Chapter 2

Review of Literature

1. General

The cultivated lychee originated in the region between southern China and northern Vietnam (Menzel, 2001). Lychee belongs to the Sapindaceae family including rambutan, longan, pulasan and Spanish lime (Subhadrabandhu and Yapwattanaphu, 2001). Lychee has been called by many names such as Lycheei, Lychee, leechee, lechia (Spanish), quenepe chinois (Haitian), and litschi in German (Sanders, 2002).

Lychee has been well distributed in the tropical and subtropical world but, currently, it is not widely grown because it does not flower and yield crop successfully over a wide range of climates. The fruits are popular in Southeast Asia, but less importance in tropical Africa and the Americas. The major commercial industries have been found in China, Taiwan, Vietnam, Thailand, India, Madagascar and South Africa (Menzel, 2001). Production in the Asia-Pacific Region accounts for more than 95 percent of world cultivation, at about 2 million tons (FAO, 2001)

There is no record of the introduction of lychee into Thailand. It is believed that many lychee varieties grown in Thailand at present had been brought into the country by early Chinese settler. Thailand is now major lychee production country in the world. Lychee is mainly grown in the northern part of the country where the climate is classified as sub-tropical. The most popular variety is 'Hong Huay' which is reported to be synonym of 'Tai So'. The fruiting season is mainly April-June. Thailand exported about 11,000 tones of lychee to Malaysia, Singapore, Hong Kong, United Kingdom, Canada and Netherlands (Ghosh, 2001).

2. The lychee cultivars in Thailand (Yapwattanaphun and Subhadrabandhu, 2001)

Lychee cultivars can be divided into two groups according to the adaptability.

1. Lowland or tropical cultivars

This group of cultivars does not require a cool period for flowering. They are commercially grown in the central part of Thailand. The descriptions of some leading cultivars are as follow;

1.1 Kom; small-large compound leaves, 26 cm wide, 21 cm long. Oblong shaped leaflet, green, 2.5 cm wide, 13 cm long, undulate margin, acumunate apex, cuneate and smooth surface. Inflorescence is small to large. Creamy flower. Fruit small; 2.8 cm in width, 2.9 cm in length, dark red skin.

1.2 Sampaokaew; medium - large compound leaves, 26 cm wide, 25 cm long, usually 4 pairs of leaflets. Medium to large leaflet; oval shape, 4 cm wide, 14.5 cm long, undulate margin, caudate apex, acute base and smooth surface.

2. Subtropical cultivars

The cultivars in this group require a longer cool period for flowering. The commercial areas are in the northern part of Thailand; Chiang Mai, Chiang Rai, Lumphun with some areas in Petchaboon, Nan and Phrae. The descriptions of some leading cultivars are as follow;

2.1 Hong Huay; medium – large compound leaves, 26 cm wide, 25 cm long. Dark green leaflets, oval shape, 4 cm wide, 14 cm long, undulate margin, cuspidate apex, acute base. Small to large inflorescence, 9 cm wide, 17 cm long. Creamy flower. Ellipsoid fruit shape, medium size, 3 cm wide, 3.2 cm long, red skin

2.2 Chakrapad; small to large compound, 22 cm wide, 18 cm long; dark green leaflets, lanceolate shape, 3.5 cm wide, 11 cm long, entire margin, acute apex, cuneate base. Inflorescence is small to large, 8 cm wide, 16 cm long. Creamy flower. Heart shape fruit, 4.3 cm wide, 4.4 cm long, red skin.

2.3 Kim Cheng: small to large compound, 19 cm wide, 16 cm long; dark green leaflets, oblanceolate shape, 3.7 cm wide, 10 cm long, entire margin, obtuse apex, cuneate base and smooth surface. Inflorescence is small to large, 5.6 cm wide, 16 cm long. Creamy flower. Medium fruit, Spheriod shape fruit, 3.3 cm wide, 3.5 cm long, dark red skin.

2.4 O-Hia; small to large compound, 30 cm wide, 24 cm long with 3-4 pairs of leaflets; dark green leaflets, oval shape, 4 cm wide, 14 cm long, undulate margin, caudate apex, cuneate base. Inflorescence are small to large, 7 cm wide, 21 cm long. Creamy flower. Heart shape fruit, 3 cm wide, 3.2 cm long, red skin.

3. Functions of essential elements and deficiency symptom

Nitrogen

Nitrogen (N) is absorbed by plants in both nitrate (NO_3^-) and ammonium (NH_4^+) forms. Nitrogen has numerous functions in plant. The NO_3^- ion undergoes transformation after it is absorbed and is reduced to the amine form (NH_2^-). It is then utilized to form amino acids, protein, nucleic acid, and N bases; nitrogen is also a constituent of other plant components including nucleotides, amides and amines. Many enzymes are proteinaceous; hence, N plays a key role in many metabolic reactions. Because nitrogen is contained in the chlorophyll molecule, a deficiency of N will result in a chlorotic condition of the plant. Nitrogen is also a structural constituent of cell walls. Protein is continually being synthesized and degraded in the plant so that N moves from older plant parts to youngest leaves, therefore, N deficiency symptoms normally appear first on old leaves (Bennett,1993).

Symptoms of N deficiency in lychee can be described as follow: uniform chlorosis of old leaves; curling of leaf margin; decrease leaflet size; chloroplasts disorganization; failure of leaf development; poor branching, flowering, fruit set and fruit retention (Menzel and Simpson, 1987)

Phosphorus

Phosphorus (P) is absorbed by plants in one of two forms, either as the monovalent phosphate ion ($H_2PO_4^-$) or as the divalent phosphate ion (HPO_4^{2-}). The ($H_2PO_4^-$) predominates in soil with a pH of less than 7.2 and HPO_4^{2-} at a pH greater than 7.2. Phosphorus is a constituent of plant compounds such as enzymes and proteins and it is a structural component of phosphoproteins, phospholipids, and nucleic acids. It "promotes" early maturity and fruit quality. Phosphorus is contained in nicotinamide adenine dinucleotide phosphate (NADP), a part of the photosynthetic process. It is also involved in electron transport in oxidation – reduction reactions. Phosphorus plays a regulatory such as sugars and starches. It is important in the maturation processes and in seed formation. It is involved in symbiotic N fixation (Bennett,1993).

Symptoms of P deficiency in lychee are tip and marginal necrosis of mature leaves proceeding towards the midrib. Lychee deficiencies are leaves curl, desiccate and abscise prematurely. Phosphorus deficiency may occur in soils which is well supplied with P. It might be due to unsuitable soil pH which availability form is reduced (acid of alkaline soil). Some sandy soil/organic soil are naturally low in P (Maynard, 1979).

Potassium

Potassium (K) is required for turgor buildup in plants and maintaining the osmotic potential of cells, which guard cells govern the opening of stomata. It is involved in water uptake from soil, water retention in plant tissue, and long distance transport of water and assimilates in phloem and xylem. With adequate K, cell walls are thicker and provide more tissue stability. These effects on cell growth normally improve resistance to loading, pests and disease. Potassium is often described as a quality element, because fruits and vegetables grown with adequate K seem to have a longer shelf life in grocery store (Bennett, 1993).

The symptom of K deficiency in lychee is loss of leaf color. Necrotic then develops in leaf apices, which gradually progresses along the margins towards the base. Mature leaves abscise prematurely. Plant flowers but does not set fruit. Deficiency of K can often occur late in the season when K is in the stage of fruit development. (Menzel and Simpson, 1987)

Calcium

Calcium (Ca) occurs in plants as calcium pectate, which is a component of every cell wall. It is involved in cell elongation and cell division. Calcium acts as a regulator ion in translocation of carbohydrates through its effect on cells and cell walls. It is cited for its beneficial effect on plant vigor and stiffness of straw and also on grain and seed formation (Bennett, 1993).

Symptoms of Ca deficiency in lychee include small leaflets, leaf necrosis along margins; severe leaf drop, poor root development. Deficiency of Ca plants grown in solution culture flower, but did not set fruit (Menzel and Simpson, 1987).

Magnesium

Magnesium (Mg) is an essential part of chlorophyll molecule. It is a cofactor for a number of enzymes including transphosphorylase, dehydrogenase, and carboxylase. Magnesium aids in formation of sugars, oils and fats. It also activates formation of polypeptide chains from amino acids (Bennett,1993).

Lychee plants with Mg deficiency display small leaves, internal necrosis, leaf abscission and poor root development (Goldweber, 1959).

Sulfur

Sulfurs (S) is a constituent of two amino acids, cysteine and methionine (some references list a third, cystine), which are essential for protein formation. It is also involved in formation of vitamins and synthesis on some hormones and also involved in oxidation-reduction reactions Sulfur deficiency cause chlorosis of the whole plant, often young leaves affects first (Bennett, 1993).

Iron

Iron (Fe) is essential for the synthesis of chlorophyll and involved in N fixation, photosynthesis and electron transfer. As an electron carrier, it is involved in oxidation –reduction reaction and also a structural component of substance involved in these reaction, such as the reduction of O_2 to H_2O during respiration (Bennett,1993).

Reuter and Robinson (1986) found that iron deficiency may cause interveinal chlorosis which in severe cases may mean total bleaching of young foliage followed by necrosis which usually occurs first on young leaves.

Zinc

Zinc (Zn) is involved in the evolution of O_2 in photosynthesis. It is a component of several enzyme systems, although requiered amount is less than other micronutrients. It also functions in chloroplasts as part of electron transfer(oxidation-reduction) reaction and electron transport system (Bennett,1993). Symptom of Zn deficiency include general bronzing of leaflets, smaller leaflets, long internodes, smaller fruit with reduced flesh recovery and sugar (Menzel and Simpson, 1987).

Boron

Boron (B) is involved in the transport of sugars across cell membranes and in the synthesis of cell wall material. It influences transpiration through the control of sugar and starch formation. It also influences cell development and elongation. It reportedly interacts with auxin. Because of its impact on cell development and on sugar and starch formation and translocation, a deficiency of B retards new growth and development; hence, the symptom will appear first as a lack of new growth. In soil reactions, Boron is similar function to P in many ways. Boron in the plant does not undergo valency changes (Bennett,1993).

Boron deficiency is a serious worldwide problem. Deficiency is commonly found in acid sandy soils where native B has been leached and on alkaline soil with free lime, on acid organic soil and sandy soils with a low organic matter content. Boron deficiency causes death of growing point. Axillary buds may burst giving a witches broom effect. Some species, e.g. grape, may be distorted characteristic of impaired metabolism of auxin. Fruits may distort or show woody pits or cracking of the surface (Menzel and Simpson, 1987).

5. The nutrient study in lychee

One, two and three year old lychee trees were uprooted and dissected into leaves, twigs branches, stem and roots (Suprakamnerd, 2000). The contents of N, P, K, Ca, Mg, Fe, Mn, Cu, B and Zn were determined. The result showed that the content of essential nutrients were greater in leaves than other plant parts except the contents of iron, copper and zinc which were greater in the small roots. Nutrient contents in leaves of three year old lychee were 20-40 times greater than those of one year old tree.

During June 1999-May 2000, recently mature shoots of first and second leaf flushes and fruits were sampled from different soil types in three representative orchard in northern Thailand. The samples were analysed for essential nutrients, subsequently, nutrient requirement for each shoot of the first and second leaf flushes and fruit growth were determined. It was found that Hong Huay lychee required approximately 51.2, 15.2, 98.9, 38.8, 23.1, 0.24, 0.62, 0.12, 0.14 and 0.12 mg/shoot of N, P, K, Ca, Mg, Fe Mn, Cu, B and Zn respectively, whereas Emperor Lychee required of those 77.0, 7.7, 50.8, 20.7, 10.8, 0.16, 0.61, 0.048, 0.056 and 0.071 mg/shoot respectively. Regarding nutrient in fruit, Hong Huay lychee required approximately 53.9, 7.4 and 57.6 mg/fruit of N, P and K whereas Emperor lychee required of those 60.6, 10.0 and 81.8 mg/fruit respectively (Suprakamnerd, 2000).

In Australia, leaf analysis was used to determine for amount of nutrient that the grower should apply to lychee plants. There was a standard mean of each nutrient that lychee requires for optimum growth during May to August as follow: 1.50–1.80% N, 0.14–0.22% P, 0.70–1.10% K, 0.60–1.00% Ca, 0.30–0.50% Mg, 50–100 µg/g Fe, 100–250 µg/g Mn, 15–30 µg/g Zn, 10–25 µg/g Cu, 25–60 µg/g B, <500 µg/g Na and < 0.25 % Cl (Menzel and Simpson, 1990

Li *et al*, (2001) found that rate of nitrogen fertilizer application and timing significantly affected soil and leaf nitrogen status, high nitrogen content in leaves enhanced vegetative flushing in which would reduce flowering and yield. In subtropical Australia, leaves were sampled from fruiting and non-fruiting branches from flower to fruit harvest. In order to obtain the best produce , grower has to monitor nutrients during production period.

Lychee can be grown on different soil types, including soils with pH ranging from 5 to 8. In alkaline soils there can be problems with deficiencies of iron, zinc, boron and other nutrients. The soil must be freely draining, although lychee tree can tolerate a wet profile for part of the day.

The good production is probably best with sandy, sandy loam and clay loam soils. Heavy clay soil has to be avoided. Lychee production is unlikely to be restricted by poor soils (FAO, 2001).

Although no soil standards are available for lychee production, values for other crops can be used as a guide (Table 2.1).

Table 2.1 Standard nutrient availability for tree, nut, vine and fruit crops suitable for assessment of lychee soils

	Standard values for tree, nut, vine and fruit crops		
	Low	No action required	High
pH	<5.0	5.0-5.5	>5.5
	Low	Medium	High
NO_3-N (mg. kg^{-1})	<20	20-40	>40
P (mg. kg^{-1})	<20	20-60	>60
K (mg. kg^{-1})	<78	78-195	>195
Ca (mg. kg^{-1})	<1200	1200-1200	>2000
Mg (mg. kg^{-1})	<192	192-384	>384
		No action required	
Cl (mg. kg^{-1})		<250	
Cu (mg. kg^{-1})		0.3-10.0	
Zn (mg. kg^{-1})		2-15	
Mn (mg. kg^{-1})		2-50	
Fe (mg. kg^{-1})		2-50	
B (mg. kg^{-1})		1.0-5.0	

Source: Derived from Anon. (1984b), except pH (Nanz, 1955), B (Kabata-Pendias, 1984) and Al (Ragland and Coleman, 1959)

Lychee leaf analysis was conducted in South Africa, Israel and Australia for determining standard nutrient availability for optimum growth as shown in Table 2.2.

Table 2.2 Leaf standards developed for lychee in South Africa, Israel and Australia

Nutrient	South Africa standard	Israel standard (Galan Sanco, 1987)	Australia (Price *et al*, 1988)
N (%)	1.30-1.40	1.50-1.70	1.50-1.80
P (%)	0.08-0.10	0.15-0.30	0.12-0.22
K (%)	1.00	0.70-0.80	0.70-1.00
Ca (%)	1.50-2.50	2.00-3.00	0.50-1.00
Mg (%)	0.40-0.70	0.35-0.45	0.25-0.50
S (%)	-	-	-
Mn(mg. kg^{-1})	5-20	4-8	4-40
Fe(mg. kg^{-1})	5-20	4-7	2.5-15
Zn(mg. kg^{-1})	1.5	1.2-1.6	1.2-2.5
B(mg. kg^{-1})	2.5-7.5	4.5-7.5	1.5-4.0

Sources: Cull (1977) for South Africa's standard
Galan Sanco (1987) for Israel's standard
Price *et al*, (1988) for Australia's standard

Soil and plant analyses are complementary. Soil analysis has the advantage of being able to measure the level of nutrients available in soil, and extent to which this will be available to crop during growing period. Leaf analysis indicates the nutrient status of plant at particular time of sampling, often in time for any deficiency to be corrected while the crop is still growing until maturity