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Effect of Gibberellin (GA_3) on Fruit Yield and Quality of Kaew Mango (*Mangifera indica* L.) cv. Srisaket 007 in Northeast Thailand

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Abstract: This investigation was carried out on Roi-Et soil series (Oxic Paleustults) at Chaiyaphum Province, Northeast Thailand during October 2004 to June 2005. The study aimed to justify the effect of different rates of Gibberellin (GA_3) on yield and fruit quality of Kaew mango cv. Srisaket 007 (*Mangifera indica* L.). The study was laid in a Randomized Complete Block Design (RCBD) with four replications. Five rates of GA_3 were used, i.e., 0 (T1, control), 1,953.25 (T2), 3,906.50 (T3), 5,859.75 (T4) and 7,813.00 ppm ha^{-1} (T5) with the actual rates being used of 0, 50, 100, 150 and 200 ppm for T1 up to T5, respectively, i.e., each rate was used for four replications of four mango trees of each treatment. The results showed that the application of GA_3 at a rate of 1,953.25 ppm ha^{-1} or 12.50 ppm $plant^{-1}$ applied to Kaew mango cv. Srisaket 007 gave the highest mango fresh fruit yield of 32,066.83 kg ha^{-1}. All rates of GA_3 being used had no significant effect on harvesting age, width, flesh firmness and total soluble solids of mango fruits but highly increased % of panicles with survived fruits, fruit yield ha^{-1}, fruit flesh content, fruit thickness, individual fruit weight and titratable acidity of flesh of fruits and also significantly increased in length of the mango fruits. GA_3 at a rate of 1,953.25 ppm ha^{-1} or 12.50 ppm $plant^{-1}$ is needed for high fruit production whenever mango trees started to produce flowers.

Key words: Gibberellin, GA_3, Kaew mango, fresh fruit, fruit yield, cv. Srisaket 007

INTRODUCTION

Kaew mango (*Mangifera indica* L.) is a distinctive typical orchard tree found in most regions of Thailand. It is one of many important kinds of mango cultivars being cultivated in Thailand, which possesses its economic significant to the Thai economy (Benjawan *et al*., 2006). Kaew mango of many varieties could thrive on well in most areas in the tropics, particularly in Northeast Thailand where the area being cultivated for fruit production reached a figure of 332,220 hectares in the 1999 and out of this figure 52,107 hectares have been occupied by Kaew mango of different cultivars (Radanachaless *et al*., 2003, Anonymous, 2005). Kaew mango has its outstanding growth characteristics, e.g., it could thrive on well even under drought conditions of high lands with a high resistant to diseases and insect pests. Growers of mango propagation normally use young plants of Kaew mango as stocks for many propagation purposes such as grafting with other important varieties of mango and others since the stocks of Kaew mango could thrive on well with a large amount of roots developed thus it favours a high survival of the grafted plants to survive with a vigorous growth and long lasted mango trees for a number of years with high production of fruits. Kaew mango fruits can be used as raw materials for industrial food transformation of different kinds such as salted mango fruits, pickled fruits, oven-dried fruit slices and many others food preservations apart from being consumed as edible fresh and also ripen fruits. The transformed products being produced in Thailand are normally consumed domestically and exported overseas.

As a result of the global warming or the changing of the weather due to both *El Nino* and *La Nino*, these conditions could have caused some effects on growth and reproductive mechanisms of many crop plants (Suksri, 1999). It has been advocated that mango trees produce its annual flowering inconsistently due to environmental conditions and its internal mechanisms where mango trees bearing its fruits in between years, such phenomena affect annual mango fruit production (Krisanapook *et al*., 2000; Negi, 2000 and Benjawan *et al*., 2006). Therefore, it is of an urgent need for scientists to carry out more scientific investigations in

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order to provide adequate information for growers of the mango orchard plants. The spraying of different rates of gibberellin (GA_3) to the mango trees at a suitable period of fruit development could possibly be one way in improving and encouraging mango trees to produce high amount of its annual fruit production since GA_3 has its significant influences on the development of fruits and preventing the drop off of young fruits (Leopold and Kriedemann, 1975; Mengel and Kirkby, 1987). This could possibly be one way in increasing annual mango fruit production. For this study, Kaew mango cv. Srisaket 007, a newly bred and a highly recommended commercial cultivar was chosen for the experiment due to its high adaptive performance to environmental conditions in Northeast Thailand where the cultivar had produced high annual fruit yields (Anonymous, 2006).

MATERIALS AND METHODS

The experiment was carried out with the use of a mango plantation of a villager, Muang District, Chaiyaphum Province, northeastern region of Thailand during June 2003 to May 2004. Twenty Kaew mango trees cv. Srisaket 007 (*Mangifera indica* L.) of an age of 10 year old with a similar girth diameter of the trucks at approximately 0.4 m above ground level and with a similar bushy structure were chosen. The mango trees are grown on Roi-Et soil series (Oxic Paleustults) with mean values of soil pH (1:2.5 soil:water by volume), nitrogen (N), available phosphorus (P) and exchangeable potassium (K) of 5.4, 0.056%, 25 and 85 ppm, respectively. The distances between rows and within rows of mango trees in the plantation were 8×8 m, respectively. That is there are approximately 156 mango trees ha^{-1} in the plantation. All of the chosen mango trees were fertilised with a complete chemical fertiliser 15-15-15 (NPK) at a rate of 3,900 kg ha^{-1}, i.e., 25 kg $plant^{-1}$ where one half of its rate (12.50 kg) was applied in May and the other half in September of the same year. A pruning of undesirable branches to shape up a similar bushy structure of the mango trees was carried out right after the initial fertiliser application. The experiment was laid in a Randomized Complete Block Design (RCBD) with four replications. Each mango tree was used as a replication. Five rates of chemical GA_3 were used, i.e., 0 (T1, control), 1,953.25 (T2), 3,906.50 (T3), 5,859.75 (T4) and 7,813.00 ppm ha^{-1} (T5), thus the actual GA_3 rates for the five treatments being used were 0, 50, 100, 150 and 200 ppm for T1 up to T5, respectively. Each rate of the latter GA_3 was diluted into 24 L of de-ionized water hence each mango tree received 6 L of the solutions. The solutions of each rate were sprayed to all leaves and flowers of its respective mango treatments where appropriate when mango fruit size had developed to a size of approximately a size of a matured peanut seed (*Arachis hypogaea*). The spraying of GA_3 was carried out only once throughout the fruiting period. The collected data include % of panicles with survived fruits, harvesting age of matured fruits (being counted from full bloom of flowers up to harvesting date), individual fruit size and weight, fresh fruit yield ha^{-1}, % of flesh content of individual fruit (flesh of fruit without seed stone), firmness of fruit texture, total soluble solids (brix %) of flesh content and % of titratable acidity of flesh content were recorded. The determinations on fruit quality i.e., % of flesh content of fruit, firmness of fruit texture, total soluble solids and titratable acidity of flesh content were carried out with the use of the methods as that of Benjawan *et al.* (2006). The collected results were statistically analysed using SPSS Computer Programme, Base 9.0 (SPSS, 1999).

RESULTS

Percentages of panicles with fruits, harvesting age, fruit yield and flesh content: The results showed that mean values of percentage of panicles with survived fruits of T2 was higher than the control treatment (T1) and this treatment gave the highest percentage of panicles with survived fruits among the treatments used with values ranged from 4.74 to 8.67 for T1 and T2, respectively. The differences were large and highly significant (Table 1). With harvesting age for matured ripen fruits, the results showed that harvesting age being counted from full bloom of flowers till maturity ranged from 116 to 122 days for T2 and T5, respectively. There were no statistical differences found on fruits harvesting age among the treatments. Fresh fruit yields ranged from 17,703.92 to 32,066.83 kg ha^{-1} for T1 and T2, respectively. T2 gave the highest fresh fruit yield followed by T3, T5, T4 and T1, respectively. The differences were large and highly

Table 1: Mean values of panicles % with survived fruits, harvesting age of mango fruits, fruit yield and flesh content of ripe fruits of Kaew mango cv. Srisaket 007 (*Mangifera indica* L.) as influenced by different rates of GA_3 application, grown on Roi-Et soil series (Oxic Paleustults) at Chaiyaphum province, Northeast Thailand

Treatments	Panicles with survived fruits (%)	Harvesting age (Days)	Fruit yield (kg ha^{-1})	Flesh content of fruit (%)
T1	4.74c	118	17,703.92c	72.95c
T2	8.67a	116	32,066.83a	83.20a
T3	7.87ab	118	27,425.83b	78.58b
T4	7.31b	122	25,426.33b	78.04b
T5	7.55b	122	27,028.80b	73.09c
F-test	**	NS	**	**
CV (%)	19.22	12.95	15.68	12.77
LSD	0.347	2.23	123.34	1.07

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

significant. For percentages of flesh contents of ripen fruits, the results showed that T2 gave the highest followed by T3, T4, T5 and T1 with values of 83.20, 78.58, 78.04, 73.09 and 72.95, respectively. The differences were large and highly significant.

Fresh fruit width, length, thickness and weight of individual fruit: The results showed that mean values of fresh matured ripen fruits measured in width ranged from 5.67 to 6.64 cm for T1 and T2, respectively (Table 2). There were no statistical differences found among the treatments due to the different rates of GA_3 application. However, when measured the fruits in length, it showed that the longest mango fruit was found with T2 followed by T4, T3, T5 and T1 with mean values of 10.10, 9.77, 8.99, 8.75 and 8.23 cm, respectively. The differences were large and statistical significant. Similarly, mean values in fruit thickness were highest for T2 followed by T5, T3, T4 and T1 with mean values of 6.35, 5.66, 5.61, 5.41 and 5.18, respectively. The differences were large and highly significant. With fruit thickness, the results indicated that mean values of fruit thickness were highest with T2 followed by T5, T3, T4 and T1 with mean values of 6.35, 5.66, 5.61, 5.41 and 5.18 cm, respectively. The differences were large and highly significant. For individual fresh fruit weights, the results showed that mean value of fresh fruit weight was highest with T2 followed by T3, T4, T5 and T1 with values of 185.27, 174.36, 173.33, 172.20 and 164.03, respectively. The differences were large and highly significant.

Fruit quality measured as firmness, total soluble solid and titratable acidity: The results revealed that different rates of GA_3 application had no significant effect on fruit firmness of mango plants. Fruit firmness values ranged from 9.78 to 11.60 for T1 and T4, respectively (Table 3). Similarly, total soluble solids of mango fruits measured as brix values did not either influence by different rates of GA_3 application. Brix % ranged from 8.77 to 9.53 for T1 and T4, respectively. However, with titratable acidity of mango juices, the results showed that the different rates of GA_3 application had a highly significant effect on titratable acidity of mango juices over the control treatment (T1) although all of the GA_3 treatments gave a similar level of titratable acidity with values ranged from 0.24 to 0.40 % for T1 and T5, respectively.

Table 2: Mean values of fruit sizes in width, length, thickness and individual fresh fruit weights of Kaew mango cv. Sirsaket 007 (*Mangifera indica* L.) as influenced by different rates of GA_3 application, grown on Roi-Et soil series (Oxic Paleustults) at Chaiyaphum province, Northeast Thailand

Treatments	Width (cm)	Length (cm)	Thickness (cm)	Fruit weight (g fruit^{-1})
T1	5.67	8.23c	5.18b	164.03c
T2	6.64	10.10a	6.35a	185.27a
T3	6.18	8.99abc	5.61b	174.36b
T4	5.98	9.77ab	5.41b	173.33b
T5	5.96	8.75bc	5.66b	172.20b
F-test	NS	*	**	**
CV (%)	12.62	14.66	10.14	11.87
LSD	0.278	0.414	0.168	1.565

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

Table 3: Mean values of fruit firmness, total soluble solid and titratable acidity of matured ripen fruits of Kaew mango cv. Srisaket 007 (*Mangifera indica* L.) as influenced by different rates of GA_3 application, grown on Roi-Et soil series (Oxic Paleustults) at Chaiyaphum province, Northeast Thailand

Treatments	Firmness (kg cm^{-2})	Total soluble solid (Brix %)	Titratable acidity (%)
T1	9.78	8.77	0.24b
T2	11.16	9.05	0.37a
T3	11.10	9.22	0.37a
T4	11.60	9.53	0.39a
T5	10.95	8.97	0.40a
F-test	NS	NS	**
CV (%)	7.82	10.96	9.00
LSD	0.529	0.184	0.014

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

DISCUSSION

Growers of mango orchard plants have experienced some difficulties in encouraging matured mango trees to flower annually due to various contributing factors such as environmental conditions and internal mechanism within the mango plants and once it flowers, there is always a problem of the dropping off of young fruits, particularly during the first four weeks after flowering (Krisanapook *et al*., 2000; Negi., 2000 and Benjawan *et al*., 2006). The dropping off of young fruits before it reached maturity had an outstanding record of a value of 80% as reported by Schaffer *et al*. (1994). Ram (1992) pointed out that the dropping off the young fruits obviously caused by growth regulators within the mango plants where abscisic acid (ABA) and ethylene had its significant effect on the abscission when the mango plants unable to attain an adequate amount of gibberellin. An inadequate amount of gibberellin in the mango plants has encouraged the production of ABA where it favours the release of ethylene and resulted in the dropping off of ovary (Talon *et al*., 1997). Thus an external application of a suitable rate of gibberellin to foliages and flowers could obstruct the production of ABA hence the dropping off of young fruits could be remedied (Zacarias *et al*., 1995). It was found with this work that the first two rates of gibberellin application (T2 and T3) prevented the dropping off of young fruits with a highly significant effect compared with the control treatment (T1) although

there was a slightly increase in fruit dropping off found with T3. The results suggested that gibberellin application of the first rate (T2) could be considered as the utmost rate to be applied when the higher rates gave a decline in percentages of fruit sets. Ross and O'Neill (2001) stated that gibberellin has its an antagonize effect on the production of abscisic acid (ABA) where their results confirm the work of Fornes *et al.* (1992) when they reported that the application of gibberellin prevented the dropping off of fruits of Clementine Mandarin oranges. Ram (1992) stated that the dropping off of young fruits of mango could have been caused by an inadequate amount of growth promoters where a large amount of growth inhibitors was produced, particularly at an early stage of flowering, i.e., 0-3 weeks after flowering. The highly significant effect of gibberellin on panicles with high percentages of fruits had encouraged fruit yields to increase and flesh contents of mango fruits indicated the same direction, particularly with T2. The higher rates of gibberellin application higher than T3 highly decreased fruit yields and flesh contents of mango fruits, particularly T4 and T5. This may be attributable to the suppression of gibberellin on fruit growth since the amounts given were relatively too high hence it manifested inhibiting effect rather than promoting growth of young fruits. The high rate of gibberellin application may have caused its effect in producing malformed of fruits as reported by Voyiatzis and Paroussi (2002) and also the dropping off of fruits as reported by Chadha and Singh (1964) and also Wolstenholme and Mullins (1982).

The results on harvesting age for matured fruits revealed that all gibberellin application rates had no significant effect in delaying senescence of fruits and extending number of days from full bloom till maturity. The results suggested that maturity age of mango fruits could have been controlled by genetic traits rather than phenotypic effect thus harvesting dates were similar in all the treated mango trees. However, it seems more likely that number of days form full bloomed of flowers till harvesting age relatively increased with an increase in gibberellin rates but the shown effect was not statistically significant. When it comes to fruit yields and flesh contents, the results showed that fruit yield and flesh content of T2 was the highest and further rates of gibberellin gave a similar fruit yield except flesh content where the highest rate (T5) gave a significant decline. The results suggested that the gibberellin rate to be applied should not be higher than that of T2 (50 ppm plant^{-1}). The highest fruit yield of T2 may be attributable to the highest percentage of panicles with a large number of survived fruits per panicle. This gibberellin rate also had its tremendous effects on length, thickness and weight of individual fruits where it had the highest but not with the width of the fruits. The results suggested that gibberellin could have its influences perhaps on cell enlargement and cell extension as reported by Talon *et al.* (1997) and Mapracha (1997). The most appropriate rate of gibberellin application may aid in the translocation of assimilates from a temporary sinks (stem and leaves) where it reserves a certain amount of starch for the development of fruits as found in oranges by Powell and Krezdorn (1977). Reserved of assimilates in temporary sinks of most crops before moving to permanent sinks has been pointed out by Evans (1975) and Suksri (1999).

For this study, the application of gibberellin (GA_3) had no significant effect on fruit firmness and total soluble solids (brix %). Both firmness and total soluble solids content in mango fruits may be influenced by other factors such as macronutrients, particularly potassium, since potassium has its significant effect on fruit quality as stated by Suksri (1999) that marketable qualities of fruits of orchard trees such as the taste and texture of flesh could be improved by potassium, i.e., potassium increases sweetness of most orchard fruits except star apple fruits (*Chrysophyllum Cainito*) where a high rate increases tannin content of star apple fruits. GA_3 application has its highly significant effect on titratable acidity percentage where all rates of GA application increased titratable acidity percentage of mango fruits. However, McDonald *et al.* (1997) and Notodimedjo (2000) did not find any increases in the amount of titratable acidity in Florida grape fruits (*Citrus paradisi*) when gibberellin was applied to the plants.

To sum up, the application of GA_3 at a rate of 50 ppm four-plant^{-1} to Kaew mango cv. Srisaket 007 at a period after fruit size had developed about the size of peanut seed signified the most appropriate rate of GA_3 application. GA_3 application rates had no significant effect on harvesting age, width, firmness and total soluble solids (brix %) of mango fruits but highly increased percentages of panicles with survived fruits, fruit yield ha^{-1}, fruit flesh content, fruit thickness, fruit weight and titratable acidity of flesh of fruits of Kaew mango cv. Srisaket 007 and also significantly increased in length of mango fruits. GA_3 application at a rate of 1,953.25 ppm ha^{-1} (12.50 ppm plant^{-1} of T2) gave the highest fresh yield of mango fruits ha^{-1} of 32,066.83 kg. Therefore, gibberellin is needed in producing high quality and yield of fruits of Kaew mango cv. Srisaket 007 for commercial utilization whenever flowering of mango trees is taken place.

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