Chapter 2

Literature review

2.1. Factors related with degradation of tangerine orchards

2.1.1 Topography

According to the production manual for growing lemon in Australia slope and aspect are two topographic factors which the grower should consider for selection of the suitable cultivated area for citrus even for lemons the species which are successfully grown in a wide range of climates, soils and locations. A gently sloping site is best and the area with steep slopes (>20%) should be avoid. A north or north easterly aspect is best providing maximum sunlight during the winter months (Hardy, 2004). According to the review of Ribeiro and Machado (2007) citrus photosynthesis is addressed as the primary source of carbon and energy for plant growth and development. The canopy position of citrus in brazil is relevant in relationship to photosynthesis rates since canopy layers may be subjected to different environmental conditions. In the north-south-oriented citrus orchard, the east canopy position received direct solar radiation during the morning when leaf-to-air vapor pressure difference (VPDL) and leaf temperature were low.

In contrast, the west position received direct solar radiation during the afternoon when VPDL and leaf temperature were high (Ribeiro *et al.*, 2005). Therefore the east position exhibits higher photosynthesis than the west position, regardless of water availability and seasons. In addition, irrigation was more effective in increasing photosynthesis in leaves of the west canopy position and increasing the differences between canopy faces.

2.1.2 Soil properties

According to Timmer and Duncan (1999) the suitable soil for citrus cultivation is loamy soil with the depth not less than meter. The soil should have good drainage and aeration because for good growth and deep penetration into the subsoil for taking up water and plant nutrients of citrus roots required soil with good aeration. In clayey and compact soil with poor aeration, citrus roots are not healthy and the growth will be limited in the surface soil only. Under such condition, water absorption and plant nutrient uptake of citrus roots are not effective. When citrus roots are not healthy the roots are easily infected by root rot diseases.

From the preliminary study of Sruamsiri *et al.(*2009) they found out that more than 60-70 % of total tangerine orchard in Chiang Mai province, the growth of tangerine roots were in the first 20-40 cm of soil depth only. In Florida, citrus trees on rough lemon root stocks had root depth up to 3.3 meters while those on sour orange root stocks had root depth about 2.7 meters (Timmer and Duncan, 1999). Though the growth of citrus roots depends on root stock and soil texture but in soil with shallow profile, citrus trees can grow also. In the area with high water table such as the seashore of Florida, the depth of citrus roots were about 48-60 cm only.

Regarding to soil chemical properties, soil pH in one of the parameter of soil quality. Soil pH has influence in chemical and biological processes (Wiwatwongwana, 2003). The suitable soil pH for citrus cultivation is 5.5-6.5 (Supakumnerd *et al*., 2005). In Florida and California, the soils for citrus cultivation have pH within 5.5-7.5 but most orchard maintained soil pH 6.0 (Timmer and Duncan, 1999). However at Sao Paulo in Brazil (Pereira *et al*., 2003) the pH of the soils in citrus growing area were within the range of 4.8-5.5 which were extremely acidic soils. Soil pH improvement by liming in this area was difficult because Al content in the soil was high. The growth of citrus roots were limited by Al toxicity. The fibrous roots could be extensively found in the soil with the depth at 30-45 cm only. In acidic soil, the availability of P was low due to high P fixation. Nevertheless, P requirement of citrus in not high. This fruit crop will respond to P fertilizer application only in the soil which is deficient in P. In addition, if the soil contains too much P, Zn, Fe and Cu uptake of citrus will be affected.

Another soil parameter which should be considered is cation exchange capacity (CEC). From the study of Duffera and Robarge (1999), Vertisol in highland soil of Ethiopia contained higher percentage of clay than Andisol and Alfisol almost one time. The percentage of clay correlated positively with CEC of soil. The soil with higher clay content had more capacity to adsorb cation thus nutrient lost from leading from clayey soil was less than sandy soil.

According to Ankerman and Large (2001) the balance ratio of K, Mg and Ca at different levels of CEC has been proposed. The level of magnesium needed or desired in a given soil for good crop production depends on the crop to be grown, CEC and the level of Ca and Mg in the soil. High rates of application of limestone or potassium could result in an induced Mg deficiency. As a rule, if the soil test indicates that the ppm of exchangeable K to exchangeable Mg ratio is more than 3 to 1, crop should be watched for Mg deficiency.

2.1.3 Effects of orchard management

Orchard management is one of the influencing factors on the mandarin orchard degradation. The factors can be identifying as follows.

1) Water supply

According to FAO (2001) water requirement of citrus is 900-1200 mm per year In case of lemon trees, the mature trees will need between 3-5 megalitres per hectare depending on load rainfall. An assured and reliable source of water is critical for production of lemon (Hardy, 2004). For Sai Nam Pueng, tangerine trees grow in Fang watershed for the production of the year 2007-2009, the average water requirement was 890 mm per year (Onpraphai and Sunthasup, 2010)

2) Planting materials

To grow citrus successfully, planting material is very important. Use of suitable rootstock is essential for the long-term health and productivity of citrus orchards. Rootstock choice will be a compromise based on a number of factors including soil type; scion variety, climate and locality. Rootstocks also determined to some extent the period of crop maturity, fruit quality and tree growth habit. Rootstocks vary significantly in their resistance to fungal and viral diseases, nematodes, soil conditions such as pH and salinity, in their effects on fruit quality (Hardy, 2004). In Thailand, air layering in common method for propagation of citrus.

However there are more than 30 kinds of plant diseases being transferred by this method of plant propagation particularly greening and Tristeza diseases. If citrus trees were infected by these diseases the growth and productivity of citrus trees will be seriously declined. The important citrus varieties for rootstocks which are resistant or tolerant to Phytopthora fungal disease are Sour orange (*Citrus auarantium* Linn.) Trifoliate (*Poncirus trifoliata* Raf.) Swingle citrumelo (*Citrus paradisi* Mazf.x) and Cleopatra (*Citrus reshni* hort. ex Tan.) While Troyer citrange (*Citrus sinencis* (L.) Osbeck.X) is susceptible to Phytopthora. Among the varieties for rootstock mentioned above or tolerant to Tristeza virus. (Chang and Peterson, 2003)

3) *farmers' knowledge*

Since there are many factors involved with good growth and productivity of citrus trees, the farmers should have some knowledge about citrus orchard management. However, Sruamsiri *et al*.(2008) reported that there were difference between tangerine farmers at Mae Ai and Mae Soon sub districts for their cultivation practices. Nevertheless there were a few farmers who had good knowledge on citrus orchard management.

4) Fertilizer Management

Chanwijit *et al.*(2008) studied fertilizer usage of tangerine farmers in Fang, Chiang Mai province and Mae Ai district and found out that there were 14 fertilizer grades used in those areas. The popular grade was 15-15-15 which was applied during vegetative stage and fruit development while 13-13-21 grade was used during flowering stage and before fruit harvest. She also found that all orchards applied N, P and K more than the requirement of tangerine crop. High application of chemical fertilizers resulted in higher content of plant nutrients in the sols than the optimum level. Fertilizer application by farmer practice did not improve yield and quality of tangerine fruits. Similar results was reported by Bhuwarodom (2004) who studied fertilizer usage of durian farmers and found out that durian and tangerine farmers applied over doses of fertilizer and such practices resulted in plant nutrient unbalance condition of the soil. Brady and Weil (2002) found out if the soil contained Mg and K more than Ca, Ca uptake by plant will be reduced. Supakumnerd *et al*. (2005) studied about plant nutrient status of tangerine and found out that N, P and K content of tangerine fruits increased with the age of the fruits. However the content of Ca and Mg increased during fruit setting period up to the stage in which the size of fruit is equal to the size of lemon. After that the content of both Ca and Mg are rather stable. If the citrus cultivated soil contained low Ca and Mg or had very high content of K, tangerine trees might take up insufficient amount of Ca and Mg. Another factor which involved with Ca deficiency beside low availability of Ca was root condition. Any condition which reduced the formation of fibrous roots could reduce Ca uptake and induced Ca deficiency in citrus (Havlin *et al*., 2005) In the case that Ca uptake by plant was reduced due to the affects of high Mg and K content in the soil such effect was called antagonistic reaction (Brady and Weil (2002).

Continuous usage of improper doses of chemical fertilizer application for a long time crated unbalance plant nutrient condition in the soil which affected availabilities of the nutrient condition in the nutrients in the soil and also the uptake of nutrients by crop. The interaction among plant nutrients could be antagonistic or simulative. For the antagonistic interaction was the case of high Ca in the soil which induced B, Fe and Mg deficiencies in the plant. Zn uptake or too much K reduced Mg availability or too much N reduced Cu availability (He *et al.*, 2003).

Sruamsiri *et al.(*2009) observed that the degree of root rot of tangerine trees in the orchards from lowland area which used to be paddy field were high disease the soils from this area were compact with poor drainage. The popular planting material for tangerine farmers is the material form grafting. It was expected that almost all of this type of planting material contained greening and Tristeza disease in the plant tissues. Such planting material had weak root system and no resistance to root rot disease. When they were planted in the lowland or degraded soil, the trees were subsequently not healthy and not productive for investment (Kuaeprakone *et al.*,2009).

2.2 Spatial assessment of the mandarin orchard degradation

According to Sasiprapa *et al.* (2009) who investigated the degradation of tangerine orchards at Fang district by using supervised classification technique for analysis of the relationship between normalized difference vegetation index (NDVI) and chlorophyll content, the degradation could be classified into 5 levels. However, after field validation, it was found that the new orchards of the orchards with the young threes were classified as the deteriorated orchards. They suggested that the productive orchards should be separated from the new orchard before classification of orchard degradation.

For complex decision situations in agriculture and management, the Analytic Hierarchy Process (AHP) is extensively accepted as the suitable analytical process (Saaty, 2003). Multi-criteria decision analysis (MCDA) is a technique for decision support which aims at providing transparent and coherent support for complex decision situations taking into account subjective preferences of the decision makers. However, MCDA does not foresee an analysis of multiple plausible future developments of a given situation. In contrast, scenario-based reasoning (SBR) is frequently used to assess future developments on the longer term. Scenario-based reasoning entails exploring possible future scenarios to select the best possible actions given the current situation (Comes *et al.*, 2009). Multi-criteria decision analysis-GIS (MCDA-GIS) is the program for integration of many spatial decision problem with GIS technique. Malczewski (2006) said that spatial decision problems typically involve a large set of feasible alternatives and multiple, conflicting and incommensurate evaluation criteria. The alternatives are often evaluated by a number of individuals (decision-makers, managers, stakeholders, interest groups).The individuals are typically characterized by unique preferences with respect to the relative importance of criteria on the basis of which the alternatives are evaluated. According to Durbach and Stewart (2003) many spatial decision problems give rise to the GIS-based multi criteria decision analysis (GIS-MCDA).It can be interpreted as a problem structuring technique paying particular attention to uncertainty modeling, making it an ideal candidate for integration into the MCDA problem structuring process. Chuong (2008) integrated social-economic and infrastructure database into GIS together with physical data in order to analysis the land suitability for promising citrus fruit crop and used the Analytic hierarchy process (AHP) to synthesize the judgments. Criteria selections for physical land suitability were: soil type, soil texture, soil effective depth, soil slope degree, soil pH and soil fertility.