

Chapter 3

Materials and Methods

To solve the objectives of the study and to have an overall view, a conceptual framework was constructed (Figure 5). The methods for producing the late season Kaew mango consist of three steps, namely, surveying the potential areas, identifying the appropriate techniques, and assessing the mango growers' response in the adopting techniques.

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 area to produce late season Kaew mango were obtained by using Geographic Information Systems (GIS) technique based on Chiang Dao areas as the prototype (Figure 6). The parameters of slope, soil type and climate condition were selected and determined to obtain the potential areas to produce late season Kaew mango like Chiang Dao district. The secondary data included the general information of Kaew mango production in different sites. These would be useful to understand the aspects of mango production system and further define where the last areas for producing late season of Kaew mango are. In addition, the information from secondary data increase the accurate identification of the potential areas. The major sources of secondary data were collected from the Department of Agricultural Extension (DOAE), Agricultural Office of Chiang Mai Province, and various relevant publications. In addition, field survey was carried out to elucidate the areas where the actual natural late season Kaew mango are.

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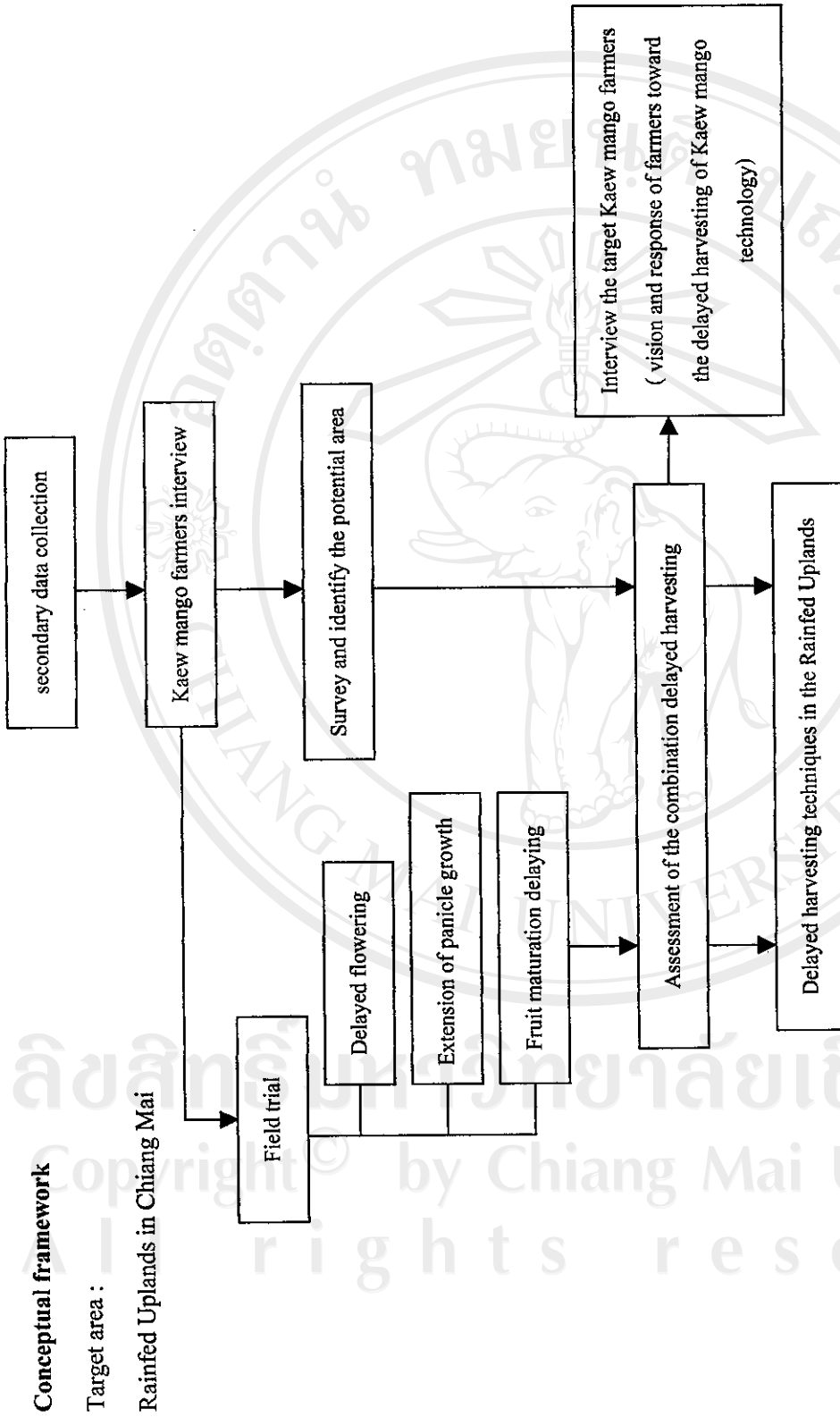


Figure 5. Conceptual framework for producing the late season of Kaew mango in the rainfed uplands of Upper North

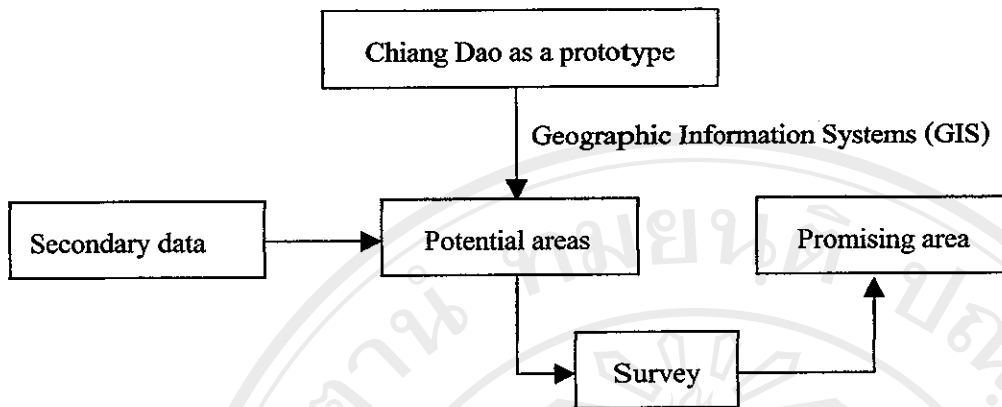


Figure 6. Diagram to identify promising area for producing late season of Kaew mango

2. Farmers' interview The field survey is necessary to implement the information of the Kaew mango production system in rainfed upland. The primary data were collected by a formal questionnaire survey in the study site Chiang Dao district, Chiang Mai province. This area is located in the Upper North of Thailand where Kaew mango is dominated. A total of 64 farmers who owned the orchard were randomly selected to interview before conducting the experiments in May 2001, in order to know the views of farmers to late season production. The information from surveying method involved with the socio-economic aspect, characteristics of mango orchard, and marketing of Kaew mango production. The aims of this field survey is to generate general information about the current mango production system, management practices and farmers' views in late-season production of Kaew mango. A formal survey data were gathered by interviewing farmers with questionnaire (Appendix A.1). The data collected as followed

1. Personal information e.g. age, sex, and education level.
2. Farm data e.g. size of farm, type of orchard, general practice management in their orchard, and harvesting time.
3. Financial data e.g. costs, market prices, and income.
4. Farmers' views on the need to produce late season mango.

Statistics from the data were computed as mean, percentage and frequency.

3. Experiments in the delayed harvestings : In order to achieve the objectives, three techniques of experimental trials were included : (1) delaying flowering, (2) extension of panicle growth and (3) delaying fruit maturation attached to the tree.

3.1 Delaying flowering

3.1.1 Pruning The six treatments were arranged in Completely Randomized Design (CRD), consisted of pruning time after harvesting in June, July, August, September and October comparing with the control (no pruning). Each treatment had four replicates, one tree as one replicate. The experiment was conducted during June 2001-June 2002, in a thirteen-year-old mango orchard, in the Chom Tong Land Reform Project Area, Doi Lor district, Chiang Mai province. Harvesting was carried out when the fruits were at the fully mature stage. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results. The parameters observed consisted of :

1. Age and size of trees (tree height, canopy diameter and trunk perimeter in cm) were measured prior to the experiment in May.
2. Growth of new leaf flushing after pruning (diameter and length in cm) were measured every month after pruning until the trees started to produce panicle.
3. Period of flowering after pruning determined as the times taken for appearing the full bloom (90-100%) on the tree.
4. The number of florets per panicle, sex ratio at full bloom.
5. Initial and final fruit set per panicle as well as number of fruits at different growth stages. The stages of fruit growth are referred to size of peanut (1 cm), bird's egg (3 cm), hen's egg (6 cm) and harvesting time.
6. Fruit growth attached the tree (width, length and thickness as cm) at all mentioned stages of growth.
7. Harvesting date and number of days from full bloom to the fully mature stage.
8. Size of fruit and seed including endocarp at harvesting (width, length, thickness and weight).
9. Percentage of the edible portion by weight.
10. Fruit quality both internal and external attributes :

10.1 External qualities

10.1.1 Peel color by using color reader Minolta CR-10, CIE system

10.1.2 Fruit stalk toughness by using firmness tester SHIMPO FGV-50A

10.2 Internal qualities

10.2.1 Total soluble solids (TSS) were recorded in Brix degree (°B) by using digital refractometer ATAGO-Pelete PR-101 (A.O.A.C., 1984)

10.2.2 Titratable acidity (TA) as percentage of citric acid, analysed by titration against NaOH 0.1 N using phenolphthalein 1% as indicator and expressed in terms of grams of citric acid per g fruit weight of tissue (A.O.A.C., 1984)

10.2.3 Flesh color by using the color reader Minolta CR-10, CIE system

10.2.4 Flesh firmness was measured by a penetrometer SHIMPO FGV - 50A with a concave probe of 11 mm of diameter. Two samples were randomly taken from each fruit, after peeling. The results were expressed in kg/cm^2

11. Meteorological data during the experiment from June 2001 to June 2002

3.1.2 Panicle thinning Four treatments were arranged in CRD, and consisted of panicle thinning at the appearance of panicle ; at 1, 10 and 20 cm in length comparing with no panicle thinning (control). Each treatment had three replicates, one tree as one replicate. The mango trees in this experiment were thirteen years old. Thirty shoots with terminal buds of similar size were tagged around the canopy. The production and development of new panicle were recorded after thinning. The experiment was carried out during December 2001-June 2002 in the Chom Tong Land Reform Project Area Doi Lor district, Chiang Mai province. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results.

3.2 Extension of panicle growth

3.2.1 PBZ concentrations and time of application Uniform trees of mango cv. Kaew (thirteen years old) in the Chom Tong Land Reform Project Area, Doi Lor district, Chiang Mai were selected. The experiment was conducted during December 2001-June 2002. Factorial in CRD was carried out with 3 replicates. Each tree represented one replicate. The experiment comprising initial panicle length of 1 and 5 cm were tagged, and five

concentrations of growth retardant, PBZ (0, 1000, 3000, 5000, 7000 ppm) were sprayed uniformly on 8 and 14 December 2001. Chemical spraying ceased when droplets started run off. Absa (2 ml/L) was added to the solution as a wetting agent. The parameters measured consisted of:

1. Panicle growth (length and diameter in cm) was recorded every week after spraying until full bloom.

2. Panicle development duration determined as the average date from the date after spraying to the full bloom (90-100%) date.

All fruits from each treatment were tagged after full bloom and harvested at full maturity. The following measurements (3-10) were undertaken as same as 2.1.1 item number 4-11. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results.

3.2.2 PBZ concentrations and application stage The field trial was laid out in CRD, 3 replicates, one tree as 1 replicate. The experiment was carried out during February 2002-August 2002, at Mae Ore Nai village, Chiang Dao district, 75 km from Chiang Mai city. PBZ (0, 1000 and 1500 ppm) was applied to the fifteen-year-old trees by foliar spraying on 11 February 2002, at the date of panicle appearance (1 cm in length). Absa (2 ml/L) was added as a wetting agent. During application, the whole trees were sprayed until droplets started run off. On each tree, 20 shoots were randomly marked to record the same measurements as the 2.2.1. In addition, each of different stages of fruit growth was analyzed as the followings :

- Total nonstructural carbohydrate contents (TNC) in leaves and flesh of fruits. The analysis followed Nelson's reducing sugar procedure. The data were expressed in terms of milligrams of D-glucose / gram dry weight (A.O.A.C., 1975)
- Reducing sugar content (RS) in leaves and flesh of fruits. The analysis followed Nelson's reducing sugar procedure. The data were expressed in terms of milligrams of D-glucose / gram dry weight (A.O.A.C., 1975)
- Chlorophyll content in leaves and peel (Whitham *et al.*, 1971)

Harvesting was done when the fruits were fully mature. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results.

3.3 Delaying fruit maturation

3.3.1 Fruit bagging Sixteen of 12-year-old mango trees cv. Kaew, grown in the farmer's orchard in the Chom Tong Land Reform Project area, Doi Lor district, Chiang Mai, were selected. The study aimed to determine the effect of fruit bagging on extending of fruit growth. The experiment was conducted during January–May 2002. The field trial was laid out in CRD, three replicates, one tree as one replicate. The fruits of 'Kaew' were wrapped with 14.5 cm x 21 cm newspaper bag at 30, 45 and 60 days after full bloom (DAF) and unbagged treatment (control). Harvesting was done at the fully mature stage. The following measurements were undertaken as same as 2.1.1 item number 5-11. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results.

3.3.2 Gibberellin (GA) application

3.3.2.1 GA concentrations and number of applications The experiment was conducted during March-May 2001, and carried out in the twelve years old mango orchard, with three replicates, one tree as one replicate, in the Chom Tong Land Reform Project Area, Doi Lor district, Chiang Mai. The treatments were arranged in Factorial in CRD with three replicates, consisting of two factors. The first factor was GA (as Pro-Gibb) with five concentrations (0, 50, 100, 150 and 200 ppm). The second factor was the number of application time with two levels (1 and 2 times). Twenty fruit panicles were allotted to individual treatments in each replicate. Aqueous solutions of these chemicals were mixed before spraying with Absa (2 ml/L). The first treatment fruits were sprayed at 80 days after full bloom and seven days later to the second ones. During application with a hand sprayer, the whole trees were sprayed until droplets started run off. Harvesting was done when the fruits were fully mature. The following measurements were undertaken as same as 2.1.1 item number 5-11. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results.

3.3.2.2 GA concentrations and fruit age In order to determine the effect of GA concentrations and fruit age on delayed harvesting under field conditions. The experiment was conducted during March -June 2002. The trial was tested on the thirteen years old Kaew mango trees, at the farmer's orchard in the Chom Tong Land Reform Project Area, Doi Lor district, Chiang Mai. Treatments were arranged in Factorial in CRD, with three replicates

(one tree as one replicate). There were two factors : GA with four concentrations (0, 50, 100 and 150 ppm) and fruit ages at 82 and 89 days after full bloom. Absa (2 ml/L) was added as a wetting agent. At time of application, the whole trees were sprayed until droplets of the spray found run off. Harvesting was done when the fruits were fully mature. The following measurements were undertaken as same as 2.1.1 item number 5-11. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results.

3.3.2.3 GA application and fruit age The experiment was conducted during May to August 2003, tested with fifteen years old mango trees, at the farmer's orchard in the Chiang Dao district, Chiang Mai. Treatments were arranged in CRD, three replicates, one tree as 1 replicate. Fifty ppm of GA was applied to the fruit ages of 85, 95 and 105 DAF. Absa (2 ml/L) was added to the solution as a wetting agent. During application, the whole trees were uniformly sprayed until droplets of chemicals started run off. The fruits from each treatment were tagged after full bloom and were harvested when the fruits reached fully green maturity. The following analysis were undertaken as same as 2.1.1 an item 5-11 and 2.2.2 an item 11-13. The data were statistically analyzed by means of F test and LSD comparison of means for interpretation the results.

4. Combination of technology in extending the harvest time of Kaew mango By using the combination of methods from the results of experiment 1 and/or 2 and/or 3 to proceed again in the target area where was the high potential for producing the late season Kaew mango was identified. These experiments aimed to determine the maximum probability and confirmation for extending period for the delayed harvesting of Kaew mango in the Rainfed Upper North.

5. Assessment of the farmers response in adopting delayed harvesting techniques 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 aims of the interviews were to obtain the farmers views on the practicability and their confidence in the

proposed technology. The data from survey were analyzed by using simple descriptive statistics.

The data gathered from interviewing individual grower include the following attributes :

1. General information on the household such as age, sex, education attainment, other occupations, assets, and farming experience in Chiang Dao mango cultivation system.
2. Characteristics of mango orchard such as total areas for agriculture, mango planting size, tree age, and mango cropping system in Chiang Dao cultivation.
3. Cultivation practices related to produce late season Kaew mango in Chiang Dao cultivation system.
4. Farmer' views on the practicability of the late season Kaew mango technology in their orchards.

Locality for proceeding experiments and collecting data

1. Horticulture department laboratory, Faculty of Agriculture, Chiang Mai University
2. Farmer's orchard in the Chom Tong Land Reform Project area, Doi Lor district, Chiang Mai
3. Farmer's orchard, Chiang Dao district, Chiang Mai