Chapter 3

MATERIALS AND METHODS

3.1. Problem identification

Before the field experiment was carried out, a preliminary study was conducted to obtain a better understanding of the existing production systems and identify major problems before relevant experiments were designed. The preliminary study includes secondary data analysis, an exploratory survey and a formal survey.

3.1.1. Secondary data analysis

Data on tomato production system components, production area, and yield distribution were collected from relevant sources (Department of Agricultural Extension, 1988) and analyzed.

3.1.2. Exploratory survey

The exploratory survey included farm survey and interview with farmers as well as the managers of 2 processing plants. During the 1989 - 1990 growing season, Yang Kram subdistrict in Chom Thong district of Chiang Mai Province was chosen for conducting the exploratory survey in order to identify key issues for developing the questionnaires for the formal survey. The managers of two tomato processing factories, San Mae Krua processing factory in Mae Rim and K. C. Northern Products Co. Ltd. in

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Sanpatong, Chiang Mai province, were also interviewed for information about quality requirements in tomato processing.

3.1.3. Formal survey

Two major production areas, San Sai district and Yang Kram subdistrict in Chom Thong district (Figure 2), were selected for conducting the formal survey with emphasis on cultivation and management practices of the farmers. A total number of 94 farmers who grew tomatoes during the 1989 - 1990 growing season were interviewed, which accounts for 15.6% of 603 farmers distributed among 14 villages. Details of the questionnaires appear in Appendix E. The sample of farmers was randomly chosen by using Lotus 1-2-3 software with an equal percentage from each village. Twenty percent of tomato growing farmers (120 farmers) were to be interviewed initially, but some of them were not interviewed due to the inconvenient time.

3.2. Field experiment

3.2.1. Site, treatment, sowing and transplanting

The experiment was carried out at the Irrigated Agricultural Research Station of the Multiple Cropping Center, Faculty of Agriculture, Chiang Mai University (19^0 N, 99^0 E). The soil was a sandy loam (San Sai series). The chemical characteristics of the first 20 cm layer of the

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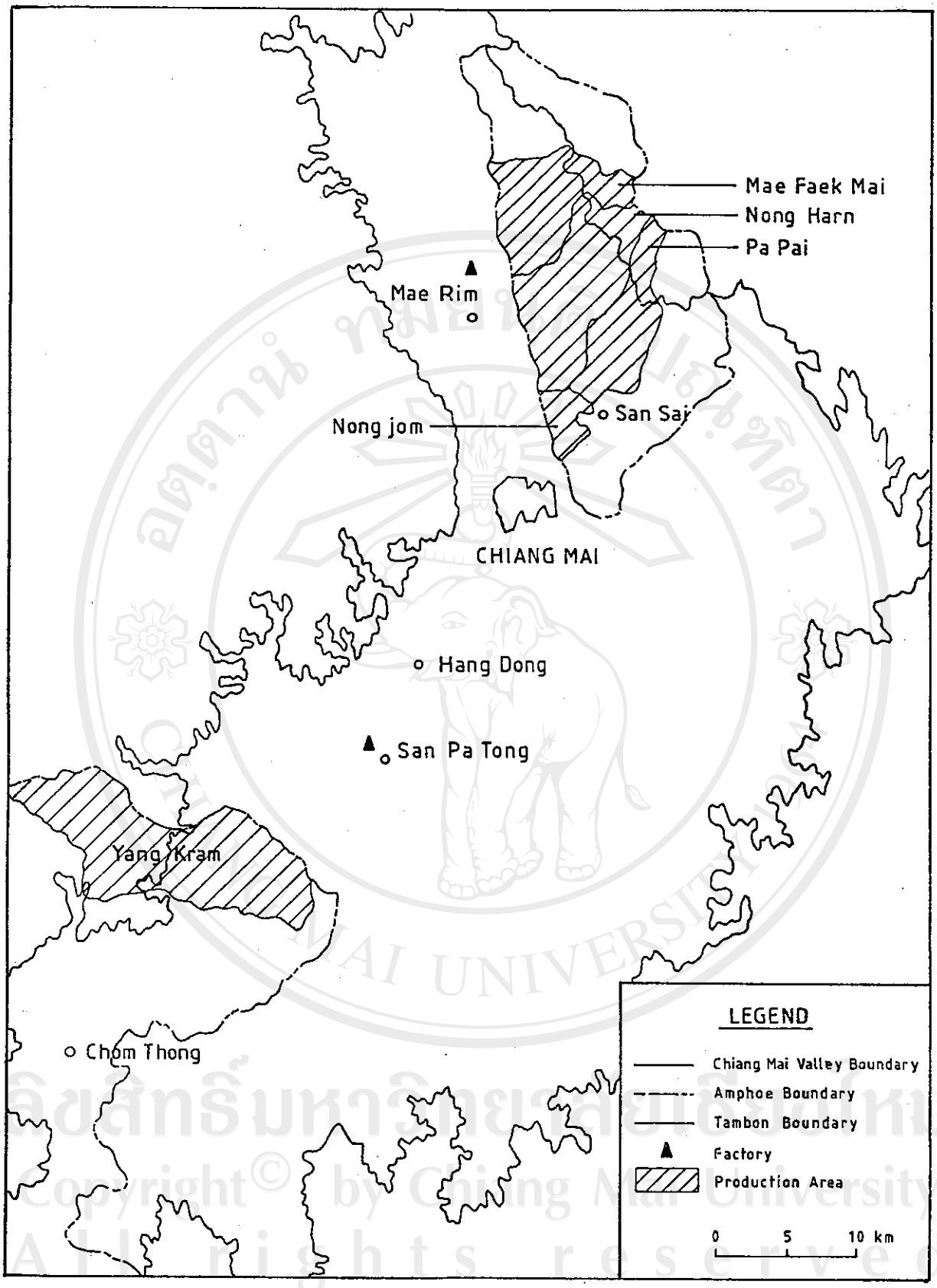

Figure 2. The map showing tomato production areas in Chiang Mai Province

soil at the experimental plots are listed in Table 1.

Table 1. The physical and chemical characteristics of soil in the experimental fields[a]

Rep	pH	O.M %	N %	P ppm	K ppm	Ca ppm	Mg ppm	Sand %	Silt %	Clay %	Texture
I	5.8	1.03	0.049	125.5	47.5	130	218.75	49.12	32.92	17.96	Loam
II	5.8	0.94	0.043	82.0	42.5	235	251.25	51.12	31.92	16.96	Sandy loam
III	6.5	0.67	0.039	50.0	40.0	160	75.00	61.12	24.92	13.96	Sandy loam

[a]The methods of soil analyses were as follows:

1. pH, by pH meter using Soil:H_2O = 1:1;
2. O.M., by Walky and Black method;
3. N, by Kjeldahl method;
4. P, by Bray II method;
5. K, Ca, Mg, extracted with 1 N NH_4OAc pH = 7 and measured by automatic absortion method;
6. Sand, silt and clay, by hydrometer method.

The experiment consisted of three factors: staking, plant density and K fertilizer levels. The staking factor was tested at two levels namely staking and nonstaking. Plant density was tested at three spacing levels (75 x 15 cm, 75 x 30 cm, 75 x 45 cm) which result in 88,889, 44,444 or 29,630 plants/ha. Potassium fertilizer was tested at four levels, 0, 100, 200, 300 kg/ha of K_2O, while 150 kg/ha of N

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and 100 kg/ha of P_2O_5 were applied to the experimental plots. The experiment was arranged as a split-split-plot design with three replications. Staking was in the main plots, plant spacing in the subplots and K fertilizer in the sub-subplots. A total area of 27 m^2 (6 m x 4.5 m), which was divided into 4 planting beds with an area of 1.5 x 4.5 m^2 for each, was occupied by each treatment. Two rows of tomatoes were planted in each bed. The layout of the experiment is shown in Appendix A.

Cultivar VF 134-1-2 was used for the experimental material. Seeds were sown in the plastic tray containing the medium which is composed of soil, rice husk ash and cow manure with the ratio of 4:3:2 in the nursery on November 3, 1990. Nine days after sowing, the seedlings were transplanted from the plastic trays to the plastic bags which contained the same medium as the tray did, one seedling in each bag. Seedlings were transplanted into the fields during December 3 to 13.

Before transplanting, newly harvested fields were plowed and harrowed by the tractor. Lime was applied at the rate of 1,250 kg/ha before bedding. Planting beds were made according to the density factor design. Holes were dug to facilitate transplanting for spacing of 75 x 30 cm and 75 x 45 cm treatments, and planting rows were used for 75 x 15 cm spacing.

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Split application of fertilizer was used based on the amount of N, P planed to be applied to the experiment and K treatment needs mentioned before. A mixture of 50 kg/ha of N (as urea), 60 kg/ha of P_2O_5 (as triple superphosphate) and 1/3 of K_2O (as potassium sulphate) was used as basal fertilizer. The first side-dressing, 50 kg/ha of N, was applied two weeks after transplanting. The second side-dressing, another 50 kg/ha of N, 40 kg/ha of P_2O_5 and 2/3 of K_2O, was applied two weeks after the first dressing. The fertilizer was applied beside the tomato plants and along the furrows. After application, fertilizer was covered with soil and the fields were watered.

Staking with 2 m bamboo poles started three weeks after transplanting. Bamboo poles were secured beside the plants and along the furrows 50 cm apart. On the top, two opposite poles in two sides of the bed were bound together. At 50 cm height above the bed, horizontal stakes were used to reinforce the supporting systems by crossing the stakes. Plastic bands were used for the binding material.

During the growing season, the fields were weeded twice. Fungicides and insecticides were regularly sprayed to prevent the infection of diseases and insects. The fields were irrigated weekly after transplanting to the termination of harvest. Rice straw was used for mulching after the first side-dressing. Harvesting occurred eight times from February

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8 to April 9, 1991.

3.3. Sampling

A sample area of 6 m^2 was used for yield recording, measurement of yield components, and collection of fruit samples for quality analysis in each treatment. Sample leaves were collected outside the sampled area. More details are explained later. Soils were sampled on the two beds in the middle for K residual analysis after harvest.

3.3.1. Yield

Yields were recorded from the sampled areas at each harvest; marketable as well as unmarketable yields were recorded. Marketable yield was defined as the fruits that can be sold to markets or to the processing factory. Unmarketable yields were those infected by diseases, damaged by insects, sunburned and rotten fruit, or very small fruits. The sum of all the marketable yield and unmarketable yield were recorded as the total yields.

3.3.2. Average fruit weight

At the same time as the yield recording, the number of fruits were counted to calculate the average fruit weight and the number of fruits per plant. In this experiment, the average fruit weight was calculated by using the sum of the marketable yield of the second, third and fourth harvest

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divided by the marketable fruit numbers of the same harvest sequence. The reason for this procedure is that the majority of the yield was concentrated in this period; and if all yields and fruit numbers were used to calculate the average fruit weight, it would greatly affect the average fruit weight, because most of the fruits were very small in all the treatments at the later harvest period.

3.3.3. Number of fruits per plant

The number of fruits per plant were measured by using the total fruit numbers, including marketable and unmarketable fruits, divided by the harvested plants in the sample area.

3.3.4. Yield per plant

The yield per plant was calculated by using the actual yield divided by the number of harvested plants.

3.3.5. Fruit quality analysis

Fruit quality considered here included pH, pulp color, soluble solid, total solid content and the total acidity. Ten mature fruits from each treatment were randomly chosen from the third harvest in the sample area for all quality items' analyses mentioned above. Fruit samples were washed, cut and blended into paste for analysis.

The pH of fruit juice was measured with the pH meter (HANNA-8417). Blended tomato was filled into a 100 ml

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beaker, and measured with the pH meter until the pH value was stable; then the value from the screen was recorded.

Pulp color was expressed in Munsell Color Codes by comparing the paste filled in the beaker and the Munsell Color Chart under the fluorescent lamp.

Soluble solid was measured with ATAGO N1 reflectometer directly and expressed as ^{0}Brix. Total solids of tomatoes were determined by the oven method (Helrich, 1990). About 10 gm of blended tomato was weighted into a moisture container and dried inside the oven at 100 ^{0}C and under one atmosphere pressure until consecutive weighings at 2 hour intervals showed the variation of $\leq$ 3 mg. The percentage of total solids was calculated as:

$$\text{Total solid}(\%) = \frac{W_1}{W_2} \times 100 \qquad (1)$$

where W_1 = dry matter weight (g)

W_2 = sample weight (g)

Titratable acidity (mainly citric acid) was measured by adding 0.05 N NaOH solution to bring fruit juice up to pH 8.1 and expressed as percentage of citric acid in fruits. The percentage of citric acid was calculated as:

$$\text{Citric acid}(\%) = \frac{V \times N \times 0.064}{Y} \times 100 \qquad (2)$$

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where V = volume of NaOH used (ml)

N = normality of NaOH (0.05 N)

Y = weight in of sample (g)

0.064 is the factor to calculate citric acid

3.3.6. Determination of K, Ca and Mg in plant leaves

Plant leaf samples were collected twice outside the sample area mentioned before for K, Ca and Mg analyses. The third or/and fourth leaves from the top were sampled one day before the second time of side-dressing and two weeks after that when tomato was in flowering stage, and nutrient critical stage (Sobulo, Fayemi and Agboola, 1975). Ten leaves were collected each time in each treatment. After sampling, the leaves were dried at 70 ^{0}C at an atmospheric pressure, then ground and stored in the paper bags for further analyses. Leaf samples were digested by using dry ashing method (Wikner, 1986). Detailed procedure for digesting leaf samples is in Appendix D.

The flame photometric method was used for K analysis and the atomic absorption method was employed for Ca and Mg analysis.

3.3.7. Determination of residuals in soil

Fifteen to 20 cm layer of soil was sampled in the 2 meddle beds of each treatment for K residual analysis. The flame photometric method was utilized for K analysis.

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3.3.8. Data processing and analysis

Lotus 1-2-3 software was used for data input and processing. Statistic (SX) software was adapted to the analysis of variance of the observed data. The results of analysis and the original data are shown in Appendix Table B and C.

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