Chapter 4

Results and Discussions

1. Promising areas for producing late season Kaew mango

The identification potential areas to produce late season of Kaew mango employed three methods, namely Geographic Information Systems (GIS) technique, secondary data collection and field survey. The physiographic characteristics of potential areas to produce late season Kaew mango were obtained by using Geographic Information Systems (GIS) technique based on the qualities of Chiang Dao areas as prototype. The parameters of slope, soil type climate condition and land use were determined to be agreed with the Chiang Dao district's conditions as followed.

1. Slope Most of Kaew mango planting areas in Chiang Dao had average slopes of 2-5%. This topography often showed the damages from erosion surface.

2. Soil type Soils in the upland of Chiang Dao agricultural areas belong to eight major groups of soil type number 7, 29 C, 29 D, 29 E, 35 B, 48 C, 48 D, and 59 (Multiple Cropping Center, 2005). Multiple Cropping Center (2005) reported that the average pH in these soil types are between 5-7.5. In addition, the characteristics of soil types found in Chiang Dao is sandy loam, which is well drained and suitable for planting the fruit trees. Meanwhile, the soil fertility is rather low because of low organic matter content only 1.5%.

3. Climate The climatic pattern of Chiang Dao is tropical wet-and-dry (Aw). During 2002-2004, the average temperature throughout the three years was 25.5°C. The average minimum and maximum temperatures were 19.3 and 31.7°C. While, the average rainfall is between 1119-1250 ml per year (Multiple Cropping Center, 2005).

4. Land use The majority of land use for these areas are mixed deciduous forest, deciduous dipterocarp forest, cultivate upland crops and some fruit trees.

From GIS technique by using the criteria of slope, soil type climate condition and land use, the results indicated that there are eleven districts of Chiang Mai, namely, Mae Aei, Fang, Chai Prakan, Wiang Haeng, Chiang Dao, Phrao, Mae Taeng, Samoeng, Mae Wang, Mae Orn,

Hang Dong, and Omkoi were the same characteristics as Chiang Dao (Figure 7). Thus, all of these areas had a potentiality to produce late season Kaew mango liked Chiang Dao district.

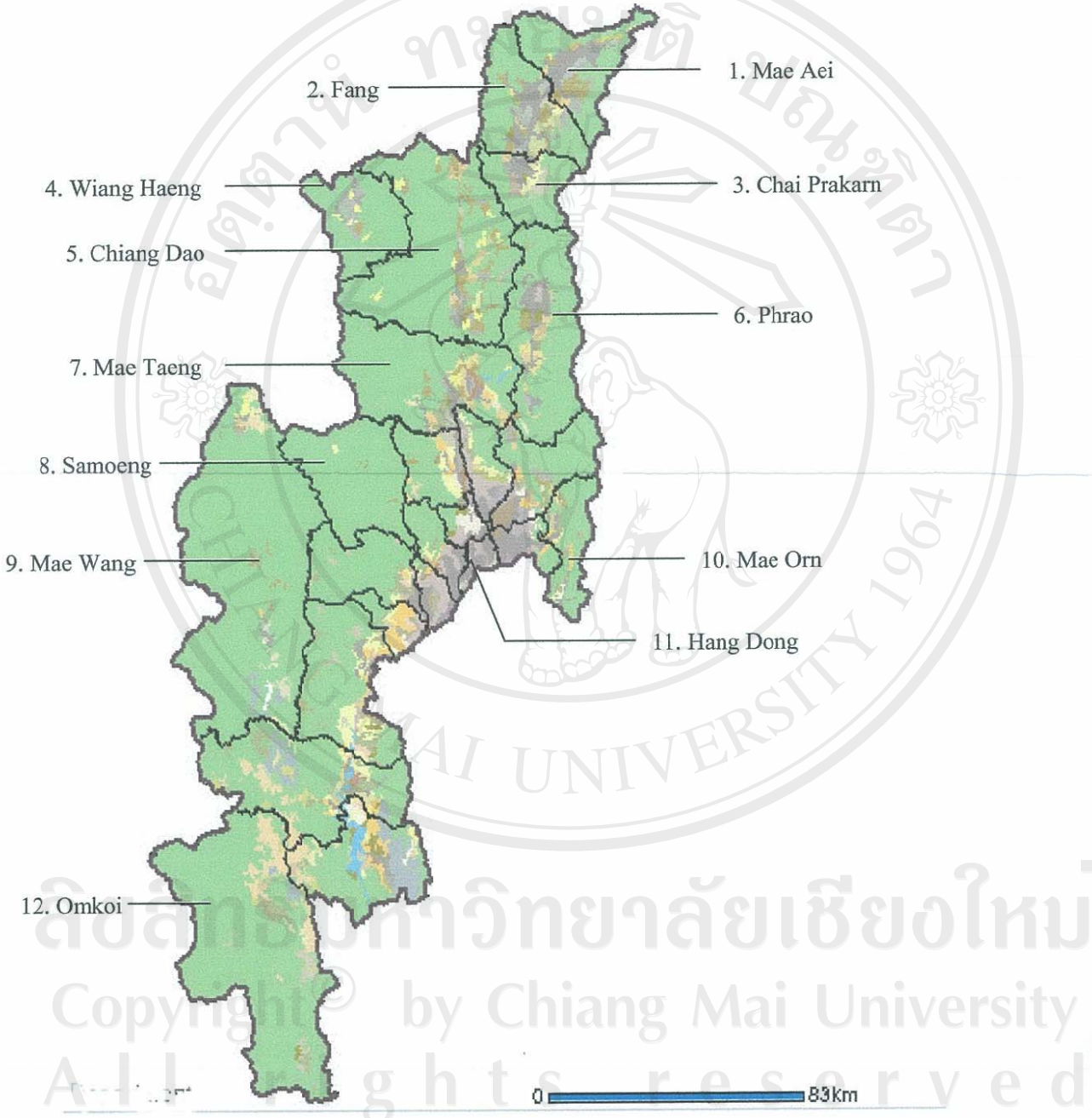

Figure 7. The potential areas at district level for producing late season Kaew mango

Source : Multiple Cropping Center, 2005

In addition, there are some Tumbols from the twelve districts where were potential areas for producing late season Kaew mango liked Chiang Dao district as followed (Figure 8).

1. Mae Aie district : Tumbol of Baangluang and Suntonmue

2. Fang district : Tumbol of Mae Ngon, Mae Kha, Mae Ka, Mae Soon, Sun Sai, Monpin and Vieng

3. Chai Prakan district : Tumbol of Sridongyen, Nuangboa, Mae Talop and Pongtum

4. Wiang Haeng district : Tumbol of Pyong Luang, Muang Haeng and Sanhai

5. Chiang Dao district : Tumbol of Muangkong, Thungkhaopuang, Muang Ngai, Pingkong, Chiang Dao and Mae Na

6. Phrao district : Tumbol of Loangkhod, Sunsai and Baanpong

7. Mae Taeng district : Tumbol of Baanpao, Inthakhin, Mae Taeng and Mae Horpra

8. Samoeng district : Tumbol of Yungmurn, Samoengnhea, Samoengtai and Mae Sarb

9. Mae Wang district : Tumbol of Baangard and Mae Win

10. Mae Orn district : Tumbol of Ornklang, Thanhea and Mae Tha

11. Hang Dong district : Tumbol of Baanpong, Numphrae, Numborluang, and Donpao

12. Omkoi district : Tumbol of Monjong and Mae Tuen

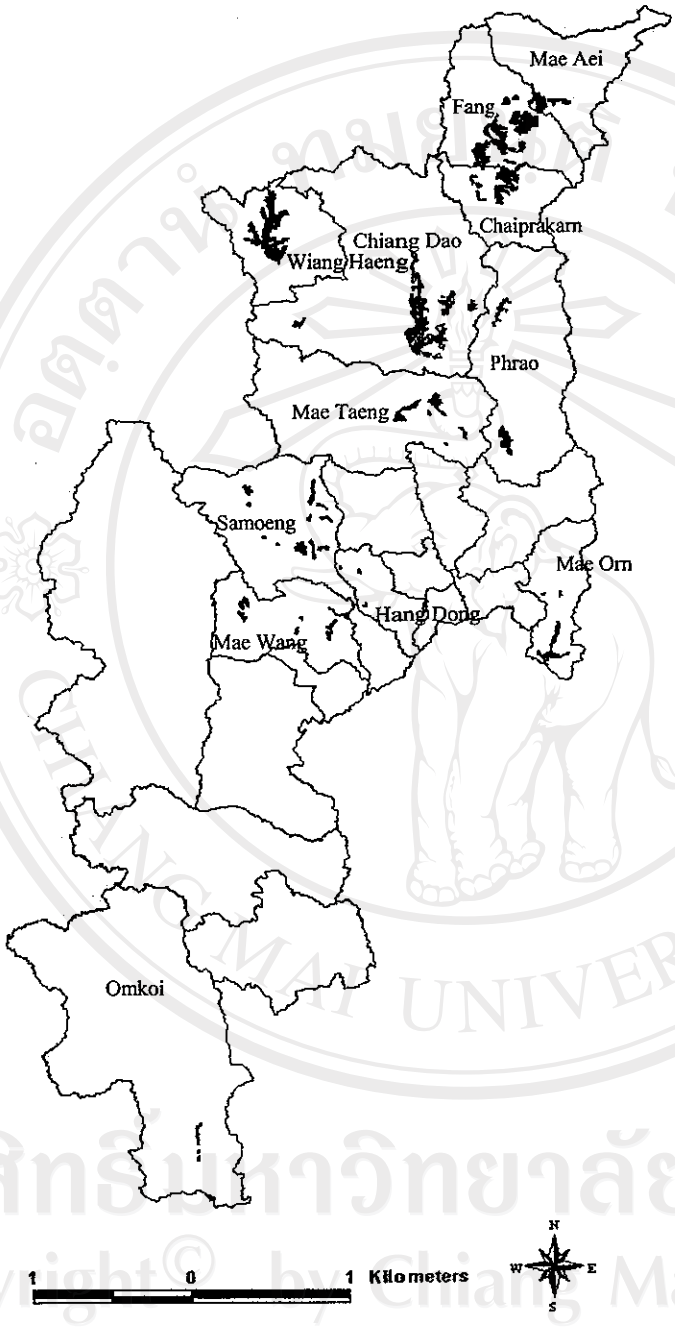

Figure 8. The geological characteristics of the potential areas (dark shading)

Source : Multiple Cropping Center, 2005

With respect to the secondary data participated with field survey, Agricultural Office of Chiang Mai Province (2002) reported that Kaew mango planting areas at Chiang Dao district were cooperative covered in the large areas (18071 rai). While Radanachaless *et al.* (2003) reported that the total Kaew mango planting areas in Chiang Mai was 30680 rai. Thus, Kaew mango planting areas in Chiang Dao was a large scale of 58.9% from the total Kaew mango planting areas in Chiang Mai. Under rainfed condition, Kaew mango was a local fruit tree and had a potential to plant in Chiang Dao district because it was able to adjust the inappropriate topography and climate, particularly water shortage (Radanachaless, 1998). Thus at Chiang Dao district, Kaew mango planting had an importance and opportunity of farmers to increase their incomes (Radanachaless *et al.*, 2003).

While Kaew mango planting in the rest 11 districts of Mae Aei, Fang, Chai Prakan, Wiang Haeng, Phrao, Mae Taeng, Samoeng, Mae Wang, Mae Orn, Hang Dong, and Omkoi had a little importance and planting areas were scattered. In addition, from the orchard survey, most farmers in the above areas did not interested to plant Kaew mango. Meanwhile they prefered to grow the other economic fruit trees such as longan : Hang Dong (9886 rai), Mae Orn (1670 rai), Mae Taeng (8544 rai), Mae Wang (10283 rai), and Phrao (18021 rai). The mandarin planting areas occurred in Mae Aei (5256 rai). In addition, mandarin, litchi and longan cultivations are popular fruit trees planted in Fang (24950, 21778 and 12234 rai) respectively. Some areas planted mango in Omkoi district, but the farmers in these areas prefered to grow the mango cv. Choakarnun (3320 rai) rather than Kaew. While most of fruit trees cultivated in Chai Prakan were litchi (7511 rai) and longan (6772 rai). Thus the promising areas to produce late season Kaew mango in Chiang dao are only found in Muang Na sub-district, Mae Ore Nai villages (18071 rai) (Table 1).

Table 1. Planting area of fruit trees in the 12 districts of Chiang Mai

District	Planting areas (rai)			
	Mango	Longan	Litchi	Mandarin
Mae Aei	3264	4206	7054	5256
Fang	3866	12234	21778	24950
Chai Prakan	3744	6772	7511	3165
Wiang Haeng	5399	360	853	-
Chiang Dao	18071	3714	2240	2578
Phrao	6300	18021	923	124
Mae Taeng	2849	8544	3241	350
Samoeng	3229	273	300	-
Mae Wang	1689	10283	92	-
Mae Orn	1175	1670	320	-
Hang Dong	1339	9886	612	-
Omkoi	3320	217	1260	-

Source : Agricultural Office of Chiang Mai Province, 2002

2. Understanding of the target farmers and area

The main information required to meet the addressed objectives of the study included the following attributes:

1. Socio-economic information covered the general information of farmers such as sex, age, education status, family size, structure of agricultural labor in family, farming experience, local knowledge, clone of Kaew mango, reason for planting and reason for giving up the planting.

2. Characteristics of mango orchard such as farm size, mango plant spacing, farmers' opinion in late season mango production, and technical practice used to delay the harvesting time.

3. Marketing issues covered harvesting time, productivity, grading, price, farmers' views in price and income.

1. Socio-economic information This section included sex, age, education, family size, structure of agricultural labor in farm, farming experience local knowledge, clone of Kaew mango, reason for planting and reason for giving up the planting.

1.1 Gender The total of 64 growers, 51 persons (79.70%) were male, 13 persons (20.30%) were female (Table 2). This indicated that most mango growers in this area were men. It is possible that male farmers can take more responsibility and decisions than female farmers, so gender was considered as a factor influence on technical efficiency.

Table 2. Gender of mango growers in Chiang Dao district

Gender	Number	Percentage
Male	51	79.70
Female	13	20.30
Total	64	100.00

Source : Survey data of 64 respondents, 2001

1.2 Age Farmer ages were classified into 5 intervals, namely, 21-30, 31-40, 41-50, 51-60 and over 60 years old. In the surveyed area, Table 3 showed that the majority of farmers

(60.94%) were between 41 and 60 years old. There were only 16 persons (25.00%) of farmers falling at the age group of younger than 40 year-old and 9 persons (14.06%) were over 60 year-old. This result indicated that the most of farmers in this area would soon become non-active (above 60 years), while there would be hardly anyone below the age of 31-40 years, to take up the farming activities. This implied that the higher percentage of non-active members would soon constrain the prevailing family labor shortage. Farmer age is an important factor affecting the managerial capacity and investment level of household head. Age also had power on the technical efficiency. It is believed that age can serve as a substitute for decision making on production process. If the age is too old, the investment would not achieve a high performance.

Table 3. Age of mango growers in Chiang Dao district

Age	Number	Percentage
21-30	2	3.12
31-40	14	21.88
41-50	20	31.25
51-60	19	29.69
Above 60	9	14.06
Total	64	100.00

Source : Survey data of 64 respondents, 2001

1.3 Education Education was measured as the number of years of schooling achieved by the household head, which was used as an agent for managerial ability. The educational level of family leaders was relatively low, ranging from grade 4 to vocational school. The survey showed that more than half of total farmers, 46 persons (71.88%) had attended only grade 4, followed by 10 persons (15.63%), 4 persons (6.25%), 2 persons (3.12%), attained education level of grade 6, lower than grade 4, and vocational school, respectively. The rest of two persons, one of them (1.56%) was educated in secondary school and one (1.56%) ended at high school (Table 4). This indicated that most of mango farmers in Chiang Dao district is poor socio-economic conditions such as poor infrastructure, lower living standard and poor level of knowledge. Thus,

the adoption of any modern agricultural technology may be limited by the education level of farmers. Increasing literacy rate may help the farmers to acquire and understand agricultural technology. As known, education or knowledge level has many effects on socio-economic development, especially in agricultural production. In addition, education, of household head is considered as factors affecting the managerial capacity of household head. When farmers with higher education level, it would help them to learn and apply new technologies easier as well as more efficient production.

Table 4. Education level of mango growers in Chiang Dao district

Education level	Number	Percentage
Primary school < grade 4	4	6.25
Grade 4	46	71.88
Grade 6	10	15.63
Secondary school	1	1.56
High school	1	1.56
Vocational school	2	3.12
Total	64	100.00

Source : Survey data of 64 respondents, 2001

1.4 Family size The survey indicated that the members of the household varied from 1 to 6 people in each family. The average household size is 3.6 people. The number of members in

Table 5. Family size of mango growers in Chiang Dao district

Family size (persons)	Number	Percentage
1-2	11	17.19
3-4	42	65.62
5-6	11	17.19
Total	64	100.00

Source : Survey data of 64 respondents, 2001

family was divided into 3 levels, namely, 1-2, 3-4 and 5-6 members per house. The result survey showed that most of the farmers (65.62%) had 3-4 members per house. 11 persons (17.19%) had 1-2 member per house and 11 persons (17.19%) had 5-6 members per house (Table 5). Family size has many effects on agricultural production and more chances to invest in mango production.

1.5 Size of family labor Many activities for fruit tree cultivation in mango orchard need many labor uses. Regarding working age (equal or more than 18 years old) of members from each house were separated into male and female. In this study, it was found that size of family labor per household was small, varied from 1 to 5 working people, with the average of 2 workable people (1 male and 1 female). Most of agricultural labor (53.20%) in house were male, and 46.80% were female. From the total of 34 male, majority of farmer families had only one male as agricultural labor (37.60%). The rest of 17 families had two male (12.80%) and three male (2 families or 2.80%) for working in farm. The total of 30 female, most families had only one female (19 families or 29.40%) works in farm. The rest of 11 families, 7 families (11.00%), 2 families (3.20%) and 2 families (3.20%) had two, three and four female, respectively work in farm (Table 6).

Table 6. Size of family labor of mango growers in Chiang Dao district

Sex	Size of family labor (persons)	Number	Percentage
Male		34	53.20
	1	24	37.60
	2	8	12.80
	3	2	2.80
Female		30	46.80
	1	19	29.40
	2	7	11.00
	3	2	3.20
	4	2	3.20
Total		64	100.00

Source : Survey data of 64 respondents, 2001

1.6 Years experience of planting Kaew mango More farming experience may lead to better assessment of the importance and understanding the complexities involved in making good decisions in farming. Experience is measured by the number of years that farmer has grown the specific Kaew mango variety. The result from Table 7 showed that years of farmers' experience for mango cultivation in Chiang Dao district were varied from 2 to 50 years with an average of 15.5 years. There was several answers replied in this section, thus this section would be divided the experience year for planting Kaew mango into 4 levels, namely 1-10, 11-20, 21-30 and over 30 years. The survey result found that most of farmers (31 persons or 48.44%) spent the long experience years in conventional Kaew mango cultivation 1-10 years. Followed by 22 persons (34.38%), 6 persons (9.38%) and 5 persons (7.80%) spent the times of 11-20, 21-30 and over than 30 years for planting, respectively (Table 7).

Table 7. Farming experience of 64 mango growers in Chiang Dao district

Farming experience (years)	Number	Percentage
1-10	31	48.44
11-20	22	34.38
21-30	6	9.38
Above 30	5	7.80
Total	64	100.00

Source : Survey data of 64 respondents, 2001

1.7 Local knowledge The technical knowledge in this section included both formal and informal sources. The majority of farmers (19 persons or 29.69%) said that technical knowledge in mango production were obtained from their self learning or by performing their own experiments. Followed by 9 (14.06%) and 9 persons (14.06%) directly received information from their neighbors and the sub-district extension officer. 7 persons (10.94%) received the source of technical knowledge from their relatives (Table 8).

Table 8. Source of local knowledge gained by mango growers in Chiang Dao district

Source of local knowledge	Number	Percentage
Self learning	19	29.69
Neighbors	9	14.06
Local extension officer	9	14.06
Relatives	7	10.94
Leader farmer	5	7.81
Chemical agent or saleman	4	6.25
Radio	4	6.25
Television	3	4.69
Field trip	3	4.69
Newspapers	1	1.56
Total	64	100.00

Source : Survey data of 64 respondents, 2001

In addition, the received local knowledge was analyzed into several aspects. The result from Table 9 indicated that total of 49 farmers from 64 farmers used to receive the distinctive knowledge

Table 9. Kind of knowledge gained by mango growers in Chiang Dao district

Knowledge	Number	Percentage
Chemical use	22	44.90
Fertilizer application	10	20.41
Pruning	7	14.29
Ground management	5	10.20
Propagation	3	6.12
Bagging	1	2.04
Pests and diseases	1	2.04
Total	49	100.00

Source : Survey data of 64 respondents, 2001

about the ground management for planting mango. 22 persons (44.90%) were used to learn the chemical use. 10 persons (20.41%) learned the fertilizer application. 7 persons (14.29%) learned the practice of pruning. The rest of 5 persons (10.20%), 3 persons (6.12%), 1 person (2.04%) and 1 person (2.04%) received the knowledge about ground management, propagation, bagging and pest control, respectively.

1.8 Clone of Kaew mango There are three clones of Kaew mango planted at Chiang Dao district. The popular clone of Kaew planting is Kaew Hua Juk found in 58 orchards (90.60%). Followed by Kaew Kiew and Kaew Kao in 5 orchards (7.80%) and 1 orchard (1.60%), respectively (Table 10).

Table 10. Clone of Kaew mango cultivated by growers in Chiang Dao district

Clone of Kaew mango	Number	Planting percentage
Kaew Hua Juk	58	90.60
Kaew Kiew	5	7.80
Kaew Kao	1	1.60
Total	64	100.00

Source : Survey data of 64 respondents, 2001

1.9 Reason for planting Kaew mango There are many reasons for accounting Kaew mango as the dominant crop in this area. Three reasons were ranked to account the Kaew planting at these areas. The first important reason was Kaew mango was a high potential local fruit tree which already existing in orchard (14 persons or 21.87%). The second was Kaew mango was ease of looking for the propagated material (12 persons or 18.75%). The third was Kaew mango had been growing rapidly and drought tolerance (10 persons or 15.62%) (Table 11).

Table 11. Reason for choice of Kaew mango planting given by growers in Chiang Dao district

Reason for choice	Number	Percentage
Already existing in orchard	14.00	21.87
Simple management	12.00	18.75
Fast growing and drought tolerance	10.00	15.62
Low cost	8.00	12.50
Market availability	8.00	12.50
Regular fruit bearing	6.60	10.31
Influence of neighbor	2.00	3.12
Land use benefit	1.00	1.55
Early harvesting	0.40	0.63
Common fruit tree	0.40	0.63
Ease of looking for the propagated material	0.40	0.63
Promoting variety	0.40	0.63
Appropriate with area and climate condition	0.40	0.63
Processing advantage	0.40	0.63
Total	64.00	100.00

Source : Survey data of 64 respondents, 2001

1.10 Kaew mango planting abolition Since 2001, Kaew mango planting areas had been continued gradually decreasing. The three reasons for dropping out the Kaew mango planting were ranked. The first rank (31 persons or 48.44%) was the produce had low price and higher income from other fruit tree. The second reason was Kaew mango often faced with the pest and disease problems (11 persons or 17.19%). The third reason was market unavailability (9 persons or 14.06%) (Table 12).

Table 12. Reason why Kaew mango is no longer attractive by growers in Chiang Dao district

Reason	Number	Percentage
Low price and higher income from other fruit tree	31	48.44
Pest and disease problem	11	17.19
Market unavailability	9	14.06
Alternate bearing and low yield	8	12.50
No longer requirement	5	7.81
Total	64	100.00

Source : Survey data of 64 respondents, 2001

In addition, 20 farmers or 32.80% from total of 64 persons began to plant the other mango variety besides Kaew mango, namely Choakanun and Kiew MoeraKod in this area. 19 persons planted Choakanun, while 1 person planted Kiew MoeraKod. The average planting Choakanun and Kiew Moerakod were 7.70 and 5 rai, respectively (data not shown).

2. General information This section composed of farm size, mango planting spacing, farmers' opinion and technical practice used to delay harvesting time.

2.1 Agricultural area Chiang Dao district has topography with combination of hilly upland, mountain and low lands. The altitude of areas ranges from 400 m to over 600 m and located in northern side of Chiang Mai. In terms of climate, Chiang Dao has three distinct types as tropical climate. Agriculture is the main sector in economy of this area, thus most of land areas are mainly devoted to agriculture. Most of the agricultural lands in Chiang Dao are traditional of paddy rice, vegetables, and many fruit trees. The result from survey found that the minimum and maximum size of farm holding area per household were 1 and 100 rai, respectively. The average landholding was about 18.9 rai per household. The farm size was divided into 4 levels, namely, small farm (1-10 rai), medium-sized farm (11-20 rai), large farm (21-30 rai) and very large farm (above 30 rai). The survey result found that majority of farmers (33 persons or 51.56%) had a land holding of 1-10 rai. Followed by 14 persons or 21.88% had medium farm (11-20 rai) and 11 persons (17.18%) had very large farm (over 30 rai) (Table 13).

Table 13. Farm size of mango growers in Chiang Dao district

Farm size (rai)	Number	Percentage
1-10	33	51.56
11-20	14	21.88
21-30	6	9.38
Above 30	11	17.18
Total	64	100.00

Source : Survey data of 64 respondents, 2001

2.2 Mango planting size At Chiang Dao district, mango cv. Kaew was more attractive to farmers than other variety. Generally, it was planted on the hilly upland zone, largely covered with forest areas. The farmers prefered planting Kaew mango in broad areas over the village. Most of orchards planted Kaew mango in the infertile soil, and majority of them often faced with drying out during the dry season between December to April. All of Kaew mango orchards in these areas were mono-crop. 60 farmers (93.75%) said that Kaew mango planting in their orchards were under the rainfed condition. The rest of 4 persons (6.25%) could supply the water from river (when available) (Table 14).

Table 14. Source of water for mango orchard in Chiang Dao district

Source of water	Number	Percentage
Unavailable	60	93.75
River	4	6.25
Total	64	100.00

Source : Survey data of 64 respondents, 2001

The smallest and largest planting area of Kaew mango were 0.5 and 50 rai, with the average of 11.2 rai. Regarding to the mango planting sizes, Table 15 showed that more than half of total farmers (42 persons or 65.62%) planted the mango trees in a small farm, between 1-10 rai. Owing to majority of small farm, these would affects to any increased investment for new

technology. While, 14 persons (21.88%) hold the mango planting in medium-sized farm (11-20 rai). However, the rest of 8 persons, 4 persons (6.25%) planted the mango in large farm (21-30 rai) and 4 persons (6.25%) planted in very large farm (above 30 rai) (Table 15).

Table 15. Size of mango orchard in Chiang Dao district

Orchard size (rai)	Number	Percentage
1-10	42	65.62
11-20	14	21.88
21-30	4	6.25
Above 30	4	6.25
Total	64	100.00

Source : Survey data of 64 respondents, 2001

2.3 Mango planting space All orchards planted Kaew mango trees from seed. In orchard, planting space will be an important factor affecting on mango's growth, productivity and management's practices. The result from Table 16 showed that farmers used the many space for planting Kaew mango, namely, 3x3, 3x4, 4x4, 4x5, 5x5, 5x10, 6x6, 7x7 and 8x8 m. The popular space for planting was 5x5 m found from 18 orchards (28.13%). Followed by 6x6 m and 4x4 m found from 17 orchards (26.56%) and 9 orchards (14.06%), respectively. 8 orchards (12.50%), 6 orchards (9.38%), and 3 orchards (4.69%) planted Kaew mango in space of 8x8, 3x3, and 7x7 m. The rest of 3 orchards, 1 orchard (1.56%) planted in space of 3x4 m, one (1.56%) planted 4x5 m and one (1.56%) planted 5x10 m (Table 16).

Table 16. Tree spacing of mango orchard in Chiang Dao district

Tree spacing (m)	Number	Percentage
3 x 3	6	9.38
3 x 4	1	1.56
4 x 4	9	14.06
4 x 5	1	1.56
5 x 5	18	28.13
5 x 10	1	1.56
6 x 6	17	26.56
7 x 7	3	4.69
8 x 8	8	12.50
Total	64	100.00

Source : Survey data of 64 respondents, 2001

2.4 Farmers' opinion in late season production Owing to Chiang Dao district was a well known source of late season production Kaew mango for fresh consumption. If this late season can be later than under natural season, it will cause a chance of growers to increase their values. The result from Table 17 showed that mango farmers were aware of the benefits from the late season production. More than half of total members (37 persons or 57.81%) interested in late season mango production because the value was increased. While, 27 persons (42.19%) did not agree with this concept because of several reasons. The main reason was Kaew mango had low price, thus the increased cost to produce late season mango might be lose their income. Some

Table 17. Farmers' interest in late season production in Chiang Dao district

Farmers' interest	Number	Percentage
Yes	37	57.81
No	27	42.19
Total	64	100.00

Source : Survey data of 64 respondents, 2001

farmers satisfied with the natural production, without chemical uses. Some farmers thought that late season practice would be damage to the trees and soil problem. In addition, several farmers were old and busy with the other activities. Furthermore, they wanted to sell their produce at the same time with other orchards because it is coincident timing with the purchase of traders.

2.5 Technical practice In these areas, there was no found of high cost, and modern cultural practices for planting Kaew mango. In this section, two technical practices (pruning and plant bioregulator application) would be pronounced.

2.5.1 Pruning The three objectives of pruning were ranked. The data from Table 18 indicated that most of 17 farmers (26.56%) said that pruning would take the light penetration or air circulation through the tree. 14 persons (21.87%) said that some of plant diseases and pests could be eradicated by pruning. 10 persons (15.63%) believed that pruning improved the healthy and increased flowering and fruit set of mango trees.

Table 18. Objective of mango pruning given by mango growers in Chiang Dao district

Objectives of pruning	Number	Percentage
Light penetration or air circulation	17	26.56
Pest and disease removal	14	21.87
Tree vigor	10	15.63
Flowering and fruit set	10	15.63
Better yield	7	10.95
Delayed harvesting	1	1.56
Increasing of fruit size	1	1.56
Better fruit color	1	1.56
Activating the new flushes	1	1.56
Convenience of chemical spraying	1	1.56
Minimizing of wind damage	1	1.56
Total	64	100.00

Source : Survey data of 64 respondents, 2001

With respect to pruning method, most of farmers simply cut the branches which insect pests or diseases attacked, by cutting the whole branches out of the tree instead of cutting branch tip. Generally, most of orchards (23 orchards or 35.95%) pruned the branches out of 21-30%. Followed by 13 orchards (20.31%) pruned the branches out of 11-20% had the same level as 13 orchards (20.31%) pruned branches out of 31-40%. The rest of 9 orchards (14.06%), 5 orchards (7.81%) and 1 orchard (1.56%) pruned branches out of 1-10, 41-50 and over 50%, respectively (Table 19).

Table 19. Amount of tree pruning practiced by mango growers in Chiang Dao district

Amount of pruning (%)	Number	Orchards (%)
1-10	9	14.06
11-20	13	20.31
21-30	23	35.95
31-40	13	20.31
41-50	5	7.81
Above 50	1	1.56
Total	64	100.00

Source : Survey data of 64 respondents, 2001

More than half of total farmers (54 persons or 84.4%) usually pruned their mango trees after harvesting. There were only 10 orchards (16.40%) did not practice pruning their mango trees. The number of pruned trees most occurred one time per year (53 orchards or 98.20%) (data not shown). Most of one time pruning occurred in September (22 orchards or 34.38%). Followed by 18 orchards (28.13%) pruned in July. 12 orchards (18.75%), and 9 orchards (14.06%) pruned in August and June. The rest of 3 orchards, one orchard (1.56%) pruned in October, one orchard (1.56%) in November and one orchard (1.56%) in December (Table 20). While, two times pruned orchard (1 orchard) would cut the branches in August and again in January.

Table 20. Pruning time by mango growers in Chiang Dao district

Pruning time	Number	Orchards (%)
June	9	14.06
July	18	28.13
August	12	18.75
September	22	34.38
October	1	1.56
November	1	1.56
December	1	1.56
Total	64	100.00

Source : Survey data of 64 respondents, 2001

2.5.2 Plant bioregulator application Most of the farmers (62 persons or 96.90%) did not apply plant bioregulators in their orchards. Only 2 persons (3.10%) used to these substances in their mango production. With respect to 2 persons (3.10%) who applied bioregulator substances, one orchard used paclobutrazol in order to activate the quicker flowering behavior of mango by pouring the soil around the bush edge. This one farmer said that the increased expense for this substance was 1,200 baht per year. While, another orchard sprayed mango panicle with gibberellin in order to extend the panicle length. The farmer who used this method spent the money 2,395.24 baht per year for this activity.

2.6 Technical practice used to delay the harvesting time General, developing countries with low literacy rates, lack of credit and capital, and insufficient physical infrastructure have great difficulties in understanding and adopting new technologies. Like as majority of the farmers in Chiang Dao practice the extensive mango cultivation by using low cost. A few of mango farmers in Chiang Dao were used to adopt the new technology in mango production. These may be due to introduction of new technologies requires intensive inputs of managerial skill or farming experience, good education and adequate infrastructure. Over half of the total farmers (49 farmers or 76.56%) did not apply any practice for delay harvesting time of Kaew

mango. The rest of 15 persons (23.44%) were used to test the delay harvesting practice in their orchards (Table 21).

Table 21. Farmers' practicing in the delayed harvesting of Kaew mango in Chiang Dao district

Farmers' practicing	Number	Percentage
Ever	15	23.44
Never	49	76.56
Total	64	100.00

Source : Survey data of 64 respondents, 2001

There were two methods which 15 farmers (23.40%) used to delay harvesting method of Kaew mango, namely, pruning and plant bioregulator application.

2.6.1 Pruning Generally, annual pruning takes place after harvesting, during September and July. 1 out of 15 farmers (6.70%), said that they could delay the harvesting time by later pruning the mango trees in October. This method could extend the harvesting time by 10-30 days.

2.6.2 Plant bioregulator application There are 14 farmers (93.30%) who used to delay the harvesting time of mango by using plant growth bioregulator. Planofix is the popular plant bioregulator used in these areas. This substance is considered as the plant growth promoter of Auxin. The farmers' use of this substance to protect the fruit drop damage by spraying to the trees around 15-30 days after full bloom. From this method, the harvesting time of Kaew mango was delayed by 15-30 days.

2.7 Criteria selection for using plant growth bioregulator There are many farmers' criteria selection for using plant growth bioregulator in their orchards. Farmers could answer more than one answer in this section. The result showed that 14.8 farmers (23.13%) selected the qualities of no toxicity and effectiveness when sprayed as the first priority for using. Some farmers wanted the low price substances (13.5 persons or 21.09%). In addition, 12.9 persons (20.15%) and 8 persons (12.50%) wanted the substances which had simple method application and no residual effect when harvested (Table 22).

Table 22. Criteria for a choice of plant bioregulator by mango growers in Chiang Dao district

Criteria for a choice	Number	Percentage
Safety	14.8	23.13
Effectiveness	14.8	23.13
Low price	13.5	21.09
Ease of use	12.9	20.15
No residual effect	8.0	12.50
Total	64.0	100.00

Source : Survey data of 64 respondents, 2001

3. Marketing These section included the harvesting time, number of harvesting time, grading, price, attitude of farmers' views in price and income.

3.1 Harvesting time This section was divided into 2 aspects, natural harvesting time and required harvesting time for mango farmers in Chiang Dao district.

3.1.1 Natural harvesting time Rainfed upland of Chiang Dao is considered as the native of late season production of Kaew mango because of favorable geological and weather conditions. Normal season flowering of Kaew mango on rainfed uppland of Chiang Dao was concentrated in late January. After that around 120 days after full bloom, the fruits were harvested at fully mature stage. Naturally, harvesting season of this area is considered as the late season, began from late May up to early June. The harvesting time of Kaew mango from each orchard was rather different in Chiang Dao district. Generally, some growers harvested their produce earlier in May 21-31 (5 persons or 7.81%). Some growers harvested their fruits later in July 21-30 (5 persons or 7.81%). But the most farmers (21 persons or 32.82%) harvested their produce in June 1-10. Followed by 17 persons (26.56%) picked the fruits out of their orchards on July 1-10. 12 persons (18.75%) and 4 persons (6.25%) harvested their produce in June 11-20 and June 21-30, respectively (Table 23).

Table 23. Common harvesting time of Kaew mango in Chiang Dao district

Month	Number	Percentage
May		
1-10	0	0.00
11-20	0	0.00
21-31	5	7.81
June		
1-10	21	32.82
11-20	12	18.75
21-30	4	6.25
July		
1-10	17	26.56
11-20	0	0.00
21-31	5	7.81
Total	64	100.00

Source : Survey data of 64 respondents, 2001

3.1.2 Required harvesting time If the harvesting time could be delay, time for harvesting the produce which were agreed with the farmers requirement from interviewing 64 farmers shown in Table 24. The result found that majority of farmers (17.8 farmers or 27.81%), agreed with the target timing of late season production was between July 1-10 because of a high level of consumer demand. Followed by 16 farmers (25.00%) and 10.7 farmers (16.72%) required to pick the fruits in August 1-10 and late July 21-31. The rest of 8.8 farmers (13.75%) wanted to harvest their produce in July 11-20 (Table 24).

Table 24. Required harvesting time of Kaew mango in Chiang Dao district

Month	Number	Percentage
May		
1-10	0.0	0.00
11-20	0.0	0.00
21-31	0.0	0.00
June		
1-10	1.8	2.81
11-20	5.3	8.28
21-30	0.0	0.00
July		
1-10	17.8	27.81
11-20	8.8	13.75
21-31	10.7	16.72
August		
1-10	16.0	25.00
11-20	0.0	0.00
21-31	3.6	5.63
Total	64.0	100.00

Source : Survey data of 64 respondents, 2001

3.2 Number of harvesting time Owing to extensive cultivation by using low cost, thus, the productivity of crops in this system relied on original soil fertility and the support from climatic condition rather than from farmers' management. Majority of orchards (52 orchards or 81.25%) in this area gave the mango yield one time per year. While, 12 orchards (18.75%) could harvest the produce two times per year (Table 25).

Table 25. Number of harvesting time of Kaew mango in Chiang Dao district

Number of harvesting time	Number	Percentage
Once	52	81.25
Twice	12	18.75
Total	64	100.00

Source : Survey data of 64 respondents, 2001

3.3 Grading After harvesting, the produce would be graded into three grades : A (3-4 fruits per kg), B (5-7 fruits per kg) and C (7-8 fruits per kg). The result from Table 26 indicated that more than half of total farmers (42 persons or 65.62%) graded their produce before selling. The rest of 22 persons (34.38%) sold their produce without sorting.

Table 26. Fruit grading practiced by mango growers in Chiang Dao district

Practicing of fruit grading	Number	Percentage
Yes	42	65.62
No	22	34.38
Total	64	100.00

Source : Survey data of 64 respondents, 2001

After grading, most of produce were classified as grade B (28.22 orchards or 44.10%).

Table 27. Fruit grading of Kaew mango in Chiang Dao district

Fruit grading	Number	Percentage
Grade A	27.71	43.30
Grade B	28.22	44.10
Grade C	8.07	12.60
Total	64.00	100.00

Source : Survey data of 64 respondents, 2001

Followed by 27.71 orchards or 43.30% and 8.07 orchards or 12.60% found in grade A and C, respectively (Table 27).

3.4 Price At Chiang Dao planting areas, farmers commonly sold their produce for fresh consumption. After harvesting, farmers sold their produce either at the farm gate or the traders from other province, such as Angthong, Bangkok, Nakorn Savan, and Ayudthya will come and purchase the produce directly from the farmers. There is surprising information that some farmers in these areas were traders besides farmers. From interviewing, farmers indicated that there was no difference in terms of mango price between the farm gate and local market. Most of mango growers sold their product to local traders who gathered the produce to the traders from other provinces. Table 28 reported that 37 farmers (57.81%) of total 64 farmers sold their produce to the in local traders and 27 farmers (42.19%) sold their produce directly to traders from other provinces at farm gate after harvesting.

Table 28. Type of mango trader in Chiang Dao district

Type of trader	Number	Percentage
Local traders	37	57.81
Non-local traders	27	42.19
Total	64	100.00

Source : Survey data of 64 respondents, 2001

The price of grade A and B when harvested in June and July is shown in Table 29. The price of mango fruits early harvested in June (8.83 Baht per kg for grade A and 6.67 Baht per kg

Table 29. Price of Kaew mango in June and July in Chiang Dao district

Month	Price (Baht per kg)	
	Grade A	Grade B
June	8.83	6.67
July	12.21	8.38

Source : Survey data of 64 respondents, 2001

for grade B) were lower than that harvested later in July (12.21 Baht per kg for grade A and 8.38 Baht per kg for grade B). At the later harvesting time in July, the price tended to increase because the mango supply was only found in the Upper North. Thus, farmers thought that the delayed harvesting time would directly benefit their family income.

3.5 Attitude of farmers' view in price The market economy of Kaew mango in these areas, price is the main incentive for agricultural production and marketing. Price affects revenues, costs and profits of various marketing agents. However, the price for selling was settled by the local traders. At present, farmers faced with the low price problem and lack of bargaining power. 56 farmers (87.50%) were not satisfied with the selling price. While, 8 persons (12.50%) agreed with these price (data not shown).

3.6 Income The questionnaire survey included the farmer income per year. There were several incomes of farmers based on on-farm, such as mango orchard, livestock, annual crops and other fruit trees and off-farm activities. Income from annual crops and other fruit trees such as garlic, shallot, chili, lemon, was the main source of income supporting the household. The minimum and maximum incomes from this section were 500 and 550,000 Baht per year, with the average of 54,794.44 Baht per year. Followed by income from mango was the secondary rank. The minimum and maximum income from producing mango were 500 and 750,000 Baht per year, with the average of 30,641.90 Baht per year. Earnings from off-farm activities was also contributed an important part in structure of household income, by ranking in the third level of total farmer incomes. The minimum and maximum earnings from off-farm activities were 1,500

Table 30. Source of mango growers' income in Chiang Dao district

Source of income	Income/year (Baht)	Percentage
Mango orchard	30,641.90	28.60
Livestocks	950.00	0.89
Annual crops & other fruit trees	54,794.44	51.14
Off-farm activities	20,751.61	19.37
Total	107137.95	100.00

Source : Survey data of 64 respondents, 2001

and 108,000 Baht per year, with the average of 20,751.61 Baht per year. Income from livestock accounted for a smaller proportion of total income, between 400 to 1,500 Baht per year, with the average of 950 Baht per year (Table 30).

3. Experiments in the delayed harvesting

3.1 Delaying flowering

3.1.1 Pruning

Generally, farmers are prone to prune mango trees after harvesting in June in order to activate the growth of new flush before flowering. The objective of this experiment is to test the effect of delaying pruning time for producing late season Kaew mango. After harvesting, pruning methods is carried out in different months, from June to October. Mango trees were pruned by hand thinning to remove all defective twigs, weakened or crowded shoots, infected twigs, and useless twigs, while left untouched as a control or no pruning trees. The degree of pruning is thinned off around 60%. After pruning, NPK-application formula 15-15-15 at 20 kg per rai was put by surface broadcasting under the tree canopy.

1. Flush appearance After different pruning months, Kaew mango trees exhibited rejuvenation stage by producing new activated vegetative shoots or flushes. Generally after pruning in June, mango trees began to produce the flushing development by 45 days. Delayed pruning months had no significant effect on increasing the time taken to produce flush. Although trees pruned in September and October spent more times to produce flush (83.81 and 93.75 days after June 15) but they were not different from the others. While flush occurrence of trees pruned in July and no pruning trees developed at nearly times by 75.50 and 69.00 days after June 15 (Table 31).

2. Flush production Under natural condition, mango trees may produce more than one flush before flowering.

2.1 First flush production Generally, before flowering mango trees often produce first flushes exceeded 80% of all branches. Delayed pruning months had no significant effect on decreasing first flush production. All trees pruned from June to October produce the similar first flush production, ranged from 80-95%, while 85% found in no pruning trees (Table 31).

2.2 Second flush production No pruning trees almost had a little second flush production only 5%. Delayed pruning months had significant effect to this figure. Trees pruned in August and September had the highest second flush production (50 and 37.50%). While, late pruned in October and no pruning trees produced the least second flushes only 5% (Table 31).

Table 31. Flush appearance and flush production of Kaew mango trees after pruning in different months

Pruning month	Flush appearance (days)	Flush production (%)	
		First flush	Second flush
No pruning	69.00	85.00	5.00 c [1]
June	45.00	95.00	17.50 bc
July	75.50	80.00	12.50 bc
August	82.50	95.00	50.00 a
September	83.81	82.50	37.50 ab
October	93.75	92.50	5.00 c
$LSD_{0.05}$	ns	ns	10.02
C.V. (%)	29.08	15.67	94.28

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3. Quantity and size of flush

3.1 Flush quantity After the last flowering, mango trees produced new flush around 2.70 flushes per shoot. Delayed pruning treatment had no significant effect on changing the amount of flushing. Although late pruning in October produced higher amount of flush per shoot (3.07) than the others but this value was not different from the others (2.15-2.85) (Table 32). There are several reports pronounced the similar vegetative growth flush production in mango. Whiley *et al.* (1989) observed that the number of vegetative flushes of mango after

pruning were 2.0 in 'Irwin' and 4.7 in 'Kensington'. While Sasaki *et al.* (2000) and Shu *et al.* (2000) indicated that after pruning, two-three flushed shoots were produced and grew to vigorous vegetative growth to serve as fruiting shoots for the next year. In addition, Campbell and Wasielewski (2000) indicated that under arid climates, the mango tree might produce only 1 or 2 growth flushes per season.

Table 32. Quantity and size of Kaew mango flush after pruning in different months

Pruning month	Flush quantity (flush/shoot)	Size of first flush		Size of second flush	
		Length	Diameter	Length	Diameter
		cm			
No pruning	2.70	15.67	0.63	4.78 b[1]	0.43 c
June	2.68	16.90	0.65	13.89 a	0.76 a
July	2.53	14.47	0.62	7.13 b	0.66 ab
August	2.85	18.55	0.65	6.61 b	0.55 bc
September	2.15	13.81	0.58	7.96 b	0.48 bc
October	3.07	16.02	0.60	6.15 b	0.63 ab
$LSD_{0.05}$	ns	ns	ns	1.79	0.06
C.V. (%)	22.75	22.72	12.80	40.07	17.57

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3.2 Flush size

3.2.1 First flush The first flush size producing from mango trees planted in nature was 15.67 and 0.63 cm in length and diameter, respectively. Regardless of delayed pruning months had no significant effect on changing the size of first flush. The size of first flush from all treatments were similar, ranged from 13.81-18.55 cm in length and 0.58-0.65 cm diameter (Table 32).

3.2.2 Second flush Under no pruning, second flush produced from mango trees had the size of 4.78 cm in length and 0.43 cm in diameter. Delayed pruning months had significant effect on reducing the size of second flush, regardless of length and diameter. Larger new second flushes (13.89 cm in length and 0.76 cm diameter) were produced from early pruned trees in June than other pruned months. While late pruning from August to October and no pruning trees gave the similar size of second flushes (4.78-7.96 cm in length and 0.43-0.63 cm diameter) (Table 32). Schaffer *et al.* (1994) indicated that the pattern, number and frequency of growth flushes after pruning were governed by various factors both internal and external forces, such as temperature conditions, tree maturity, age of the plant and nutrient availability (Pandey, 1988 ; Rom, 1996).

4. Flowering development periods

4.1 Panicle appearance Generally, no pruning trees began to show the initial panicle appearance (1 cm panicle in length like cock's spur) around 176 days after June 15. Pruning treatments, whether applied in the different months had no effect on extending this period. All treatments produced the first signs of panicle appearance initiated at the same time, ranged from 176-184.33 days after June 15, 2001 (Table 33). These may be due to low temperatures in winter provided a strong induction stimulus to initiate floral morphogenesis (Pandey, 1988 ; Nunez-Elisea and Davenport, 1995 ; Sasaki *et al.*, 2000). Thus, short span of time to exposure the cool temperatures as 4 to 45 days could activate mango floral induction in late pruned trees (Nunez-Elisea and Davenport, 1995). In addition, the early-pruned trees (June and July) produced the panicle appearance throughout the trees. While the reduction of flower bud formation was found in October-pruned trees by showing the sparsely panicle appearance. Scholefield *et al.* (1986) observed that shoot vigor and age involved in floral initiation. Nunez-Elisea (1986, 1988) reported that the optimum age of stems for flowering should be at least 6 months. The fully matured or older shoots seems to be more synchronized flowers initiation than younger shoots because of more sensitive to floral stimulus (Sasaki *et al.*, 2000 ; Sergent *et al.*, 2000). The early initiation and development of new flush, followed by an appropriate dormant period helped the shoots to attain the proper physiology for flower initiation (Singh, 1978). In addition, Oosthuyse and Jacobs (1999) indicated that assimilate availability had been inversely related to the intensity of flowering. In other word, the starch accumulation had an important

role in supporting flowering (Whiley *et al.*, 1996). The absence of food reserve could affect to reduce floral production of late pruned trees.

4.2 Full bloom stage Each panicle appearance gradually increased its growth and reached a complete development at full bloom stage. No pruning mango trees entered to full bloom stage by 27.84 days after panicle appearance. Delayed pruning months had no significant effect on extending the time from panicle appearance to full bloom. Full bloom stage of all treatments was just about the same time, ranged from 25.97-31.03 days after panicle appearance (Table 33). Daecha *et al.* (2002) reported that under rainfed condition, the period from Kaew panicle appearance to full bloom stage was lower by 21 DAF. While, Schaffer *et al.* (1994) indicated that the period from floral appearance to full bloom could be as short as 4 weeks under tropical conditions.

Table 33. Flower development of Kaew mango trees after pruning in different months

Pruning month	Flower development (days)	
	15 Jun-panicle appearance	Panicle appearance-full bloom stage
No pruning	176.00	27.84
June	176.00	25.97
July	176.00	31.03
August	184.33	29.37
September	176.00	27.75
October	183.67	29.37
$LSD_{0.05}$	ns	ns
C.V. (%)	4.48	8.57

ns Non significant difference at 95% level ($P > 0.05$) by LSD

5. Panicle size At full bloom stage, no pruning trees had panicle size of 29.35 cm in length and 18.00 cm diameter. Pruning treatments had no significant effect on changing the panicle size. At full bloom stage, all treatments had the similar panicle size of 29.35-34.98 cm in length and 16.54-18.56 cm diameter, respectively (Table 34).

Table 34. Panicle size, floral sex and floral sex ratio of Kaew mango trees after pruning in different months

Pruning month	Panicle size (cm)		Floral sex (%)		Floral sex ratio
	Length	Diameter	Male	Perfect	(male/perfect flower)
No pruning	29.35	18.00	65.62	30.15	2.22
June	33.54	18.56	68.85	27.59	3.27
July	31.36	18.28	49.75	50.25	1.32
August	31.56	16.02	74.25	31.53	3.71
September	34.98	16.54	57.68	43.17	1.51
October	32.48	17.79	78.28	17.67	3.78
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	13.54	11.89	22.19	42.07	60.00

ns Non significant difference at 95% level ($P > 0.05$) by LSD

6. Floral sex percentage and floral sex ratio Mango trees had two floral sex types on each panicle, namely male and perfect flowers. No pruning trees had male and perfect flowers as 65.62 and 30.15%. Delayed pruning months had no significant effect on both flower types. Male and perfect flowers among all treatments were more than 49.75 and 17.67%. In addition, floral sex ratio between male and perfect flowers were similar among all treatments, ranged from 1.32-3.78 (Table 34). Issarakraisila *et al.* (1992) indicated that there was no difference in the perfect flower percentage between early and late emerging panicles of mango cv. Kensington growing in a warm temperate climate in Western Australia. These may be due to temperatures in these period were rather constant.

7. Developmental stages of fruit

7.1 Peanut stage After full bloom, the initial fruit development of mango is peanut stage or fruit length was around 1 cm. No pruning trees spent the time taken from full bloom to this stage by 25.43 days after full bloom (DAF). Delayed pruning months had no significant effect on extending this fruit development. All treatments spent the same time for fruit development at peanut stage, ranged from 25.43-29.22 DAF (Table 35). While, Daecha *et al.*

(2002) reported that the total time for Kaew mango fruit development in this stage under rainfed condition was around 20 DAF.

7.2 Bird's egg stage The second stage of mango fruit development after full bloom is bird's egg stage. This stage' fruit length is around 3 cm. Mango fruits from no pruning trees spent the time taken for developing from peanut to bird's egg stage around 15.05 days after peanut stage. Different pruning months had no effect to this fruit development, ranged from 14.86-15.96 days after peanut stage (Table 35). This fruit development period agreed with Daecha *et al.* (2002) who reported that Kaew mango planting under rainfed condition spent the time of 15 days for developing the fruits from peanut to bird's egg stage.

7.3 Hen's egg stage After full bloom, the third stage of mango fruit development is hen's egg stage. This stage' fruit length is around 6 cm. Under natural condition, fruits from no pruning trees spent the time of 20.19 days to enter this stage. Delayed pruning months had significant effect on delaying this development stage. Trees pruned in August spent more time for this fruit development (22.15 days) than the others (18.35-20.07 days) (Table 35). While Daecha *et al.* (2002) suggested that this fruit development stage spent the total time less than 17 days.

7.4 Full bloom to harvesting stage No pruning tree spent the time taken from full bloom to harvest around 127.04 DAF. Late pruning treatment had no significant effect on delaying this period. Regardless of delayed pruning months, the period from full bloom to harvest of all treatments were just about the same time, ranged from 122.01-132.16 DAF (Table 35). However, this period was longer than report of Daecha *et al.* (2002) who indicated that the development of Kaew mango from full bloom to harvest was around 103 DAF. The reason for explaining the same harvesting time of all treatments might be due to climatic condition, especially day temperatures during fruit development had an effect to fruit development (Burondkar *et al.*, 2000 ; deLeon *et al.*, 2000). After March, the increasing of average temperature (26.3°C) led to hasten the fruit biochemistry (Subramanyam *et al.*, 1975). While, Wangnai (1986) indicated that mango fruit maturity on trees had closely relationship with temperature. When temperatures were more than 21°C, mango fruits would enter to early maturity.

Table 35. Days to each developmental stage of Kaew mango after pruning in different months

Pruning month	Days to each developmental stage				
	Full bloom	Peanut	Bird's egg	Hen's egg	Harvesting
No pruning	29.71	25.43	15.05	20.19 b [1]	127.04
June	28.48	28.11	15.27	19.54 b	132.16
July	30.66	25.75	14.86	20.07 b	123.74
August	29.53	27.62	14.93	22.15 a	125.64
September	29.66	27.21	15.17	18.35 b	128.37
October	29.38	29.22	15.96	18.64 b	122.01
$LSD_{0.05}$	ns	ns	ns	0.64	ns
C.V. (%)	3.37	6.67	6.36	6.50	5.43

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

8. Fruiting panicle Panicle which is able to produce fruit is called fruiting panicle. Although mango tree has several flower per panicle but fruit retention is little. Fruit retention attached on fruiting panicle was recorded in term of percentage 4 stages, namely peanut, bird's egg, hen's egg and at harvesting. The initial fruit retention started from fruit size liked mung bean was set as 100%. The more fruit development, the less fruit retention was found. Fruit retention percentage from no pruning tree as the stage of peanut, bird's egg, hen's egg and at harvesting were 85.59, 72.49, 48.10 and 12.86%. Delayed pruning months had significant effect on decreasing the retention on fruiting panicle. Early pruning in June gave the higher fruit retention at all fruit development stage. While, late pruning month in October had the least fruit retention from initial fruit set at peanut stage (59.13%) through at harvesting (5.73%) (Table 36). This may be due to several factors, both internal and external involved with fruit retention (Krisanapook *et al.*, 2000). Whiley *et al.* (1996) indicated fruit retention was largely dependent on storage carbohydrate. Owing to the new flushing occurrence of October-pruned trees was just about the same time with panicle appearance, these affected to the competition between

vegetative and reproductive organs for nutrients (Saunders *et al.*, 1991). Because of this exhaustion, the tree might unable to retain fruit (Narwadkar and Pandey, 1982).

Table 36. Fruiting panicle of Kaew mango after pruning in different months

Pruning month	Fruiting panicle (%)			
	Peanut stage	Bird's egg stage	Hen's egg stage	At harvesting
No pruning	85.59 ab[1]	72.49 b	48.10 bc	12.86 b
June	91.07 a	85.23 a	69.10 a	28.75 a
July	87.75 ab	74.57 b	53.00 b	28.18 a
August	79.12 c	69.84 b	36.00d	15.36 b
September	81.68 bc	62.48 c	45.03 c	8.44 c
October	59.13 d	19.77 d	11.41 e	5.73 c
$LSD_{0.05}$	5.15	7.59	11.23	12.97
C.V. (%)	2.08	2.43	2.46	1.07

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

9. Number of fruit per panicle No pruning trees gave the number of fruit per panicle at peanut, bird's egg, hen's egg and harvesting as 1.54, 1.40, 1.20 and 1.03 fruit per panicle. Delayed pruning months had significant effect to this figure at initial fruit stage (peanut and bird's egg stage) and at harvesting. A reduction in fruit numbers was associated with delay pruning month. Trees pruned in July gave the higher number of fruit per panicle at peanut (2.97) and hen's egg stage (2.54) than the others (1.22-2.15) and 1.05-1.36 at peanut and hen's egg stage, respectively. Chacko (1984) indicated the ability of a fruit retaintion depended upon both assimilate availability and the capacity of the fruit itself to act as a sink for assimilates. The nutrition would be shared among the fruits attached to the panicle. If nutrition were not sufficient, fruits would largely drop (Chacko, 1984). At harvesting, trees pruned in July also gave the highest number of fruit of 1.2 fruit per panicle, while the least number of fruit (1 fruit)

received from trees pruned in October (Table 37). Schaffer *et al.* (1994) reported that most of mango tree usually carried only one fruit per panicle to maturity.

Table 37. Number of fruit per panicle of Kaew mango after pruning in different months

Pruning month	Number of fruit per panicle			
	Peanut stage	Bird's egg stage	Hen's egg stage	At harvesting
No pruning	1.54 b [1]	1.40 b	1.20	1.03 bc
June	1.36 b	1.34 b	1.16	1.07 bc
July	2.97 a	2.54 a	1.65	1.20 a
August	2.15 ab	1.90 ab	1.34	1.10 b
September	1.74 b	1.81 ab	1.36	1.10 b
October	1.22 b	1.15 b	1.05	1.00 c
$LSD_{0.05}$	34.39	31.15	ns	5.77
C.V. (%)	0.31	0.26	0.13	0.03

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

10. Yield At harvesting, no pruning trees gave the yield around 176.88 kg per tree. Delayed pruning months had significant effect on reducing yield. Late pruned trees in September and October gave the lower yield of 87.08 and 37.58 kg per tree. These may be due to late pruned trees in October affected to interfere with the insufficient vegetative dormancy before flowering. These condition caused to initiate carbohydrate stress which was detrimental to floral initiation and fruit retention (Wolstenholme *et al.*, 1990 ; Cull, 1991 ; Davenport and Nunez-Elisea, 1997). While, the higher yield received from July-pruned trees (249.59 kg/tree) (Table 38). Scholefield *et al.* (1986) suggested that vegetative shoots emerging from early pruned trees exhibited the vigorous growth. Because more age of mango shoots was associated with more food reserve content. These starch accumulation had an effect to support the flowering and

productivity (Whiley *et al.*, 1996). Thus, the best pruning period should done after harvesting suddenly (Crane and Campbell, 1994).

Table 38. Yield of Kaew mango at harvesting after pruning in different months

Pruning month	Yield (kg/tree)
No pruning	176.88 b[1]
June	201.88 ab
July	249.59 a
August	188.23 ab
September	87.08 c
October	37.58 c
$LSD_{0.05}$	24.25
C.V. (%)	30.91

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

11. Size and weight of fruit At harvesting, fruit from no pruning trees had size in terms of width, length and thickness as 5.98, 8.48 and 5.50 cm, respectively. Different pruning months had a significant effect to fruit size. Fruit size in terms of width and thickness were found significantly different among the six treatments, excepted for fruit length of all six treatments showed the similar in fruit length, ranged from 8.32-8.85 cm. At harvesting, trees pruned in October and June gave bigger fruit size than the others (6.23-6.38 cm in width and 5.75-5.84 cm in thickness). While trees pruned in August and no pruning trees gave smaller fruit size than the others (5.89-5.98 cm in width and 5.41-5.50 cm in thickness) (Table 39).

At harvesting, mango fruit from no pruning trees weighed around 156.38 g. Delayed pruning months had significant effect to fruit weight. Fruits from trees pruned in June (179.40 g) and October (187.86 g) had more weight than the others. These may be due to size of fruit was inversely proportional to the fruit load on the tree (Forshey and Elfving, 1977). Thus, October

pruned trees gave the higher size and weight of fruits was equal to early pruned trees in June because of a little competition among fruits themselves for their growth (Kataoka *et al.*, 2003).

Table 39. Fruit size, fruit weight and flesh percentage of Kaew mango after pruning in different months

Pruning month	Fruit size (cm)			Fruit weight	Flesh
	Width	Length	Thickness	(g)	(%)
No pruning	5.98 cd [1]	8.48	5.50 c	156.38 bc	70.12
June	6.23 ab	8.68	5.75 ab	179.40 ab	70.84
July	5.99 cd	8.60	5.54 bc	159.24 bc	69.61
August	5.89 d	8.32	5.41 c	149.15 c	69.37
September	6.12 bc	8.81	5.54 bc	169.44 abc	69.51
October	6.38 a	8.85	5.84 a	187.86 a	71.09
$LSD_{0.05}$	0.08	ns	0.07	7.98	ns
C.V. (%)	2.53	4.40	2.60	9.56	1.74

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

12. Flesh content Fruit from no pruning trees had flesh content around 70.12% W/W at harvesting. Delayed pruning months had no affect to flesh content. Among all treatments had the same flesh contents, range from 69.37-71.09 % W/W (Table 39).

13. Size and weight of seed At harvesting, the size of seed from no pruning trees was 3.07, 7.27 and 1.97 cm in terms of width, length and thickness, respectively. Delayed pruning months had no significant effect on increasing seed size, excepted for thickness. Seed from all treatments had the similar width (3.07-3.24 cm) and length (7.16-7.49 cm). Early pruned trees in June and late pruned trees in September and October gave the more seed thickness (2.05-2.09 cm) compared with the others (1.95-2.01 cm) (Table 40). These may be due to trees pruned

in October gave the bigger fruits, thus, seed from these trees had bigger size. In addition, regardless of different pruning months had no effect to seed weight, ranged from 23.75-26.83 g.

Table 40. Size and weight of Kaew mango seed after pruning in different months

Pruning month	Seed size (cm)			Seed weight
	Width	Length	Thickness	(g)
No pruning	3.07	7.27	1.97 cd [1]	23.75
June	3.22	7.36	2.05 ab	26.61
July	3.12	7.30	1.95 d	24.36
August	3.08	7.16	2.01 bc	25.29
September	3.23	7.49	2.06 ab	26.63
October	3.24	7.46	2.09 a	26.83
$LSD_{0.05}$	ns	ns	0.22	ns
C.V. (%)	4.27	5.96	2.14	8.94

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

14. Peel color Peel color measurement was done at three sections : shoulder, middle and apex of fruit. Three values of L (lightness), c (chroma) and h (hue) were shown as peel color. At harvesting, fruits from no pruning trees showed the peel color of L, c and h at three sections ranged from 33.38-38.30, 23.72-25.10 and 178.77-181.36, respectively. Different pruning months had significant effect to peel color, particularly at shoulder section. Peel color of fruit from trees-pruned in October had lower L (35.34), c (23.74) and h (178.75) values than the others. These peel color level showed that fruits from this treatment had lighter green color at shoulder section. Meanwhile, fruits from trees pruned in July had more L (38.64), c (26.94) and h (179.00) than the others. These indicated that fruits from trees pruned in July had darker green color at shoulder section. While, the results from peel color at middle and apex sides showed

significant effect only L value at middle side and c value at apex side. But these results were almost little differences compared with the overall of peel color (Table 41).

15. Fruit stalk toughness At harvesting, fruits from no pruning trees had fruit stalk toughness of 3.01 kg. Different pruning months had no significant effect on increasing fruit stalk toughness, ranged from 2.95-3.27 kg (Table 42).

16. Fruit firmness Under natural condition, fruits from no pruning trees had fruit firmness after peeling around 11.70 kg/cm^2. Different pruning months had no significant effect to this figure, ranged from 11.70-13.85 kg/cm^2 (Table 42).

17. Flesh color No pruning trees gave the fruits which had flesh color in terms of L, c and h as 49.64, 36.57 and 180.97, respectively. Delayed pruning months had significant effect to flesh color. Fruits from early pruned in June and August had higher flesh color in terms of L, c and h as 49.17-49.81, 37.50-37.52 and 181.07-181.24. These values indicated that early pruned trees in these months gave the flesh which were more intense green color than the others (Table 42).

Table 41. Peel color of Kaew mango after pruning in different months

Pruning month	Shoulder portion			Middle portion			Apex portion		
	L	c	h	L	c	h	L	c	h
No pruning	38.30 ab [1]	24.91 bc	179.12 a	34.76 b	24.74	178.77	33.38	23.72 d	181.24
June	35.61 d	24.54 bc	178.66 c	33.07 c	25.10	178.64	33.19	24.94 bcd	181.36
July	38.64 a	26.94 a	179.00 a	35.94 a	26.57	178.80	33.47	24.54 cd	181.20
August	37.67 b	25.73 ab	178.90 ab	34.64 b	26.47	178.65	33.03	25.32 abc	181.35
September	36.76 c	26.57 a	178.76 bc	33.81 c	25.46	178.67	33.79	26.29 ab	181.34
October	35.34 d	23.74 c	178.75 bc	33.18 c	24.29	178.89	33.55	26.48 a	181.11
$LSD_{0.05}$	0.31	3.27	0.08	0.27	ns	ns	ns	3.70	ns
C.V. (%)	1.64	0.42	0.09	1.60	4.67	0.09	0.28	0.47	0.10

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 42. Fruit stalk toughness, fruit firmness and flesh color of Kaew mango after pruning in different months

Pruning month	Fruit stalk toughness (kg)	Fruit firmness (kg/cm^2)	Flesh color		
			L	c	h
No pruning	3.01	11.70	49.64 a[1]	36.57 b	180.97 b
June	3.19	12.01	49.17 ab	37.52 ab	181.24 a
July	3.23	13.01	49.66 a	37.68 a	181.06 ab
August	2.95	13.10	49.81 a	37.50 ab	181.07 ab
September	3.25	13.85	49.24 ab	36.46 b	180.68 c
October	3.27	12.06	48.44 b	37.99 a	180.89 bc
$LSD_{0.05}$	ns	ns	0.28	0.37	0.91
C.V. (%)	7.08	0.74	1.14	1.96	0.10

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

18. Total soluble solids (TSS) TSS content in fruits from no pruning trees was around 9.19 °Brix. Different pruning months had significant effect to TSS content. Fruits from trees pruned in June (9.96 °Brix) and October (10.54 °Brix) had higher TSS levels than the others (8.97-9.46 °Brix) (Table 43). These may be due to a little resource limitation among the few fruits attached to the October pruned trees. Meanwhile, early pruned trees in June may had enough food reserve content from the new vigorous flushing, which was benefit for fruit growth (Scholefield *et al.*, 1986).

19. Titratable acidity (TA) TA content in fruits from no pruning trees at harvesting as 0.30%. TA levels were not affected by different pruning months. All six treatments had the similar TA contents, ranged 0.28-0.33% (Table 43).

Table 43. Fruit quality of Kaew mango after pruning in different months

Pruning month	Total soluble solids (°Brix)	Titratable acidity (%)
No pruning	9.19 bc [1]	0.30
June	9.96 ab	0.30
July	9.46 bc	0.30
August	8.97 c	0.28
September	9.41 bc	0.29
October	10.54 a	0.33
$LSD_{0.05}$	0.30	ns
C.V. (%)	5.63	8.80

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3.1.2 Panicle thinning

1. Return bloom percentage General mango panicles were produced at the terminal shoots. After removing terminal panicle, the formation of axillary panicle buds adjacent to the point of cutting would be activated (Figure 9).

Figure 9. Formation of axillary panicle after thinning

All treatments produced the new axillary panicles at the basal cut. Panicle thinning at four stages (1, 5, 10 and 20 cm) had significant effect on producing the return bloom appearance in term of percentage. The longer panicle thinning, the less production of new axillary panicles was found. Early panicle thinning at 1 and 5 cm in length produced the high return bloom percentage (62.22 and 55.56%). While late panicle thinning at 10 and 20 cm occurred the poor return bloom appearance, only 5.00 and 1.67%, respectively (Table 44). Davie *et al.* (2000) and Pongsomboon *et al.* (1997) indicated that food reserves in mango tree played an important role for activating flower bud formation. Phavaphutanon *et al.* (2000) indicated that the accumulation of carbohydrates in mango trees decreased significantly during panicle emergence. Thus the longer panicle thinning, the less remaining food reserves in mango trees. These conditions caused to negligible return bloom on the trees from 10 and 20 cm panicle-thinned trees.

Table 44. Return bloom appearance of axillary panicles after thinning at different panicle lengths

Treatment	Return bloom appearance (%)
Panicle thinning at 1 cm	62.22 a[1]
Panicle thinning at 5 cm	55.56 a
Panicle thinning at 10 cm	5.00 b
Panicle thinning at 20 cm	1.67 b
$LSD_{0.05}$	4.48
C.V. (%)	24.94

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

2. Axillary panicle appearance Different panicle thinning length had no significant effect on delaying the axillary panicle appearance (1 cm in length). Regardless of panicle thinning at four lengths, all treatments produced the axillary panicle appearance at the same time, ranged from 18.0-21.0 days after thinning (Table 45).

Table 45. Panicle appearance of axillary panicle after thinning at different panicle lengths

Treatment	Axillary panicle appearance (days)
Panicle thinning at 1 cm	18.00
Panicle thinning at 5 cm	21.00
Panicle thinning at 10 cm	18.67
Panicle thinning at 20 cm	17.67
$LSD_{0.05}$	ns
C.V. (%)	13.96

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3. Panicle size Generally the figure of mango panicles looks like conical, pyramidal and broadly pyramidal. 28 days after panicle appearance (DAPA), panicles of control trees reached the maximum size, 19.01 cm diameter and 36.72 cm in length (data not shown). While panicle of control trees reached the maximum size, the initial axillary panicles after thinning started to develop.

3.1 Length Panicle thinning had a significant effect on decreasing axillary panicle size, regardless of length and diameter. Axillary panicle sizes produced from early thinning at 1 cm (4.79 cm) were longer than late thinning from 5 cm to 20 cm. In addition, axillary panicle after thinning at 5, 10 and 20 cm had the same length, ranged from 1.25-2.07 cm. Late panicle thinning at 10 and 20 cm had affected to inhibit the axillary panicle growth. The new axillary panicles, produced from these late thinning, ceased their growth and dried. While, axillary panicle from thinning at 1 and 5 cm continued to development to full bloom. At full bloom stage, axillary panicles from thinning at 1 and 5 cm had the same length, ranged from 6.56-8.61 cm (Table 46).

Table 46. Axillary panicle length after thinning at different panicle lengths

Treatment	Axillary panicle length (cm)				
	28 DAPA	35 DAPA	42 DAPA	49 DAPA	56 DAPA
Panicle thinning at 1 cm	4.79 a[1]	6.03 a[2]	7.34 a[2]	8.06 a[2]	8.61
Panicle thinning at 5 cm	1.98 b	2.90 b	4.65 b	5.50 b	6.56
Panicle thinning at 10 cm	2.07 b	-	-	-	-
Panicle thinning at 20 cm	1.25 b	-	-	-	-
$LSD_{0.05}$	0.51	-	-	-	-
C.V. (%)	34.74	11.73	9.27	9.96	12.26

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

[2] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

3.2 Diameter Only axillary panicles from thinning at 1 and 5 cm could develop until full bloom. Panicle thinning stage had significant effect on decreasing the diameter

Table 47. Axillary panicle diameter after thinning at different panicle lengths

Treatment	Axillary panicle diameter (cm)	
	49 DAPA	56 DAPA
Panicle thinning at 1 cm	3.17	5.83 a[1]
Panicle thinning at 5 cm	1.78	3.26 b
Panicle thinning at 10 cm	-	-
Panicle thinning at 20 cm	-	-
$LSD_{0.05}$	-	-
C.V. (%)	25.15	8.99

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$)

of axillary panicles. At full bloom stage, axillary panicle sizes produced from thinning at 1 cm (5.83 cm) had more diameter than thinning at 5 cm (3.26 cm) (Table 47).

4. Male and perfect flowers percentage Mango flower composes of male and perfect flowers on the same panicle or polygamous. At full bloom stage, control trees had male and perfect flowers percentage as 76.94 and 23.06%. Panicle thinning at different stages had no effect on changing floral sex percentage. Thus, all treatments had similar male (61.15-80.94%) and perfect flowers (19.06-38.85%) (Table 48). In addition, control trees had floral sex ratio (male/perfect flower) around 1.72. Delayed panicle thinning had no significant effect on changing this ratio. Although the floral sex ratio from panicle thinning at 1 (6.49) and 5 cm (6.33) were rather more than control, but there were no significant difference (Table 48). Sasaki *et al.* (2000) reported that in mango, the ratio of flower type was little different among all axillary panicles. Conversely, Singh and Dhillon (1988) reported that the axillary panicles produce a higher proportion of perfect flowers compared with terminal panicles.

Table 48. Floral sex percentage and ratio of axillary panicle after thinning at different panicle lengths

Treatment	Floral sex percentage (%)		Floral sex ratio
	Male	Perfect	(male/perfect flower)
Control (no thinning)	76.94	23.06	1.72
Panicle thinning at 1 cm	80.94	19.06	6.49
Panicle thinning at 5 cm	61.15	38.85	6.33
Panicle thinning at 10 cm	-	-	-
Panicle thinning at 20 cm	-	-	-
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	22.00	59.49	83.77

ns Non significant difference at 95% level ($P > 0.05$)

5. Blooming stage The florets on panicle started to bloom from basal to terminal shoot. Control trees spent the times taken from panicle appearance to full bloom in 28.67 days.

Panicle thinning had significant effect on delaying the period from panicle appearance to full bloom. Both panicle thinning at 1 (41.33 days) and 5 cm (37.00 days) spent the similar times taken for this period and more than control trees (Table 49). Thus, full bloom stage of panicle thinning at 1 and 5 cm were later than control by 12.66 and 8.33 days. After breaking from basal cuts, the growth of axillary panicles from 10 and 20 cm panicle-thinned treatments ceased in a rapid times and failed to open.

6. Yield After full bloom, fruits from control trees continued to develop until harvesting (data not shown). While, panicle thinning not only inhibited the axillary panicle growth from late thinning, but also caused to absolute fruit drop in early thinning. Fruits on the axillary panicles-thinned at1 and 5 cm could carry fruits only at the initial fruit set of peanut stage then all of them drop afterwards. These conditions affected to a loss of yield. The results illustrated that the panicle thinning in order to activate the new axillary panicles had a negative effect on flowering and fruiting of Kaew mango. Yield reduction was associated with the axillary panicles from late thinning at 10 and 20 cm were unable to complete their development. In addition, early panicle thinning at 1 and 5 cm also affected to severe fruit drop before harvesting.

Table 49. Days from panicle appearance to full bloom stage of control and axillary panicle after thinning at different panicle lengths

Treatment	Panicle appearance to full bloom stage (days)
Control (no thinning)	28.67 b[1]
Panicle thinning at 1 cm	41.33 a
Panicle thinning at 5 cm	37.00 a
Panicle thinning at 10 cm	-
Panicle thinning at 20 cm	-
$LSD_{0.05}$	1.55
C.V. (%)	7.54

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

Wolstenholme *et al.* (1990) indicated that the factor limiting fruit set may be carbohydrate stress. Owing to the decreased accumulation of TNC in shoots during panicle development (Inglese *et al.*, 1998), these results affected to develop the little axillary panicles (late panicle thinning at 10 and 20 cm) and all fruits drop at initial fruit stage (early panicle thinning at 1 and 5 cm).

3.2 Extension of panicle growth This section was divided into two experiments (1) Paclobutrazol (PBZ) concentrations and time of application panicle growth period and (2) effect of PBZ on panicle appearance as followed.

3.2.1 PBZ concentrations and time of applications Paclobutrazol (PBZ) (Cultar®, ICI) is one of the plant bioregulators arranged as a growth retardant. These substance has been widely used for producing off season mango in many countries including Thailand. Due to its quality for inhibiting the tree growth, thus these substance was taken to explore the extending of the panicle growth for producing late season of Kaew mango, leading to subsequent higher returns.

1. Panicle development The collected data may be divided into three traits : panicle diameter, panicle length and blooming percentage. 15 days after panicle appearance, normal panicles developed nearly to full size (34.44 cm in length) and showed some panicle opening around 16.56%. At this stage PBZ concentrations had affected to decrease the panicle size by showing the shortened panicle and visibly compacted as a consequence of PBZ concentrations. In addition, PBZ at 1000-7000 ppm had also reduced the blooming appearance only 0.01-0.12% (Table 50).

30 days after panicle appearance, panicle length was around 30.92 cm and mango trees reached to full bloom stage (around 90%). PBZ spraying at panicle 5 cm in length caused to decrease the panicle to half size of normal panicle and delay blooming stage approximately 78.17%. While PBZ at 1000-7000 ppm lost their effects to panicle size and blooming contents at 30 days after panicle appearance (Table 50).

Several reports indicated that most plant growth retardants not only inhibited the formation of growth-active gibberellins (GAs) by inhibiting the conversion of geranylgeranyl+pyrophos phate to *ent*-kaurene (Rademacher, 1995), but also acted as

Table 50. Panicle development of Kaew mango after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Panicle development at 15 days after PBZ spraying			Panicle development at 30 days after PBZ spraying		
	Diameter (cm)	Length (cm)	Blooming (%)	Diameter (cm)	Length (cm)	Blooming (%)
PBZ conc. (ppm)						
0	16.53 a [1]	34.44 a	16.56 a	6.08	30.92	88.28
1000	9.35 b	18.70 b	0.12 b	6.56	30.66	90.03
3000	7.73 c	15.55 c	0.03 b	12.27	23.86	79.74
5000	7.32 c	14.49 c	0.05 b	10.90	20.10	85.48
7000	7.63 c	15.07 c	0.01 b	10.13	20.25	82.66
$LSD_{0.05}$	0.48	0.75	0.30	ns	ns	ns
C.V. (%)	12.01	9.32	22.20	42.89	34.81	14.33
Panicle length (cm)						
1	10.23	19.31	3.35	16.87 a [2]	31.15 a	92.31 a
5	9.19	19.99	3.35	9.51 b	19.16 b	78.17 b
Pair test	ns	ns	ns	**	**	**
C.V. (%)	38.42	40.62	204.81	35.22	29.36	11.40

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

[2] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$)

antigibberellin activity (Whiley, 1993). Quinlan and Richardson (1986) also found that PBZ from spraying could move directly into young stems or shoot tips to rapidly inhibit growth. Retardation of panicle growth was the most striking visible effect of growth retardants (Rademacher, 1995) because the role of plant growth retardant was primarily achieved by not only diminished cell elongation but also by a lowered rate of cell division (Kulkarni, 1988).

2. Sex of flower Mango flowers comprise two sexes, namely male and perfect flowers. Generally there are perfect flowers more than male flowers. Sex ratio of panicle at full development equaled to 4.75-8.83. The percentage between male and perfect flowers and sex

Table 51. Male and female flowers of Kaew mango after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Male flowers (%)	Perfect flowers (%)	Sex ratio
PBZ conc. (ppm)			
0	88.31	11.62	8.15
1000	49.03	19.99	4.89
3000	85.02	14.98	8.83
5000	86.21	13.80	8.49
7000	77.17	22.83	4.75
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	10.34	52.84	67.50
Panicle length (cm)			
1	86.22	13.75	8.84 a[1]
5	80.07	19.54	5.20 b
Pair test	ns	ns	*
C.V. (%)	10.46	53.21	63.70

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$)

ratio was unaffected from PBZ application, ranged from 77.17-88.31, 11.62-22.83%, and 4.75-8.83 respectively (Table 51).

3. Developmental periods after panicle appearance Each developmental stage from panicle appearance to harvest recorded five stages : (1) full bloom, (2) peanut stage, (3) bird's egg stage, (4) hen's egg stage and (5) full bloom to harvest.

3.1 Full bloom stage Panicle appearance at 1 cm in length was first observed by December 8. PBZ concentrations did not have a significant effect on these period. The development of most panicles increased gradually until it reached full development completed by

Table 52. Days to each developmental stage of Kaew mango after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Days to each developmental stage				
	Full bloom	Peanut stage	Bird's egg stage	Hen's egg stage	Harvesting
PBZ conc. (ppm)					
0	28.47	16.41	19.65	21.94 c [1]	117.55 d
1000	35.30	18.68	22.21	26.46 a	127.73 a
3000	36.55	19.25	21.06	22.99 bc	125.46 ab
5000	36.74	18.01	20.52	25.78 ab	121.91 bc
7000	35.15	18.53	22.93	24.56 abc	119.42 cd
$LSD_{0.05}$	ns	ns	ns	1.11	1.31
C.V. (%)	15.86	16.89	12.23	11.14	2.63
Panicle length (cm)					
1	30.70 b [2]	20.52 a	20.47	25.41	124.23 a
5	38.19 a	15.83 b	22.08	23.29	120.60 b
Pair test	**	**	ns	ns	*
C.V. (%)	13.50	10.33	12.28	11.91	3.73

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

[2] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant at 95% level ($P > 0.05$)

early to middle of January or within 28.47-36.74 days after panicle appearance. While panicle stages when sprayed, had a significant effect on advancing the date of full bloom. The later panicle in length 5 cm (38.19 days) when sprayed PBZ, further delayed the date of full bloom by 7.49 days compared to sprayed at 1 cm. (30.7 days) (Table 52).

3.2 Peanut stage Only the factor of panicle stages when sprayed, had significant effect to these period. The times taken for panicle sprayed PBZ at 1 cm reached peanut stage was extended to 20.52 days compared with sprayed PBZ at 5 cm (15.83 days). While, PBZ concentrations did not advance these period, between 16.41-19.25 days (Table 52).

3.3 Bird' s egg stage Both PBZ concentrations and panicle stages when sprayed had no significant effect to these period. The total for these period were taken about 19.65-22.93 days (Table 52).

3.4 Hen's egg stage Only PBZ concentrations had significant affected for these period. Panicle sprayed PBZ 1000 ppm spent the maximum period (26.46 days), while the minimum period found from unsprayed panicle (21.94 days). Panicle stages when sprayed, did not affect to these period, between 23.29-25.41 days (Table 52).

3.5 Full bloom to harvest Both two factors (PBZ concentrations and panicle stages when sprayed) had significant affected to these period. It is revealed from Table 52, that all the four doses of PBZ applied, gave siginficantly later harvesting over the control trees. The stage of full bloom to maturity of fruits from panicle sprayed PBZ 1000 ppm (127.73 days) was more advanced over the unsprayed (117.55 days), amounted 10.18 days. In considering the stages of panicle when sprayed, panicle sprayed PBZ at 1 cm (124.23 days) had a significant effect on delaying the more time than sprayed at 5 cm (120.6 days) (Table 52). These results confirm an earlier report that ABA was known to be involved in triggering ethylene production in citrus (Goren, 1983). Although the underlying mechanism for delaying of senescence is not yet fully understand, a reduction in ethylene formation and increases in cytokinin levels seem to be of major relevance (Grossmann, 1990).

4. Number of fruit per panicle Initial fruit set at peanut stage, there are 2.75 fruits per panicle. The number of fruit drop occurred all over fruit development, particularly at peanut stage found more than 50% fruit drop. PBZ concentrations employed in this experiment had no effect to the number of fruit per panicle throughout the fruit development. It is observed from

Table 53 that number of fruit set decreased when fruit approached to maturity. PBZ application at 5 cm panicle in length affected to reduce the number of fruit per panicle in a short time. But these results ended before harvesting. The results from Table 53 showed that at hen's egg stage, panicle sprayed PBZ at 1 cm (1.23 fruits) carried more fruit per panicle than sprayed PBZ at 5 cm (1.07 fruits). The final fruit set at harvesting, Kaew mango provided the number of fruit per panicle around 1.06. Among the treatments had the same number of fruit per panicle, ranged from 1.02-1.06.

Table 53. Number of fruit per panicle of Kaew mango after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Number of fruit per panicle			
	Peanut stage	Bird's egg stage	Hen's egg stage	Harvest
PBZ conc. (ppm)				
0	2.75	1.36	1.15	1.06
1000	2.55	1.29	1.23	1.05
3000	2.43	1.41	1.11	1.05
5000	2.34	1.20	1.17	1.02
7000	1.99	1.18	1.09	1.04
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	22.04	30.71	14.48	5.32
Panicle length (cm)				
1	2.26	1.33	1.23 a [1]	1.05
5	2.57	1.25	1.07 b	1.05
Pair test	ns	ns	**	ns
C.V. (%)	22.50	29.72	12.64	5.15

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$)

Despite high initial fruit set, the ultimate retention of fruits was quite low in mango. These result may be due to several factors, both internal and external (Negi, 2000). Krisanapook *et al.* (2000) reported that fruit abscission in mango cv. Khiew Sawoey may occur in different stages of fruit growth. Schaffer *et al.* (1994) presented that first fruit drop, occurred remarkedly during the first four weeks after full bloom, was severe with more than 80% of the initial fruit. Davenport and Nunez-Elisea (1997) indicated these early abscission of fruitlets derived from unfertilization (Krisanapook *et al.*, 2000), and often associated with embryo abortion (Ram *et al.*, 1976). Krisanapook *et al.* (2000) presented the second abscission of mango fruit usually occured 3-7 weeks after full bloom. The main course of abscission came from the competition among the fruits for reserve food and plant bioregulators, especially hormonal balances in developing fruits (Davenport and Nunez-Elisea, 1997). After that, fruit abscission decreased and was no longer observed in week 6 until week 12 which was the harvesting time (12 weeks after full bloom). Thus, many cultivars of mango usually only bear one fruit per panicle through to maturity (Schaffer *et al.*, 1994).

5. Yield Kaew mango trees aged 13 years old planted in rainfed upland yield approximately 164.67 kg per tree. Although PBZ application did not affect the number of fruit per panicle but it caused to increase the yield. The significant difference of yield found only from the factor of PBZ concentrations. Panicle sprayed with PBZ all concentrations (267.17-296.0 kg per tree) gave higher yield over than unsprayed (164.67 kg per tree). Panicle sprayed PBZ 1000 ppm gave the highest yield (296 kg per tree). PBZ spraying on panicle both 1 cm and 5 cm provided the not different yield, approximately 246.07 and 275.6 kg per tree (Table 54). Thus PBZ application could perform at any stage from panicle appearance to 5 cm in length. Adato (1990) indicated Cultar® sprayed avocado trees cv. Fuerte with before or at the flowering stage, resulted the higher number of harvested fruits per tree, reaching 97 and 174% above the controls. In addition, Winston (1992) suggested that mango tree cv. Kensington Pride applied PBZ, as a foliar spray, followed the harvest, gave the higher yield compared with the control.

Table 54. Yield of Kaew mango fruit after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Yield (kg /tree)
PBZ conc. (ppm)	
0	164.67 b [1]
1000	296.00 a
3000	290.50 a
5000	267.17 a
7000	285.83 a
$LSD_{0.05}$	10.16
C.V. (%)	9.54
Panicle length (cm)	
1	246.07
5	275.60
Pair test	ns
C.V. (%)	20.63

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant at 95% level ($P > 0.05$)

6. Fruit weight, fruit size and flesh content

6.1 Fruit weight Weight of Kaew mango fruit planted under rainfed condition was 176.94 g per fruit or 5-6 fruits per kg. The result from Table 55 showed that all fruits from panicle sprayed PBZ, had lighter weight as compared to unsprayed, excepted PBZ at 5000 ppm. PBZ spraying at 5000 ppm affected to increase the fruit weight (191.05 g). While, panicle stages when sprayed, did not affect to these figure, ranged of 175.57 and 166.95 g for spraying panicle at 1 and 5 cm, respectively (Table 55). These result may be due to weight per fruit was influenced by fruit load (Steffens *et al.,* 1993). Thus, the mean fruit weight was inversely proportional to the number of fruit on the tree (Forshey and Elfving, 1977). This inverse relation between crop load

and the size of the fruit making up that crop supported the concept that the fruits themselves were in competition with each other for resources required for their growth, while their growth was resource-limited (Steffens *et al.*, 1993).

6.2 Fruit size The record of fruit size was devided into three figures : width, length and thickness. At harvesting, Kaew mango fruit size in terms of width, length and thickness were 6.21, 8.91 and 5.58 cm, respectively. PBZ concentrations had a dramatic

Table 55. Fruit weight, fruit size and flesh content of Kaew mango at harvest after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Fruit weight (g)	Fruit size (cm)			Flesh (%)
		Width	Length	Thickness	
PBZ conc. (ppm)					
0	176.94 ab [1]	6.21 ab	8.91 a	5.58	70.75
1000	162.34 b	6.11 b	8.53 b	5.48	70.81
3000	160.38 b	6.03 b	8.57 b	5.46	69.97
5000	191.05 a	6.39 a	9.14 a	5.67	70.74
7000	165.58 b	6.11 b	8.60 b	5.60	69.22
$LSD_{0.05}$	7.29	0.06	0.09	ns	ns
C.V. (%)	10.43	2.51	2.47	3.12	2.02
Panicle length (cm)					
1	175.57	6.24 a [2]	8.80	5.63 a	70.45
5	166.95	6.10 b	8.70	5.48 b	70.14
Pair test	ns	*	ns	*	ns
C.V. (%)	11.75	2.91	3.61	2.98	2.10

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

[2] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant differenceat 95% level ($P > 0.05$)

reduction effect on fruit size, regarding width and length. Excepted for spraying PBZ at 5000 ppm caused to increase the width (6.39 cm) and length (9.14 cm) of fruits more than other PBZ treatments (6.03-6.11 cm width and 8.53-8.6 cm in length). With respect to panicle stages when sprayed, fruits from spraying PBZ on 1 cm panicle were bigger than sprayed at 5 cm, regardless of width and thickness (Table 55).

The decreased size of fruit from panicle sprayed PBZ may be due to fruit size depended upon cell division and cell expansion (Gao *et al.*, 2001). PBZ was known to counteract the physiological effects of gibberellins which stimulate the multiplication and lengthening the meristem cells in fruit growth (Krisanapook *et al.*, 2000 ; Notodimedjo, 2000). Owing to PBZ had a role of its antigibberellin activity (Whiley, 1993 ; Pozo, 2001) and inhibited the synthesis of gibberellins (Blaikie *et al.*, 2004). Thus, there are several reports of reduced fruit size due to increased crop load (Embree *et al.*, 1987). Steffens *et al.* (1993) presented that PBZ treatment at 500 or 1000 mg/l, 2,4 and 6 weeks after full bloom, caused to reduce the length to width ratio (flatter fruit) of apple fruit cv. Gala. Huang *et al.* (1989) indicated that under higher concentrations of PBZ (1000 and 2000 ppm) sprayed as foliar application, strongly decreased fruit weight and reduced fruit length / diameter ratio of watermelon. In addition, Kataoka *et al.* (2003) reported that early tomato fruit growth cv. Severianin was suppressed by uniconazole (an inhibitor of gibberellin biosynthesis) treatment, applied at anthesis or a few days after anthesis. Moreover, the younger fruits at the time of uniconazole treatment, the smaller fruits at maturation. While, there are several reports of reduced fruit size due to PBZ application. Wieland and Wample (1985) presented though PBZ was a strong inhibitor of vegetative growth, but did not cause a significant reduction in fruit size when applied at rates that effectively reduce growth (Tukey, 1981 ; Greene, 1982 ; Williams, 1982). Furthermore, Kulkarni (1988) also found mango fruit size to be unaffected by PBZ.

6.3 Flesh content Kaew mango fruits had flesh content about 70.75%. PBZ concentrations according to specify in this experiment did not affect to change the flesh content compared with control trees. The data from Table 55 showed that all treatments had similar flesh content, in the range of 69.22-70.81%.

7. Weight and size of seed

7.1 Seed weight Kaew mango grew up under rainfed upland had seed weight

28.63 g or 16.2% weight by fruit weight. PBZ application affected to increase not only the fruit weight but also seed weight. All fruits from panicles sprayed with PBZ (25.10-26.26 g) had lighter seed weight than unsprayed (28.63 g), excepted for fruits from sprayed with PBZ at 5000 ppm (29.83 g). While, panicle stages when sprayed PBZ had no effect to seed weight. Seed from fruits sprayed on panicle 1 and 5 cm had similar weight, 27.46 and 26.73 g, respectively (Table 56).

Table 56. Weight and size of Kaew mango seeds at harvest after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Seed weight (g)	Seed size (cm)		
		Width	Length	Thickness
PBZ conc. (ppm)				
0	28.63 ab [1]	3.52 a	7.89 a	2.13 a
1000	25.65 c	3.33 b	7.39 b	2.01 b
3000	25.10 c	3.36 b	7.47 b	2.03 b
5000	29.83 a	3.52 a	7.99 a	2.12 a
7000	26.26 bc	3.32 b	7.44 b	2.12 a
$LSD_{0.05}$	0.90	0.05	0.11	0.03
C.V. (%)	8.16	3.43	3.50	3.43
Panicle length (cm)				
1	27.46	3.45	7.66	2.09
5	26.73	3.37	7.61	2.07
Pair test	ns	ns	ns	ns
C.V. (%)	10.30	4.05	4.74	4.16

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$)

7.2 Seed size At fully mature stage, seed size in terms of width, length and thickness were 3.52, 7.89 and 2.13 cm, respectively. PBZ application had significant effect to reduce seed size, excepted for PBZ at 5000 ppm. Seed size in terms of width, length and thickness from all panicle sprayed with PBZ (3.32-3.36, 7.39-7.47 and 2.01-2.03 cm) had less size than unsprayed (3.52, 7.89 and 2.13 cm), excepted for panicle sprayed with PBZ at 5000 ppm (3.52, 7.99 and 2.12 cm). While, fruits from panicle sprayed at both 1 and 5 cm gave the similar seed size (3.45-3.37 cm width, 7.61-7.66 cm length and 2.07-2.09 cm thickness), respectively (Table 56). Thus PBZ application could apply on panicle either 1 cm or 5 cm in length.

8. Internal quality

8.1 Fruit stalk toughness At fully mature stage, fruit stalk toughness of Kaew mango fruit was 3.06 kg. Both PBZ concentrations and panicle stages when sprayed had no significant effect on changing fruit stalk toughness. The data from Table 57 showed that fruit stalk toughness values among the treatments were between 2.84-3.06 kg.

8.2 Fruit firmness After peeling, fruit firmness harvested at fully mature stage was 13.48 kg/cm^2. PBZ application caused to increase the firmness of fruits. PBZ at higher and lower than 5000 ppm had negative effect to reduce fruit firmness, excepted for PBZ at 1000 ppm. While, there was no significant differences in resistance to puncture of fruit among the panicle stages at 1 and 5 cm when sprayed, 13.07 and 13.33 kg/cm^2 (Table 57). Luo *et al.* (1989) suggested that Golden Delicious apple fruits applied PBZ as foliar spraying, at 1500 mgl^{-1}, during first bloom and petal fall, gave more fruit firmness and the concentrations of Ca, Mg and P increased when compared with fruit from untreated trees. Furthermore, fruit sprayed with PBZ at full bloom or petal fall softened less than the others during storage. These may be due to ABA could exert an inhibitory effect upon the expression of α-amylase genes (Jacobsen *et al.*, 1995).

8.3 Total soluble solids (TSS) Kaew mango fruit had TSS content of 9.38°brix at fully mature stage. PBZ concentrations had no significant effect to TSS contents. All of treatments had the similar TSS, between 8.86-9.21°Brix. While fruits from panicle sprayed PBZ at 1 cm (9.34°Brix) had more TSS contents than sprayed at 5 cm (8.89°Brix) (Table 57). Tanner (1980) and Brenner (1989) claimed that ABA functions as a stimulator of unloading of assimilates from phloem into sink and as an promoter of sink activity. Wieland and Wample

Table 57. Internal qualities of Kaew mango fruits at harvest after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Fruit stalk toughness (kg)	Fruit firmness (kg/cm^2)	TSS (° Brix)	TA (%)
PBZ conc. (ppm)				
0	3.06	13.48 ab [1]	9.38	0.31 b
1000	2.97	13.77 a	9.21	0.34 a
3000	3.05	12.98 bc	9.14	0.33 ab
5000	2.89	13.25 ab	8.86	0.35 a
7000	2.84	12.53 c	9.00	0.34 a
$LSD_{0.05}$	ns	0.22	ns	0.01
C.V. (%)	6.90	4.16	6.15	6.70
Panicle length (cm)				
1	3.03	13.07	9.34 a [2]	0.33
5	2.90	13.33	8.89 b	0.34
Pair test	ns	ns	*	ns
C.V. (%)	6.80	5.06	5.59	7.34

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

[2] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$)

(1985) presented that the increased soluble carbohydrate (sugars and starch) levels in the leaf tissue treated PBZ of apples cv. Topred Delicious, might be caused by reducing growth and carbohydrate transport, coupled with reducing shoot growth. Furthermore, these increased sugars may be more readily available for increased sink growth, such as fruit growth.

8.4 Titratable acidity (TA) At harvesting, TA content was around 0.31%. PBZ application had positive effect to increase TA contents. Fruits from trees treated with all

PBZ concentrations had similar TA contents, ranged from 0.33-0.35%. While untreated trees had TA content only 0.31% (Table 57). In addition, there was no significant difference of TA contents among the panicle sprayed with PBZ at both 1 and 5 cm, 0.33 and 0.34%, respectively. Khader (1990) indicated that applied PBZ, as foliar spray 2000 or 3000 mgl^{-1}, advanced ripening significantly in 'Dashehari' mangoes, as judged from the pattern of post-harvest biochemical changes. Fruits harvested from fruits applied PBZ, attained better quality as judged from the total soluble solids, total acidity, ascorbic acid content, total chlorophyll, total carotenoids, amylase and peroxidase activity from harvest to 12 days of storage at ambient conditions.

9. Peel color Peel color measurements (L, c and h values) were taken at three sides : shoulder, middle and apex sides of fruit. PBZ application had no significant effect to change peel color of fruit, regarding of shoulder and middle, excepted for apex side. The results from Table 58 showed that fruits at end portion from panicle sprayed with PBZ (32.04-32.58) had the higher L values than unsprayed (31.74). These indicated that PBZ could retain the more lightness of green peel color at this side than control trees.

Table 58. Peel color of Kaew mango fruit at harvest after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Shoulder			Middle			Apex		
	L	c	h	L	c	h	L	c	h
PBZ conc. (ppm)									
0	35.12	22.83	178.92	32.44	22.74	181.35	31.74 b [1]	22.95	178.74
1000	35.26	23.56	178.79	32.58	23.05	181.36	32.31 a	23.40	178.69
3000	34.90	23.07	178.89	32.30	23.05	181.35	32.04 ab	22.75	179.18
5000	34.60	22.35	178.61	32.66	23.24	181.35	32.58 a	22.85	178.67
7000	35.76	22.77	178.76	33.43	23.09	181.35	32.48 a	22.92	178.66
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	0.19	ns	ns
C.V. (%)	2.61	6.10	0.12	2.05	4.21	0.01	1.43	3.37	0.29
Panicle length (cm)									
1	34.92	22.55	178.81	32.40 b [2]	22.58 b	181.35	32.07	22.51 b	178.68
5	35.34	23.28	178.77	32.97 a	23.49 a	181.35	32.39	23.43 a	178.89
Pair test	ns	ns	ns	*	**	ns	ns	**	ns
C.V. (%)	2.65	5.80	0.13	2.13	3.48	0.01	1.58	2.62	0.29

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

[2] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$)

10. Flesh color PBZ application had no effect to change flesh color, excepted for c values. Fruits from spraying PBZ 3000 ppm (35.34) had the highest c value than the others (33.81-34.69) (Table 59). While, fruits from panicle sprayed at 1 and 5 cm had the similar values of L, c and h, 49.64-49.56, 34.43-34.57 and 181.51-181.5, respectively.

Table 59. Flesh color of Kaew mango fruit at harvest after spraying with different PBZ concentrations at panicle length of 1 and 5 cm

Treatment	Flesh color		
	L	c	h
PBZ conc. (ppm)			
0	49.81	34.69 b [1]	181.51
1000	49.17	34.08 bc	181.50
3000	49.80	35.34 a	181.51
5000	49.60	33.81 c	181.51
7000	49.62	34.57 b	181.51
$LSD_{0.05}$	ns	0.22	ns
C.V. (%)	1.34	1.55	0.01
Panicle length (cm)			
1	49.64	34.43	181.51
5	49.56	34.57	181.50
Pair test	ns	ns	ns
C.V. (%)	1.36	2.15	0.01

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$)

3.2.2 PBZ concentrations and application stage

1. Panicle appearance stage Most of Inflorescence emerged in 11 February 2003, where average panicle length was 1.5-1.8 cm. Panicle gradually increased and reached a maximum size in 12-14 March 2003.

2. Moisture, chlorophyll, total nonstructural carbohydrate (TNC) and reducing sugar (RS) contents in leaves Leaves for measuring moisture content gained from a secondary pair of leaves attached to the panicle appearance shoot. At panicle appearance stage, moisture content of leaves attached to the panicle shoot was 49.47%. At this period, leaf moisture content of control and trees were the same as trees treated with PBZ, between 49.47-50.14% (Table 60). While chlorophyll contents in a secondary pair of leaves among the treatments were between 316.56-337.07 mg/g flesh weight (Table 60). In addition, at panicle appearance stage, TNC in leaves were higher than RS contents. Among all treatments, leaves on panicle appearance shoot contained the similar TNC and RS contents between 122.76-130.21 and 81.35-89.5 mg/g dry weight, respectively about, (Table 60).

Table 60. Moisture percentage, chlorophyll content, total nonstructural carbohydrate (TNC) and reducing sugar (RS) of Kaew mango leaves treated with three PBZ concentrations at panicle appearance stage

Treatment	Moisture content	Chlorophyll content	TNC	RS
	(%)	(mg/g flesh weight)	mg/g dry weight	
Control	49.47	337.07	130.21	81.35
PBZ 1000 ppm	49.77	325.49	122.76	88.72
PBZ 1500 ppm	50.14	316.56	127.85	89.50
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	2.96	9.99	4.71	10.67

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3. Flowered shoots All mango shoot did not develop to wholly panicle shoot because some shoots continued to be vegetative shoots. Full bloom stage of most inflorescence (80-90%) occurred during 12-14 March. The results indicated that average flowered shoot among the treatments were the same between 41.26-46.65% (Table 61). Yamashita (2000) indicated that flowering percentage of the shoot was positively correlated with nitrogen contents of the leaves, but negatively correlated with starch content of the leaves (Hamada, 1997).

Table 61. Flowering percentage and panicle size of Kaew mango treated with three PBZ concentrations at panicle appearance stage

Treatment	Flowered shoot (%)	Panicle size (cm)	
		Length	Diameter
Control	41.26	31.36 a[1]	16.32
PBZ 1000 ppm	46.57	24.64 ab	13.06
PBZ 1500 ppm	46.65	19.94 b	12.71
$LSD_{0.05}$	ns	2.27	ns
C.V. (%)	27.15	20.06	18.79

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

4. Panicle size Panicle size of mango at full bloom were 31.36 cm in length and 16.32 cm diameter. PBZ treatments had a negative effect on panicle size, particularly panicle length. The results from Table 61 indicated that panicles of the trees treated with PBZ at 1000 ppm (24.64 cm) had the same length as control trees (31.36 cm). While PBZ at 1500 ppm affected the length of panicle shorter than the others (19.94 cm). While panicle diameter did not affect the PBZ application. At full bloom, the diameter of mango panicle was 16.32 cm. PBZ application had no effect to panicle diameter. Among the treatments when 80-90% bloom, the size of panicle diameters ranged from 12.71-16.32 cm. Eiadthong *et al.* (2000) reported that the average size of inflorescence in *M. indica* distributed in Thailand have long terminal inflorescence (30 cm in

length). While the length of 1000 and 1500 ppm treated PBZ concentrations had shorter than control, 24.64 and 19.94 cm, respectively. The shorter panicle length were received from the more concentration of PBZ treated (Table 61). Due to PBZ was the most effective compound in retarding the growth, resulting in the shorter panicles treated with PBZ (Winston, 1992).

5. Span of time from panicle appearance to full bloom Panicle generally appeared in March 12-14. The appearance of panicles was not uniform among mature shoots. Span of time from panicle appearance to full bloom of mango trees was 29.46 days. PBZ application not exceed 1500 ppm did not affect the extension of full bloom stage. The times taken for panicle development from panicle appearance to reached nearly full bloom stage (80-90%) were similarly between 29.46-31.32 days (Table 62). Schaffer *et al.* (1994) presented that the period between floral initiation and anthesis could be as short as four weeks under tropical conditions.

Table 62. Span of time from panicle appearance to full bloom, floral sex percentage and floral sex ratio of Kaew mango treated with three PBZ concentrations at panicle appearance stage

Treatment	Days to full bloom	Floral sex percentage		Floral sex ratio (male/perfect flower)
		Male	Perfect	
Control	29.46	81.88	18.12	4.64
PBZ 1000 ppm	31.02	80.22	19.78	4.32
PBZ 1500 ppm	31.32	82.47	17.53	4.89
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	4.00	4.79	21.13	25.14

ns Non significant difference at 95% level ($P > 0.05$) by LSD

6. Floral sex percentage and sex ratio At full bloom, floral sex percentage between male and perfect flowers were 81.88 and 18.12%. In addition, sex ratio between male and perfect flower was 4.64. Both floral sex percentage and sex ratio were unaffected by PBZ application at the initial stage of flower development. The number of male and perfect flowers per panicle were similarly among all treatments between 80.22-82.47 and 17.53-19.78%, respectively. While sex ratio between male and perfect flower were 4.32-4.89 (Table 62). Singh *et al.* (1966) indicated

that the ratio between male and perfect flowers in each panicle varied from year to year depending on the temperature, location of the panicle in the tree (Schaffer *et al.,* 1994) and endogenous biotic factors in mango (Davenport and Nunez-Elisea, 1997).

7. Leaf moisture content Leaves of mango trees at full bloom contained the moisture contents of 52.06%. There was no significant difference about leaf moisture percentage among the control and trees treated with PBZ during full bloom, ranged from 52.06-52.73% (Table 63).

8. Leaf chlorophyll content Leaves of Kaew mango trees at full bloom comprised chlorophyll content 277.45 mg/g FW. PBZ spraying at panicle appearance did not affect the leaf chlorophyll contents. Among all three treatments, chlorophyll content in leaves was similarity between 262.67- 277.45 mg/g FW (Table 63).

Table 63. Moisture, chlorophyll, total nonstructural carbohydrate (TNC) and reducing sugar (RS) contents of Kaew mango leaves treated with three PBZ concentrations at panicle appearance stage

Treatment	Moisture content (%)	Chlorophyll content (mg/g flesh weight)	TNC content	RS content
			mg/g dry weight	
Control	52.06	277.45	128.37	76.10
PBZ 1000 ppm	52.73	262.67	129.31	73.75
PBZ 1500 ppm	52.08	263.07	141.85	73.75
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	1.56	11.86	8.21	7.36

ns Non significant difference at 95% level ($P > 0.05$) by LSD

9. TNC and RS in leaf At full bloom, TNC and RS in mango leaves of panicle shoots were 128.37 and 76.1 mg/g DW. PBZ application had no effect to these figures. Leaf TNC and RS contents were not significantly different among three treatments. The average TNC and RS contents in leaves of panicle shoot were between 128.37-141.85 and 73.75-76.1 mg/g dry weight, respectively (Table 63). The RS levels at this stage decreased slightly when compared with the initial stage of 1 cm panicle length (81.35-89.5 mg/g dry weight), this may be due to

soluble carbohydrates are utilized during panicle develop (Pongsomboon *et al.*, 1997) and stored carbohydrates in leaves may be more readily to be utilized (Phavaphutanon *et al.*, 2000). While, TNC at both stages remained constant levels.

Fruits at peanut stage

10. Span of time from full bloom to peanut stage Full bloom is a stage of pollination and fertilization was completed. The period from full bloom to peanut stage was 15.86 days after full bloom (DAF). PBZ had no effect to extend span of time from full bloom to peanut stage. Among the three treatments spent this period as same as 13.57-15.89 DAF (Table 64).

Table 64. Span of time from full bloom to peanut stage, fruited panicle and number of fruit per panicle of Kaew mango at peanut stage treated with three PBZ concentrations at panicle appearance stage

Treatment	Days to peanut stage	Fruited panicle (%)	Number of fruit/panicle
Control	15.86	53.00	2.37
PBZ 1000 ppm	13.57	56.00	2.57
PBZ 1500 ppm	15.89	56.25	2.89
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	16.04	22.39	17.95

ns Non significant difference at 95% level ($P > 0.05$) by LSD

11. Fruited panicle and fruit set The natural Kaew mango fruit started to set from a base toward the end of panicle. Peanut stage is the initial fruit set after full bloom. This stage fruit length was 1 cm or likes peanut seed. Generally fruited panicle at this stage was 53%. PBZ did not increase the fruited panicle. Among the treatments gave the same fruited panicle between 53.0-56.25%. As well the initial first sets in this stage were similar ranged from 2.37-2.89 fruit per panicle (Table 64). Davenport and Nunez-Elisea (1997) reported that early abscission of fruitlets derived from non-fertilized flowers. However, fruitlet abscission in this stage is often associated with embryo abortion (Ram *et al.*, 1976).

12. Fruit weight and fruit size The mango fruits develop right after pollination and fertilization. The growth of fruit was slowly at the first stage of growth. Weight and size of fruits at peanut stage were 1.02 g and 1.25, 1.83 and 1.17 cm, respectively. During this stage fruit size was increased in length more than width but the difference was not remarkable. PBZ did not affect weight and size of fruit at peanut stage. The average weight and size of fruits in terms of width, length and thickness were 1.02-1.6 g, 1.02-1.25, 1.5-1.83 and 1.0-1.17 cm, respectively (Table 65).

Table 65. Weight and size of Kaew mango fruit at peanut stage treated with three PBZ concentrations at panicle appearance stage

Treatment	Fruit weight (g)	Fruit size (cm)		
		Width	Length	Thickness
Control	1.02	1.25	1.83 a[1]	1.17 a
PBZ 1000 ppm	1.58	1.02	1.50 b	1.01 b
PBZ 1500 ppm	1.60	1.10	1.57 b	1.00 b
$LSD_{0.05}$	ns	ns	0.05	0.04
C.V. (%)	24.21	9.38	4.86	5.90

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

13. Leaf and fruit moisture contents Moisture contents in leaf and fruit of Kaew mango at peanut stage were 51.1 and 82.83%. There were no significant difference of leaf and fruit moisture contents among three treatments (Table 66). The moisture contents of leaves adhering panicle at peanut stage were between 50.36-51.14%, while the higher moisture contents found in fruits, ranged from 82.83-83.82%.

14. Leaf and fruit chlorophyll contents Chlorophyll contents in leaf and fruit at peanut stage were 300.15 and 33.06 mg/g FW. Among three treatments, PBZ did not affect the leaf and fruit chlorophyll contents. At peanut stage, the chlorophyll content in leaves were

between 259.54-300.15 mg/g FW while the higher contents contained in fruits (32.59-33.76 mg/g FW) (Table 66).

Table 66. Moisture and chlorophyll contents of Kaew mango leaves and fruits at peanut stage treated with three PBZ concentrations at panicle appearance stage

Treatment	Moisture content (%)		Chlorophyll content (mg/g flesh weight)	
	Leaves	Fruits	Leaves	Fruits
Control	51.10	82.83	300.15	33.06
PBZ 1000 ppm	51.14	83.82	274.45	33.76
PBZ 1500 ppm	50.36	83.37	259.54	32.59
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	2.09	0.91	10.86	8.69

ns Non significant difference at 95% level ($P > 0.05$) by LSD

15. Leaf and fruit TNC contents At peanut stage, TNC contents in leaf and fruit of Kaew mango were 119.48 and 202.49 mg/g DW. Initial fruit set at peanut stage, fruits started to accumulate TNC, which found the higher TNC contents than leaves. PBZ had no effect to change the TNC contents in leaves and fruits at this initial fruit set. Among all treatments indicated the similar TNC contents in leaves and fruits, ranged from 119.48-146.46 and 200.05-211.42 mg/g dry weight (Table 67). Leaf and fruit TNC contents of treated and non-treated trees tended to increase after the fruit setting period because following fruit set, starch accumulates in twigs, branches and trunk (Schaffer *et al.*, 1994) and mesocarp (Sirisakulwat *et al.*, 2001) then mobilized for fruit growth. In addition, total carbohydrates contents in bark of longkong started to decrease at the same time with fruits growth (Sethapukdee and Tuntiyawarong, 1997).

16. Leaf and fruit RS contents Leaves and fruit of Kaew mango showed the RS contents of 83.83 and 113.42 mg/g DW. At this stage, leaves adhering fruit, had lower RS content in fruits because the young fruits acted as the strong sinks. PBZ application had no effect to change both RS contents in leaf and fruit at this stage between 83.83-86.47 and 113.42-146.76 mg/g DW, respectively (Table 67).

Table 67. Total nonstructural carbohydrate (TNC) and reducing sugar (RS) contents in leaves and fruits of Kaew mango at peanut stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	TNC		RS	
	Leaves	Fruits	Leaves	Fruits
	mg/g dry weight			
Control	119.48	202.49	83.83	113.42
PBZ 1000 ppm	139.56	200.05	85.86	136.61
PBZ 1500 ppm	146.46	211.42	86.47	146.76
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	22.57	6.35	8.94	17.23

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Fruit at bird's egg stage

17. Span of time from peanut to bird's egg stage The duration of fruit development from peanut to bird's egg stage was 25.38 days. PBZ spraying on panicle appearance had no effect on extending this period. The time taken for this period from three treatments were

Table 68. Span of time from peanut to bird's egg stage, fruited panicle and number of fruit per panicle of Kaew mango at bird's egg stage after treated with three PBZ concentrations at panicle appearance

Treatment	Days to bird's egg stage	Fruited panicle (%)	Number of fruit per panicle
Control	25.38	36.00	1.34
PBZ 1000 ppm	23.38	39.00	1.31
PBZ 1500 ppm	25.11	38.75	1.23
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	6.51	42.96	13.29

ns Non significant difference at 95% level ($P > 0.05$) by LSD

similarly between 23.38-25.38 days (Table 68).

18. Fruited panicle and number of fruit per panicle Fruited panicle of Kaew mango at bird's egg stage was approximately 36%. In addition, number of fruit per panicle was about 1.34. After spraying PBZ, fruited panicle and number of fruit per panicle were not different among the treatments, ranged from 36.0-39.0% and 1.23-1.34 fruit per panicle, respectively (Table 68). Schaffer *et al.* (1994) found the problem of mango fruit drop is severe particularly during the first four weeks after set because during this stage nutrition will be shared among the young fruits. If nutrition is not sufficient, fruit will drop.

19. Fruit weight and fruit size Weight and size of fruit at bird's egg stage were 37.68 g and 2.31 cm width, 3.6 cm in length and 1.94 cm thickness. PBZ application had no effect to alter the weight of fruit at bird's egg stage. Among the treatments, there was no significant difference in fruit weight, ranged 34.28-39.17 g per fruit. In addition, PBZ also did not affect the

Table 69. Weight and size of Kaew mango fruit at bird's egg stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	Fruit weight (g)	Fruit size (cm)		
		Width	Length	Thickness
Control	37.68	2.31	3.60 a[1]	1.94
PBZ 1000 ppm	39.17	2.33	3.49 ab	1.94
PBZ 1500 ppm	34.28	2.19	3.30 b	1.88
$LSD_{0.05}$	ns	ns	0.07	ns
C.V. (%)	7.49	3.31	4.17	3.42

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

fruit size, excepted for fruit length. The results from Table 69 showed that fruit size in term of length decreased after spraying PBZ at 1500 ppm (3.3 cm) comparing with the others (3.49-3.6 cm).

20. Leaf and fruit moisture contents At bird's egg stage, leaf and fruit contained the moisture contents approximately 51.65 and 84.21%. PBZ spraying at panicle appearance had no affect the moisture contents both in leaf and fruit, ranged from 51.65-52.7 and 84.04-84.21%, respectively (Table 70).

Table 70. Moisture and chlorophyll contents of Kaew mango leaves and fruits at bird's egg stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	Moisture content		Chlorophyll content	
	Leaves	Fruits	Leaves	Fruits
	%		mg/g flesh weight	
Control	51.65	84.21	289.35	28.07
PBZ 1000 ppm	51.76	84.04	297.70	36.16
PBZ 1500 ppm	52.70	84.16	263.13	29.85
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	2.60	1.35	15.49	19.82

ns Non significant difference at 95% level ($P > 0.05$) by LSD

21. Leaf and fruit chlorophyll contents At bird's egg stage, chlorophyll contents in leaves (289.35 mg/g FW) were more than fruits (28.07 mg/g FW) around ten fold. PBZ application did not affect the chlorophyll content both leaves and fruits, ranged from 263.13-297.7 and 28.07-36.16 mg/g FW, respectively (Table 70).

22. Leaf and fruit TNC contents At bird's egg stage, Kaew mango fruits (205.57 mg/g DW) composed of TNC content more than leaves (130.6 mg/g DW). PBZ application did not affect the TNC contents in leaves. Among the treatments comprised the similar TNC contents between 125.27-131.43 mg/g DW. While PBZ concentration at 1500 ppm (225.08 mg/g DW)contained the TNC contents more than other treatments (202.61-205.57 mg/g DW) (Table 71).

Table 71. Total nonstructural carbohydrate (TNC) and reducing sugar (RS) contents of Kaew mango at bird's egg stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	TNC		RS	
	Leaves	Fruits	Leaves	Fruits
	mg/g dry weight			
Control	130.60	205.57 b[1]	72.67	143.58 b
PBZ 1000 ppm	125.27	202.61 b	73.51	140.42 b
PBZ 1500 ppm	131.43	225.08 a	75.81	157.72 a
$LSD_{0.05}$	ns	3.96	ns	3.54
C.V. (%)	6.87	3.75	6.70	4.80

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

23. Leaf and fruit RS contents Fruit development at bird's egg stage, fruit (143.58 mg/g DW) comprised RS contents more than leaves (72.67 mg/g DW) approximately two fold. PBZ had no effect on the RS contents in leaves. Among the treatments had the same RS contents of 72.67-75.81 mg/g DW. Wieland and Wample (1985) indicated that carbohydrates in leaves were presented as sugars and starch. These decreased sugars may be more readily available for increased sink growth, such as fruit growth. While PBZ had affect the RS contents in fruits. PBZ spraying at 1500 ppm (157.72 mg/g DW) contained RS contents more than the others (140.42-143.58 mg/g DW) (Table 71). Islam *et al.* (1996) suggested that a concurrent increase in reducing sugar with tomato fruit development. Changes in starch metabolism during fruit development have greatly influence the sugar content of the fruit.

Fruit at hen's egg stage

24. Span of time from bird's egg stage to hen 's egg stage Generally, the duration for fruit development from bird's egg to hen's egg stage was 35.58 days. PBZ spraying could not extend

the period for this fruit development. The time taken for this period were not different among the treatments (34.71-37.39 days) (Table 72).

Table 72. Span of time from bird's egg stage to hen's egg stage, fruited panicle and number of fruit per panicle of Kaew mango at hen's egg stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	Days to hen's egg stage	Fruited panicle (%)	Number of fruit per panicle
Control	35.58	25.00	1.18
PBZ 1000 ppm	34.71	18.00	1.15
PBZ 1500 ppm	37.39	25.00	1.09
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	8.54	62.57	8.35

ns Non significant difference at 95% level ($P > 0.05$) by LSD

25. Fruited panicle and number of fruit per panicle All of three treatments continued to reduce not only the fruited panicle but also the number of fruit per panicle at this stage. After bird's egg stage, fruited panicle at hen's egg stage decreased to 25%. In addition, there is 1.18 fruits per panicle at this stage. PBZ had no effect on changing both fruited panicle and number of fruit per panicle. Among the treatments contained the same fruited panicle and number of fruit per panicle, between 18.00-25.00% and 1.09-1.18 fruit, respectively (Table 72). Krisanapook *et al.* (2000) attributed that the main course of abscission at this stage was the competition among the fruits for reserve food. A fruit acquired all of its carbohydrates content from photosynthetic assimilates of the parent plant (Sirisakulwat *et al.*, 2001). Thus many fruits can fall at this stage if a tree has insufficient nutrition.

26. Weight and size of fruit Kaew mango fruit weight at hen's egg stage was 56.85 g. While size of fruit in terms of width, length and thickness were 4.37, 6.94 and 3.79 cm, respectively. PBZ application did not affect both the weight and size of fruit. At this stage, the weight and size of fruit among the treatments were not different (Table 73).

Table 73. Weight and size of Kaew mango fruit at hen's egg stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	Fruit weight (g)	Fruit size (cm)		
		Width	Length	Thickness
Control	56.85	4.37	6.94	3.79
PBZ 1000 ppm	60.01	4.47	7.05	3.89
PBZ 1500 ppm	53.82	4.37	6.70	3.73
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	18.55	7.00	5.28	6.49

ns Non significant difference at 95% level ($P > 0.05$) by LSD

27. Seed weight and flesh contents At this stage, seed weight and flesh content of Kaew mango fruit were only 4.24 g and 71.79%. PBZ did not affect the seed weight and flesh content. Among the treatments had the same seed weight (3.12-4.24 g) and flesh content (71.79-72.9%) (Table 74).

Table 74. Seed weight and flesh content of Kaew mango at hen's egg stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	Seed weight (g)	Flesh content (%)
Control	4.24	71.79
PBZ 1000 ppm	4.14	72.35
PBZ 1500 ppm	3.12	72.90
$LSD_{0.05}$	ns	ns
C.V. (%)	37.07	2.48

ns Non significant difference at 95% level ($P > 0.05$) by LSD

28. Leaf and fruit moisture contents At hen's egg stage, fruit moisture (76.6%) were higher levels than leaves adhering fruit (55.42%). There was no different of moisture content both in leaves (54.13-55.42%) and fruits (76.6-79.76%) at hen's egg (Table 75).

Table 75. Moisture and chlorophyll contents of Kaew mango leaves and fruits at hen's egg stage treated with three PBZ concentrations at panicle appearance stage

Treatment	Moisture content		Chlorophyll content	
	Leaves	Fruits	Leaves	Fruits
	%		mg/g flesh weight	
Control	55.42	76.60	220.86	147.62
PBZ 1000 ppm	54.13	79.76	236.20	153.01
PBZ 1500 ppm	54.34	78.68	247.17	161.50
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	4.16	3.74	15.21	8.40

ns Non significant difference at 95% level ($P > 0.05$) by LSD

29. Leaf and fruit chlorophyll contents At hen's egg stage, chlorophyll in leaves (220.86 mg/g FW) had more contents than fruits (147.62 mg/g FW). PBZ had no effect on increasing the chlorophyll contents. Among the treatments had the same chlorophyll levels in leaves and fruits as 220.86-247.17 and 147.62-161.5 mg/g FW (Table 75).

30. Leaf and fruit TNC contents Kaew mango fruits (266.5 mg/g DW) at hen's egg stage composed of TNC contents more than leaves (131 mg/g DW) approximate two fold. PBZ did not affect the TNC contents both in leaves and fruits, ranged from 127.58-134.32 and 266.5-283.32 mg/g DW weight, respectively (Table 76). Davie *et al.* (2000) attributed that starch reserves in source organs remain at their lowest levels during the period of rapid fruit growth or meaning that the depletion of starch reserves coincides with fruit set and fruit development.

31. Leaf and fruit RS contents RS contents in leaves (60.1 mg/g DW) were lower than fruits (147.13 mg/g DW) at this fruit stage. PBZ had no significant effect to these figures. Among the treatments had the same levels of RS in leaves and fruits, between 60.1-67.99 and 147.13-162.99 mg/g DW, respectively (Table 76). Islam *et al.* (1996) reported that there is a greater translocation of photosynthate into the fruit of cherry tomatoes, during fruit growth, because of the accumulation of sugars.

Table 76. Total nonstructural carbohydrate (TNC) and reducing sugar (RS) contents of Kaew mango leaf and fruit at hen's egg stage after treated with three PBZ concentrations at panicle appearance stage

Treatment	TNC		RS	
	Leaves	Fruits	Leaves	Fruits
	mg/g dry weight			
Control	131.00	266.50	60.10	147.13
PBZ 1000 ppm	134.32	278.43	67.99	162.99
PBZ 1500 ppm	127.58	283.32	67.10	154.95
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	5.29	4.77	9.16	5.74

ns Non significant difference at 95% level ($P > 0.05$) by LSD

At harvesting time

32. Harvesting times Under natural condition, the total period for fruit development was approximately 113.98 DAF. Both two PBZ concentrations had significant effect on delaying the harvesting period of Kaew mango comparing with the control. The application of PBZ at 1000 and 1500 ppm gave the same results. These two treatments could delay the harvesting period later than control by 6.37 and 5.05 days (Table 77). Nishizawa (1993) applied PBZ as a soil treatment to strawberry plants cultivar 'Nyoho' at the rate of 0, 0.01, 0.04, 0.09, 0.16 and 0.25 mg a.i. per pot. He found that the ripening of the berries was delayed by about 5 days. While, Khader (1990) applied PBZ as foliar spray at 250, 500, 1000, 2000 or 3000 mg l^{-1} on 15 October 1987 followed by another spray 20 days before harvest (13 May 1988) in 'Dashehari' mango trees. The results indicated that PBZ extended ripening significantly in 'Dashehari' mangoes, as judged from the pattern of post-harvest biochemical changes. In addition, ABA has been shown to affect the amounts and composition of storage proteins. ABA not only inhibited synthesis of hydrolytic enzymes that are essential for the breakdown of storage reserves in seeds, but also it inhibited the GA-dependent enzyme synthesis by inhibiting the transcription of α-amylase mRNA (Taiz and Zeiger, 1998).

Table 77. Span of time from full bloom to harvest stage, fruited panicle and number of fruit per panicle of Kaew mango after treated with three PBZ concentrations at panicle appearance stage

Treatment	Days to harvest (DAF)	Fruited panicle (%)	Number of fruit per panicle
Control	113.98 b[1]	22.00	0.85
PBZ 1000 ppm	120.35 a	16.00	0.69
PBZ 1500 ppm	119.03 ab	21.25	0.84
$LSD_{0.05}$	1.63	ns	ns
C.V. (%)	2.76	56.79	12.61

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

33. Fruited panicle and number of fruit per panicle At harvesting, fruited panicle of mango trees was around 22%. In addition, the number of fruit per panicle at this stage was 0.85 fruit per panicle. PBZ had no effect on decreasing the fruited panicle and number of fruit per panicle. The remaining fruited panicle and number of fruit per panicle of all three treatments at harvesting were between 16.0-22.0% and 0.69-0.84, respectively (Table 77).

34. Yield Yield of Kaew mango trees was approximately 127.25 kg /tree. The data pertaining to yield indicated that PBZ had no effect on increasing the yield of Kaew mango trees. Among the treatments, the yield did not show any difference, between 127.25-211.0 kg/tree (Table 78).

External characteristics of Kaew mango fruits at harvesting date

35. Size and weight of fruit at harvesting At harvesting, the size of Kaew mango fruits in terms of width, length and thickness were 7.25, 11.08 and 6.67 cm, respectively. It is revealed from Table 79 that more less all the PBZ treated trees showed a significantly reduction in size and weight of fruit comparing with the untreated trees. PBZ at 1000 ppm caused to decrease both fruit size (6.88 cm width, 10.09 cm in length and 6.42 cm thickness) and fruit

Table 78. Yield of Kaew mango fruits treated with three PBZ concentrations at panicle appearance stage

Treatment	Yield (kg/tree)
Control	127.25
PBZ 1000 ppm	211.00
PBZ 1500 ppm	156.25
$LSD_{0.05}$	ns
C.V. (%)	28.19

ns Non significant difference at 95% level ($P > 0.05$) by LSD

weight (262.26 g)at harvesting date (Table 79). Huang *et al.* (1989) reported that the effect of spraying PBZ 6 concentrations (200, 300, 400, 500, 1000 and 2000 ppm) by foliar application on watermelon growth. The results found that PBZ strongly inhibited plant growth and influenced fruit size. The effect occurred immediately after application. From this reason, may lead to retard cell division and cell expansion of fruit after anthesis. Under higher concentrations the mean fruit weight decreased, the fruit length / diameter ratio was reduced.

Table 79. Size and weight of fully maturity Kaew mango fruits after treated with three PBZ concentrations at panicle appearance stage

Treatment	Fruit size (cm)			Fruit weight
	Width	Length	Thickness	(g)
Control	7.25 a[1]	11.08 a	6.67 a	298.5 a
PBZ 1000 ppm	6.88 b	10.09 b	6.42 b	262.26 b
PBZ 1500 ppm	7.14 a	10.23 b	6.69 a	285.60 a
$LSD_{0.05}$	0.06	0.12	0.06	6.78
C.V. (%)	1.82	2.65	1.93	4.81

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

36. Size and weight of seed At harvesting, the size of Kaew mango seed at harvesting were 4.26 cm width, 9.23 cm in length and 2.07 cm thickness. In addition, seed weight was 37.78 g. PBZ application affected to decrease the size and weight of seed, particularly at 1000 ppm (Table 80). These may be due to the effect of PBZ caused to lower the fruit size.

Table 80. Size and weight of Kaew mango seeds and flesh content treated with three PBZ concentrations at panicle appearance stage

Treatment	Seed size (cm)			Seed weight	Flesh content
	Width	Length	Thickness	(g)	(%)
Control	4.26 a[1]	9.23	2.07 a	37.78 a	80.64
PBZ 1000 ppm	4.00 b	8.70	1.92 b	31.24 b	80.93
PBZ 1500 ppm	4.27 a	8.89	2.14 a	39.48 a	79.93
$LSD_{0.05}$	0.06	ns	0.03	1.99	ns
C.V. (%)	2.87	3.09	3.02	11.00	0.92

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

37. Flesh percentage Kaew mango fruit at fully mature stage had flesh content approximately 80.64%. PBZ application had no effect on decreasing flesh content. Among all treatments had flesh contents exceed 79% weight by weight (Table 80).

38. Peel color The difference of peel color after applying PBZ was distinctly at the middle and apex sides of fruit. At both side, 1000 ppm PBZ had affected on increasing the c values at middle (27.4) and at apex sides (27.55) than the others (25.78-25.81 and 26.28-26.32, respectively). These indicated that PBZ treatment at 1000 ppm, had affect on containing more vividness of green color, particularly at middle and apex sides of fruit (Table 81).

Table 81. Peel color of Kaew mango fruits treated with three PBZ concentrations at panicle appearance stage

Treatment	Shoulder portion			Middle portion			Apex portion		
	L	c	h	L	c	h	L	c	h
Control	29.93	24.68 a[1]	93.82	32.43	25.81 b	99.18 b	32.68 b	26.32 b	101.25 b
PBZ 1000 ppm	28.99	23.79 a	93.71	31.66	27.40 a	100.74 a	33.49 ab	27.55 a	102.04 a
PBZ 1500 ppm	29.45	22.45 b	93.48	32.81	25.78 b	100.85 a	33.95 a	26.28 b	102.55 a
$LSD_{0.05}$	ns	0.28	ns	ns	0.33	0.21	0.28	0.28	0.21
C.V. (%)	2.51	2.37	1.22	2.26	2.52	0.42	1.65	2.06	0.41

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

External characteristics of Kaew mango fruits at harvested day

39. Fruit firmness and fruit stalk toughness Kaew mango fruits harvested at fully maturity measured the fruit firmness and fruit stalk toughness of 9.65 kg/cm^{2}and 4.74 kg, respectively. PBZ application did not affect these two figures. It was revealed from Table 83 that fruits from all three doses of PBZ application, gave the same fruit firmness and fruit stalk toughness, between 9.65-9.98 kg/cm^2 and 4.35-4.74 kg, respectively (Table 82).

Table 82. Fruit firmness and fruit stalk toughness of Kaew mango treated with three PBZ concentrations at panicle appearance stage

Treatment	Fruit firmness (kg/cm^2)	Fruit stalk toughness (kg)
Control	9.65	4.74
PBZ 1000 ppm	9.77	4.53
PBZ 1500 ppm	9.98	4.35
$LSD_{0.05}$	ns	ns
C.V. (%)	3.99	6.10

ns Non significant difference at 95% level ($P > 0.05$) by LSD

40. Flesh color PBZ application affect the flesh color of Kaew mango fruits when harvested at fully maturity. The difference of peel color in terms of L and h values showed after spraying 1000 ppm PBZ on panicle appearance. Fruits from trees treated with 1000 ppm PBZ gave the higher L (52.03) and h values (87.46) than the others (Table 83). These indicated that PBZ at 1000 ppm provided the greener flesh than untreated.

41. Total soluble solids (TSS) and titratable acidity (TA) At harvesting, Kaew mango fruits had TSS and TA contents of 8.06°brix and 0.22%, respectively. PBZ application on panicle appearance had no effect on changing these two figures. Among the treatments had the same TSS and TA contents, ranged from 8.06-8.72 °brix and 0.21-0.23%, respectively (Table 84). Anggarwati (1985) presented that application of plant growth regulators did not give any effect

Table 83. Flesh color of Kaew mango fruits treated with three PBZ concentrations at panicle appearance stage

Treatment	Flesh color		
	L	c	h
Control	51.07 b	33.73	86.06 b[1]
PBZ 1000 ppm	52.03 a	34.15	87.46 a
PBZ 1500 ppm	51.23 b	34.66	85.73 b
$LSD_{0.05}$	0.16	ns	0.33
C.V. (%)	0.59	2.37	0.77

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

on the qualities of fruits. These characters might be dued to the effect of genetic factors or the environmental factors.

Table 84. Total soluble solids (TSS) and titratable acidity (TA) of Kaew mango fruits treated with three PBZ concentrations at panicle appearance stage

Treatment	TSS (° Brix)	TA (%)
Control	8.06	0.22
PBZ 1000 ppm	8.72	0.21
PBZ 1500 ppm	8.38	0.23
$LSD_{0.05}$	ns	ns
C.V. (%)	4.49	7.80

ns Non significant difference at 95% level ($P > 0.05$) by LSD

42. Moisture percentage of fruits and leaves Moisture contents in fruits and leaves measured at harvesting were 78.31 and 49.56%. PBZ caused to reduce moisture contents to 76.8-

77.06% comparing with control (78.31%). While PBZ did not change the moisture levels in leaves, all treatments gave the same moisture contents not exceed 50% (Table 85).

Table 85. Moisture and chlorophyll contents of Kaew mango fruits treated with three PBZ concentrations at panicle appearance stage

Treatment	Moisture percentage		Chlorophyll contents	
	Fruits	Leaves	Fruits	Leaves
	%		mg/g flesh weight	
Control	78.31 a[1]	49.56	100.56 b	266.78
PBZ 1000 ppm	76.80 b	49.58	128.33 a	292.32
PBZ 1500 ppm	77.06 b	49.58	122.77 a	283.94
$LSD_{0.05}$	0.24	ns	1.97	ns
C.V. (%)	0.61	1.49	3.36	6.70

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

43. Chlorophyll content of fruits and leaves At harvesting, leaves (266.78 mg/g FW) contained more chlorophyll contents than fruits (100.56 mg/g FW). Leaf chlorophyll content after treatment did not affect by the PBZ application. Chlorophyll contents in leaves among the treatments are the similar levels, ranged from 266.78-292.32 mg/g FW. Wieland and Wample (1985) presented that PBZ at 25, 50 and 150 mg active ingredient applied as a soil drench or stem application to 1-year-old 'Topred Delicious' apples. The results showed that chlorophyll contents were not affected from both application methods. In addition, Steffens *et al.* (1993) indicated that PBZ treated 'Gala' apple (*Malus domestica* Borkh.) trees sprays at 500 or 1000 mg/L 2,4 and 6 weeks after full bloom.

PBZ application of mango fruits treated with two PBZ concentrations (122.77-128.33 mg/g FW) retained higher chlorophyll contents than untreated trees (100.56 mg/g FW) (Table 85). Khader (1990) applied PBZ as foliar spray at 250, 500, 1000, 2000 or 3000 mg/L on 15 October

1987 followed by another spray 20 days before harvest (13 May 1988) in 'Dashehari' mango (*Mangifera indica* L.) trees. These treatments attained better quality as judged from the total chlorophyll content from harvest to 12 days of storage at ambient conditions. While, Gianfagna (1995) reported that growth retardants generally increase the green color. For example, in apple, daminozide will inhibit ethylene production by blocking the conversion of methionine to aminocylclopropane 1- carboxylic acid, and delay the appearance of the respiratory climacteric. This will permit a delay in the harvest date. However, Takamiya *et al.* (2000) indicated that chlorophyll degradation could take place during various phases of the life cycle of plants, but the mechanism of this degradation was largely unknown.

44. Total non structural carbohydrate (TNC) in fruits and leaves At harvesting, mango fruits (716.81 mg/g DW) comprised TNC contents more than leaves (173.06 mg/g DW). Both TNC contents in fruits and leaves were not affected from PBZ application among the treatments provided the similar TNC contents in fruits (684.25-733.34 mg/g DW) and leaves (167.24-173.06 mg/g DW) (Table 86). Wieland and Wample (1985) showed the increased carbohydrate levels in the tissue might also be caused by reduced growth and carbohydrate transport. While Tanner (1980) and Brenner (1989) claimed that ABA functions to accumulate

Table 86. Total nonstructural carbohydrate (TNC) and reducing sugar (RS) contents of Kaew mango fruits and leaves treated with three PBZ concentrations at panicle appearance stage

Treatment	TNC		RS	
	Fruits	Leaves	Fruits	Leaves
	mg/g dry weight			
Control	716.81	173.06	215.50	73.89
PBZ 1000 ppm	684.25	167.43	199.60	76.03
PBZ 1500 ppm	733.34	167.24	211.54	76.41
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	4.28	5.86	11.06	9.05

ns Non significant difference at 95% level ($P > 0.05$) by LSD

assimilates, by functions of ABA as a stimulater of unloading of assimilates from phloem into sink and as an promoter of sink activity.

45. Reducing sugars (RS) in fruits and leaves RS contents in leaves (73.89 mg/g DW) were less than fruits (215.5 mg/g DW) at harvesting. PBZ did not change the RS contents in fruits and leaves. Among the treatments comprised the similar RS levels in fruits and leaves, between 199.6-215.5 and 73.89-76.41 mg/g DW, respectively (Table 86).

3.3 Delaying the preharvest fruit maturity This stage was divided into two experiments : bagging and Giberellin application.

3.3.1 Fruit bagging Bagging is another method in order to test the effect of delay fruit maturation attached to the tree. Newspaper bag size of 14.5 x 21 cm was taken to wrap mango fruit. Fruit bagging was taken at 3 fruit ages, namely 30, 45 and 60 DAF. These ages, size of mango fruit in terms of width, length and thickness were around 3.43, 5.3 and 3.0 cm at 30 DAF, 5.35, 8.14 and 4.67 cm at 45 DAF and 5.94, 8.83 and 5.21 cm at 60 DAF.

1. Fruit size

1.1 Fruit width Under normal growing conditions at 30 DAF, fruit width was more than 3.4 cm. After that, fruit width continued to increase until harvesting. Fruit bagging at 30, 45 and 60 DAF had no effect to widen and enlargement along the width of fruit.

Table 87. Fruit width of Kaew mango after bagging at 30, 45 and 60 DAF

Treatment	Fruit width (cm)				
	30 DAF	40 DAF	50 DAF	60 DAF	harvest
Control (no bagging)	3.43	4.29	5.35	5.94	6.23
Bagging 30 DAF	3.42	4.35	5.49	6.03	6.30
Bagging 45 DAF	3.46	4.43	5.58	6.08	6.29
Bagging 60 DAF	3.52	4.53	5.62	6.24	6.50
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V.(%)	4.29	5.49	6.16	5.83	6.24

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Fruit width and width enlargement from bagging at 3 fruit ages (30, 45 and 60 DAF) was not different when compared with control trees. The average fruit width of all treatments at harvesting was over than 6.2 cm (Table 87).

1.2 Fruit length Before bagging on fruit 30 DAF, fruit size was nearly to hen's egg stage. The length of fruit was around 5.3 cm. Fruit elongation in term of length still increased their size after 30 DAF until harvesting. Regardless of bagging at 3 fruit ages had no significant effect to fruit length. Among all treatments had the same fruit length when harvested at fully mature stage. This stage, the average fruit length is over than 9 cm (Table 88).

Table 88. Fruit length of Kaew mango after bagging at 30, 45 and 60 DAF

Treatment	Fruit length (cm)				
	30 DAF	40 DAF	50 DAF	60 DAF	harvest
Control (no bagging)	5.30	6.67	8.14	8.83	9.10
Bagging 30 DAF	5.33	6.89	8.53	9.24	9.46
Bagging 45 DAF	5.29	6.86	8.38	9.13	9.31
Bagging 60 DAF	5.43	7.00	8.53	9.29	9.57
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V.(%)	3.95	4.84	6.27	5.77	6.07

ns Non significant difference at 95% level ($P > 0.05$) by LSD

1.3 Fruit thickness At 30 DAF, fruit thickness was around 3.0 cm. Fruit growth in term of thickness enlargement was still increasing from 30 DAF until harvesting. Fruit bagging at 3 stages had no significant effect to this figure. At harvesting, fruit thickness of all treatments was over than 5.4 cm (Table 89). de Leon *et al.* (2000) reported that growth curve of mango fruit exhibited a simple sigmoid type. Rapid fruit growth during 14 to 42 DAF is associated with cell division and enlargement (Ram, 1992 ; Schaffer *et al.*, 1994). While further fruit growth, between week 5-8 was dependent on cell enlargement and after that growth rate was slow (Schaffer *et al.*, 1994 ; Krisanapook *et al.*, 2000). At present, there is a general assumption that fruit set and fruit growth are under endogenous hormonal control, particularly three hormonal

compounds of auxin, gibberellins and cytokinins (Santes *et al.*, 1995 ; Talon *et al.*, 1997). Thus, fruit bagging did not affect to fruit size in this experiment.

Table 89. Fruit thickness of Kaew mango after bagging at 30, 45 and 60 DAF

Treatment	Fruit thickness (cm)				
	30 DAF	40 DAF	50 DAF	60 DAF	harvest
Control (no bagging)	3.00	3.83	4.67	5.21	5.47
Bagging 30 DAF	2.98	3.78	4.77	5.18	5.46
Bagging 45 DAF	3.02	3.88	4.90	5.35	5.56
Bagging 60 DAF	3.10	3.97	4.92	5.45	5.71
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V.(%)	5.96	8.13	8.84	8.16	7.19

ns Non significant difference at 95% level ($P > 0.05$) by LSD

2. Fruit drop In this experiment, fruit drop was computed in term of percentage from the remainder of fruit number between previous and next stage. Thus, there were 4 times for

Table 90. Fruit drop of Kaew mango after bagging at 30, 45 and 60 DAF

Treatment	Fruit drop (%)			
	40 DAF	50 DAF	60 DAF	70 DAF
Control (no bagging)	7.50	10.00	10.00	12.50
Bagging 30 DAF	15.00	18.75	17.50	17.50
Bagging 45 DAF	7.50	7.50	11.25	11.25
Bagging 60 DAF	8.75	11.25	17.50	16.25
$LSD_{0.05}$	ns	ns	ns	ns
C.V.(%)	106.14	86.38	88.74	84.90

ns Non significant difference at 95% level ($P > 0.05$) by LSD

recording fruit drop. Mango fruit drop may occur in different stages of fruit growth. Under normal growing condition, 10 days after bagging on fruit 30 DAF, fruit drop was lower than 15%. Further drop continued to occur after 30 DAF until harvesting. Fruit bagging at 3 fruit ages had no significant effect on decreasing this figure. Before harvesting, there was no different fruit drop among all treatments, ranged from 11.25-17.5% (Table 90). Krisanapook *et al.* (2000) reported that both internal and external factors involved with fruit retention. Many fruits are abscised during growth apparently due to the competition among the fruits for assimilate availability (Ruiz and Guardiola, 1994). Majority fruit drop (24.4%) of mango cv. 'Khiew Sawoey' occurred at two-three weeks after full bloom. After that the fall of fruit became constant around 7.4% at week 6 until harvesting (Krisanapook *et al.*, 2000). Thus, fruit drop of all treatments in this experiment were not different because bagging treatment which started at 30 DAF had passed the timing of heavy fruit drop already.

3. Fruit retention Before bagging on fruit 30 DAF, each panicle carried 1.32-1.47 fruits per panicle. After that fruits on panicle of all treatments continued to occur a little drop until harvesting. Fruit bagging at 3 fruit stages had no significant effect to alter the fruit retention per panicle. At harvesting, although control trees (1.28 fruits) tended to have higher fruit retention per panicle than the others (1.13-1.22 fruits) but there was not different among the treatments (Table 91). Chacko (1984) indicated that the ability of a fruit retention depended upon

Table 91. Fruit retention of Kaew mango after bagging at 30, 45 and 60 DAF

Treatment	Fruit retention per panicle				
	30 DAF	40 DAF	50 DAF	60 DAF	70 DAF
Control (no bagging)	1.41	1.35	1.32	1.28	1.28
Bagging 30 DAF	1.47	1.35	1.30	1.26	1.22
Bagging 45 DAF	1.32	1.25	1.19	1.18	1.15
Bagging 60 DAF	1.35	1.22	1.20	1.19	1.13
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V.(%)	15.10	12.94	10.96	9.46	8.87

ns Non significant difference at 95% level ($P > 0.05$) by LSD

both assimilate availability and the capacity of the fruit itself to act as a sink for assimilates. Schaffer *et al.* (1994) reported that the heavy fruit drop in mangos appeared particularly during the first four weeks after setting. Thus, many mango cultivars usually carried only one fruit per panicle through to harvest.

4. Fruit weight and flesh content According to natural condition, fruit weight of Kaew mango at harvesting was around 181.64 g per fruit. Fruit bagging had no significant effect on increasing weight of fruit. At harvesting, although fruits from bagging (196.81-216.93 g) tended to have more weight than control (181.64 g) but there was not different between treatments (Table 92).

When taken weight of seed and peel subtracted from fruit weight and calculated as flesh content. Fruit bagging had no significant effect on increasing the flesh content. At harvesting, among all treatments had the same flesh content, ranged from 76.26-77.82%, excepted for bagging at 45 DAF gave the less flesh content (74.68%) (Table 92).

Table 92. Fruit weight and flesh content of fully mature Kaew mango at harvesting after bagging at 30, 45 and 60 DAF

Treatment	Fruit weight (g)	Flesh content (%)
Control (no bagging)	181.64	76.26 ab[1]
Bagging 30 DAF	210.45	77.60 a
Bagging 45 DAF	196.81	74.68 b
Bagging 60 DAF	216.93	77.82 a
$LSD_{0.05}$	ns	1.94
C.V. (%)	12.84	1.94

[1] Mean within column with different alphabets differ significantly at $P \leq 0.05$ by LSD

ns Non significant at 95% level ($P > 0.05$)

5. Size and weight of seed At harvesting, size of seed (width, length and thickness) from general tree were 3.71, 8.11 and 1.83 cm, respectively. Bagging had no significant effect on increasing seed size at harvesting, excepted for seed width. Bagging taken

on fruits at 45 DAF affected to increase a little seed width (4.43 cm) when compared with the others (3.71-4.1 cm) (Table 93). In addition, bagging had no significant effect on increasing seed weight. At harvesting, all treatments gave the similar seed weight, between 27.85-35.22 g (Table 93). Ram (1992) reported that mango seed took about 77 d to complete their major part of growth. While, Krisanapook *et al.* (2000) indicated that after week 8, seed weight seemed to cease already.

Table 93. Size and weight of Kaew mango seeds at harvesting after bagging at 30, 45 and 60 DAF

Treatment	Seed size (cm)			Weight
	Width	Length	Thickness	(g)
Control (no bagging)	3.71 b [1]	8.11	1.83	27.85
Bagging 30 DAF	3.71 b	8.63	1.95	32.00
Bagging 45 DAF	4.43 a	9.03	2.01	35.22
Bagging 60 DAF	4.10 ab	9.01	1.80	28.65
$LSD_{0.05}$	0.15	ns	ns	ns
C.V. (%)	7.60	6.79	8.16	13.58

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

6. Internal qualities

6.1 Fruit stalk toughness At harvesting, fruit stalk toughness of Kaew mango fruits under natural condition, were 3.78 kg. Bagging had no significant effect on changing fruit stalk toughness. Among all treatments had the same fruit stalk toughness, ranged from 3.67-3.83 kg (Table 94).

6.2 Fruit firmness At fully mature stage, mango fruit had the firmness value after peeling of 14.84 kg/cm^2. Bagging at all 3 stages had no significant effect on

decreasing the firmness of fruit. All treatments gave the same fruit firmness values of over than 14 kg/cm^2 (Table 94).

6.3 Total soluble solids (TSS) Fruits harvested at fully mature stage had TSS contents 9.46 ° Brix. Bagging on fruits at early stage (30 and 45 DAF) had a significant effect on decreasing the TSS levels ranged from 7.5-7.91° Brix. While, bagging at later stage of 60 DAF and control trees gave the higher TSS contents of 8.99-9.46° Brix (Table 94). Owing to the direct effect of light on biochemical reactions and metabolic processes, it provides the physical impetus for the production of sugars. Thus poor light utilization due to shading might be limited carbohydrate resources for growth or the active uptake of essential nutrient elements. Rom (1996) also indicated that the condition of light levels less than 70 to 80% full sun, TSS content of apple fruits was reduced.

6.4 Titratable acidity (TA) At harvesting, TA content in mango juice was 0.45%. The application of bagging did not have any effect on changing TA levels. All treatments which harvested at fully mature stage had the same TA contents of 0.37-0.50% (Table 94).

Table 94. Internal fruit qualities of fully mature Kaew mango at harvesting after bagging at 30, 45 and 60 DAF

Treatment	Fruit stalk toughness (kg)	Fruit firmness (kg/cm^2)	TSS (° Brix)	TA (%)
Control (no bagging)	3.78	14.84	9.46 a[1]	0.45
Bagging 30 DAF	3.76	14.43	7.91 b	0.43
Bagging 45 DAF	3.67	14.69	7.50 b	0.37
Bagging 60 DAF	3.83	14.77	8.99 a	0.50
$LSD_{0.05}$	ns	ns	0.22	ns
C.V.(%)	9.49	4.37	5.17	14.61

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

7. Peel color Peel color in terms of L, c and h was measured at three sections : shoulder, middle and apex. Under natural condition, peel color of harvested fruit at three sections had L, c and h values ranged from 45.32-47.53, 27.51-29.18 and 178.67-178.73, respectively. Bagging fruit at 3 stages had no significant effect to peel color in terms of c and h values at all three sections, excepted for L values from shoulder and middle portions. Both these two sections, fruits from bagging at all three fruit stages (50.83-54.17 at shoulder and 49.64-51.88 at middle fruit) had higher L values than control trees (47.53 at shoulder and 45.84 at middle fruit) (Table 95). These indicated that bagging treatment could retain the higher lightness of green color at peel than unbagging. But these L values difference was a little effect to peel color when compared with the overall view. Tyas *et al.* (1998) reported that the bagging taken when fruits are developing could improve the color quality in many fruits. In addition, Kays (1999) reported that bagging is an application to delay the mango fruit color development.

Table 95. Peel color of fully mature Kaew mango fruits at harvesting after bagging at 30, 45 and 60 DAF

Treatment	Shoulder			Middle			Apex		
	L	c	h	L	c	h	L	c	h
Control (no bagging)	47.53 c [1]	27.51	178.67	45.84 b	28.16	178.71	45.32	29.18	178.73
Bagging 30 DAF	54.17 a	28.37	178.67	51.88 a	30.45	178.69	47.09	28.38	178.75
Bagging 45 DAF	53.20 ab	31.07	178.67	51.37 a	28.47	178.72	48.49	28.42	178.75
Bagging 60 DAF	50.83 b	28.11	178.68	49.64 a	27.64	178.71	47.77	26.86	178.75
$LSD_{0.05}$	0.89	ns	ns	1.05	ns	ns	ns	ns	ns
C.V.(%)	3.47	12.90	0.02	4.24	8.18	0.01	3.54	6.91	0.01

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

8. Flesh color Bagging had a significant effect to flesh color in terms of L and h values, excepted for c value. L and h values of flesh color among the all treatments were similar, ranged from 67.8-72.3 and 178.49-179.64. While bagging fruit at early stage (30 DAF) showed less c value (32.26) than the others (33.52-35.57) (Table 96). These indicated that early bagging at 30 DAF caused to decrease the green color vividness of flesh color.

Table 96. Flesh color of fully mature Kaew mango fruits at harvesting after bagging at 30, 45 and 60 DAF

Treatment	L	c	h
Control (no bagging)	67.80	35.57 a[1]	178.91
Bagging 30 DAF	72.30	32.26 b	179.64
Bagging 45 DAF	69.81	33.52 ab	178.97
Bagging 60 DAF	71.70	33.86 ab	178.49
$LSD_{0.05}$	ns	0.68	ns
C.V.(%)	4.16	3.99	0.43

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

9. Harvesting period Generally, Kaew mango was ready to harvest at fully mature stage around 117.86 DAF. Bagging fruit at three stages did not affect to extend the harvesting period. Fruits of all treatments were harvested at the same time, ranged from 117.86-122.27 DAF (Table 97). From evaluation the maturity indices for harvesting which are determined on external characteristics, such as skin color participate with internal qualities, such as fruit stalk toughness, fruit firmness and titratable acidity. These indices taken into assume the harvesting time between trees treated with bagging and control trees is not different. Because at harvesting mango fruits maintain the same external and internal qualities.

Table 97. Days to harvesting of Kaew mango after bagging at 30, 45 and 60 DAF

Treatment	Days to harvesting (DAF)
Control (no bagging)	117.86
Bagging 30 DAF	120.85
Bagging 45 DAF	122.27
Bagging 60 DAF	119.38
$LSD_{0.05}$	ns
C.V.(%)	1.94

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3.3.2 GA concentrations and number of applications Gibberellin (GA) application was an another alternatives for delaying the maturity of Kaew mango fruits on the tree. However, available report did not mention that the effect of preharvest application of GA with Kaew mango for these purpose. Thus preliminary research was studied about the probability about GA concentration and number of application times which was the optimum practical method for extending the mature of fruits on the tree to produce late season.

1. Fruit growth After GA application on fruits at 80 DAF, mango fruits of all treatments continued to increase their size in the same trend, regardless of width, length and thickness.

1.1 Fruit width Generally, the width of mango fruit is nearly stop to increase the width at 90, 100 and 110 DAF. The average of these figures were 6.26, 6.87 and 6.74 cm, respectively. GA spraying on fruits at 80 DAF, had no a significant effect on increasing the fruit width. Thus, there was not different in fruit width between trees treated with GA and untreated trees. Fruit width among all treatments at 90, 100 and 110 DAF did not exceed 6.4, 6.9 and 7 cm, respectively. In addition, the number of GA application (one and two times) also had no a significant effect on increasing fruit width. The fruit widths from spraying with GA at 90, 100 and 110 DAF, were around 6.22-6.23, 6.53-6.63 and 6.63-6.79 cm, respectively (Table 98).

Table 98. Fruit width of Kaew mango after GA applications at 80 DAF

Treatment	Fruit width (cm)		
	90 DAF	100 DAF	110 DAF
GA conc. (ppm)			
0	6.26	6.87	6.74
50	6.20	6.59	6.77
100	6.33	6.69	6.88
150	6.13	6.49	6.62
200	6.21	6.57	6.54
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	2.48	3.08	3.30
No. of application			
1	6.22	6.53	6.63
2	6.23	6.63	6.79
Pair test	ns	ns	ns
C.V. (%)	2.59	2.96	3.37

ns Non significant difference at 95% level ($P > 0.05$) by LSD

1.2 Fruit length Under natural condition, the length of mango fruits at 90, 100 and 110 DAF had a little increment as 9.22, 9.71 and 9.85 cm, respectively. All GA four concentrations did not effect to fruit length differed from untreated trees. Mango fruits of all treatments had the same length as 9.21-9.3, 9.71-9.89 and 9.85-10.08 cm, respectively. The application times also had no a significant effect on increasing fruit length at 90, 100 and 110 DAF. Fruit length at 90, 100 and 110 DAF from trees treated with GA 1 and 2 times were 9.16-9.19, 9.67-9.82 and 9.81-9.93 cm, respectively (Table 99).

Table 99. Fruit length of Kaew mango after GA applications at 80 DAF

Treatment	Fruit length (cm)		
	90 DAF	100 DAF	110 DAF
GA conc. (ppm)			
0	9.22	9.71	9.85
50	9.21	9.86	9.99
100	9.30	9.89	10.08
150	9.08	9.65	9.72
200	9.06	9.62	9.71
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	2.84	3.47	3.92
No. of application			
1	9.19	9.67	9.81
2	9.16	9.82	9.93
Pair test	ns	ns	ns
C.V. (%)	2.87	3.39	3.96

ns Non significant difference at 95% level ($P > 0.05$) by LSD

1.3 Fruit thickness At 90, 100 and 110 DAF, the thickness of fruits were nearly ceasing as 5.55, 5.81 and 5.96 cm, respectively. GA spraying had no a significant effect on increasing the fruit thickness at 90 and 100 DAF, ranged of 5.35-5.56 and 5.69-5.87 cm, respectively. Excepted for GA 150 ppm caused a little decrement in fruit thickness to 5.67 cm at 110 DAF. GA application times, regardless of one or two times did not change the fruit thickness. Fruits from both applying GA one and two times had the same thickness through three fruit ages. At 90, 100 and 110 DAF, fruit thickness were around 5.46-5.49, 5.76-5.79 and 5.89-5.91 cm, respectively (Table 100).

Table 100. Fruit thickness of Kaew mango after GA applications at 80 DAF

Treatment	Fruit thickness (cm)		
	90 DAF	100 DAF	110 DAF
GA conc. (ppm)			
0	5.55	5.81	5.96 a [1]
50	5.48	5.79	5.96 a
100	5.56	5.87	6.06 a
150	5.35	5.69	5.67 b
200	5.42	5.72	5.85 ab
$LSD_{0.05}$	ns	ns	0.09
C.V. (%)	2.59	2.85	3.60
No. of application			
1	5.49	5.76	5.89
2	5.46	5.79	5.91
Pair test	ns	ns	ns
C.V. (%)	2.84	2.90	4.08

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

The reason for explaining the similar fruit size among the treatments, regardless of different GA concentrations and application times, when sprayed with fruits at 80 DAF may be due to the developmental of mango fruits passed the period to respond the substance (Guardiola *et al.*, 1981). Krisanapook *et al.* (2000) reported the good relationship between the levels of this bioregulators level and fruit growth of mango cv. Khiew Sawoey. During 3-4 weeks after full bloom, GA levels increased quickly and reached the maximum peak (96.6 ng/g FW) in week 5-8 after full bloom followed by increasing of fruit growth. While the level of GA in fruits dropped remarkedly after 8 week from fruit set, these caused the fruit growth proceeded at a slower rate

and after that it ceased until maturity (Ram, 1992 ; de Leon *et al.*, 2000). In addition, Ram (1992) reported that fruit and seed of mango took about 77 DAF to complete their major part of growth. Thus fruit growth was slow with a little growth after 77 DAF and reaching a constant size 2-3 weeks before horticultural maturity (Ram, 1983 ; Prakash and Ram, 1984). The application of GA with Satsuma mandarin, one month before commercial maturation, had no significant effect on fruit growth (Garcia-Luis *et al.*, 1992). At present, in case of GA treatment had a significant effect on decreasing the fruit size, there is no explanation for this aspect. Burge *et al.* (1990) only reported that late GA treatment at 100 mg per l to kiwifruit canes, when most shoots were longer than 100 mm, had effect on reducing fruit diameters.

2. Harvesting age Generally in natural condition, the harvesting period of Kaew mango is approximately 132.17 DAF. GA application on fruits 80 DAF had no significant effect on delaying the harvesting time. Fruits from trees treated with GA and untreated trees had the same harvesting times, ranged of 129.83-134.5 DAF. In addition, number of GA spraying with fruits at 80 DAF had no significant effect on extending the harvesting time of Kaew mango. The harvesting times of all treatments were just about the same time, did not exceed 132 DAF (Table 101). These results may be due to the unfitting application time such as the GA was applied too fast. In addition, the capacity level of GA applied to the fruit, was decreased by catabolism, or conjugation with monosaccharide (glucose) then formed gibberellin glycoside. Thus the response appeared unremarkable effect to improve the harvesting time (Davenport and Nunez-Elisea, 1997, Taiz and Zeiger, 1998).

3. Size and weight of fruit At harvesting, the size of Kaew mango fruits in terms of width, length and thickness were 6.8, 9.9 and 6.03 cm, respectively. GA application with fruits nearly maturity at 80 DAF had no significant effect on increasing the fruit size at harvesting stage. Fruits from both trees treated with GA and untreated trees had the same size. The fruit sizes of all treatments were 6.71-6.88, 9.67-10.09 and 5.92-6.1 cm, respectively. Application times also had no significant effect on increasing fruit size, regardless of 1 or 2 times. Thus, fruits from both application times had the similar size, as 6.75-6.83, 9.84-9.92 and 6.0-6.03 cm in terms of width, length and thickness, respectively (Table 101).

Table 101. Days to harvesting, size and weight of Kaew mango fruits treated with different GA concentrations and number of applications at 80 DAF

Treatment	Days to harvesting (DAF)	Fruit size (g)			Fruit weight (g)
		Width	Length	Thickness	
GA conc. (ppm)					
0	132.17	6.80	9.90	6.03	218.56
50	134.50	6.87	10.09	6.10	226.26
100	132.00	6.88	9.97	6.08	224.82
150	131.00	6.68	9.76	5.92	210.17
200	129.83	6.71	9.67	5.95	212.78
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	4.04	0.08	3.69	0.05	7.58
No. of application					
1	131.80	6.75	9.84	6.00	215.41
2	132.00	6.83	9.92	6.03	221.62
Pair test	ns	ns	ns	ns	ns
C.V. (%)	4.01	2.83	3.79	2.35	7.63

ns Non significant difference at 95% level ($P > 0.05$) by LSD

At harvesting stage, the average weight of Kaew mango fruit is 218.56 g per fruit. More or less all the GA treated trees showed no difference in fruit weight compared with untreated trees. The fruit weight of all treatments were similarly between 210.17-226.26 g. In addition, application times also had no significant effect on increasing the fruit weight, between 215.41-221.62 g (Table 101). Agreed with Krisanapook *et al.* (2000) who indicated that good relationship between levels of this bioregulators and fruit growth appeared remarkedly only at the first stage of growth. While Khader (1991) reported that late application of GA did no affect the fruit size.

4. Size and weight of seed At harvesting stage, size of mango seed in terms of width, length and thickness were 3.69, 9 and 2.28 cm, respectively. Seed weight at this stage was 34 g. With respect to size and weight of seed, also found the same manner as fruit. GA applied at four concentrations had no significant effect to seed size. Seed from all treatments had the similar size, ranged of 3.52-3.83, 8.65-9.3 and 2.14-2.28 cm, in terms of width, length and thickness respectively. Seed weight of all treatments were also the same, ranged from 32.19-34.87 g. In addition, application times, regardless of 1 or 2 times had no significant on increasing size and

Table 102. Size and weight of Kaew mango seeds and flesh percentage of fruits treated with different GA concentrations and number of applications at 80 DAF

Treatment	Seed size (cm)			Seed weight	Flesh
	Width	Length	Thickness	(g)	(%)
GA conc. (ppm)					
0	3.69	9.00	2.28	34.00	74.73
50	3.83	9.30	2.21	34.87	74.67
100	3.77	9.12	2.25	33.80	74.96
150	3.52	8.84	2.14	33.34	75.85
200	3.62	8.65	2.16	32.19	75.59
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	5.51	4.92	6.06	5.90	2.13
No. of application					
1	3.63	8.88	2.19	33.49	74.36 b[1]
2	3.75	9.09	2.23	33.79	75.96 a
Pair test	ns	ns	ns	ns	**
C.V. (%)	0.99	5.19	6.14	6.18	1.81

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$) by LSD

weight of seed. Seed from both 1 and 2 times GA application were similar size around 3.63-3.75, 8.88-9.09 and 2.19-2.23 cm and 33.49-33.79 g by weight (Table 102). These results agreed with Ram (1992) who indicated that since the period when the tissues of fruit and seed started to growth absolutely, thus cell elongation in fruit and seed did not respond obviously for GA spraying at these times. Furthermore, these may be due to seed of Kaew mango fruit at 70-75 DAF had been stopped their growth (Luengsuwalai, 1994), thus GA application at these period (80 DAF) had no affect to the size of seed.

5. Flesh percentage At harvesting, flesh content in Kaew mango fruit, for consuming was around 74.73% weight by weight at harvesting stage. The treatment of GA at 80 DAF had no significant effect to flesh content. Fruits from trees treated with GA and untreated trees had the same flesh contents, did not exceed 76% weight by weight. While, number of applications had a significant effect on increasing the flesh content. Fruits from trees treated with GA 2 times had more flesh percentage (75.96%) than 1 time (74.36%) (Table 102). These may be due to at harvesting, though there is no significant difference of fruit weight between two treatments. But fruit weight from applying GA 2 times tended to increase fruit weight (221.62 g) compared with spraying 1 time (215.41 g). While, seed weights of these two treatments were the same as 33 g. Thus, these attributes may affect to increase the higher flesh content from GA application 2 times than 1 time.

6. Fruit drop Mango fruit at 90, 100 and 110 DAF had a little fruit drop as 1.67, 2.5 and 4.17%, respectively. GA application with mango fruits at 80 DAF had no significant effect on decreasing the natural fruit drop. Both fruit drops from trees treated with GA and untreated trees had the same figures, namely 0.83-1.67, 0.83-2.5 and 0.83-5.0% at 90, 100 and 110 DAF. GA application time also had no significant effect to fruit drop. Fruits from both spraying GA 1 and 2 times had the similar drop percentages as 1.0-1.67, 1.33-2.0 and 2.33-3.67% at 90, 100 and 110 DAF, respectively (Table 103). Utumpan *et al.* (2002) observed Kaew mango fruit drop at different stages and indicated that drop of fruit was a natural phenomenon which occurred at all stages of fruit growth (Wangnai, 1986). There were several factors involved fruit drop (Negi, 2000), including competition among the fruits for reserved food and bioregulator balances in developing fruits for protecting the abscission zone (Krisanapook *et al.*, 2000). Schaffer *et al.* (1994)

reported that the mango fruit drop, particularly during the first four weeks after fruit set, was severe with more than 80% of the initial fruit before maturity. These findings agreed with Krisanapook *et al.* (2000) who reported that fruit drop in mango cv. Khiew Sawoey remarkedly appeared during fruits aged 1-3 and 3-6 weeks after full bloom. The dropped figure became constant around 7.44%. It was no longer observed in week 6 until week 12, the harvesting time. In addition, it is indicated that the decrement in fruit drop of mango cv. Nam Dok Mai would be effective when GA was applied at the first stage of fruit (1-3 weeks after full bloom) (Kaewladdakorn *et al.*, 2003). Thus, the response to exogenously GA applied with fruits at later stage (80 DAF) in this study had no effect on improving the fruit set.

Table 103. Fruit drop percentage of Kaew mango treated with different GA concentrations and number of applications at 80 DAF

Treatment	Fruit drop (%)		
	90 DAF	100 DAF	110 DAF
GA conc. (ppm)			
0	1.67	2.50	4.17
50	0.83	1.67	5.00
100	1.67	1.67	1.67
150	1.67	1.67	3.33
200	0.83	0.83	0.83
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	233.19	192.87	117.06
No. of application			
1	1.67	2.00	3.67
2	1.00	1.33	2.33
Pair test	ns	ns	ns
C.V. (%)	221.09	184.01	120.60

ns Non significant difference at 95% level ($P > 0.05$) by LSD

7. Number of fruit per panicle In the beginning of 80 DAF, all treatments had the similar number of fruit per panicle between 1.1-1.2 fruits per panicle. In general, mango trees had the number of fruit around 1.1 fruit per panicle from 90 to 110 DAF. GA application had no significant effect on retaining the fruits attached to the panicle. Thus, between trees treated with GA and untreated trees, there was similar number of fruit per panicle as 1.07-1.17, 1.07-1.17 and 1.06-1.15 fruits per panicle at 90, 100 and 110 DAF. These attributes continued to harvest stage. GA application times also had no effect on number of fruit per panicle. Trees from 1 and 2 times treated with GA had the same average number of 1.1 fruit per panicle (Table 104). This results

Table 104. Number of retained fruit per panicle of Kaew mango treated with different GA concentrations and number of applications at 80 DAF

Treatment	Number of retained fruit per panicle		
	90 DAF	100 DAF	110 DAF
GA conc. (ppm)			
0	1.13	1.12	1.11
50	1.07	1.07	1.06
100	1.17	1.17	1.15
150	1.09	1.08	1.07
200	1.15	1.14	1.14
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	9.13	8.50	8.09
No. of application			
1	1.11	1.11	1.09
2	1.13	1.12	1.12
Pair test	ns	ns	ns
C.V. (%)	9.26	8.78	8.25

ns Non significant difference at 95% level ($P > 0.05$) by LSD

also agreed with Utumpan *et al.* (2002) who found that Kaew mango fruit usually only carried 1.6 fruit per panicle at fully mature to harvest stage.

8. Fruit stalk toughness At harvesting, Kaew mango fruit had the fruit stalk toughness value of 3.32 kg. Although GA application tended to increase the fruit stalk toughness values, between 3.32-3.8 kg. But there was no significant difference from untreated trees (3.32 kg). In addition, there was no significant difference in term of fruit stalk toughness between 1 and 2 times spraying. Kaew mango fruits from both 1 and 2 times application had the similar fruit stalk toughness lower than 3.6 kg (Table 105).

9. Fruit firmness Measurement of Kaew mango fruit firmness was done after harvesting the fruit in fully mature stage. After peeling, the average fruit firmness was 13.6 kg/cm^2. GA application did not affect the firmness of fruit at harvest. Thus, fruit from trees treated with GA and untreated trees had the similar firmness values, lower than 14.5 kg/cm^2. GA application times, regardless of 1 or 2 times, had no effect to this figure. The average firmness values from this factor did not exceed 14.5 kg/cm^2 (Table 105). These results agreed with findings of Mapracha (1997) who reported that GA had no affect on firmness of mango fruit cv. Nam Dok Mai and Fha Lun, especially the fruits planted from semi arid region. While El-Otmani *et al.* (1990) and Schirra *et al.* (1999) found that GA spraying at 10 ppm could retain the high fruit firmness of orange and cactus pear fruit.

10. Total soluble solids (TSS) Mango fruits when picked at fully mature stage had TSS 9.49° Brix. TSS of fruits from trees treated with GA and untreated trees had the same contents, ranged from 8.97-10.35° Brix. In addition, times of GA spraying did not affect TSS contents. Both trees treated with GA and untreated trees gave the fruits which had the same TSS levels of 11.26-11.61° Brix (Table 105).

11. Titratable acidity (TA) The measurement of citric acid in mango fruit when harvested at fully mature stage is 0.41%. Both GA concentrations and times of application had no significant effect on the TA contents in fruits. These values of fruit from all treatments showed a similar pattern as the case of TSS which ranged from 0.39-0.42% (Table 105). These results agreed with Garcia-Luis *et al.* (1992) who reported that GA application with mandarin fruits, did

Table 105. Fruit stalk toughness, fruit firmness, contents of total soluble solids (TSS) and titratable acidity (TA) of Kaew mango treated with different GA concentrations and number of applications at 80 DAF

Treatment	Fruit stalk toughness (kg)	Fruit firmness (kg/cm^2)	TSS (°Brix)	TA (%)
GA conc. (ppm)				
0	3.32	13.60	9.49	0.41
50	3.34	14.06	10.35	0.40
100	3.52	13.94	8.97	0.40
150	3.62	14.28	9.97	0.39
200	3.80	13.73	9.29	0.42
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	10.71	10.07	10.36	11.08
No. of application				
1	3.47	13.76	11.61	0.41
2	3.57	14.08	11.26	0.40
Pair test	ns	ns	ns	ns
C.V. (%)	11.33	9.60	9.05	1.08

ns Non significant difference at 95% level ($P > 0.05$) by LSD

not affect juice compositions. While, McDonald *et al.* (1997) presented that GA application in form of ProGibb with grapefruit before color break stage, did not affect internal qualities, such as, TSS and TA. Because these internal qualities might be controlled by the genetic factors or the environmental factors (Anggrawati, 1985).

12. Peel color Fruits at fully mature stage were picked to measure the color of peel in three sides, namely, shoulder, middle and apex. The peel color of fruit in this stage was measured in terms of L (lightness), c (chroma or intensity) and h (hue or color value) ranged from 43.85-46.89, 25.33-26.77 and 105.33-109.46, respectively. GA applications had no significant effect on

peel color at three sides. Fruits from trees treated with GA and untreated trees gave the same peel color as 43-47, 24-29 and 103-117 in terms of L, c and h, respectively. Peel color in these levels is arranged as brightly green. Times of GA spraying also did not affect to peel color, regardless of three sides. Fruits from both trees sprayed 1 time and 2 times had the peel color in terms of L, c and h as 43-47, 25-27 and 104-111, respectively. These figures also showed the peel color of brightly green (Table 106). Excepted for peel color at middle side, fruits from spraying GA 2 times gave more L value (45.3) than fruits sprayed 1 time (44.2). But this result was a small issue which almost had no effect to the majority of peel color. Anggrawati (1985) reported that plant growth regulators application had no significant effect on the fruit color. These might be due to fruit color attribute was controlled by genetic factors or the environment. Contrary with Garcia-Luis *et al.* (1992) ; McDonald *et al.* (1997) and Schirra *et al.* (1999) who indicated that GA had an importance roles for delaying the fruit coloration from green to orange of mandarin, grapefruit and cactus pear respectively. These indicated that fruit color attribute could be changed by applying the plant growth regulator (El-Otmani *et al.*, 1990). McDonald *et al.* (1997) reported that the most effective time for GA applications to delay harvesting period should be prior to colorbreak stage or applied during the period of chlorophyll degradation would result in a high response, earlier and later applications would have a smaller response. Furthermore, GA was converted promptly by metabolized and / or translocated from active sites to other non active form, these attributed the less response to plant bioregulator application (Guardiola *et al.*, 1981).

13. Flesh color Flesh color of mango fruit was measured after harvesting at fully mature stage. The result of flesh color in terms of L, c and h are around 67.04, 39.08 and 94.6, respectively. From interpreting these results found that flesh color was a bright yellow color. GA application had a significant effect to L values of flesh. Fruits from treated with GA at 200 ppm had the lowest L value (65.35), while the others were similar values, between 67.04-68.18. But this figure is no significant in flesh color because the rest of color measurement in terms of c and h of all treatments were not different, ranged of 39.08-39.99 and 92.93-95.92, respectively. In addition, times of GA spraying also had no effect on improving the flesh color. Fruits from both trees treated with GA and untreated trees had the same flesh color. The average of flesh color in terms of L, c and h were not exceed 68, 40 and 96, respectively (Table 107).

Table 106. Peel color of Kaew mango fruits treated with different GA concentrations and number of applications at 80 DAF

Treatment	Shoulder portion			Middle portion			Apex portion		
	L	c	h	L	c	h	L	c	h
GA conc. (ppm)									
0	46.89	26.05	105.33	43.96	25.33	109.25	43.85	26.77	109.46
50	46.91	25.29	103.90	44.83	25.30	107.62	43.75	24.80	110.36
100	46.24	27.70	105.87	45.93	28.86	107.50	45.10	27.04	108.63
150	46.65	25.41	116.88	44.48	26.32	107.70	43.64	24.94	109.01
200	45.74	24.92	106.06	44.48	25.34	108.03	43.62	25.63	109.68
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	5.10	15.08	12.71	3.44	8.64	1.21	3.71	11.14	1.35
No. of application									
1	46.25	26.02	110.40	44.15 b[1]	26.24	107.83	43.57	25.26	109.56
2	46.72	25.72	104.82	45.32 a	26.22	108.21	44.42	26.41	109.30
Pair test	ns	ns	ns	*	ns	ns	ns	ns	ns
C.V. (%)	4.89	14.77	12.55	3.32	9.79	1.29	3.61	10.92	1.39

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 107. Flesh color of Kaew mango fruits treated with different GA concentrations and number of applications at 80 DAF

Treatment	Flesh color		
	L	c	h
GA conc. (ppm)			
0	67.04 ab[1]	39.08	94.60
50	68.18 a	39.27	92.93
100	67.34 a	39.29	95.25
150	68.17 a	39.55	93.46
200	65.35 b	39.99	95.92
$LSD_{0.05}$	0.68	ns	ns
C.V. (%)	2.46	3.46	2.46
No. of application			
1	67.61	39.53	93.82
2	66.82	39.34	95.04
Pair test	ns	ns	ns
C.V. (%)	2.75	3.36	2.53

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3.3.3 GA concentrations and fruit age After discovering the GA use to produce the late season of Kaew mango was possible. The next experiment would search the relation of GA concentration and application time on delaying fruit maturity attached to the tree.

1. Fruit Growth on tree after GA application

1.1 Fruit width Before spraying GA (82 DAF) fruit widths were similar between 5.2-5.3 cm. Generally, mango fruits at 96 DAF until 124 DAF continued to increase their width in a little rate, not exceed 0.2 cm. Fruit width at 96 DAF was 5.38 cm and increased to 5.5 cm at harvest. Throughout 42 days after applying GA followed to the experiment, both GA concentrations (0, 50, 100 and 150 ppm) and fruit ages (82 and 89 DAF) had no significant effect

Table 108. Fruit width of Kaew mango treated with different GA concentrations and fruit ages

Treatment	Fruit width (cm)				
	96DAF	103DAF	110DAF	117DAF	124DAF
GA conc. (ppm)					
0	5.38	5.46	5.52	5.55	5.50
50	5.54	5.63	5.62	5.66	5.80
100	5.60	5.76	5.69	5.80	5.80
150	5.51	5.65	5.66	5.57	5.66
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	3.46	3.65	3.96	4.38	3.70
Ages of fruit (DAF)					
82	5.49	5.60	5.61	5.67	5.66
89	5.53	5.65	5.63	5.62	5.72
Pair test	ns	ns	ns	ns	ns
C.V. (%)	3.61	3.98	3.94	4.53	4.18

ns Non significant difference at 95% level ($P > 0.05$) by LSD

on fruit enlargement (width). The result from Table 108 showed that after spraying GA 2 weeks or 96 DAF until 124 DAF, fruits from all treatments enlarged their width not exceeded 0.6 cm. Before harvesting, the average fruit width of all treatments were similar, between 5.5-5.8 cm.

1.2 Fruit length At 82 DAF before applying GA, the lengths of fruits were similar between 7.5-7.7 cm. General, from 96 DAF (7.77 cm) to 124 DAF (7.81 cm), mango fruits had a little length increment, not exceed 0.3 cm. Both GA 4 concentrations and two fruit ages when spraying had no significant effect to fruit length from 96 DAF to 124 DAF. Before harvesting 42 days, fruit length had very low enlargement, about or lower than 0.6 cm. At harvesting, the averages fruit length of all treatments were similar ranged from 7.81-8.23 cm (Table 109).

Table 109. Fruit length of Kaew mango treated with different GA concentrations and fruit ages

Treatment	Fruit length (cm)				
	96DAF	103DAF	110DAF	117DAF	124DAF
GA conc. (ppm)					
0	7.77	7.78	7.84	7.88	7.81
50	8.07	8.10	8.19	8.18	8.23
100	8.09	8.18	8.24	8.23	8.19
150	7.96	8.01	8.07	8.10	8.04
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	3.21	3.30	3.32	3.27	3.76
Ages of fruit (DAF)					
82	7.96	7.99	8.06	8.07	8.02
89	7.98	8.05	8.11	8.12	8.12
Pair test	ns	ns	ns	ns	ns
C.V. (%)	3.48	3.68	3.74	3.55	4.15

ns Non significant difference at 95% level ($P > 0.05$) by LSD

1.3 Fruit thickness Before spraying GA at 82 DAF, fruit thickness of all treatments were similar, between 4.9-5.0 cm. After spraying GA 2 weeks (96 DAF) until 124 DAF, fruit increment in term of thickness was very low rate about 0.4 cm. Not only GA concentrations but also fruit ages when spraying had no significant effect on increasing the thickness of fruit. All treatments gave the similar fruit thickness from 96 DAF to 124 DAF. The average of fruit thickness measured on 96, 103, 110, 117 and 124 DAF were 5.05-5.2, 5.08-5.24, 5.06-5.3, 5.16-5.24 and 5.38-5.6 cm, respectively (Table 110). Agreed with de Leon *et al.* (2000) and Krisanapook *et al.* (2000) presented that growth pattern of mango fruit after eight weeks from fruit set proceeded at a slower rate until maturity. Due to at week 7, the level of GA-like substances was steady, but fruit growth of mango still continued to increase during week 8 to week 9, after that the growth rate was slow (Krisanapook *et al.*, 2000). In addition, Khader

Table 110. Fruit thickness of Kaew mango treated with different GA concentrations and fruit ages

Treatment	Fruit thickness (cm)				
	96DAF	103DAF	110DAF	117DAF	124DAF
GA conc. (ppm)					
0	5.05	5.08	5.06	5.16	5.38
50	5.12	5.16	5.28	5.24	5.54
100	5.20	5.24	5.30	5.20	5.60
150	5.13	5.17	5.20	5.24	5.51
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	2.93	3.20	3.09	3.33	3.46
Ages of fruit (DAF)					
82	5.11	5.14	5.18	5.26	5.49
89	5.14	5.18	5.24	5.16	5.53
Pair test	ns	ns	ns	ns	ns
C.V. (%)	2.99	3.23	3.43	3.08	3.61

ns Non significant difference at 95% level ($P > 0.05$) by LSD

(1991) and Garcia-Luis *et al.* (1992) indicated that GA application time had no effect on the fruit growth.

2. Fruit weight At harvesting, mango fruit weight was around 122.75 g. GA application at 50, 100 and 150 ppm had significant effect on increasing the weight of fruits, ranged from 146.15-155.23 g. While, fruit ages when spraying did not affect this figure, between 141.71-146.95 g (Table 111). These reason may be due to fruits attached to the tree continued to increase their weight until harvesting (Krisanapook *et al.*, 2000). Furthermore, Singh *et al.* (1992) indicated that fruit weight improvement was conducted by applying GA.

Table 111. Fruit weight, flesh content and fruit size at harvesting of Kaew mango fruits treated with different GA concentrations and fruit ages

Treatment	Fruit weight (g)	Flesh content (%)	Fruit size (cm)		
			Width	Length	Thickness
GA conc. (ppm)					
0	122.75 b [1]	67.30	5.46	7.80	5.02
50	155.23 a	69.21	5.77	8.39	5.34
100	153.19 a	69.14	5.88	8.44	5.43
150	146.15 a	68.85	5.69	8.19	5.25
$LSD_{0.05}$	6.65	ns	ns	ns	ns
C.V. (%)	11.29	2.04	4.77	5.22	5.07
Ages of fruit (DAF)					
82	141.71	68.61	5.68	8.17	5.22
89	146.95	68.63	5.72	8.24	5.30
Pair test	ns	ns	ns	ns	ns
C.V. (%)	14.13	2.24	5.32	5.90	5.66

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3. Flesh percentage Mango fruits harvested at fully mature stage had the flesh contents of 67.3%. Although GA application followed to mention by three concentrations tended to increase the flesh content (68.85-69.21%), but they were not different from untreated trees (67.3%). Two fruit ages (82 and 89 DAF) also had no significant effect to this figure. Thus GA application may either spray at 82 or 89 DAF because they gave the same flesh percentage (68.6%) (Table 111).

4. Fruit size At fully mature stage, fruit size in terms of width, length and thickness is 5.46, 7.8 and 5.02 cm. Neither GA concentrations nor fruit ages had no significant effect to these figures. At harvesting, fruit size in terms of width, length and thickness were similar among the all treatments, ranged from 5.46-5.88, 7.8-8.44 and 5.02-5.43 cm, respectively (Table 111). Notodimedjo (2000) suggested that the role of GA 30 ppm sprayed to Arumanis mango trees at the first stage of fruits (14 DAF), was to multiply and to lengthen the meristem cells which resulted in the increase of the fruit volume. While, Khader (1991) reported that the application of GA at later of fruit growth did not affect the fruit size. These results demonstrated that one of factor controlled the response to plant growth regulator treatments was stage of fruit development at application time (El-Otmani *et al.*, 1990).

5. Weight and size of seed At harvesting, mango seed weight was around 19.59 g. Both GA concentrations and fruit ages had no effect on seed weight, between 19.59-24.53 g. (Table 112). When the fruits were harvested at fully mature stage, seed size in terms of width, length and thickness were 3, 6.71 and 1.88 cm, respectively. The application of GA three concentrations with fruit ages at 82 and 89 DAF had no significant effect to seed size. Among all treatments had the same seed sizes at harvesting, ranged from 3.0-3.18, 6.71-7.16 and 1.88-2.04 cm, in terms of width, length and thickness respectively (Table 112). Krisanapook *et al.* (2000) indicated after week 8, seed of mango cv. Khiew Sawoey seemed to cease their growth already, thus the application time taken with fruit aged 82 and 89 DAF, did not affect these figures.

Table 112. Weight and size at harvesting of Kaew mango seeds treated with different GA concentrations and fruit ages

Treatment	Seed weight (g)	Seed size (cm)		
		Width	Length	Thickness
GA conc. (ppm)				
0	19.59	3.00	6.71	1.88
50	22.61	3.16	7.16	1.95
100	24.53	3.18	7.08	2.04
150	22.39	3.13	6.98	1.99
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	14.01	5.79	4.75	6.36
Ages of fruit (DAF)				
82	21.71	3.09	7.01	1.93
89	22.85	3.14	6.96	2.00
Pair test	ns	ns	ns	ns
C.V. (%)	15.47	5.92	5.16	6.50

ns Non significant difference at 95% level ($P > 0.05$) by LSD

6. Yield General mango yield at harvesting was around 229.33 kg per tree. GA application at 50 and 100 ppm had significant effect on increasing the yield to 272.17 and 252.67 kg per tree. While the higher GA concentration at 150 ppm had no significant effect to this figure. It gave the similar yield (243.83 kg per tree) with untreated trees (229.33 kg). While, fruit ages when application had no significant effect to these figure. Thus the GA application time could use whether at 82 or 89 DAF because trees treated with GA at these stage gave the similar yield of 250 and 249 kg per tree (Table 113). The higher yield received from GA application may be due to GA increased the mobilization of metabolites to citrus fruits (Powell and Krezdorn, 1977). In addition, GA treatment was found to be the effective method in increasing the fruit weight over than untreated trees (Singh *et al.*, 1992).

Table 113. Yield and days to harvesting of Kaew mango treated with different GA concentrations and fruit ages

Treatment	Yield (kg/tree)	Days to harvesting (DAF)
GA conc. (ppm)		
0	229.33 b [1]	122.11 b [1]
50	272.17 a	127.87 a
100	252.67 ab	131.26 a
150	243.83 b	127.98 a
$LSD_{0.05}$	0.04	1.50
C.V. (%)	9.41	2.89
Ages of fruit (DAF)		
82	250.00	126.47
89	249.00	128.14
Pair test	ns	ns
C.V. (%)	11.07	3.80

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

7. Harvesting period In general, harvesting period of Kaew mango planted at the Chom Tong Land Reform Project Area Doi Lor district counted to 122.11 DAF. GA three concentrations (50, 100 and 150 ppm) had significant effect on extending the harvesting period to 127.87-131.26 DAF, while, these figure of control trees were only 122.11DAF. Thus, fruits treated with GA could extend the harvesting time more than untreated fruits 5.76-9.15 days. GA application time at 82 and 89 DAF had no significant effect to this figure. Thus, GA application could spray on fruits at 82 or 89 DAF because both of them had the similar harvesting periods, ranged from 126.47 and 128.14 DAF (Table 113). The retarding effect of gibberellin on fruit ripening and senescence was widely recognized (Nooden, 1988). Khader (1991) suggested that mango fruits cv. 'Dashehari' received GA_3 at 200 mg per L after fruit set, exhibited lower

amylase and peroxidase activity at harvest. These caused the delay ripening time of mango fruits significantly for up to 6 days. In addition, Schirra *et al.* (1999) applied GA 10 ppm with Cactus pear cv. Gialla, 10 weeks after full bloom, could delay fruit ripening as evaluated by reducing the rate of peel color change and delayed the appearance of full orange color on the skin.

8. Internal qualities

8.1 Fruit stalk toughness The measurement of fruit stalk toughness when harvested mango fruits at fully mature stage was 2.27 kg. GA application tended to increase this figure (2.55-2.72 kg) but they were not different from untreated trees (2.27 kg). Both GA application at 82 and 89 DAF had no significant effect to this figure. Thus GA application could spray on fruits at 82 or 89 DAF because fruit stalk toughness at harvesting were similar between 2.42-2.66 kg (Table 114).

8.2 Fruit firmness Mango fruits at fully mature stage measured the firmness after peeling 9.02 kg/cm^2. GA application at 100 ppm gave the higher firmness (11.21 kg/cm^2) than untreated trees (9.02 kg/cm^2). GA application at two fruit ages (82 and 89 DAF) had no significant effect to this figure, between 9.83-10.51 kg/cm^2 (Table 114). Agreed with El-Otmani *et al.* (1990) applied GA (10 mg per L), as a foliar spray during color break with 'Clementine' mandarin, significantly delayed rind softening by at least a month. While, Khader (1991) reported mango fruits cv. 'Dashehari' received GA at 200 mg per L exhibited lower amylase and peroxidase activity at harvest. These results caused the ripening of mango fruits significantly delayed for up to 6 days. In addition, McDonald *et al.* (1997) indicated that 'Marsh' grapefruit from GA treatments maintained significantly greater peel puncture resistance than untreated fruit.

8.3 Total soluble solids (TSS) TSS content in mango fruits when picked at fully mature stage was 9.21°Brix. GA application at 50 ppm had significant effect on decreasing TSS content at harvesting stage to 8.56 °Brix. This indicated that TSS in fruits from trees treated with GA 50 ppm proceeded at slower than the others. While the others gave the similar TSS levels between 8.9-9.21 °Brix. While, fruits treated GA at 82 and 89 DAF had no significant effect to this figure. Fruits from spraying GA at these two fruit ages gave the similar TSS contents, between 8.81-9.05°Brix (Table 114). Khader (1991) indicated that GA application at 200 mg per L after fruit set could retarded the ripening of mango fruits cv. 'Dashehari' for up to 6

Table 114. Internal fruit qualities of Kaew mango treated with different GA concentrations and fruit ages

Treatment	Fruit stalk toughness (kg)	Fruit firmness (kg/cm^2)	TSS (^{0} Brix)	TA (%)
GA conc. (ppm)				
0	2.27	9.02 b [1]	9.21 a	0.29 c
50	2.63	10.27 ab	8.56 b	0.35 a
100	2.72	11.21 a	8.90 ab	0.32 b
150	2.55	10.16 ab	9.06 a	0.30 c
$LSD_{0.05}$	ns	0.46	0.13	0.01
C.V. (%)	15.82	11.13	3.52	4.48
Ages of fruit (DAF)				
82	2.42	9.83	8.81	0.32
89	2.66	10.51	9.05	0.31
Pair test	ns	ns	ns	ns
C.V. (%)	15.84	12.81	4.13	8.96

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

days by lower TSS level. The reason for accounting the less TSS from fruits treated with GA may be due to the rate of import of photosynthate into fruit appeared to be controlled by the metabolic activity of the fruit (Islam *et al.*, 1996). In addition, Khader (1991) reported that GA had an effect to lower enzyme activity, such as amylase and peroxidase activities.

8.4 Titratable acidity (TA) TA in term of citric acid in mango fruits when harvested at fully mature stage was 0.29%. GA application had significant effect on retaining higher TA than untreated trees. GA concentration particularly at 50 ppm had higher TA (0.35%) than the others (0.29-0.32%). Two fruit ages (82 and 89 DAF) when spraying had no significant effect to this figure. Fruits from these two treatments gave the similar TA levels between 0.31-0.32% (Table 114). Singh *et al.* (1992) reported that fruit qualities improvement in terms of total

soluble solids and acidity were conducted through the application of GA 60 ppm seven days after fruit set. Contrary with Garcia-Luis *et al.* (1992) presented that the irrespective of the GA application times with seedless Clementine mandarin trees, had no effect on the juice compositions. Furthermore, McDonald *et al.* (1997) suggested that fruit qualities in terms of TSS and TA of grapefruit were generally nor affected by GA treatment.

9. Peel color The peel color measurement of Kaew mango fruits in terms of L (lightness), c (chroma) and h (hue) at three sides of shoulder, middle and apex ranged from 33.04-35.88, 24.05-25.09 and 178.65-178.87, respectively. These results implied that peel color of mango fruits at harvesting stage was bright green. GA application at three concentrations had no significant effect to peel color. Regardless of shoulder, middle and apex of fruit, peel color of all treatments had the similar L, c and h values, not exceed 37, 26 and 180, respectively. Anggrawati (1985) reported that the application of plant growth regulators did not give any effect on the quality of fruit that considered of the color of the skin. These figures might be due to fruit color was controlled by the genetic factors. Two fruit ages when spraying GA had no significant effect to peel color, excepted for L values at middle side of fruit. Fruits treated with GA at 89 DAF gave higher L value (34.29) than sprayed at 82 DAF (33.59). But this difference is a few effect when compared with the overall peel color. Thus GA application can spray on fruits whether at 82 or 89 DAF (Table 115).

10. Flesh color At harvesting, flesh color measurement at middle side in terms of L, c and h was 50, 36.24 and 180.65, respectively. GA application at three concentrations had no significant effect to this figure. Flesh color of fruits from trees treated with GA were similar with untreated trees as 49.4-50, 36.24-37.19 and 180.47-180.73, respectively. These results showed the flesh color as bright yellowish green. In addition, GA application at two fruit ages (82 and 89 DAF) had no significant effect to flesh color. The average L, c and h values of these two treatments were the same values not exceed than 49, 37 and 181, respectively (Table 116).

Table 115. Peel color of Kaew mango fruits treated with different GA concentrations and fruit ages

Treatment	Shoulder			Middle			Apex		
	L	c	h	L	c	h	L	c	h
GA conc. (ppm)									
0	35.88	25.09	178.87	34.15	24.66	178.70	33.04	24.05	178.65
50	36.54	24.86	178.90	33.62	25.12	178.70	32.75	24.85	178.73
100	36.54	25.58	178.94	33.83	24.99	178.71	33.36	24.35	178.77
150	36.46	24.93	178.94	34.14	24.54	178.66	33.29	23.78	178.65
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	2.68	5.32	0.09	2.28	3.80	0.05	2.85	4.03	0.05
Ages of fruit (DAF)									
82	36.63	25.15	178.92	33.59 b[1]	24.87	178.68	33.25	24.32	178.68
89	36.08	25.09	178.91	34.29 a	24.78	178.71	32.97	24.19	178.72
Pair test	ns	ns	ns	*	ns	ns	ns	ns	ns
C.V. (%)	2.56	5.20	0.09	2.01	3.75	0.05	2.78	4.20	0.05

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 116. Flesh color of Kaew mango fruits treated with different GA concentrations and fruit ages

Treatment	Flesh		
	L	c	h
GA conc. (ppm)			
0	50.00	36.24	180.65
50	49.40	37.06	180.73
100	49.72	36.88	180.53
150	49.96	37.19	180.47
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	0.99	1.78	0.40
Ages of fruit (DAF)			
82	49.67	37.00	180.57
89	49.87	36.69	180.62
Pair test	ns	ns	ns
C.V. (%)	1.05	1.94	0.38

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3.3.4 GA application and fruit age After finding the effect of GA at 50 ppm had significant effect on extending the harvesting period of Kaew mango later than untreated trees by 5.76-9.15 days. While, GA application time at 82 and 89 DAF had no significant effect to this figure. Thus, the objective of this experiment is to find the appropriate fruit age for GA application to produce late season of Kaew mango.

1. Fruit retention percentage Owing to this experiment commenced at 85 DAF, fruit carried on the panicle at this time was set to have fruit retention equal to 100%. Every week after 85 DAF, Kaew mango fruits continued to decrease their retentions on the tree because of fruit drop. Fruit retention at harvesting stage remained to 75% of total. Although GA application tended to increase the fruit retention (81.25-86.25%) at harvesting but this figure was not different

from untreated trees (75.0%) (Table 117). Each panicle of all treatments had the same amount of 1.0-1.08 fruit per panicle at harvesting (data not shown). Krisanapook *et al.* (2000) suggested that mango fruit retention was low because fruitlets on the panicle continued to drop until harvesting. While, Talon *et al.* (1997) indicated that fruit retention was a complex phenomenon depending upon several sets of internal and external factors. Furthermore, Schaffer *et al.* (1994) reported that most of mango cultivars usually carried only one fruit per panicle until harvesting, because of the competition for mineral elements and photoassimilates (Ruiz and Guardiola, 1994).

Table 117. Fruit retention percentage of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Fruit retention (%)				
	85 DAF	92 DAF	99 DAF	105 DAF	At harvesting
Control	100.00	93.75	86.25	78.75	75.00
GA 50 ppm at 85 DAF	100.00	98.75	93.75	90.00	82.50
GA 50 ppm at 95 DAF	100.00	98.75	96.25	93.75	81.25
GA 50 ppm at 105 DAF	100.00	98.75	95.00	91.25	86.25
$LSD_{0.05}$	-	-	-	-	ns
C.V. (%)	-	-	-	-	10.43

ns Non significant difference at 95% level ($P > 0.05$) by LSD

2. Total nonstructural carbohydrate (TNC) contents in leaf and fruit at different age

2.1 TNC in leaf TNC content in leaf at 85 DAF was 177.63 mg/g dry weight (DW). During fruit development from 85 DAF until harvesting, leaf TNC tended to decrease their contents to 173.06 mg/g DW. GA application at 3 fruit ages (85, 95 and 105 DAF) had no significant effect to TNC content in leaf. At harvesting, leaf TNC in both treated and non-treated trees were relatively stable, ranged from 163.62-173.06 mg/g DW (Table 118). Leaves are considered to be functions as carbohydrate production from photosynthesis activity (Oliveira and Pristley, 1988). After producing sugars in the leaf cells, they can move from cell to cell by diffusion and ultimately into the transport tissues of the phloem for translocation to other plant

tissues including fruits. In addition, these carbohydrates may be further metabolized into more complex carbon structures such as starch for carbohydrate storage (Rom, 1996). It is known that mobilization of photoassimilates from leaves to developing fruits is essential for fruit development (Davenport and Nunez-Elisea, 1997 ; Talon *et al.*, 1997). Most of these assimilates contribute to support fruit development, which is high sink strength (Phavaphutanon *et al.*, 2000). A relatively stable TNC of leaves during fruit development indicated that most of carbohydrates produced in these leaves were sent to contribute for fruit development. Thus, there is no high level of TNC accumulation in leaf, while the starch reserve levels show a notable TNC accumulation in fruit. These leaf TNC decrement coincides with fruit development indicated that stored carbohydrates in leaves may be more readily to be utilize for fruit development (Davie *et al.*, 2000).

2.2 TNC in fruit TNC in fruit had more content than leaf. At 85 DAF, TNC in fruit was 369.06 mg/g DW. The accumulation of carbohydrates in fruit associates with fruit development. After 85 DAF, TNC in fruit continued to increase their contents until harvesting. TNC in fruit harvested at fully mature stage was around 716.81mg/g DW. GA application had no significant effect to this figure. At harvesting, TNC contents in fruit among all treatments were similar, ranged from 684.22-720.49 mg/g DW (Table 118). Although fruits can exhibit photosynthetic acitvity but their relative contribution to growth is small compared with that of leaves (Singh, 1954). Thus, fruit tissues are considered to be storage sinks, they prefer to storage carbohydrate content from photosynthetic assimilates of the parent plant (Whiley *et al.*, 1996). Starch, itself, is the essential storage form of energy in the plant (Harborne, 1998). Following fruit set, starch accumulates in the mesocarp (Jagtiani *et al.*, 1998). Arthey and Ashurst (1996) indicated that the accumulation of carbohydrate in fruit was a developmental process linked to maturation. The fruit entered more maturity, higher TNC content in fruit was found.

Table 118. Total nonstructural carbohydrate (TNC) contents in Kaew mango leaves and fruits treated with GA 50 ppm and different fruit ages

Treatments	TNC contents (mg/g DW)									
	Leaves					Fruits				
	85 DAF	92 DAF	99 DAF	105 DAF	Harvesting	85 DAF	92 DAF	99 DAF	105 DAF	Harvesting
Control	177.63	132.79	154.38 bc[1]	146.85	173.06	369.06	399.42	424.07	438.66	716.81
GA 50 ppm at 85 DAF	183.49	137.70	165.41 ab	153.59	164.93	385.98	403.58	409.50	430.72	684.22
GA 50 ppm at 95 DAF	188.95	141.23	152.84 c	143.34	163.62	379.27	401.45	408.62	419.25	703.42
GA 50 ppm at 105 DAF	190.46	147.30	169.71 a	165.26	167.92	387.82	404.25	417.02	424.63	720.49
$LSD_{0.05}$	ns	ns	0.0169	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	5.44	5.95	4.57	8.80	6.78	4.02	3.75	2.78	3.18	3.26

[1] Mean within the same column followed by the same letters do not significantly differ at 5% level ($P<0.05$) by LSD.

ns Non significant difference at 95% level ($P > 0.05$) by LSD

3. Reducing sugars (RS) contents in leaf and fruit at different age

3.1 RS in leaf RS content in leaf at 85 DAF had more than 95 mg/g DW. After 85 DAF until harvesting, RS in leaf continued to decrease their levels. At harvesting, RS in leaf was found less than 80.36 mg/g DW. GA application had no significant effect to this figure. RS contents in leaf of all treatments were similar, ranged from 70.63-80.36 mg/g DW (Table 119). Reducing sugars are a single sugar, such as glucose and fructose (Harborne, 1998). The drop in leaf RS level at harvesting can be ascribed to the carbohydrate demand of fruit, particularly before harvesting.

3.2 RS in fruit RS in fruit had the similar content as in leaf at 85 DAF. Fruit RS at 85 DAF was more than 81.51 mg/g DW. After that until harvesting, RS in fruit continued to increase and had more content than leaf. At harvesting, fruit RS contents were lower than 245.54 mg/g DW. GA application had no significant effect to fruit RS. All treatments had the similar fruit RS between 208.88-245.54 mg/g DW (Table 119). Sucrose, glucose and fructose are the principal sugars of fruit. In general, fruit contains more reducing sugar than sucrose. Islam *et al.* (1996) and Hofman *et al.* (1997) indicated that a concurrent increase in reducing sugar with fruit development. Because these substances are promptly incorporated into the energy-generation metabolism, culminating in rapid production of ATP and also used for production the raw materials (protein, nucleic acids, carbohydrates and lipids in fruit cells (Mayer and Poljakoff-Mayber, 1975 ; Buckeridge *et al.*, 2000).

Table 119. Reducing sugar (RS) contents in Kaew mango leaves and fruits treated with GA 50 ppm and different fruit ages

Treatments	RS contents (mg/g DW)									
	Leaves					Fruits				
	85 DAF	92 DAF	99 DAF	105 DAF	Harvesting	85 DAF	92 DAF	99 DAF	105 DAF	Harvesting
Control	95.54	88.11	83.07	70.83	73.89	93.65	121.42	140.14	173.54	215.50
GA 50 ppm at 85 DAF	100.89	88.14	88.53	64.11	80.36	81.51	108.24	121.18	148.22	245.54
GA 50 ppm at 95 DAF	97.68	91.43	82.41	68.69	77.56	91.70	100.77	123.77	170.98	226.03
GA 50 ppm at 105 DAF	99.20	87.53	83.29	74.64	70.63	87.94	110.80	131.75	150.85	208.88
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	5.62	3.50	5.23	9.41	6.07	15.37	11.69	8.52	13.33	9.21

ns Non significant difference at 95% level ($P > 0.05$) by LSD

4. Chlorophyll contents in leaf and fruit at different ages

4.1 Chlorophyll in leaf At 85 DAF, leaf chlorophyll content had less than 295.5 mg/g fresh weight (FW). Leaf chlorophyll increased with a little content after 85 DAF until harvesting. At harvesting, leaf chlorophyll content did not exceed 316.99 mg/g FW. GA application had no significant effect to leaf chlorophyll content. At harvesting, though trees treated with GA (266.6-316.99 mg/g FW) had more leaf chlorophyll content than untreated trees (262.42 mg/g FW) but there was not significant difference between treated and untreated trees (Table 120).

4.2 Chlorophyll in fruit From 85 DAF until harvesting, chlorophyll content in fruit peel was less than in leaf. Fruit chlorophyll content at 85 DAF was more than 150.82 mg/g FW. From 85 DAF until harvesting, chlorophyll in fruit continued to decrease its content. Agreed with Ram (1992) reported that GA production in fruit sharply decreased and remained low during fruit maturation. This GA decrement was accompanied by an increase in enzyme activity leading to chlorophyll degradation (Hedden, 1999). At harvesting, fruit chlorophyll did not exceed 112.84 mg/g FW. GA application had significant effect on retaining the chlorophyll content in fruit. Fruits from trees treated with GA continued to retain the chlorophyll higher than untreated trees, particularly before harvesting and at harvesting time. The results from Table 120 showed that chlorophyll degradation from trees treated with GA occurred later than untreated trees. At harvesting, fruits from trees treated with GA (104.53-112.84 mg/g FW) had more chlorophyll content than untreated trees (88.92 mg/g FW). The higher fruit chlorophyll retention from trees treated with GA may be due to GA had an antagonistic effect on the biogenesis of ABA and endogenous ethylene (Pozo, 2001; Ross and U'Neilla, 2001). While, McDonald *et al.* (1997) cited the major role of GA not only delayed the loss of rind pigments chlorophyll but also enhanced the chlorophyll concentration. Furthermore, Garcia-Luis *et al.* (1992) reported that a peak response application of GA to retard chlorophyll degradation in the peel of fruit, should be applied GA between the onset of chlorophyll degradation or before the onset of peel pigmentation. Earlier and later applications resulted in a smaller response.

Table 120. Chlorophyll contents in Kaew mango leaves and fruits treated with GA 50 ppm and different fruit ages

Treatments	Chlorophyll contents (mg/g FW)									
	Leaves					Fruits				
	85 DAF	92 DAF	99 DAF	105 DAF	Harvesting	85 DAF	92 DAF	99 DAF	105 DAF	Harvesting
Control	245.91	248.47	270.14	250.11	262.42	151.80	137.75	117.25	98.95 b[1]	88.92 b
GA 50 ppm at 85 DAF	295.50	262.02	319.49	250.10	279.99	150.82	137.77	134.31	125.40 a	112.84 a
GA 50 ppm at 95 DAF	275.50	277.44	292.55	268.90	316.99	166.27	144.59	137.04	117.73 a	110.14 a
GA 50 ppm at 105 DAF	284.82	266.06	299.92	266.34	266.60	151.33	145.75	131.82	123.16 a	104.53 ab
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	0.03	0.04
C.V. (%)	16.98	6.28	14.09	10.79	12.34	14.23	14.32	10.35	9.90	10.48

ns Non significant difference at 95% level ($P > 0.05$) by LSD

5. Fruit weight At 85 DAF, fruit weight was over than 253.9 g per fruit. After that, this figure continued to increase until harvesting. At harvesting, fruit weight was not less than 276 g. GA application had no significant effect to this figure after spraying until harvesting. The harvested fruits at fully mature stage had a similar weight among the all treatments, ranged from 276.53-299.58 g (Table 121). Concurred with Krisanapook *et al.* (2000) indicated that after week 8, fruit weight of mango continued to increase after maturity until harvesting.

Table 121. Fruit weight of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Fruit weight (g)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	260.97	282.86	245.35	323.60	298.50
GA 50 ppm at 85 DAF	265.77	287.43	280.52	291.47	276.53
GA 50 ppm at 95 DAF	290.96	303.00	293.91	287.56	299.58
GA 50 ppm at 105 DAF	253.90	293.44	297.44	324.16	299.42
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	11.58	11.92	13.43	8.72	5.75

ns Non significant difference at 95% level ($P > 0.05$) by LSD

6. Fruit size At 85 DAF, fruit size in terms of width, length and thickness were 7.02, 10.72 and 6.23 cm, respectively. Every week after spraying, fruits continued to increase a little size until harvesting. At harvesting, fruit size were 7.2, 10.96 and 6.65 cm, respectively. GA application had no significant effect on increasing the fruit size (Table 122-124). After spraying, fruit size on each fruit age, among the all treatments were similar. All treatments had the same fruit size at harvesting stage, range from 7.13-7.3, 10.57-10.96 and 6.6-6.8 cm, respectively. Krisanapook *et al.* (2000) presented that after 77 days of fruit set, growth rate of mango fruit occurred remarkedly slow or with a little growth. Thus, GA application on late fruit growth had no affect the fruit size (Khader, 1991).

Table 122. Fruit width of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Fruit width (cm)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	7.02	7.26	6.80	7.34	7.20
GA 50 ppm at 85 DAF	6.88	7.29	7.21	7.43	7.13
GA 50 ppm at 95 DAF	7.02	7.46	7.19	7.08	7.26
GA 50 ppm at 105 DAF	7.12	7.44	7.53	7.41	7.30
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	2.47	2.70	4.71	2.77	1.64

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 123. Fruit length of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Fruit length (cm)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	10.72	11.02	10.53	11.54	10.96
GA 50 ppm at 85 DAF	10.40	11.06	10.47	10.74	10.57
GA 50 ppm at 95 DAF	10.67	11.15	11.25	10.97	10.83
GA 50 ppm at 105 DAF	10.73	10.81	10.89	11.61	10.85
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	3.01	4.29	3.70	3.43	2.41

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 124. Fruit thickness of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Fruit thickness (cm)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	6.23	6.58	6.26	6.86	6.65
GA 50 ppm at 85 DAF	6.21	6.57	6.59	6.66	6.60
GA 50 ppm at 95 DAF	6.33	6.73	6.74	6.66	6.80
GA 50 ppm at 105 DAF	6.38	6.81	6.71	6.86	6.74
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	2.41	5.12	5.03	2.27	1.78

ns Non significant difference at 95% level ($P > 0.05$) by LSD

7. Weight and size of seed Seed weight at 85 DAF was around 35.13 g. After that, seed weight was rather constant until harvesting. GA application had no significant effect to seed weight. After spraying until harvesting, among the all treatments gave the similar seed weights, ranged from 35.92-40.15 g (Table 125).

Table 125. Seed weight of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Seed weight (g)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	35.13	33.18	31.81	42.77 a	37.78
GA 50 ppm at 85 DAF	38.13	38.27	32.11	39.18 a	35.92
GA 50 ppm at 95 DAF	44.57	39.59	37.07	29.89 b	40.15
GA 50 ppm at 105 DAF	37.62	34.68	34.41	36.56 ab	36.79
$LSD_{0.05}$	ns	ns	ns	2.41	ns
C.V. (%)	14.86	10.47	7.43	11.23	7.60

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

In addition, at 85 DAF seed size in terms of width, length and thickness were 4.33, 9.39 and 1.86 cm, respectively. After 85 DAF until harvesting, seed growth in terms of width (Table 126) and length (Table 127) tended to decrease their size while, seed thickness (Table 128) stopped their growth after 85 DAF. GA application had no significant effect to seed size after spraying until harvesting. At harvesting, seed size of all treatments did mot exceed 4.3, 9.2 and 2.2 cm, respectively. Krisanapook *et al.* (2000) reported that the growth pattern of seed was similar to fruit. After week 8, size and weight of seed seemed to cease already (Ram, 1992).

Table 126. Seed width of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Seed width (cm)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	4.33	4.60	4.02	4.11	4.26
GA 50 ppm at 85 DAF	4.60	4.63	4.21	4.20	4.05
GA 50 ppm at 95 DAF	4.48	4.46	5.04	3.98	4.28
GA 50 ppm at 105 DAF	4.43	4.32	4.49	4.23	4.23
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	4.76	4.19	21.57	4.61	2.89

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 127. Seed length of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Seed length (cm)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	9.39	9.27	8.77	9.17	9.23
GA 50 ppm at 85 DAF	9.47	9.35	8.47	8.92	8.86
GA 50 ppm at 95 DAF	9.73	9.01	8.96	8.80	9.16
GA 50 ppm at 105 DAF	9.52	8.82	9.14	9.42	9.00
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	6.09	5.29	4.72	4.27	3.29

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 128. Seed thickness of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Seed thickness (cm)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	1.86	2.15	2.06	2.37 a[1]	2.07
GA 50 ppm at 85 DAF	2.02	2.28	2.24	2.23 ab	2.14
GA 50 ppm at 95 DAF	2.17	2.18	2.26	2.13 b	2.05
GA 50 ppm at 105 DAF	2.07	2.05	1.90	2.13 b	2.17
$LSD_{0.05}$	ns	ns	ns	0.06	ns
C.V. (%)	8.69	7.92	11.01	4.28	3.33

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

8. Flesh percentage At 85 DAF, flesh content was not lower than 75%. GA application had no significant effect on increasing the flesh percentage. After spraying, flesh

Table 129. Flesh content of Kaew mango fruits treated with GA 50 ppm and different fruit ages

Treatment	Flesh content (%)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	76.02	78.70	81.30	80.20 b[1]	80.64
GA 50 ppm at 85 DAF	74.93	78.22	80.01	79.52 b	81.20
GA 50 ppm at 95 DAF	75.84	77.63	82.19	82.26 a	80.79
GA 50 ppm at 105 DAF	76.78	78.26	82.98	81.92 a	80.93
$LSD_{0.05}$	ns	ns	ns	0.45	ns
C.V. (%)	2.49	1.37	3.79	0.97	0.84

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

content was increased until 99 DAF (over than 80%), after that until harvesting it tended to decrease its flesh. At harvesting, all treatments gave the similar flesh content, between 80.64-81.2% (Table 129).

9. Moisture contents in leaves and fruits

9.1 Leaf moisture content There is a poor change in leaf moisture content from 85 DAF until harvesting. At 85 DAF, leaf moisture content was not lower than 49.57%. After that, leaf moisture content was rather constant through harvesting. GA application had no significant effect to this figure. At harvesting, leaf moisture content of all treatments were the same as 48.84-49.56% (Table 130).

Table 130. Leaf moisture content of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Leaf moisture content (%)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	53.13	51.99	52.54	52.03 b[1]	49.56
GA 50 ppm at 85 DAF	49.57	49.96	50.94	53.85 a	49.17
GA 50 ppm at 95 DAF	55.18	52.16	52.36	54.09 a	48.84
GA 50 ppm at 105 DAF	52.30	51.79	50.96	53.85 a	49.30
$LSD_{0.05}$	ns	ns	ns	0.34	ns
C.V. (%)	7.52	3.31	1.78	1.10	2.34

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

9.2 Fruit moisture content Moisture content in fruit had higher level than leaf. At 85 DAF, fruit moisture content was not lower than 82%. After spraying until harvesting, fruit moisture contents tended to decrease their levels. GA application had no significant effect to this figure at different fruit ages through harvesting. At harvesting, fruit moisture contents were decreased to 77.68-78.31% (Table 131). Lizada (1991) reported that at the later stages of fruit maturation, the decreasing of pulp moisture content was accompanied by increasing in total

sugars. While, Hofman *et al.* (1997) indicated that there is a relationship between harvest date and dry matter percentage in the mango fruit cv. 'Kensington'.

Table 131. Fruit moisture content of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Fruit moisture content (%)				
	85 DAF	92 DAF	99 DAF	105 DAF	harvesting
Control	82.44	82.84	79.43	79.72	78.31
GA 50 ppm at 85 DAF	82.48	82.22	79.61	78.35	77.81
GA 50 ppm at 95 DAF	83.38	82.06	80.28	79.56	77.68
GA 50 ppm at 105 DAF	84.41	81.98	81.31	79.39	77.90
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	2.30	0.95	1.18	1.88	1.288

ns Non significant difference at 95% level ($P > 0.05$) by LSD

10. Color of peel Before taking the experiment, fruits at 85 DAF were measured the peel color in terms of L (lightness), c (chroma) and h (hue). The results found that L, c and h values of peel color at this stage was 33, 24 and 102, respectively. These color values implied that the tonality of peel color was deep green. After that until harvesting, all of L, c and h measured at 3 sides (shoulder, middle and apex) tended to decrease their values. GA application had no significant effect to peel color after spraying until harvesting. At harvesting, L, c and h values from three sides of fruit were similar, ranged of 29-34, 23-28 and 93-103, respectively (Table 132-134).

Table 132. Peel color of Kaew mango fruits at shoulder side treated with GA 50 ppm and different fruit ages

Treatments	Peel color at shoulder side											
	92 DAF			99 DAF			105 DAF			Harvesting		
	L	c	h	L	c	h	L	c	h	L	c	h
Control	37.69 a[1]	27.63 b	101.30 a	35.31 a	28.11 b	181.51	34.49 a	26.46 b	181.44	30.28	23.75	93.82
GA 50 ppm at 85 DAF	33.97 b	31.29 a	94.50 b	29.96 b	30.94 a	181.46	31.66 b	31.60 a	181.45	29.34	24.31	93.72
GA 50 ppm at 95 DAF	35.80 ab	26.95 b	100.51 a	35.05 a	27.33 b	181.47	31.84 b	28.28 b	181.47	29.22	23.63	94.38
GA 50 ppm at 105 DAF	35.73 ab	27.64 b	100.15 a	35.64 a	27.28 b	181.47	32.86 ab	27.75 b	181.49	29.41	24.06	93.65
$LSD_{0.05}$	0.71	0.65	0.83	0.81	0.54	ns	0.66	0.88	ns	ns	ns	ns
C.V. (%)	3.95	4.59	1.68	4.74	3.78	0.02	4.04	6.17	0.02	2.15	3.81	1.33

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 133. Peel color of Kaew mango fruits at middle side treated with GA 50 ppm and different fruit ages

Treatments	Peel color at middle side											
	92 DAF			99 DAF			105 DAF			Harvesting		
	L	c	h	L	c	h	L	c	h	L	c	h
Control	36.66 a[1]	27.35 b	103.91	36.09 a	25.83 b	181.37	33.71	24.97 c	181.35	32.68 a	26.23	100.55
GA 50 ppm at 85 DAF	31.93 c	30.43 a	101.49	31.66 b	29.39 a	181.39	31.31	29.86 a	181.36	32.02 b	27.25	99.23
GA 50 ppm at 95 DAF	34.02 bc	28.09 ab	104.05	35.79 a	25.96 b	181.35	32.55	26.39 bc	181.37	32.42 ab	26.36	100.38
GA 50 ppm at 105 DAF	35.51 ab	27.11 b	103.27	35.13 a	26.90 b	181.37	32.51	28.24 ab	181.36	31.95 b	25.58	100.71
$LSD_{0.05}$	0.74	0.79	ns	0.73	0.79	ns	ns	0.87	ns	0.18	ns	ns
C.V. (%)	4.29	5.56	1.63	4.20	5.87	0.02	3.32	6.37	0.02	1.13	2.87	0.73

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 134. Peel color of Kaew mango fruits at apex side treated with GA 50 ppm and different fruit ages

Treatments	Peel color at apex side											
	92 DAF			99 DAF			105 DAF			Harvesting		
	L	c	h	L	c	h	L	c	h	L	c	h
Control	34.64	26.54	103.95	34.75	24.81	181.33	34.56 a[1]	25.91 b	181.34	33.49	27.26	102.54 a
GA 50 ppm at 85 DAF	33.18	29.01	102.15	34.87	28.40	181.37	32.33 b	28.77 a	181.34	32.79	27.44	101.30 b
GA 50 ppm at 95 DAF	33.31	26.81	104.60	35.65	27.03	181.33	32.40 b	24.80 b	181.36	32.95	27.01	102.26 a
GA 50 ppm at 105 DAF	33.35	27.20	102.98	35.59	26.68	181.38	32.01 b	25.26 b	181.34	32.48	26.79	101.95 ab
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	0.5492	0.6020	ns	ns	ns	0.2613
C.V. (%)	4.66	5.20	1.13	4.71	8.89	0.02	3.35	4.60	0.02	2.41	2.21	0.51

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

11. Harvesting period Generally, Kaew mango fruits were picked after maturing on 113.98 DAF. GA application had significant effect on delaying the harvesting time. All of trees treated with GA delayed the harvesting periods to 123.48-124.13 DAF or later than untreated trees 9.5-10.15 days (Table 135). This results may be due to GA had an antagonistic effect on the biogenesis of ABA and endogenous ethylene (Pozo, 2001; Ross and U'Neilla, 2001). Thus, many ripening enzyme activity (Mehta *et al.*, 1986), chlorophyll degradation, and ethylene production were inhibited (Khader *et al* .,1988). These results indicated that the GA application had an effect on delaying fruit maturity attached to the tree.

Table 135. Days to harvesting and yield of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Days to harvesting (DAF)	Yield (kg/tree)
Control	113.98 b[1]	130.50 b
GA 50 ppm at 85 DAF	122.73 a	191.75 a
GA 50 ppm at 95 DAF	124.13 a	119.25 b
GA 50 ppm at 105 DAF	123.48 a	131.75 b
$LSD_{0.05}$	1.30	12.12
C.V. (%)	2.15	16.92

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

12. Yield According to natural conditions, mango trees gave the yield around 130.5 kg per tree. GA application had significant effect on increasing the yield, particularly GA sprayed to fruits 85 DAF. The highest yield received from trees treated with GA 50 ppm on fruits 85 DAF (191.75 kg per tree). While trees treated with GA 50 ppm on fruits 95 and 105 DAF and untreated trees gave the similar yield, approximately 119.25 and 131.75 kg per tree (Table 135).

13. Internal qualities

13.1 Fruit stalk toughness The fruit stalk toughness value of mango fruits

picked at fully mature stage was around 4.74 kg. GA application had no significant effect to this figure. Fruit stalk toughness values among the all treatments were the similar, ranged from 4.21-4.77 kg (Table 136).

13.2 Fruit firmness Kaew mango fruits harvested at fully mature stage had fruit firmness after peeling around 9.65 kg/cm^2. GA application had no effect on increasing this figure. Although fruits from trees treated with GA (9.82-10.01 kg/cm^2) had higher fruit firmness than untreated trees (9.65 kg/cm^2) but these values were not significant difference (Table 136). Inversely, McDonald *et al.* (1997) reported that GA application could retain the high peel puncture resistance of grapefruit. While, Pozo (2001) reported the GA could delayed rind softening of citrus fruit.

13.3 Total soluble solids (TSS) and titratable acidity (TA) Generally, mango fruits picked at fully mature stage had TSS content around 8.06°Brix. GA application at three fruit ages had no significant effect to this figure. At harvesting, TSS contents of fruits from all treatments were similar, ranged from 8.06-8.47°Brix (Table 136). With respect to TA, fruits harvested at fully mature stage had TA content around 0.22%. Like TSS, GA application had no effect to TA content. Fruits from all treatments had the same TA content of 0.22% (Table 136). Anggarwati (1985) indicated that the application of plant growth bioregulators had no effect to the internal qualities of fruit. In addition, McDonald *et al.* (1997) presented that GA had no effective on SS or TA of grapefruit pulp qualities.

134. Flesh color After peeling, flesh color of fruits picked at fully maturity had the L, c and h values as 51.21, 33.73 and 87.72, respectively. GA treatment had no significant effect to flesh color. Among the all treatments had the same both L (50.65-51.35) and h (86.5-87.72) values, excepted for c values. Fruits from spraying GA at 85 DAF (35.29) had the higher c value than the others (33.73-34.51) (Table 136). But this is a little difference compared with the overall flesh color measurement.

Table 136. Fruit stalk toughness, fruit firmness, total soluble solids (TSS), titratable acidity (TA) and flesh color of Kaew mango treated with GA 50 ppm and different fruit ages

Treatment	Fruit stalk toughness (kg)	Fruit firmness (kg/cm^2)	TSS (°Brix)	TA (%)	Flesh color		
					L	c	h
Control	4.74	9.65	8.06	0.22	51.21	33.73 b[1]	87.72
GA 50 ppm at 85 DAF	4.62	9.82	8.44	0.21	50.65	35.29 a	86.50
GA 50 ppm at 95 DAF	4.44	10.01	8.07	0.22	51.35	34.51 ab	86.63
GA 50 ppm at 105 DAF	4.21	9.80	8.47	0.22	51.18	34.27 b	86.93
$LSD_{0.05}$	ns	ns	ns	ns	ns	0.29	ns
C.V. (%)	7.15	4.49	4.51	0.01	0.84	1.66	0.80

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

4. Combination of technology for delayed harvesting of Kaew mango

The previous experiments searched for delaying the harvesting of Kaew mango was carried on three stages (1) delayed flowering by pruning and flower thinning, (2) extension of panicle growth by PBZ, and (3) delaying fruit maturation by bagging and GA. After testing each three stages, the succeed method for producing late season of Kaew mango came from the stage (2) extension of panicle growth by PBZ and (3) delaying fruit maturation by GA. Thus, this combination experiment aimed to determine the effect again in the target area where was the high potential for producing late season Kaew mango.

1. Panicle growth Most of mango flowering buds were remarkedly appeared at the terminal shoot. Panicle appearance at 1 cm in length is an initial visibility of flower bud development. The characterisitc of panicle appearance is bend and acuity at an apex similar as a cock's spur. The appearance of initial panicle started simultaneously in January 10, 2004 at Mae Ore Nai village. Flower shoots of both trees treated with PBZ and untreated trees had the same pyramidal panicle shape.

Paclobutrazol (PBZ) spraying at panicle appearance (1 cm in length) had a dramatic effect on panicle size, both diameter and length. The panicle development from spraying PBZ 1000 ppm was gradually increased, while panicle of untreated was rapidly grew at the same time. The effect of PBZ to panicle size, started after spraying seven days after spraying (DAS) until full bloom. With respect to diameter, there was a significant difference between PBZ treated and untreated trees. The result from Table 137 showed that at full bloom stage, panicle sprayed PBZ 1000 ppm (11.45 cm) showed the less diameter than control (15.07 cm).

The effect of PBZ were not only inhibited to panicle diameter, but also reduced the panicle length. It was observed from Table 138 that there were significant difference in panicle length among treatments. Length of panicle between PBZ treated (3.07 cm) and untreated (3.73 cm) started to show significant influenced at seven DAS. These difference still continued through the full bloom stage. At these stage, untreated panicle (28.34 cm) showed longer than panicle treated with PBZ (18.57 cm). These may be due to PBZ behaves as an inhibitor of growth promoter such as gibberellin biosynthesis. Thus, the development of panicle was suppressed when applied on the initial panicle appearance (Kataoka *et al.*, 2003).

Table 137. Panicle diameter of Kaew mango after spraying PBZ 1000 ppm on panicle appearance

Treatment	Panicle diameter (cm)				
	7 DAS	14 DAS	21 DAS	28 DAS	35 DAS
Control	0.23 a [1]	2.33 a	8.15 a	12.99 a	15.07 a
PBZ 1000 ppm	0.00 b	1.20 b	5.14 b	9.63 b	11.45 b
Pair test	*	*	*	*	*
C.V. (%)	153.46	56.51	32.35	25.14	22.29

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

Table 138. Panicle length of Kaew mango after spraying PBZ 1000 ppm on panicle appearance

Treatment	Panicle length (cm)				
	7 DAS	14 DAS	21 DAS	28 DAS	35 DAS
Control	3.73 a [1]	9.96 a	19.43 a	26.13 a	28.34 a
PBZ 1000 ppm	3.07 b	5.37 b	11.08 b	16.16 b	18.57 b
Pair test	*	**	**	**	**
C.V. (%)	14.70	29.41	25.76	23.78	22.57

[1] ** Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by Pair test comparison

* Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

2. Blooming stage Full bloom stage is the last flowering development. The shape of mango panicle was pyramidal form. The blooming of mango florets had the same characteristic, by starting from basal end towards the tip of panicle, both treated with PBZ and untreated ones. After spraying with PBZ at panicle appearance, blooming percentage of florets on the panicle was less than untreated trees. PBZ had the role not only inhibition the panicle

growth, but also effeciency in delaying the full bloom stage. However, the delaying bloom, found only at the initial of 21 DAS. The result from Table 139 showed that small number of florets about 0.22% of the panicle treated PBZ were less bloomed compared with untreated (2.11%). Afterwards blooming percentage between control and PBZ-treated trees were not different until nearly full bloom (35 DAS). The time taken Full bloom stage of panicle treated PBZ and unsprayed was completed at the same time in 16 and 14 February, respectively. While Katz *et al.* (2003) reported that the spraying of Uniconazol (GA-biosynthesis inhibitor) with five concentrations (0, 10, 40, 100 and 250 mgl^{-1}), had a dramatic advance on flowering of *G. sarcophylla.*

Table 139. Blooming percentage of Kaew mango after spraying PBZ 1000 ppm on panicle appearance

Treatment	Blooming (%)		
	21 DAS	28 DAS	35 DAS
Control	2.11 a [1]	73.60	93.43
PBZ 1000 ppm	0.22 b	60.48	92.80
Pair test	*	ns	ns
C.V. (%)	133.80	21.96	7.33

[1] * Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by Pair test comparison

ns Non significant differences at 95% level ($P>0.05$)

3. Floral sex ratio The mango panicle composed of densely flowered arranged on the panicle. There are two floral sex on each panicle called polygamous, namely male and perfect flower. When most of panicles were 80-90% in bloom, both male and perfect flowers were not significantly influenced by PBZ application during panicle appearance at 1 cm in length. Among the treatments, male and perfect flowers were similar between 84.05-88.94 and 11.97-15.95%, respectively (Table 140). In addition, PBZ treatment had no significant effect on changing the floral sex ratios in term of male per perfect flowers. Among all treatments had similar floral sex

ratio, ranged from 6.46-9.29 (Table 140). Radanachaless *et al.* (2003) suggested that floral sex ratio of Kaew mango was rather large. While Kurian and Iyer (1992) suggested that soil application of PBZ at rate of 10 g a.i. per tree significantly increased the ratio of perfect to male flowers.

Table 140. Floral percentage and floral sex ratio of Kaew mango after spraying PBZ 1000 ppm on panicle appearance

Treatment	Floral percentage (%)		Floral sex ratio
	Male	Perfect	
Control	84.05	15.95	6.46
PBZ 1000 ppm	88.94	11.97	8.37
PBZ 1000 ppm + GA 50 ppm	86.68	12.10	8.03
GA 50 ppm	87.16	12.84	9.29
$LSD_{0.05}$	ns	ns	ns
C.V. (%)	6.61	44.14	50.92

ns Non significant differences at 95% level (P>0.05)

4. Developmental stages from panicle appearance at 1 cm long to harvest The data recorded in accordance with five spans : full bloom, fruit at peanut, bird's egg, hen's egg, and harvest at fully mature stage.

4.1 Full bloom stage Full bloom is an easily observation stage. When most of the florets (80-90%) on the panicle bloom is called full bloom. Most of panicle appearance at 1 cm in length was first observed on January 10, 2004. From this stage, the panicle gradually developed and proceeded to the full bloom. Generally, mango trees spent the time taken for this stage by 23 days after panicle appearance. It was revealed from Table 141 that PBZ sprayed on panicle appearance had significant effected on delaying the full bloom stage later than untreated trees by 1.54-1.82 days. The periods from panicle appearance to full bloom stage of trees treated with PBZ was 36.87-37.15 days, while this same period from untreated trees was 35.33 days. While, Daecha *et al.* (2002) reported that the time taken for developing from panicle appearance

at 1 cm long to full bloom was 21 days. There were several reports mentioned the environment exerted a profound influence on the flowering behavior of mango trees. Schaffer *et al.* (1994) indicated that the short duration during panicle emergence until full bloom occurred more quickly, as little as 4 weeks under tropical conditions. These might be accounted for that panicle development after floral induction was promoted by high temperature (Sasaki *et al.*, 2000).

4.2 Peanut stage The initial fruit developmental stage after blooming in this study was peanut stage. The size of fruit in this stage had 1 cm long. This fruit stage sometimes observed the style attached to the fruit. Under natural condition, mango fruits enter to this initial fruit stage 13.25 DAF. PBZ application at panicle appearance not only delayed the full bloom stage, but it also effected on delaying the fruit growth. It was revealed from Table 141 that fruits from untreated trees entered to this stage by 13.25 DAF. While fruits from trees treated with PBZ spent the time taken for this stage by 14.95-15.35 DAF, or later than untreated trees 1.7- 2.1 days.

4.3 Bird's egg stage The second stage of fruit development after peanut stage was bird's egg. At this stage, fruit length is about 3 cm and no appearance of style on the fruit. There was significant differences duration of fruit development from peanut to bird's egg stage among the treatments. The time taken for this stage of fruit development from untreated trees was 23.48 days. While trees treated with PBZ spent the longer time of 25.2 days (Table 141). Thus, fruits from the untreated trees entered to this stage earlier than trees treated with PBZ by 1.72 days.

4.4 Hen's egg stage After bird's egg stage, fruit development proceeded to the third stage, namely hen's egg stage. In this stage the fruit size was 6 cm long. PBZ application had significant effect on delaying fruit development at hen's egg stage. The result from Table 141 showed that trees treated with PBZ spent the longer time taken to enter this fruit development by 35.35-37.76 days. While untreated trees spent the shorter time taken for developing this fruit stage by 32.35 days. Thus, fruits from trees treated with PBZ enter to this stage later than control trees by 3.0-5.41 days.

Table 141. Days to each developmental stage of Kaew mango after application of two bioregulators

Treatment	Days to each developmental stage				
	Full bloom	Peanut	Bird's egg	Hen's egg	Harvest
Control	35.33 b [1]	13.25 b	23.48 b	32.35 c	115.59 c
PBZ 1000 ppm	37.15 a	15.35 a	24.25 ab	35.86 ab	133.88 a
PBZ 1000 ppm+ GA 50 ppm	37.12 a	14.95 a	25.20 a	37.76 a	135.99 a
GA 50 ppm	36.87 a	14.15 ab	23.43 b	35.35 b	127.31 b
$LSD_{0.05}$	0.25	0.42	0.42	0.62	1.04
C.V. (%)	1.39	5.76	3.52	3.51	1.62

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

4.5 Harvesting stage After hen's egg stage, treatments of GA and GA plus PBZ were sprayed with GA 50 ppm at 85 DAF. The harvesting stage of each treatment was done at fully mature stage. The total time taken from full bloom to harvesting of mango trees was 115.59 DAF. Both the application of PBZ and combination of PBZ and GA gave the same results and had significant effect on delaying the harvesting period, ranged from 133.88-135.99 DAF. GA treatment at 85 DAF (after hen's egg stage) had also significant effect on delaying the harvesting to 127.31 DAF. But this period was shorter than PBZ and combination of PBZ and GA. While control trees spent the shortest time taken to harvest (115.59 DAF) (Table 141). Thus, PBZ treated trees at panicle appearance resulted in prolonging the harvesting time by 18.29-20.4 days later than control trees. While the results from previous experiment of PBZ concentrations and time of application to panicle growth indicated that PBZ application had effect on delaying the harvesting period by 10.2 DAF under the conditions of Chom Tong Land Reform Project Area Doi Lor district.

There were several documents reported the role of PBZ and GA involving the retarded senescence of fruit. Jacobsen *et al.* (1995) presented that PBZ was known an inhibitory effect upon the expression of many genes related to ripening stage, such as, α-amylase genes. While,

Mehta *et al.* (1986) indicated that GA treatment had an antagonistic effect on the biogenesis of endogenous ethylene (Dilley, 1969) by inhibiting the enzyme activities leading to ripening process such as amylase and peroxidase activity (Fry, 1980). Khader (1991) also presented that foliar spraying gibberellic acid (GA) at 200 mg/L after fruit set, to the mango cv. Dashehari, had significant effect on the ripening inhibition by retaining a green color in the shoulder region, for up to six days. While, the investigation in citrus fruit El-Otmani and Coggins (1995) suggested that morphological changes in epicuticular wax may be delayed by preharvest treatments with gibberellic acid (GA_3). Schirra *et al.* (1999) also reported that cactus pear fruit cv. Gialla treated with 10 ppm gibberellic acid (GA_3), 10 weeks after the second induced-bloom flush, could delayed the peel color change.

Nevertheless the result of delayed harvesting Kaew mango for fresh consumption could not extend to the target date of July 15 because there are some stipulations related with the late season production. These may be due to the climate variation in the year of 2004 caused the panicle appearance occurred quicker than the past year by 1 month (January). In addition, the mean temperatures from April, May and June were rather high of 28.9, 27.9 and 26.4°C. Thus, the maturity of fruit may be accelerated by these conditions and the production of late season was limited. Radanachaless *et al.* (2003) suggested that the environment, particularly temperature had high influence for late season production of mango. This factor limited the natural maturity of fruit attaching to the tree.

5. Fruited panicle percentage The initial fruit set at peanut stage, the high amount fruited panicles was around 30.76% of total panicles. After that the fruited panicles were decreased throughout the fruit development. The application of two bioregulators had no effect on changing the amount of fruited panicle at all fruit developments. Among all treatments had the similar amount of fruited panicle at peanut, bird's egg and hen's egg stage ranged from 30.76-40.34, 20.45-28.35 and 13.15-24.09%, respectively. At harvesting, fruited panicle of control trees was decreased to 4.92%. While trees treated with two bioregulators had higher fruited panicles (7.3-7.97%) but these values were not different from control trees (Table 142). Radanachaless *et al.* (2003) reported that under the rainfed upland condition, fruited panicle of Kaew mango trees was only 7% at harvesting.

Table 142. Fruited panicle percentage of Kaew mango after application of two bioregulators

Treatment	Fruited panicle (%)			
	Peanut	Bird's egg	Hen's egg	Harvest
Control	30.76	20.45	13.15	4.92
PBZ 1000 ppm	32.64	28.35	24.09	7.97
PBZ 1000 ppm + GA 50 ppm	40.34	27.88	19.00	7.30
GA 50 ppm	35.15	25.25	17.10	7.74
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	25.69	31.49	32.67	26.63

ns Non significant difference at 95% level ($P > 0.05$) by LSD

6. Number of fruit per panicle At initial fruit set (peanut stage), the number of fruit per panicle was around 2.18. When fruit advanced their development, the less number of fruit per panicle was found. Generally at harvesting, the number of fruit per panicle was decreased to 1.06%, which was less than 50% of initial fruit set. Two bioregulators had no effect on changing the numbers of fruit per panicle throughout at all fruit developments. All treatments had the similar number of fruit per panicle at peanut, bird's egg, hen's egg and harvesting ranged from 2.05-3.00, 2.05-2.85, 1.30-1.95 and 1.04-1.08, respectively (Table 143). Negi (2000) presented that in mango despite high initial fruit set, the ultimate retention of fruits was quite low due to several factors, both internal and external factors (Krisanapook *et al.*, 2000). Schaffer *et al.* (1994) suggested that many mango cultivars usually carried only one fruit per panicle through to maturity. While Radanachaless *et al.* (2003) also reported that Kaew mango trees planted under rainfed upland usually produced 1-3 fruits per panicle. Despite many field experiments demonstrated that PBZ had effect to activate the process of abscission (Goren, 1993 ; Pozo, 2001 ; Kataoka *et al.*, 2003), but PBZ application in this experiment did not cause remarkedly fruit abscission when applied to the panicle appearance at 1 cm long. However, the available information did not mention the role of endogenous growth promoters and growth inhibitors in the regulation of fruit abscission (Pozo, 2001).

Table 143. Number of fruit per panicle of Kaew mango after application of two bioregulators

Treatment	Number of fruit per panicle			
	Peanut	Bird's egg	Hen's egg	Harvest
Control	2.18	2.15	1.30	1.06
PBZ 1000 ppm	3.00	2.85	1.95	1.05
PBZ 1000 ppm + GA 50 ppm	2.05	2.80	1.70	1.04
GA 50 ppm	2.53	2.05	1.55	1.08
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	28.44	19.08	24.48	4.44

ns Non significant difference at 95% level ($P > 0.05$) by LSD

7. Fruit size at harvesting Mango fruit which is harvested at fully mature stage had the size in terms of width, length and thickness as 7.26, 10.06 and 6.74 cm, respectively. At harvesting, two bioregulators had no effect on increasing the fruit size, excepted fruit length. All treatments gave the similar fruit width and thickness, ranged from 6.81-7.26 and 6.42-6.74 cm, respectively. The application of two bioregulators had significant effect on decreasing fruit length. Fruits from trees treated with PBZ and/or GA (9.19-9.84 cm) had shorter than fruits from untreated trees (10.06 cm) (Table 144). There was a general assumption that fruit growth (cell division and cell expansion) was under hormonal control (Santes *et al.*, 1995 ; Gao *et al.*, 2001). The smaller fruit size received from two bioregulators treated trees may be due to PBZ was known to be counteract the physiological effects of gibberellins in fruit growth. Thus, PBZ had been considered to play a negative role in reproductive development of fruit (Kojima *et al.*, 1993). Kataoka *et al.* (2003) also reported that the younger of tomato fruits cv. Severianin treated with uniconazole (an inhibitor of gibberellin biosynthesis), the smaller of fruits received at maturation. With respect to Gibberellin, Talon *et al.* (1997) indicated that gibberellin is an activators of cell division and cell enlargement processes. The gibberellin presence in fruit was generally associated with an activating signal of initial ovary growth leading to fruit development (Talon *et al.*, 1997). Singh *et al.* (1992) reported that the most effective of GA application in increasing the

Table 144. Fruit size at harvesting after application of two bioregulators

Treatment	Fruit size (cm)			Fruit weight
	Width	Length	Thickness	(g)
Control	7.26	10.06 a[1]	6.74	274.60
PBZ 1000 ppm	7.08	9.84 a	6.68	263.64
PBZ 1000 ppm + GA 50 ppm	6.81	9.60 ab	6.42	245.16
GA 50 ppm	6.82	9.19 b	6.50	237.69
$LSD_{0.05}$	ns	0.19	ns	ns
C.V. (%)	3.77	3.89	3.18	7.42

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$)

fruit size should be applied at the initial fruit growth. Thus, GA application at late fruit stage (85 DAF) when the majority of fruit growth had passed already, had no significant increased on fruit size. In addition, application of two bioregultors had no significant effect on increasing fruit weight. At harvesting, all treatments had similar fruit weight, ranged from 237.69-274.6 g per fruit (Table 144).

8. Seed size and flesh content at harvesting At harvesting, seed size of control trees in terms of width, length and thickness were 3.92, 8.42 and 2.04 cm, respectively. GA treated at 85 DAF had significant effect on reducing seed size, regardless of width, length and thickness. Fruit from treated with GA gave the small seed size (3.62 cm width, 7.63 cm in length and 2.04 cm thickness). In addition, there was not different of seed weight among the treatments, ranged from 33.61-36.42 g (Table 145). At harvesting, Kaew mango fruit had the flesh content after peeling around 80.45%. Two bioregulators had no significant effect on increasing the flesh content. All treatments gave the similar flesh contents, ranged from 79.26-81.23% (Table 145).

Table 145. Seed size and flesh content of Kaew mango at harvesting after application of two bioregulators

Treatment	Seed size (cm)			Seed weight	Flesh content
	Width	Length	Thickness	(g)	(%)
Control	3.92 a[1]	8.42 a	2.04 b	36.42	80.45
PBZ 1000 ppm	3.81 ab	8.14 ab	2.32 a	33.61	81.23
PBZ 1000 ppm + GA 50 ppm	3.48 c	7.98 ab	1.78 b	34.98	80.64
GA 50 ppm	3.62 bc	7.63 b	2.04 b	33.92	79.26
$LSD_{0.05}$	0.07	0.18	0.09	ns	ns
C.V. (%)	4.00	4.37	8.81	9.57	2.00

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$)

9. Moisture percentage at 85 DAF to harvest At 85 DAF moisture content in mango fruit was 83.89%. The moisture content in Kaew mango fruit decreased after 85 DAF until harvesting. At fully mature stage, the fruit moisture content was 78.95%. Bioregulator application had no significant effect on changing the fruit moisture content from 92 DAF to

Table 146. Moisture content of Kaew mango fruits after the application of two bioregulators

Treatment	Moisture content (%)				
	85 DAF	92 DAF	99 DAF	106 DAF	Harvest date
Control	83.89	82.37	81.79	80.03	78.95
PBZ 1000 ppm	84.02	82.27	80.80	80.74	79.08
PBZ 1000 ppm+ GA 50 ppm	83.44	82.14	80.62	81.46	78.31
GA 50 ppm	82.77	81.48	81.99	80.03	79.39
$LSD_{0.05}$	ns	ns	ns	ns	ns
C.V. (%)	1.44	1.07	1.40	2.17	1.22

ns Non significant difference at 95% level ($P > 0.05$) by LSD

harvesting. At harvesting, fruit moisture contents of all treatments ranged from 78.31-79.39% (Table 146). These similar values showed the regular of fully maturity of fruit when harvested. Hofman *et al.* (1997) presented that the determination of moisture content in fruit was a reliable method for judging the maturity index of mango cv. Kensington Pride. The result of similar moisture content among the treatments in this experiment, indicated that fruits from trees treated with PBZ and GA still had the same moisture contents as control in spite of delayed harvesting by twenty days.

10. Chlorophyll content at 85 DAF to harvest At 85 DAF, chlorophyll content in peel of mango fruit measured as 125.47 mg/g fresh weight. From 85 DAF to harvesting, less chlorophyll content in mango fruit was found. At fully mature stage, fruit chlorophyll content was around 74.79 mg/g fresh weight. From 92 DAF until harvesting, the application of single PBZ and combination of PBZ and GA gave the same results and had significant effect on retaining higher chlorophyll content than other treatments. At harvesting, trees treated with single PBZ and combination of PBZ and GA had the same chlorophyll contents, ranged from 89.93-97.62 mg/g fresh weight. While fruit chlorophyll content from trees treated with GA and untreated trees decreased to 77.03 and 74.79 mg/g fresh weight (Table 147). Naturally,

Table 147. Chlorophyll content of Kaew mango after application of two bioregulators

Treatment	Chlorophyll content (mg/g fresh weight)				
	85 DAF	92 DAF	99 DAF	106 DAF	Harvest date
Control	125.47	109.11 b[1]	100.59	92.07 b	74.79 c
PBZ 1000 ppm	145.28	141.67 a	122.85	115.37 a	89.93 ab
PBZ 1000 ppm+ GA 50 ppm	140.07	126.62 ab	108.72	98.95 b	97.62 a
GA 50 ppm	132.95	121.32 b	110.18	101.99 b	77.03 bc
$LSD_{0.05}$	ns	5.99	ns	3.27	4.58
C.V. (%)	8.29	9.60	9.93	6.40	10.81

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

chlorophyll degradation was a typical of plant tissues, which took place during various phases of the life cycle through senescence (Simpson *et al.*, 1976). The mechanism responsible for this chlorophyll degradation of plants was not yet fully understand (Takamiya *et al.*, 2000). Although, the available information did not mention the effect of PBZ plus GA on delaying the harvesting period of mango fruits. However, a reduction in ethylene formation and increased in cytokinin levels seemed to be the major effect (Grossmann, 1990).

11. Total nonstructural carbohydrate content (TNC) At 85 DAF, the TNC content in mango fruit was 391.21 mg/g fresh weight (FW). During 85 to 116 DAF, TNC contents in fruit were rather stable. After that fruit TNC decreased to 345.62 mg/g FW. PBZ and GA applications had no significant effect on changing TNC content in fruits from 85 DAF until harvesting. At harvesting, all treatments had similar TNC contents in fruits, ranged from 345.62-368.49 mg/g FW (Table 148). Arthey and Ashurst (1996) reported that the accumulation of carbohydrate was a developmental process linked to maturation. At maturation, Phavaphutanon *et al.* (2000) reported that a decraesed in fruit TNC because the stored carbohydrates in fruits may be more readily to be utilized for several purposes such as energy generation and production of raw materials (protein, nucleic acids, carbohydrates and lipids) (Buckeridge *et al.*, 2000).

Table 148. Total nonstructural carbohydrate (TNC) contents of Kaew mango after application of two bioregulators

Treatment	TNC content (mg/g FW)			
	85 DAF	99 DAF	116 DAF	Harvest date
Control	391.21	358.72	391.89	345.62
PBZ 1000 ppm	344.61	376.11	387.51	357.97
PBZ 1000 ppm+ GA 50 ppm	376.06	367.99	383.04	368.49
GA 50 ppm	378.85	370.97	381.32	360.00
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	5.70	4.26	3.14	5.01

ns Non significant difference at 95% level ($P > 0.05$) by LSD

In addition, rate of import of photosynthate appeared to be controlled by the metabolic activity of fruit (Walker and Ho, 1977 ; Walker and Thornley, 1977).

12. Reducing sugar content (RS) At 85 DAF, the RS content in mango fruit was around 128.52 mg/g dry weight (DW). During 99 to 116 DAF, the decreased of fruit RS were found then these contents increased again at harvesting. The RS content of mango fruits at fully mature stage was 135.62 mg/g DW. PBZ and GA application had no significant effect on changing RS contents in fruits at 85 DAF until harvesting. At harvesting, all treatments had similar RS contents, ranged from 112.74-135.62 mg/g DW (Table 149).

The concurrence of TNC droped and RS increased at harvesting may be due to storage starch was composed of RS which is single sugar such as glucose and fructose. This RS were promptly incorporated into the energy-generation metabolism, culminated in rapid production of ATP and also yielded carbon for biosynthesis of most biomolecules in the plant cells (Buckeridge *et al.*, 2000). Furthermore, a little was known about the mechanisms underlying sugar accumulation in developing fruit (Islam *et al.*, 1996).

Table 149. Reducing sugar (RS) contents of Kaew mango after application of two bioregulators

Treatment	RS content (mg/gDW)			
	85 DAF	99 DAF	116 DAF	Harvest date
Control	128.52	114.62	96.70	135.62
PBZ 1000 ppm	135.63	116.91	79.02	112.74
PBZ 1000 ppm+ GA 50 ppm	131.05	128.44	90.55	115.48
GA 50 ppm	119.39	112.00	89.29	130.16
$LSD_{0.05}$	ns	ns	ns	ns
C.V. (%)	15.42	8.41	12.52	21.08

ns Non significant difference at 95% level ($P > 0.05$) by LSD

13. Peel color from fruit 85 DAF to harvest Peel color measurement was recorded in terms of L (lightness of color), c (chroma or color intensity), and h (hue angle or chromatic tonality). The results from Table 150-152 showed that peel color had a little change after 85 DAF

until harvesting. At harvest, there was no significant difference of L (31.79-34.3) and c values (25.35-29.83) at three parts of fruit (shoulder, middle and apex) among the treatments. These indicated that the lightness and intensity of green color decreased when fruits were fully maturity. The result of L and c values on fruit peel in these experiment corresponded with Atchariyamontree (2004) who reported that the average L values of raw material mango used in processing plants was 33.8, the maximum and minimum values were 37.3 and 31.1. In addition, the average c values of raw material mango optimum for processing was 27.8, the maximum and minimum values were 29.3 and 26.0. This indicated that although the fruits from trees treated with PBZ which delayed by 20 days, still gave the peel color agreed with the requirement for processing.

At harvesting the significant difference of color found only from h values. The fruits from bioregulator treatments had more hue values than untreated trees, both shoulder and apex sides (Table 150 and 152). The higher h values of fruits from bioregulator treatments at shoulder and apex ranged of 94.15-94.7 and 101.76-103.66 or classified as brilliant green. The result of h values corresponded with Atchariyamontree (2004) who suggested that the average h values of raw mango material optimum for processing should be 101.7 or ranged of 97.6-120.0. These indicated that fruits from trees treated bioregulators could retain the greener of peel at shoulder and apex side than fruits from untreated trees.

While, fruits from untreated trees had the least h values at shoulder and apex were 90.94 and 97.24 or arranged as green-yellow. In other words, the color of fruits from untreated trees had the highest displayed a distinctly yellower than bioregulator treatments (Gonnet, 1998).

However, no report is available to the effect of PBZ on delayed harvesting in mango fruits. While, there are several researchers presented the effect of GA applications on delayed the harvesting by inhibiting enzyme activity, delaying chlorophyll degradation (El-Otmani *et al.*,1990 ; Khader, 1991 Garcia-Luis *et al.*, 1992 ; McDonald *et al.*, 1997) and ethylene production (Schirra *et al.*, 1999).

14. Flesh color from fruit 85 DAF to harvest The pulp used for consumption was mesocarp. The color of measocarp depended upon the fruit development. After 85 DAF, there was no significant difference of flesh color, in terms of L, c and h values, among the all treatments. The color of mesocarp in this period (85 DAF) was whitish green. These similar

values still continued to 106 DAF (Table 153). At harvesting stage, flesh color of all treatments had the higher c values than 85-106 DAF. These indicated that flesh color changed from whitish green to greenish yellow. The result from Table 153 showed that at harvesting, there was significant difference of flesh color in term of c values among the treatments. The c values of flesh from PBZ (32.61) and PBZ plus GA (32.32) treatments were less than control (35.87) and GA (33.64) treatments (Table 153). Gonnet (1998) indicated that the more value of c (color intensity), the more intensity of color was found. These indicated that at harvesting, flesh color of control and GA treatments became darker yellow than PBZ and PBZ plus GA treatments. In other words, fruits from untreated and GA treatment entered to ripe quicker than PBZ and PBZ plus GA treatments. Atchariyamontree (2004) suggested that the average L, c and h values of flesh color which was requirement for processing plants was 52.4 ranged of 51.1-53.4, 32.3 ranged of 33.6-30.2, and 85.7 ranged of 91.7-82.1, respectively. When considering these values compared with the result values, the delayed harvesting of fruits from PBZ plus GA treatments still available for processing requirement because the flesh color were still similar with the processing plants requirement.

Table 150. Peel color at shoulder side of Kaew mango fruits at interval seven days from 85 DAF until harvesting

Treatment	85 DAF			92 DAF			99 DAF			106 DAF			Harvest ing		
	L	c	h	L	c	h	L	c	h	L	c	h	L	c	h
Control	36.46	31.25	102.63	34.90	30.73	101.60	37.79	31.70	99.85	35.55 a[1]	33.10	98.54 b	32.71	27.78	90.94 b
PBZ1000ppm	35.58	30.76	102.95	35.40	31.30	102.59	36.79	30.09	100.60	31.55 b	30.13	101.48 a	33.17	25.35	94.70 a
PBZ1000ppm+ GA50ppm	35.00	29.54	101.76	35.70	32.19	101.13	36.56	30.85	100.31	36.11 a	32.79	101.68 a	32.38	28.16	94.59 a
GA50ppm	36.16	30.49	102.08	35.84	31.29	102.31	34.89	30.45	101.56	34.16 ab	31.14	101.01 a	33.89	27.63	94.15 a
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.85	ns	0.65	ns	ns	0.87
C.V. (%)	4.85	11.04	1.38	5.09	8.52	0.78	8.34	9.57	1.93	4.96	5.42	1.30	7.90	10.57	1.86

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 151. Peel color at middle side of Kaew mango fruits at interval seven days from 85 DAF until harvesting

Treatment	85 DAF			92 DAF			99 DAF			106 DAF			Harvesting		
	L	c	h	L	c	h	L	c	h	L	c	h	L	c	h
Control	34.26	29.38	103.73	33.84	29.19	103.40	34.84	29.24	101.93	35.13	30.73 a[1]	102.66	33.56	28.66	100.33
PBZ1000ppm	35.70	30.68	102.84	34.45	28.71	103.83	36.09	28.25	101.98	32.16	27.18 b	103.39	32.69	27.11	101.42
PBZ1000ppm+GA50ppm	34.75	29.79	103.46	34.40	29.65	102.78	35.00	30.74	102.13	35.63	32.24 a	101.43	31.79	27.76	97.14
GA50ppm	34.90	31.23	102.65	36.64	31.01	102.81	35.26	28.16	102.69	34.83	30.90 a	103.05	33.67	29.23	98.84
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.76	ns	ns	ns	ns
C.V. (%)	5.82	6.10	1.21	4.67	8.05	0.74	8.50	7.23	1.06	7.27	4.99	1.09	4.85	7.78	2.23

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.01$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 152. Peel color at apex side of Kaew mango fruits at interval seven days from 85 DAF until harvesting

Treatment	85 DAF			92 DAF			99 DAF			106 DAF			Harvesting		
	L	c	h	L	c	h	L	c	h	L	c	h	L	c	h
Control	35.16	30.15	103.53	34.09	29.10	102.43 b[1]	35.30	28.65	101.09	36.90	31.00 a	101.93	34.30	28.90	97.24 b
PBZ1000ppm	35.55	29.79	103.63	34.10	31.13	104.29 a	35.31	28.43	102.55	32.33	26.25 b	102.75	32.74	26.52	103.66 a
PBZ1000ppm+GA 50ppm	35.33	30.08	103.76	34.91	29.43	103.49 ab	36.64	29.59	103.33	35.88	31.88 a	104.11	32.80	29.83	102.62 a
GA50ppm	35.68	31.45	102.76	37.54	31.95	103.48 ab	34.21	28.86	102.35	35.95	30.44 a	102.03	33.81	29.40	101.76 a
$LSD_{0.05}$	ns	ns	ns	ns	ns	0.43	ns	ns	ns	ns	1.06	ns	ns	ns	1.18
C.V. (%)	3.80	6.69	1.15	5.90	12.14	0.78	9.68	7.09	1.31	7.14	7.07	1.41	7.18	7.48	2.33

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

Table 153. Flesh color of Kaew mango fruits at interval seven days from 85 DAF until harvesting

Treatment	85 DAF			92 DAF			99 DAF			106 DAF			Harvesting		
	L	c	h	L	c	h	L	c	h	L	c	h	L	c	h
Control	52.65	31.00	89.75	52.38	30.21	89.69	52.93	30.69	88.43	53.68	31.70	85.78	53.16	35.87 a	85.56
PBZ 1000 ppm	52.66	30.89	91.81	52.34	31.28	89.61	53.21	30.85	87.35	52.98	31.05	88.31	53.06	32.61 b	86.13
PBZ 1000 ppm+ GA 50 ppm	53.14	29.96	91.86	52.86	29.95	89.03	53.26	30.10	88.34	53.23	30.66	87.96	52.27	32.32 b	84.93
GA 50 ppm	52.76	30.96	91.39	53.35	30.51	87.88	52.78	30.89	91.91	53.61	31.44	87.30	51.39	33.64 ab	83.19
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.73	ns
C.V. (%)	1.58	3.70	2.06	1.74	2.56	2.16	0.88	4.03	2.68	0.92	4.50	1.80	2.36	4.34	1.87

[1] Means within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

15. Fruit firmness Mango fruits when harvested at fully mature stage had fruit firmness value of 9.72 kg/cm^2. PBZ and GA application had no significant effect on changing the fruit firmness. All treatments had similar fruit firmness values, ranged from 9.72-10.4 kg/cm^2 (Table 154). Atchariyamontree (2004) indicated that the mango fruit's firmness requirement for processing plants should be ranged from 11.2-14.7 kg/cm^2. When considering this figure compared with these results, the fruits from late season may not be appropriate for processing plants which wanted the higher fruit firmness.

Table 154. Fruit firmness, fruit stalk toughness, total soluble solids (TSS) and titratable acidity (TA) of Kaew mango at harvesting, after application of two bioregulators

Treatment	Fruit firmness (kg/cm^2)	Fruit stalk toughness(kg)	TSS (°Brix)	TA (%)
Control	9.72	3.35	9.51a [1]	0.23
PBZ 1000 ppm	10.40	4.60	9.20 a	0.24
PBZ 1000 ppm+ GA 50 ppm	9.84	4.24	9.61 a	0.24
GA 50 ppm	9.67	5.08	8.71 b	0.23
$LSD_{0.05}$	ns	ns	0.15	ns
C.V. (%)	4.96	19.58	3.34	4.26

[1] Mean within the same column followed by different alphabets were significantly difference at $P \leq 0.05$ by LSD

ns Non significant difference at 95% level ($P > 0.05$) by LSD

16. Fruit stalk toughness At fully mature stage, fruit stalk toughness of mango fruit was around 3.35 kg. Two bioregulators application had no significant effect to fruit stalk toughness. All treatments had the similar fruit stalk toughness, ranged from 3.35-5.08 kg (Table 154).

17. Total soluble solids (TSS) The harvested mango fruits were measured the TSS content. The results found that TSS content in fruit was around 9.51°Brix. At harvesting, GA application had significant effect on decreasing TSS content. Fruits from trees treated with GA

(8.71°Brix) had lower TSS contents than other treatments (9.2-9.61 °Brix) (Table 154). These may be due to GA treatment had an important role by inhibiting enzyme activity, such as peroxidase and amylase (Fry, 1980). In addition, Atchariyamontree (2004) who reported that the TSS contents of raw mango material which were appropriate for processing should range from 7.1-11.0° Brix.

18. Titratable acidity (TA) Mango fruits harvested at fully mature stage had TA content 0.23%. Two bioregulators application had no significant effect to TA content. All treatments gave the similar TA contents, ranged from 0.23-0.24% (Table 154).

19. Yield Under natural condition, mango trees gave the average yield of 332 kg/tree. Though trees treated with bioregulators (403-431.5 kg per tree) tended to improve the mango productivity more than untreated trees (332 kg per tree), but there was no significant difference of yield among the treatments (Table 155). These may be due to the tree size and its carbohydrate storage capacity, were the important factors that determined the number of fruit, which the tree could nurture through harvesting (Davie *et al.*, 1995).

Table 155. Yield of Kaew mango, after application of two bioregulators

Treatment	Yield (kg/tree)
Control	332.00
PBZ 1000 ppm	422.00
PBZ 1000 ppm+ GA 50 ppm	403.00
GA 50 ppm	431.50
$LSD_{0.05}$	ns
C.V. (%)	22.98

ns Non significant differenceat 95% level ($P > 0.05$) by LSD

There are several reports cited that both PBZ and GA were not hazardous substances because the several agricultural activities used these substances in extensive scale. With respect to paclobutrazol, Windholz *et al.* (1983) indicated that PBZ had a low acute toxicity to mammal. Lethal Dose 50 (LD_{50}) of PBZ (oral toxicity in rat) was around 1300-2000 mg/kg which was

classed as moderate toxic. Iamsub (1992) studied the residual effect of PBZ from foliar spraying at 1000 ppm to the semi-mature leaves of mango trees cv. Nam Dok Mai. During spraying, there were some PBZ solution ran off from leaves and other parts of tree. These droplets were contaminated with soil particles and had long residual effect in soil for 3 months after application. No chemical residue was detected in the mature fruit because this substance moved via only xylem and could be degraded by plant process. Furthermore, the response of mango tree to PBZ application was between 2-3 months after application (Iamsub, 1992).

While, GA_3 and mixtures of GA_4 and GA_7 are available commercially. LD_{50} of GA (oral, rat) was around 6300 mg/kg which was classed as slightly toxic (Windholz *et al.*, 1983). In addition, generally gibberellins are biosynthesized from mevalonic acid via the hydrocarbon ent-kaurene and present in all growing plant tissues (Kendrew and Lawrence, 1994). Thus, the usage of PBZ and GA to produce late season of Kaew mango is practicability and agreed with the Good Agricultural Practice (GAP) which is wide-spread in many countries.

5. Assessment of the farmers' opinions and views on the practicality of the new technology

To have an overall view, farmer interviews are necessary in order to get the opinions of mango growers about the effective technique for producing late season of Kaew mango in the upland mango production system. To implement in this study, 45 mango farmers who owned orchards at Mae Ore Nai village, Chiang Dao district, Chiang Mai province, were interviewed to collect their opinions at a meeting on December 26, 2004 by using questionnaire (Appendix A.2). The recording data composed of general personal data, basal production data, farmers' opinion, possibility of the technology, technology appropriate and farmers' confidence.

1. General personal data This part included gender, age, education level, total agriculture area, mango planting size, experience of mango cultivation, other occupation and household's assess. This general personal information is considered a factor affecting the decision making on accepting the technology for producing late season of Kaew mango.

1.1 Gender There were 45 mango growers who attended the meeting in December 26, 2004. 38 people (82.6%) were male, 7 people (17.4%) were female (Table 156).

Table 156. Gender of farmers who interested in producing late season Kaew mango

Sex	Number	Percentage
Male	38	82.60
Female	7	17.40
Total	45	100.00

Source : Survey data of 45 respondents, 2004

1.2 Age The growers who came to the meeting of the broadcast technology for producing late season of Kaew mango aged between 27 and 67 years old with an average of 45.8 years old. Regarding to workable age (younger than 40 years old), there were 15 persons or 33.33% of members. 30 persons or 66.67% were over 40 years old. This result indicated that the mango growers in this area were relatively old. The economically active group (15-60 years), from Table 157 indicated that 41 persons or 91.11% fell into this group. The non-active group (above 60 years) was 4 persons or 8.89% of the total sample growers. This high percentage of active members (41 persons or 91.11%) would further demonstrate the easier admission of late season technology than the non-active members (8.89%).

Table 157. Age of the farmers who interested in producing late season Kaew mango

Age (years)	Number	Percentage
21-30	2	4.44
31-40	13	28.89
41-50	16	35.56
51-60	10	22.22
Above 60	4	8.89
Total	45	100.00

Source : Survey data of 45 respondents, 2004

1.3 Education level The education was measured as the year number of schooling achieved by mango grower, which was used as a proxy for managerial ability. As known,

education or knowledge level has many effects on socio-economic development, especially in agricultural production. Increasing literacy may help farmers acquire and understand the agricultural technology. Farmers with higher education level can more easily learn and apply new technologies. The educational level of mango growers in Mae Ore Nai village was relatively low. The survey showed that majority of mango growers who came to the meeting 34 persons or 75.56% of the members had education level in Grade 4. 9 persons or 20% of them attained educational levels in Grade 6. The remaining, 1 person or 2.22% reached levels high school, and 1 person (2.22%) was illiterate (Table 158). These meant that most of growers live in poor socio-economic conditions such as poor infrastructure, lower living standard and poor level of knowledge as well as far away from the city. Perhaps adoption of any modern agricultural technology may be limited by the education level of farmers.

Table 158. Education level of farmers who interested in producing late season Kaew mango

Education level	Number	Percentage
Illeterate	1	2.22
Grade 4	34	75.56
Grade 6	9	20.00
High school	1	2.22
Total	45	100.00

Source : Survey data of 45 respondents, 2004

1.4 Planting areas Chiang Dao district is hilly upland district with sea level elevation of 300-600 m. These areas were traditional paddy rice, vegetables, and many fruit trees included mango cultivation. Kaew mango is a dominant fruit tree and is planted over the large areas, particularly Mae Ore Nai village (Radanachaless *et al.*, 2003). These areas are well known as the the native of late-season Kaew mango production because of favorable geological and weather conditions. The characteristics of Kaew mango planting system in this areas was pure mango orchard planting in the rainfed upland condition (Radanachaless *et al.*, 2003). The average Kaew mango orchard size was about 17.7 rai per grower or 70.2% of total cultivated

areas 25.4 rai. In order to understand the mango planting areas, orchard size was divided into 4 groups, namely, small farms (less than 10 rai), medium farm (10-20 rai), large farm (21-30 rai) and very large farm (more than 30 rai). The smallest and largest Kaew mango planting area observed in Mae Ore Nai village was 2 and 40 rai, respectively. Table 159 shows that most growers (21 persons or 46.67%) in the study area own an average mango farm of 11-20 rai. Followed by 11 persons or 24.44% hold the large farm size of 21-30 rai. There were 10 persons or 22.22% who hold the small farm size lower than 10 rai. 3 persons or 6.67% hold the very large farm size of more than 30 rai. One of decisive factors to adopt the new technology is the farm size. Because most growers in Mae Ore Nai village owned the medium mango planting areas, it is easier to adopt the technology to produce late season in their orchards. In contrast, if the farm size is too small, investment is more difficult and inefficient. However the investment of the mango orchard also depends on other factors, such as household labor.

Table 159. Orchard size of the farmers who interested in producing late season Kaew mango

Orchard size (rai)	Number	Percentage
1-10	10	22.22
11-20	21	46.67
21-30	11	24.44
Above 30	3	6.67
Total	45	100.00

Source : Survey data of 45 respondents, 2004

1.5 Age of mango tree Age of mango tree is very important to affect on yield and investment level. If the age is too young or too old, the yield would be low and investment would not achieve a high performance. In the surveyed orchards, tree age was varied from 5 years up to 30 years with an average of 14.9 years. In order to understand about the tree age, distribution of tree age group was established. The result from Table 160 showed that the Kaew mango growers which had the tree aged range of 1-10 years, 11-20 years and 21-30 years were 13, 25 and 7 farms

or 29.55, 54.55 and 15.9%, respectively. Thus, tree ages of most sample farms (25 farms or 54.55%) concentrated mainly in the group of farm 11 to 20 years. This indicated that any investment to produce late season had a high potential.

Table 160. Age of Kaew mango tree mentioned by farmers who interested in producing late season Kaew mango

Age of Kaew mango (years)	Number	Percentage
1-10	13	29.55
11-20	25	54.55
21-30	7	15.90
Total	45	100.00

Source : Survey data of 45 respondents, 2004

1.6 Years of farmers' experience Management of mango orchards requires the use of knowledge and experience adapted to modern technology. Experience is measured by the number of year that farmers grow the specific Kaew mango variety. More farming experience coupled with higher level of educational achievement may lead to better assessment of the importance and understanding the complexities involved in making good decisions in farming. The number of Kaew mango cultivation experience years varied from 4 years to 40 years with an average of 14.6 years. Table 161 shows the years of farmer experience in Mae Ore Nai village. The experience in years in Kaew mango cultivation in ranges of 1-10, 11-20, 21-30 and more than 30 years as 20, 17, 7 and 1 persons or 44.44, 37.78, 15.56 and 2.22%. Regarding to mango cultivation experience of the mango growers in Mae Ore Nai village, most of the sample mango growers who came the meeting had the rather long years of experience during 1-10 years.

Table 161. Experience years of the farmers who interested in producing late season Kaew mango

Experience years	Number	Percentage
1-10	20	44.44
11-20	17	37.78
21-30	7	15.56
Above 30	1	2.22
Total	45	100.00

Source : Survey data of 45 respondents, 2004

1.7 Category of occupation The household income consisted of two components, on-farm income and off-farm income. Major occupations were classified into four categories : farmer, trader, government officer and employee. Table 162 shows that more than half the total sample of farmers (25 persons or 55.60%) earned their livelihoods both from on-farm income and off-farm activities as employees. There were 14 farmers whose income was only based on on-farm activity (31.10%). Other growers when opportunities allowed, became engaged in off-farm jobs. The other occupations of the growers was trader (5 persons or 11.10%), government official (1 person or 2.20%).

Table 162. Occupation category of the farmers who interested in producing late season Kaew mango

Occupation category	Number	Percentage
Grower and employee	25	55.60
Grower only	14	31.10
Grower and trader	5	11.10
Grower and government official	1	2.20
Total	45	100.00

Source : Survey data of 45 respondents, 2004

1.8 Assets The family assets affected the decision making of farmer to adopt the new technique to produce late season of Kaew mango. House assets of farmer sample were divided into land (27.22%), bank deposit (10.76%), truck (8.86%), motor truck (2.54%), television (22.78%), radio (15.82%) and telephone (12.02%) (Table 163). The result of farmer assets evaluation indicated that land is a major asset of farmers. Land is considered by farmers' valuable property and the most important means of production to produce foods and goods in order to maintain and improve their life. Moreover, at present mass communication such as television, radio and telephone is very popular of the farmers.

Table 163. Assets of the farmers who interested in producing late season Kaew mango

Asset	Number	Percentage
Land	12	27.22
Television	10	22.78
Radio	7	15.82
Telephone	6	12.02
Bank deposit	5	10.76
Pick-up	4	8.86
Local truck (E-tan)	1	2.54
Total	45	100.00

Source : Survey data of 45 respondents, 2004

2. Basic production data

2.1 Harvesting period Marketing aspect of Kaew mango in Mae Ore Nai village is normally cultivated for fresh consumption. Normal season flowering of Kaew mango in Mae Ore Nai village occurred mostly in January. The mango harvesting season for the last three years (2002-2004), peaked at the same time, mainly from June 15 to July 15.

2.2 Value of produce Mango marketing is an important factor affecting the income of the mango growers. In a market economy, price is the main incentive for agricultural production and marketing. Crop marketing, particularly local market plays an important role and settle the

price for Kaew mango purchase in this area. Therefore, farmers commonly sold their produce either at the farm gate or the local market after harvesting. Most of farmers indicated that there was no difference in terms of mango price between the farm gate and local market. Owing to the harvesting period on season (June 15 to July 15) was at the same time. During this peak season, the mango price was low. After grading, the value of produce was consistent with fruit size. Generally, mango for selling was divided into three grades, namely grade A (3-4 fruits per kg), B (5-6 fruits per kg) and C (over 6 fruits per kg). Table 164 presented that mango price tended to decrease in 2002-2004. In 2002, the price for selling grade A, B and C were 6.45, 3.91 and 2.16 Baht per kg. In 2003, the price for selling grade A, B and C were 6.04, 3.66 and 1.90 Baht per kg. In 2004, the price for selling grade A, B and C were 5.23, 3.26 and 1.59 Baht per kg (Table 164).

From evaluation of mango price three years ago (2002-2004), 91.30% of the grower sample responded that the mango price was very low, and the remaining farmers (8.70%) indicated that mango price was rather fair. Thus, most of the growers sample were not satisfied with these figure because they got very low benefit from mango production.

Table 164. Farm gate price of Kaew mango between year 2002-2004 at Mae Ore Nai village, Chiang Mai

Year	Price (Baht/kg)		
	Grade A	Grade B	Grade C
2002	6.45	3.91	2.16
2003	6.04	3.66	1.90
2004	5.23	3.26	1.59

Source : Survey data of 45 respondents, 2004

3. Opinion

3.1 Reason of low value At present, most of the mango growers are facing marketing problems because it is less attractive in terms of unfavorable price. The main three reasons accounted for the unsatisfied farmers with the low price came from the lack of bargaining power because the price was set by the local trades (14.4 persons or 32 %). The other reasons

were low quality of produce (13.51 persons or 30.02%) and a few marketplaces (12.41 persons or 27.58 %) (Table 165).

Table 165. Reasons for low price of Kaew mango given by the farmers who interested in producing late season Kaew mango

Reason for low price	Number	Percentage
Low quality	13.51	30.02
Price oppression	14.40	32.00
Limited market	12.41	27.58
Surplus supply	2.48	5.50
Limited consumers	1.82	4.05
Government price support	0.09	0.20
Practical neglect	0.09	0.20
High cost	0.20	0.45
Total	45.00	100.00

Source : Survey data of 45 respondents, 2004

3.2 Opinion on the improving of Kaew mango price More than half of total growers (20 persons or 45.1%) wanted to increase the value of Kaew mango by delaying the natural harvesting period. The following reasons was the better orchard management (15 persons or 33.33 %). The increasing marketplace (5 persons or 11.77%) was another method for bargaining the value. In addition, 4 persons or 7.84% of farmer wanted to change the variety of mango grown as Chokanun. While, one grower (1.96%) had no comment (Table 166).

Table 166. Opinions of the mango growers on the improving of Kaew mango price

Farmers' opinion	Number	Percentage
Delay harvesting time	20	45.10
Better orchard management	15	33.33
Increase marketplace	5	11.77
Change cultivar	4	7.84
No comment	1	1.96
Total	45	100.00

Source : Survey data of 45 respondents, 2004

3.3 Area for producing late season Not only these land is elevated from the sea level of 300-600 m but also the optimum climate factors in this region which is attributed to rather cold weather in the winter season. These caused Mae Ore Nai village is dominated for late season of mango production. The result from Table 167 showed that most of growers (34 persons or 75.56%) recognized the important natural source to produce late season of Kaew mango was at their sites. While, the rest of 11 persons or 24.44% did not recognize that their village was the last harvesting of Kaew mango because of location and climate benefit.

Table 167. Farmers' recognition of the area producing late season Kaew mango

Farmers' recognition	Number	Percentage
Recognized	34	75.56
Did not recognize	11	24.44
Total	45	100.00

Source : Survey data of 45 respondents, 2004

3.4 Price mechanism Most of farmer samples (38 persons or 84.44 %) recognized of better earning by delayed harvesting of Kaew mango. While 7 persons or 15.56% did not recognize this advantage (Table 168).

Table 168. Farmers' recognition of better earning by delayed harvesting of Kaew mango

Farmers' recognition	Number	Percentage
Recognized	38	84.44
Did not recognize	7	15.56
Total	45	100.00

Source : Survey data of 45 respondents, 2004

3.5 Delayed harvesting time method Most of growers (42 persons or 91.11%) were not used to employ any management for delaying the harvesting period in their orchards. However, in mango production there are some farmers (4 persons or 8.89%) who had the experience of practicing delayed the harvesting period of Kaew mango. These 4 persons found that there were possible two methods for extending the harvesting time of Kaew mango, namely, delaying the pruning period and foliar application formula of 0-52-34. The method of delaying pruning period was employed by 3 farmers (6.67%) (Table 169). While foliar application formula of 0-52-34 was tested by 1 farmer (2.22%). Those two methods could delay the harvesting period by 15 and 14-20 days, respectively.

Table 169. Farmers' experience of practicing delayed harvesting of Kaew mango

Farmers' experience	Number	Percentage
Never practiced	41	91.11
Ever practiced	4	8.89
- Delayed pruning	3	6.67
- Foliar fertilizer application	1	2.22
Total	45	100.00

Source : Survey data of 45 respondents, 2004

In addition, the optimum time for increasing the values of late season Kaew mango should be later harvested than natural season by 20 days. Because the market had almost no produce from natural season mango from the other areas.

3.6 Farmers' acceptance Most of growers (42 persons or 93.33%) accepted with the late season production of Kaew mango by using plant bioregulators because the value would be increased. The findings showed that majority of mango farmers were aware of the benefits of adopting the late season of Kaew mango. A minority (3 persons or 6.67%) opposed with this concept because of anxiety about marketing a sale with trader. This problem may be corrected by the mango growers forming a cooperative to sell their produce (Tavatchai *et al.*, 2003) (Table 170).

Table 170. Farmers' acceptance of using plant bioregulator

Farmers' acceptance	Number	Percentage
Acceptance	42	93.33
Did not acceptance	3	6.67
Total	45	100.00

Source : Survey data of 45 respondents, 2004

Main purpose of Kaew mango at Mae Ore Nai village is to sell mango fresh for immediate consumption. Tavatchai *et al.* (2003) suggested that the strategy to increase the value of Kaew mango should be the late season. The target timing for delay harvesting was July 15 of every year. During this time there was lack of mango for supply to the market. If the technology to produce late season is practicability, the farmers will receive the higher price.

4. Possibility

4.1 Possibility of producing late season Kaew mango With respect to the possibility to produce late season Kaew mango in Mae Ore Nai village, most of mango growers (39 persons or 86.67%) agreed with this technology. The main reason accounted for the experiment was used to work and meet with success in this area. In addition, the climate in natural of this area was appropriate for late season production. Nobody answered that it was impossible to proceed. 6 growers or 13.33% had no response to this question (Table 171).

Table 171. Possibility of producing late season Kaew mango

Farmers' opinion	Number	Percentage
Possible	39	86.67
Impossible	0	0.00
No comment	6	13.33
Total	45	100.00

Source : Survey data of 45 respondents, 2004

4.2 Mango growers' requirement Most of the growers (41 persons or 91.11%) required to use plant bioregulator to produce late season of Kaew mango, for increasing the value. In addition, another reason to produce late season of Kaew mango is the problem of rain during June harvest. This causes a problem for moving the produce out of their orchard. If the harvesting period is delayed, this problem would be corrected. 4 persons or 8.89% of growers did not require to produce late season of Kaew mango for several reasons. The first reason is the growers are worried about the out of purchasing time for trader. In addition, some growers were busy with other activities. Some growers wanted to see the result of bioregulator usage from other orchards before using in their orchards. Some growers rejected to produce late season because they wanted to produce organic mango i.e. without chemicals (Table 172).

Table 172. Farmers' requirement for producing late season Kaew mango

Farmers' requirement	Number	Percentage
Required	41	91.11
Did not require	4	8.89
Total	45	100.00

Source : Survey data of 45 respondents, 2004

4.3 Opinion related to late season technology There were two opinions in case of the plant bioregulators usage to produce late season of Kaew mango. Most of farmers (35 persons or 77.78%) said that this technique was simple and ease of practice. While, 10 persons or

22.22% thought that it was complicated, and difficult to practice. These data suggested that there was more chance to produce late season of mango production in these areas (Table 173).

Table 173. Farmers' opinions about the practical method to produce late season Kaew mango

Farmers' opinions	Number	Percentage
Simple and ease of practice	35	77.78
Complicate and difficult to practice	10	22.22
Total	45	100.00

Source : Survey data of 45 respondents, 2004

4.4 Farmers' expectation The assessment of the effect of plant bioregulator usage conducted in growers' orchards. Table 174 indicated that the growers of 31 persons or 68.89% indicated that if they took this technique to operate in their orchards, the result should be agreed with the previous experiment because the researcher was used to worked this experiment in this area. Furthermore, each orchard had the similar general practice in mango orchard, thus the result should not much different between the orchards. While 2 persons or 4.44% of the growers thought that the result should not correspond with the previous experiment

Table 174. Farmers' expectation of the delayed harvesting technology

Farmers' expectation	Number	Percentage
Agreed with the previous experiment	31	68.89
Disagreed with the previous experiment	2	4.44
No comment	12	26.67
Total	45	100.00

Source : Survey data of 45 respondents, 2004

because during the delayed harvesting time may encountered with the pest and diseases troubles. 12 growers or 26.67% did not know because they did not apply these substances and some

growers wanted to test this trial with some mango trees in their orchards before conducting this technique with wholly trees.

4.5 Limitation of the delayed harvesting technique In these section, limitation of late season Kaew mango was divided into 5 aspects, namely environment, natural factor, production factor, technique and marketing. The three limitations which it would affected to produce late season of Kaew mango were ranked by growers (Table 175). Thus, each grower may responed more than one answers. The highest score limitation to produce late season of mango in Mae Ore Nai village, was pests and diseases (15 persons or 33.33%). Owing to the serious problem of insect pests in Mae Ore Nai village mostly occurred in dry season (March to May).

The second limitation was enviromental factors (13 persons or 28.89%). This factor was divided into climate and storm. The growers thought that climate conditions between later harvesting would be the effect of SW-monsoon brings rains from mid-May until mid-October. Furthermore, between later season may be faced with occasional dry spells and strong winds or storms occur during June and July. The third limitation score from grower replies was production factors (11 persons or 24.45%). This factor was composed of increased input cost, lack of water for spraying the substances, lack of information about these substances and engaged with the

Table 175. Limitation of the delayed harvesting technique

Limitation of late season production	Number	Percentage
Pests and diseases	15	33.33
Environmental factors	13	28.89
Production factors	11	24.45
Application technique	6	13.33
Total	45	100.00

Source : Survey data of 45 respondents, 2004

other works. The last aspect of limitation was application technique to produce late season Kaew mango (6 persons or 13.33%). This trait splited into 3 characteristics, namely lack of knowledge

about bioregulator preparation, the duration for spraying bioregulators and the longer period to oversee the fruits attached to the tree. These problem could be corrected by providing the acknowledge of this technologies management with the growers.

V. Appropriateness

5.1 Usefulness of late season production Many farmers (44 persons or 97.78%) agreed that late season production of Kaew mango was useful to them because it would correct the low price of produce. The rest of 1 person or 2.22% disagreed with this concept because he worried about the trader purchase between the later harvesting (Table 176).

Table 176. Usefulness of the delayed harvesting technology

Usefulness	Number	Percentage
Useful	44	97.78
Useless	1	2.22
Total	45	100.00

Source : Survey data of 45 respondents, 2004

5.2 Appropriateness of delayed harvesting technology Evaluation of acceptability is a tool to assess the technology adoption. Almost the all farmers (42 persons or 93.33%) agreed with these technologies to produce late season of Kaew mango. The rest of 3 persons or 6.67% answered on the contrary (Table 177).

Table 177. Appropriateness of the delayed harvesting technology

Appropriateness	Number	Percentage
Appropriate	42	93.33
Inappropriate	3	6.67
Total	45	100.00

Source : Survey data of 45 respondents, 2004

5.3 Satisfaction of the experimented result All of growers (45 persons or 100%) were satisfied with the result of the delayed harvesting Kaew mango by twenty days. Because the delayed harvesting season would be advantage for them, particularly the large area production.

5.4 Farmers' opinion about input cost of producing Kaew mango The objective of this section is to highlight the farmers' opinion about input costs of mango production. The scope of analysis included the investigation of input costs of production of each orchard. The analysis of farmers' opinion was assessed in two sections, on season mango production costs and additional costs of late season.

5.4.1 Input cost of Kaew mango in season From interviewing, the cost of each mango production orchard under rainfed condition differed from each other. The on season costs for producing Kaew mango/kg in orchards were divided into seven levels, namely, 0, 0.5, 1, 2, 3, over 3 Baht/kg and not known. The results from Table 178 pointed out that the mango production cost at these areas was low. It was very surprising that majority of the grower (14 persons or 31.11%) had no comment in their mango production costs. Followed by the production cost was approximately 2 (13 persons or 28.89%), 3 (9 persons or 20%), over 3 (5

Table 178. Farmers' opinion about input cost of producing a kilogram of in season Kaew mango

Input cost (Baht/kg output)	Number	Percentage
0	1	2.22
0.5	3	6.67
1	0	0.00
2	13	28.89
3	9	20.00
Above 3	5	11.11
No comment	14	31.11
Total	45	100.00

Source : Survey data of 45 respondents, 2004

persons or 11.11%), and 0.5 (3 persons or 6.67%) Baht for producing Kaew mango/kg. In addition, there was 1 person (2.22%) who was never invested for mango production (Table 178).

5.4.2 Raised cost of late season mango production With respect to the selecting a practice management, the mango farmers normally required the low input cost. Most of growers (20 persons or 44.44%) accepted that the increased value of chemical usage for this purpose should be not exceed 1 Baht/kg. The rest of 8 persons (17.78%), and 9 person (20%) considered that the raised costs for this activity should not be exceed 2.00 and 3.00 Baht/kg, respectively. While 2 persons (4.45% of growers) were able to spend more than 3 Baht to produce late season mango/kg. The surprising data found that 6 persons or 13.33% of growers sample did not know the optimum expenses to produce late season of Kaew mango (Table 179).

Table 179. Farmers' acceptance of the additional cost for producing a kilogram of late season Kaew mango

Acceptance of the additional cost (Baht/kg output)	Number	Percentage
0.5	10	22.22
1	10	22.22
2	8	17.78
3	9	20.00
Above 3	2	4.45
No comment	6	13.33
Total	45	100.00

Source : Survey data of 45 respondents, 2004

5.5 Target harvesting period Generally, the harvesting season of Kaew mango at Mae Ore Nai village began from end May and ended to early June. There were six durations of delayed Kaew mango harvesting which the mango growers satisfied. Most of growers (19 persons or 42.22%) wanted to delay the harvesting time to July 21-30, followed by 10 persons or 24.44% in July 11-20. The other of 5 persons (11.11%), 5 persons (11.11%), 3 persons (6.68%) and 2

persons (4.44%) wanted to delay the harvesting time to June 11-20, July 1-10, August 1-10 and June 21-30, respectively (Table 180).

Table 180. Target harvesting period of mango growers

Target harvesting period	Number	Percentage
June 11-20	5	11.11
June 21-30	2	4.44
July 1-10	5	11.11
July 11-20	11	24.44
July 21-30	19	42.22
August 1-10	3	6.68
Total	45	100.00

Source : Survey data of 45 respondents, 2004

5.6 Required minimum price/kg for late season Kaew mango Seasonality of price was a reflection of seasonality of production. Late season mango production affected the price of the produce due to changes in the level of demand and supply of agricultural products. Most of growers (22 persons or 48.89%) required the minimum price for late season Kaew mango should

Table 181. Required minimum price/kg for late season Kaew mango

Required minimum price (Baht/kg)	Number	Percentage
5-8	10	22.22
9-12	12	26.67
13-16	22	48.89
17-20	1	2.22
Total	45	100.00

Source : Survey data of 45 respondents, 2004

be 13-16 Baht per kg. The following levels were 9-12, 5-8, and 17-20 Baht per kg equaled to 26.67, 22.22, and 2.22%, respectively (Table 181).

6. Confidence

6.1 Confidence in the delayed harvesting experiment In Mae Ore Nai village, the majority of growers (17 persons or 37.78%) gave the much confidence on this technology (61-80%). The following confidence levels of medium (41-60%), very much (81-100%), little (21-40%) and very little (1-20%) found as 13 persons (28.89%), 10 persons (22.2%), 4 persons (8.89%) and 1 person (2.22%), respectively (Table 182).

Table 182. Farmers' confidence in the delayed harvesting experiment

Confidence level (%)	Number	Percentage
Very little (1-20)	1	2.22
Little (21-40)	4	8.89
Medium (41-60)	13	28.89
Much (61-80)	17	37.78
Very much (81-100)	10	22.22
Total	45	100.00

Source : Survey data of 45 respondents, 2004

6.2 Practicability of the delayed harvesting technology Farmer's decision making is regarded as very important aspect, which considerably affects the opportunity practise. After the meeting, 41 persons or 91.11% of growers were likely to work this technique in their orchards. While, the rest of 4 persons or 8.89 %of them were unlikely to work this technique in their orchards. (Table183). This finding indicated that most of mango growers in Mae Ore Nai village had the positive attitude to adopt this technology for producing late season of Kaew mango in the next season.

Table 183. Practicability of the delayed harvesting technology

Practicability of technology	Number	Percentage
Likely to work	41	91.11
Unlikely to work	0	0.00
No comment	4	8.89
Total	45	100.00

Source : Survey data of 45 respondents, 2004

6.3 Transfer of the technology The new technology knowledge could be transferred via the several sources included neighbors. Most of growers (40 persons or 88.89%) would tell about this technique to their neighbors who did not come the meeting. 2 persons or 4.44% would not inform to their neighbors because of these uncertainty about the method (Table 184). The main reason of these answer was although most areas were similar to climatic condition, but land potential in each orchard was quite different.

Table 184. Transfer of the delayed harvesting technology to the neighbor

Transfer of the technology	Number	Percentage
Yes	40	88.89
No	2	4.44
No comment	3	6.67
Total	45	100.00

Source : Survey data of 45 respondents, 2004

6.4 Faults of this technique Any comment of late season mango technology was put in this part. However, farmers in developing countries with low literacy rates, poor extension services, lack of credit and capital, and insufficient physical infrastructure have great difficulties in understanding and adopting new technologies. Several comments were offered from the mango growers such as the dissemination or publication requirement. Some growers proposed that the technology testing should experiment in more than one orchard to see the certain result.

In addition, the study should concentrate on the problem of residual effects in produce and problem of the spread of pests and diseases during delayed harvesting too.