower panicle lengths of mango flower racemes in order to evaluate its effect on flower initiation, fruit development and fruit production, where the obtained results may be of important value to growers of mango plantations in Thailand, particularly in the northeastern region.

MATERIALS AND METHODS

This investigation was carried out with the use of a mango plantation of a villager, Muang District, Chaiyaphum Province, northeastern region of Thailand during October 2004 to June 2005. Forty Kaew mango trees (*Mangifera indica* L.) with an age of 10-year old with a similar girth diameter of the trunk at approximately 0.5 m above ground and a similar bushy structure were chosen for the experiment. The mango trees are grown on Raynu soil series (Oxic Paleustults) with the distances between rows and within rows of 8×8 m. The experiment was laid in a Completely Randomized Design (CRD) with four replications. Each mango tree was used as a replication. Five rates of chemical Paclobutrazol (PBZ) were used. That is 0, 1,000; 3,000; 5,000 and 7,000 ppm/plant. The spraying of chemical Paclobutrazol to the whole plant of each replication of mango trees was carried out twice. This made two-set of treatments, i.e. all rates of chemical Paclobutazol were used for the first set (T_1 to T_5) when an extension of flower racemes of each replicate reached approximately 1 cm long and the second set of treatments (T_6 to T_{10}) was carried out at 4 days after the spraying of the first set when the flower racemes had extended up to 5 cm long. Therefore, the treatments used were altogether ten treatments. They are: 0 ppm PBZ @ 1 cm (T_1, control), 1,000 ppm PBZ @ 1 cm (T_2), 3,000 ppm PBZ @ 1 cm (T_3), 5,000 ppm PBZ @ 1 cm (T_4), 7,000 ppm PBZ @ 1 cm (T_5), 0 ppm PBZ @ 5 cm (T_6, control), 1,000 ppm PBZ @ 5 cm (T_7), 3,000 ppm PBZ @ 5 cm (T_8), 5,000 ppm PBZ @ 5 cm (T_9), and 7,000 ppm PBZ @ 5 cm (T_{10}), The following items were used for data collection: number of days to full bloom (being counted from flower initiation up to full bloom), percentages of dropping off of fruits and harvesting age for fruit production after maturity (both being counted from flowering stage up to fruit maturity), fruit sizes, flesh percentage, seed stone sizes, individual fruit weight, mango yield/ha and fruit quality. The fruit quality determination was carried out with the use of Fruit Pressure Tester Model FT 327 (3-27 lbs), Italy for fruit firmness (kg cm^{-2}), total soluble solids of edible flesh of fruits by the method of AOAC (1984) with the use of a hand Refractometer, E type, series 2111-W10, Model N-1E, Japan. Titratable acidity content was determined (TA) with the use of citric acid%, titration against NaOH 0.1 N using phenolphthalein 1% as indicator (AOAC, 1984). The obtained data were statistically analysed using SPSS Computer Programme, Base 9 (SPSS, 1999).

RESULTS

Flowering period of Kaew mango trees was initiated in late November 2004 and then spraying of different rates of chemical Paclobutrazol was carried out accordingly. The results showed that number of days from flower initiation up to full bloom ranged from 23.31 to 31.75 days for T_6 and T_9, respectively. There was no significant difference due to treatments found on number of days from initiation to full bloom (Table 1). The results on fruit dropping off percentages indicated that the dropping off was highest with the treatments without Paclobutrazol application, i.e., T_1 and T_6 (controls) with percentages of dropping off of 94.53 and 87.31, respectively. In most cases, the dropping off of fruits was relatively higher for those sprayed at 1 cm raceme extension than those sprayed at 5 cm raceme extension. The lowest figure of dropping off of fruits was found with T_7 and became greater from T_9 to T_8, T_{10}, T_2, T_3, T_5, T_4, and T_6, respectively and the greatest number was found with T_1. The differences were large and statistically significant.

Table 1: Number of days from flower initiation to full bloom (NDF), fruit dropping% and harvesting age (days from flowering initiation till harvest) of Kaew mango fruits (*Mangifera indica* L.) as influenced by different rates of chemical Paclobutrazol and spraying periods (lengths of flower racemes: 1 and 5 cm), grown on Raynu soil series (Oxic Paleustults) at Chaiyaphume Province, Northeast Thailand

Treatments	NDF	Fruit dropping (%)	Harvesting age
T_1	24.53	94.53a	146.98
T_2	28.42	83.42bc	150.14
T_3	29.01	84.01bc	152.55
T_4	30.75	86.75ab	152.64
T_5	30.71	85.08abc	154.01
T_6	23.31	87.31ab	146.57
T_7	29.19	76.19c	151.43
T_8	30.86	77.86c	152.21
T_9	31.75	76.75c	150.38
T_{10}	30.15	80.15c	152.56
LSD (p = 0.05)	NS	*	NS
CV%	14.73	6.73	2.55

Letter(s) within columns and LSD indicate significant differences at *p = 0.05, NS = non Significant, NDF = number of days from flower initiation to full bloom

With harvesting age for mango fruits, the results revealed that there was no difference in maturity age of the treatments used. The maturity age commenced from 146.57 to 152.56 days for T_6 and T_1, respectively. Maturity age tends to be delayed by the application of chemical Paclobutrazol although it was not significantly shown.

With fruit dimensions, the results showed that fruit width was highest with T_4 followed by T_9 with values of 7.48 and 7.23 cm, respectively. Whilst the rest were similar and even lower than T_1 (control treatment). The differences were highly significant (Table 2). Fruit length was longest with T_4 but similar to T_1 (control) and T_2 with the values of 9.86, 9.63 and 9.51 cm, respectively. In most cases, fruit length seems to have reduced by chemical Paclobutrazol application. The differences were large and highly significant. For fruit thickness, the results showed that Paclobutrazol application increased fruit thickness only up to 5,000 ppm (T_4) but similar to T_1, T_3 and T_{10} with the values of 6.36, 6.17, 6.16 and 6.16 cm, respectively. The application of chemical Paclobutrazol significantly decreased fruit thickness. There were no differences in flesh content percentages found among treatments used. For fruit yields, the results showed that fresh fruit yields were highest for T_7 (48,281.25 kg ha^{-1}) but similar to all treatments treated with chemical Paclobutrazol except T_4 and T_6 where their values were lower but significantly greater than control. The lowest fruit yield was found with T_1 (control) with a value of 22,187.50 kg ha^{-1}. The application of chemical Paclobutrazol highly increased fruit yields of Kaew mango.

For seed weights without flesh, the results showed that seed weight was highest with T_9 but similar to T_1 (control) with values of 31.34 and 30.73 g/seed, respectively (Table 3). There was no consistent trend found due to the different rates of chemical Paclobutrazol applied but the difference was large and highly significant. Seed width was highest with T_1 and lowest with T_2, T_8 and T_{10} with values of 4.17, 3.80, 3.80 and 3.80 cm/seed, respectively. In most cases, seed width seems to decrease with the application of chemical Paclobutrazol. The differences were large and highly significant. A similar result to seed width was found with seed length, i.e., chemical Paclobutrazol tends to decrease seed length of the mango fruits. However, there were no statistical differences due to treatments found on seed thickness and individual fruit weight.

With quality of mango fruits, the results showed that fruit firmness was highest with T_7 but similar to T_6 with the values of 14.51 and 13.79 kg cm^{-2}, respectively. Fruit firmness was similar for all treated mango plants except T_6 and T_7 where their values were significantly greater than

Table 2: Fruit dimensions, flesh contents, and fruit yields of Kaew mango fresh fruits as influenced by different rates of Chemical Paclobutrazol and spraying periods (lengths of flower racemes: 1 and 5 cm), grown on Raynu soil series (Oxic Paleustults) at Chaiyaphum Province, Northeast Thailand

Treatments	Width (cm)	Length (cm)	Thickness (cm)	Flesh (%)	Fruit yields (kg ha^{-1})
T_1	7.19bc	9.63ab	6.17ab	73.03	22,187.50d
T_2	7.05bc	9.51abc	6.03bc	72.78	44,218.75a
T_3	7.16bc	9.41bcd	6.16ab	73.38	44,739.06a
T_4	7.48a	9.86a	6.36a	73.39	38,332.81b
T_5	7.16bc	9.26de	6.10b	70.28	45,104.69a
T_6	7.14bc	9.53abc	6.04bc	72.71	27,604.68c
T_7	7.10bc	9.33cde	6.00bc	73.08	48,281.25a
T_8	6.48d	8.97e	5.82c	70.80	47,707.81a
T_9	7.23b	9.43bcde	6.04bc	72.32	45,156.25a
T_{10}	7.00cd	9.27cde	6.16ab	72.39	48,229.69a
LSD (p = 0.05)	**	**	*	NS	**
CV (%)	2.01	2.42	2.54	1.79	4.47

Letter(s) within columns and LSD indicate significant differences at p ** = 0.01, * = 0.05, NS = non Significant

Table 3: Seed weights without flesh (seed stone), seed dimensions (cm) and fresh weights (g/fruit) of Kaew mango as influenced by different rates of chemical Paclobutrazol and spraying periods (lengths of flower racemes: 1 and 5 cm), grown on Raynu soil series (Oxic Paleustults) at Chaiyaphum Province, Northeast Thailand

Treatments	Seed weight (g/seed)	Width (cm)	Length (cm)	Thickness (cm)	Fruit weight (g/fruit)
T_1	30.73a	4.17a	8.52ab	2.26	191.22
T_2	25.29cd	3.80c	7.91c	2.06	171.90
T_3	28.20abc	3.97b	8.26bc	2.16	185.80
T_4	31.19a	4.05ab	8.57ab	2.26	208.00
T_5	29.01ab	3.91bc	8.11bc	2.31	186.54
T_6	29.38ab	3.92bc	8.50ab	2.24	188.91
T_7	28.87ab	3.93bc	8.11bc	2.19	179.02
T_8	24.86d	3.80c	7.91c	2.13	161.21
T_9	31.34a	4.05ab	8.64a	2.22	200.33
T_{10}	26.37bcd	3.80c	8.01c	2.17	170.87
LSD (p = 0.05)	**	**	*	NS	NS
CV %	7.06	2.71	3.62	2.85	10.87

Letter(s) within columns and LSD indicate significant differences at p ** = 0.01, * = 0.05, NS = non Significant

Table 4: Fruit firmness (texture), soluble solid content (SS) and titratable acidity (TA) of Kaew mango fruits as influenced by different rates of chemical Paclobutrazol and spraying periods (lengths of flower racemes: 1 and 5 cm), grown on Raynu soil series (Oxic Paleustults) at Chaiyaphum Province, Northeast Thailand

Treatments	Fruit firmness (kg cm^{-2})	Soluble solid content (%)	Titratable acidity content (%)
T_1	13.41bc	9.98a	0.39abc
T_2	13.28bc	10.06a	0.39abc
T_3	13.03c	9.17bc	0.39abc
T_4	13.22bc	9.03bc	0.41ab
T_5	13.04bc	9.12bc	0.42ab
T_6	13.79ab	9.03bc	0.40ab
T_7	14.51a	8.61c	0.38abc
T_8	13.17bc	9.37ab	0.41ab
T_9	13.52bc	8.95bc	0.42ab
T_{10}	12.26d	9.14bc	0.39abc
LSD (p = 0.05)	**	**	*
CV%	7.06	4.47	5.99

Letters within columns and LSD indicate significant differences at p ** = 0.01, *= 0.05, NS = non Significant

the rest, whilst T_{10} attained the lowest. There was no consistent trend due to chemical Paclobutrazol rates of application but T_6 and T_7 were highly significant over T_1 (Table 4). With soluble solid content in fruits, the results showed that T_2 gave the highest value but similar to T_1 (control treatment) and T_8 with values of 10.06, 9.98 and 9.37%, respectively. In most cases, chemical Paclobutrazol rates seem to decreased soluble solid% of mango fruits. The differences were large and highly significant. For titratable acidity content, the results showed that T_7 gave the lowest titratable acidity% but similar to all treatments used. The differences were large and statistically significant. In most cases, chemical Paclobutrazol application tends to increase titratable acidity% of the mango fruits. There was no consistent trend found due to the application rates of Paclobutrazol.

DISCUSSION

The results on number of days from flower initiation up to full bloom indicated that the application of chemical Paclobutrazol (PBZ) had no significant effect in extending number of days from flower initiation up to full bloom of the mango plants, since all racemes gave a similar period of full bloom, whilst the fruit dropping percentage was significantly affected by different rates of PBZ. This could have been attributed to the short duration in flowering period, which was not enough for PBZ to show its effect in delaying flowering period but affected percentages of fruit dropping off in the early period of fruit development (Addicott, 1978). The result on percentage of fruit dropping off, in most cases, was higher for those sprayed with 1 cm extended raceme than 5 cm. The results tend to suggest that the application of chemical PBZ should be done, more or less, when flower raceme had extended up to 5 cm long rather than 1 cm. The best result on number of dropping fruits was found with T_7 with a rate of 1,000 ppm PBZ but this was similar to all other higher rates of PBZ application. The results indicated that PBZ encourages better fruit set development and at the same time prevents the dropping off of fruits of mango plants. Feungchan *et al.* (1991) stated that the application of PBZ gave significantly higher number of flowers and fruit production of mango plants than without. Some other researchers have stated that by nature there is always a tendency for mango plants to attain low fertilization of flowers with a small amount of fruits developed due to both internal and external factors (Ram, 1992; Schaffer *et al.*, 1994; Davenport and Nunez-Elisea, 1997; Negi, 2000 and Krisanapook *et al.*, 2000). Therefore, it might be inferred that PBZ application is required for better fruit set and development. It was found with this study that there was no significant difference found due to PBZ on harvesting age. This could have been attributed to genetic traits of the mango plants where dominant genes have affected fruit maturity age rather than other factors such as environmental temperatures and nutrients. It could have been possible that the period in applying chemical PBZ from flower initiation up to harvesting age was relatively too short for this growth regulator to manifest its effect in delaying flowering period and harvesting age of mango fruits (Addicott, 1978).

The results on fruit width for the first set of treatments (T_1-T_5, 1 cm extended raceme) showed that T_4 with a rate 5,000 ppm of PBZ gave significantly greater fruit width than the rest. Similarly, with the second set of treatments (T_6-T_{10}, 5 cm extended raceme), T_9 gave significantly greater fruit width than the rest. The results imply that for both sets of treatments, a rate of 5,000 ppm PBZ manifested its significant effect on fruit width than the rest where, in most cases, fruit widths were similar. The results on fruit length for the first set of treatments indicated that PBZ at a rate of 5,000 ppm gave significantly greater fruit length than the rest but with the second set of treatments (the 5 cm extended raceme of flowers), all rates of PBZ significantly depressed fruit length. A similar result to fruit width and length was found with fruit thickness. The results suggested the inconsistent effect of PBZ application on fruit width, length and thickness although it seems more likely that a rate of 5,000 ppm had its significant effect. The flesh percentage of fruits was similar for all treatments but fruit yields/ha were significantly affected by the application of PBZ, i.e., 1,000 ppm gave the best fruit yields/ha for both sets of treatments with fresh fruit yields of 7,075 and

7,725 kg ha^{-1} for T_2 (1,000 ppm PBZ) and T_7 (1,000 ppm PBZ), respectively. These fruit yields/ha of both treatments were significantly greater than control treatments. The results signified the effect of PBZ where fruit yields were significantly increased as a result of perhaps a better growth of the mango trees and it may be possible that PBZ hastens photosynthetic activities where more assimilates were accumulated, thus mango fruit yields significantly increased (Winston, 1992; Burondkar and Gunjate, 1993; Burondkar *et al.*, 2000). Furthermore, T_7 gave the highest fruit firmness than the rest where PBZ manifested its effect on fruit texture and perhaps a greater amount of macro nutrient contents (Elfusing *et al.*, 1987; Luo *et al.*, 1989 and Chutichudet, 2005). In addition, PBZ at a rate of 1,000 ppm (T_7) gave the lowest soluble solid% of 8.61 with lowest titratable acidity of 0.38%. Jacobsen *et al.* (1995) reported that PBZ manifests its effect on gene expressions where it controls activities of α-amylase Thus soluble solid content and titratable acidity were relatively lower than the rest. The results indicated that a rate of 1,000 ppm PBZ/plant (T_7) may be considered to be the most appropriate rate to be applied but the spraying of this chemical PBZ should be carried out when the mango flower raceme has extended up to 5 cm long. Its fruit yield (48,281.25 kg ha^{-1} of edible fruit yield) was significantly greater than the control treatments. Therefore, it is always necessary to spray chemical PBZ to mango flower racemes annually (if mango plants could flower annually) in order to achieve a significant amount of edible fruit production. There were significant differences on seed weight, width, and length but not with fruit thickness and fruit weight/fruit. The results suggested that chemical PBZ possessed its significant effect in reducing seed size of mango fruits and encouraged more flesh tissues of individual fruit, thus the treated mango plants gave a similar fruit weight, i.e., they possessed a similar marketable size of mango fruits. It may be of interest to carry out more experiments on the spraying of chemical PBZ to flower racemes of mango trees, e.g., each rate is divided into 3 equal rates and spray them for three times at one week interval in order to obtain more intensive results for further evaluation.

ACKNOWLEDGMENTS

The authors wish to thank Mahasarakham University Financial Office for financial assistance. Professor Amnuaysilpa Suksri for his kind suggestion and assistance in preparing the manuscript. Thanks are also due to research staff members of the Faculty of Technology, Mahasarakham University for their assistance when this work was carried out.

REFERENCES

Addicott, F.T., 1978. Abscission Strategies in the Behavior of Tropical Trees. In Tomlinson, P.B. and M.H. Zimmermann (Eds.). Tropical trees as Living Systems Cambridge University Press, London, pp: 48.

AOAC, 1984. Official Methods of Analysis. 14th Edn., Association of Official Analytical Chemists. Arlington. Virginia. USA., pp: 1200.

Anonymous, 2005. Thailand provincial statistical information on mango cultivation of the 2003. http:www.doae.go.th/data/fruit/29.pdf.

Burondkar, M.M. and R.T. Gunjate, 1993. Control of vegetative growth and induction of regular and early cropping in 'Alphonso' mango with paclobutrazol. Acta Hortic., 341: 206-215.

Bally, I.S.E., P.R. Johnson and V.J. Kulkarni, 2000. Mango production in Australia. Acta Hortic., 509: 59-67.

Burondkar, M.M., R.T. Gunjate, M.B. Magdum and M.A. Govekar. 2000. Rejuvenation of old and overcrowded Alphonso mango orchard with pruning and use of Paclobutrazol. Acta Hortic., 509: 681-686.

Chutichudet, B., 2005. Delayed harvesting to increase value of mango cv. Kaew in the semi-arid area of the Upper North. A Ph. D. Thesis, (Horticulture), Department of Horticulture, Chiang Mai University, Thailand, pp: 246.

Davenport, T.L. and R. Nunez-Elisea, 1997. Reproductive Physiology. pp: 69-146. In Litz, R.E. (Eds.). The Mango Botany, Production and Uses. CAB International. Wallingford, pp: 587.

Elfusing, D.C., C.L. Chu, E.C. Lougheed and R.A. Cline. 1987. Effect of daminozide and Paclobutrazol treatment on fruit ripening and storage behavior of apple. J. Am. Soc. Hortic. Sci., 112: 910-915.

Feungchan, S., H. Daito and N. Hongsbhanich. 1991. Effect of plant growth substances on mango flowering. Thai J. Agric. Sci., 24: 163-168.

Feungchan, S., 1995. Technologies for fruit trees, Department of Horticulture, Faculty of Agriculture, Khon Kaen University, Khon Kaen 40002, Thailand, pp: 199 (in Thai).

Jacobsen, J.V., Gubler, F. and P.M. Chandler, 1995. Giberellin action in germinated cerealgrains. In: Davies, P. (Ed.). Plant Hormones. Physiology, Biochemistry and Molecular Biology. Dordrecht, The Netherlands: Kluwer Academic Publishers, pp: 246-271.

Khader, S.E.S.A., R.N. Pal and K.C. Srivastava. 1988. Studies on delaying panicles expansion and flowering by growth retardants in mango. Acta Hortic., 231: 412 -423.

Krisanapook, K., L. Phavaphutanon, V. Kaewladdakorn, A. Pichakum and K. Jutamanee, 2000. Studies on fruit growth, levels of GA-like substances and CK-like substances in fruits of mango cv. Khiew Sawoey. Acta Hortic., 509: 697-704.

Luo, Y., H. Wainwright and K.G. Moore, 1989. Effects of orchard applications of paclobutrazol on the composition and firmness of apple fruits. Sci. Hortic., 39: 301-309.

Nartvaranant, P., S. Subhadrabandhu and P. Tongumpai, 2000. Practical aspect in producing off-season mango in Thailand. Acta Hortic., 509: 661-668.

Negi, S.S. 2000. Mango production in India. Acta Hortic., 509: 69-78.

Ram, S., 1992. Naturally occurring hormones of mango and their role in growth and drop of the fruit. Acta Hortic., 321: 400-411.

Rademacher, W., 1995. Growth retardants: Biochemical features and applications in horticulture. Acta Hortic., 394: 57-73.

Radanachaless, T., P. Gypmantasiri and R.U. Rungtip, 2000. Kaew mango for uplands under rainfed conditions. Center for the Improvement of Agricultural Production, Chiang Mai University, Chiang Mai 111N. Thailand.

Schaffer, B., A. W. Whiley and J. H. Crane, 1994. Mango. In Schaffer, B. and P.C. Andersen (Eds.). Handbook of Environmental Physiology of Fruit Crops. Vol. II. Subtropical and Tropical Crops. CRC Press, Boca Raton, pp: 165-197.

SPSS, 1999. Base 9.0 for Windows Users Guide. SPSS Inc., USA.

Suksri, A., 1999. Some Agronomic and Physiological Aspects in Growing Crops in Northeast Thailand. 1st Edn., khon kaen University Press, Khon Kaen, Thailand.

Winston, E.C., 1992. Evaluation of Paclobutrazol on growth, flowering and yield of mango cv. Kensington Pride. Aust. J. Exp. Agric., 32 : 97-104.