GROWTH AND YIELD ANALYSES OF CITRUS ORCHARD'S FARMERS

Aos Mohammad Akyas
Laboratory of Horticulture, Padjadjaran University, Bandung Indonesia

Abstract

Almost all Citrus fruit-trees' centers in Java and Bali had been destroyed by green disease. Some farmers tried to establish new orchards around but out of the old centers. Some were successful, but most of their orchards were depressed, due to some reasons. The aim of this study is to demonstrate a diagnostic technique, to make those orchards more productive; and which is financially sound for the small farmer.

For that reason a thorough field survey was carried out. This survey showed two dominated types of citrus orchard; the first is a young depressed, not yet productive citrus orchard of 3-4 year old, and the second was a depressed productive citrus orchard of 6-10 year old.

The canopy type of the young not yet productive orchard belongs to broomstick and ellipse. The light penetrates better in the broomstick canopy than in the ellipse canopy. The growth rate of the two was however the same, that was very low. The nutrient status in the leaf tissue may not correspond with the available nutrient in the soil. The first to note is that the moderate Ca in the soil is coupled with the deficiency Ca status in leaf tissue; and the second is that the moderate N in soil is coupled with its excessive status in leaf tissue. All the fact indicates that the main cause in this orchard was the poor aeration, due to the poor drainage. So that it can not be corrected by adding more Ca to the fertilizer program.

On the contrary in the depressed fruiting trees, the available nutrient in soil correspond with the nutrient status in leaf tissue, except the N that was low in soil but excessive in leaf tissue. Its indicates a typical reaction of the trees that suffer from over-exploitation. In this case the proposed corrective measure would be promoting the tree to growth vigorously without bearing fruits for at least one year; and just than it would be fruited in the next following years.

Key words: Citrus, growth analyses, canopy structure, nutrient status, soil and leaf tissue analyses

Introduction

A citrus-disease caused by bacteria like organism (BLO) - known as Asian greening, spread out in many Asian countries; like in the Philippines, Taiwan, Ceylon and Nepal. This disease is also found in Brazil, and a different strain is found in Africa, called African greening. Its spread out in Indonesia was reported since the year of 1960 (Tirtawidjaya, 1964). In the present day that green disease had destroyed almost all the Citrus fruit-trees' centers in Java and Bali.

One of the citrus fruit centers that destroyed by green disease located in Garut District, West Java; at a distance of about 100 miles from the capital city Jakarta. Once, the superior citrus fruit quality, famous since the old colonial time, comes out from this region. Some farmers tried to establish new orchards around but out of the old centers to avoid from the pathogen. Some were successful, but most of their orchards were depressed, due to some reasons.

Those depressed orchards have to be corrected that based on a reliable diagnostic technique; which is usually based on routine leaf analyses that called crop logging (Clements, 1960). It is; however, not possible that each farmer carries out a routine analysis with his or her own budget. The aim of this study is to develop a breakthrough - but still reliable- in diagnostic technique, which is financially sound for the small farmer.

Logical Construct

The following logic would be used as diagnostic process.

The basic assumption is that in the "normal" condition the available nutrient in the soil correlates with the nutrient status in leaf tissue. So far this condition is normal; the depressed tree performance may be due to shortage, excessive or disproportion in one or more available nutrition in the soil, so that proper fertilizer management could correct it. In fact however, tree nutrition may be indirectly influenced by many factors. For examples, if a root system is impaired by too much water in the soil, nematodes, or disease, deficiency symptom of an element may appear. In other case any damage in new flush, excessive nitrogen in leaf tissue may appear, although the available nitrogen in soil is low.

Any abnormality reflects in a symptom, although as mentioned above it is not so easy to determine whether it is a direct or indirect symptom. To overcome it, a tool, which will sharpen the diagnostic capability, and to some extent can indicate the cause before the symptom emerges, is needed. The tool is Canopy Structure Analyses that has been proofed as useful elsewhere (Akyas, 2000).

Methods of study

Garut district in West Java, one of the famous citrus fruit centers in Indonesia was chose for study object. The methods used were descriptive, at first was a field survey to identify the dominant type of the depressed orchard. And then purposive random sampling was used to draw orchard sample for diagnosis. The diagnosis was based on the analyses of the canopy structure (Feucht, 1968, Schumacher, 1975, Friedrich and Preuse, 1970, Akyas, 2000) and the nutrient correlation analyses (available in the soil, Mengel and Kirby, 1987, Chapman, 1967, and status in the leaf tissue Embelton, et. al., 1973, Reuther, et. al., 1988).

Result and discussion

In the past the citrus orchards in Garut concentrates in the sub-district Wanaraja, but after the attack of that pathogen, has been shifted to the neighbor sub-district Samarang. The ecological conditions of the two locations are not the same. The old center was found at an altitude of 700 meters, whereas new center was found at an altitude of 1000 meters. The old center has rainfall type D, according to Smith-Fergusson's classification, and the soil type andosol, whereas the new center has rainfall type C with the soil type grumosol and latosol.

Two cultivars were dominant in citrus orchard in Garut, that is *Citrus retiulata* Blanco *cu*var. "keprok-Garut", and *Citrus retiulata* Blanco, cuvar. "Keprok Siem". As predicted, in the new established orchards the "Keprok Siem" growth and yield better than "keprok-Garut", whereas in the old center is the reverse. Akyas (2000) and Terra (1952) confirmed that cultivar keprok growth well in the dryer climates than siem. That is why in the new center "keprok-siem" is dominant. In other words the "Keprok Garut" can not well adapt in the new location.

Further, the survey envisage two dominant conditions of citrus orchard; the first is a young depressed, not yet productive citrus orchard of 3-4 year old, and the second was a depressed productive citrus orchard of 6-10 year old. One sample for each was drawn for diagnostic purposes. Following are the results.

(a) The depressed, non-bearing fruits citrus orchard

The cultivar of the sample orchard belongs to the "Keprok-Garut", that was 4 year old, grown in plant distance of 3 x 4 meters, in a land formerly used as rice field. The irrigation and drainage canal of this orchard had not well constructed, so that if the rain come down fast enough the field would be inundated.

There are two canopies type, that is ellipse and broomstick. The light may penetrate more evenly in the broomstick canopy than in the ellipse canopy. As can be seen in the Table 1, the broomstick has more canopies' volume but lesser branch-density than ellipse canopy.

Nevertheless, the two shows a depressed canopy. One of its indicators is the fact that at 4 year old, the trees have not yet been fruited. Usually if it is grown in a more suitable environment, it will begin to bear fruit at two or at least three years old.

Table 1. The canopy structure and rate of growth of the non-bearing depressed citrus trees (*Citrus reticulata* Balnco, cuvar. "keprok-Garut") 4 years old.

Canopy Type	Tree height (m)	Diameter of Canopy (m)	Angel of Branch First Order (^{0})	Volume of Canopy (m^3)	Branch (second order) Density (m^{-1})	Growth Rate cm week $^{-1}$ flush^{-1}
Broomstick	1.5±0.1	1.3±0.1	34.0 ± 7.1	0.95±0.15	22.8±3.1	2.1±0.4
Ellipse	1.5±0.1	1.2±0.0	31.9±2.5	0.89±0.22	66.7±6.7	1.8±0.4

The next indicator is the depressed flushing cycle. This observation was carried out in rainy season that was from October 2001 to March 2002. Nevertheless the trees flushed only until the end of January; and the number of flushing cycle was only 3 times (usually it would be 5 to 6 times). As stated above, after that the flush -if otherwise emerge- was die back, although the rain still goes further. It means that the total growth rate yearly was very low. The cause was the poor drainage as would be proofed by nutrient correlation analysis as follows.

Table 2. The macronutrients content and its status in the leaf tissue and in the soil of the depressed non-bearing fruit trees

Canopy Type		Macro nutrient content and status (%)$^{*)}$					Growth Rate Cm week $^{-1}$ flush^{-1}
		N	P	K	Ca	Mg	
Broomstick	Leaf	3.01 excessive	0.33 excessive	1.39 high	1.27 deficiency	0.25 low	2.1±0.4
	Soil	0.2375 moderate	0.0048 very high	0.0391 moderate	0.1398 moderate	0.0202 moderate	
Ellipse	Leaf	3.35 excessive	0.33 excessive	1.68 high	0.149 deficiency	0.29 optimum	1.8±0.4
	Soil	0.2400 moderate	0.0073 very high	0.0479 high	0.1357 moderate	0.0166 moderate	

Notes: $^{*)}$ leaf nutrient status sees Embelton, et. Al (1973), and for soil, see Bogor Soil and Agroclimate Research Institute (2002), Chapman (1967)

The results of macronutrient analyses are given in Table 2; and envisage that the nutrient status in the leaf tissue may not correspond with the available nutrient in the soil. The first to note is that the moderate Ca in the soil is coupled with the deficiency Ca status in leaf tissue; and the second is that the moderate N in soil is coupled with its excessive status in leaf tissue.

This phenomenon could be explained as follows. As mentioned above, the root system in this orchard may impair by too much water due to waterworks not well constructed. The first and the most severe damage by this condition are of course the younger root. Clarkson and Sanderson (1978), cit. Mengel and Kirby (1987) confirmed that Ca^{2+} can be absorbed only by young root tips in which the cell wall of the endodermis are still unsuberized. In turn Ca deficiency may cause any damage in the new emerging flush (Chapman, 1967), so that the elements, especially the nitrogen that has been absorbed was not further utilized and was accumulated in situ. The damage of young root may also affect the production of cytokinin, since cytokinin is considered primarily produced by actively dividing regions of young root (Miura and Miller 1969, cit. Naqvi, 1995). Further, cytokinin has a significant role in breaking bud dormancy (Volkenbourgh, E. V., 1995, Mediford, et. al., 1989), so that it may not only the young flush would be damage, but also the bud will remain dormant.

Table 3. The micro nutrient content and its status in soil and in leaf tissue of the depressed non-bearing fruit trees

Canopy Type		Micro nutrient content (ppm) *)				Growth Rate cm week $^{-1}$ flush^{-1}
		Mn	Cu	Zn	B	
Broomstick	leaf	45.8 optimum	4.3 low	26.3 optimum	76.8 optimum	2.1±0.4
	soil	4.42 low	1.20 moderate	3.02 moderate	0.65 moderate	
Ellipse	leaf	46.0 optimum	7.5 optimum	26.8 optimum	73.5 optimum	1.8±0.4
	soil	4.91 moderate	1.12 moderate	2.62 moderate	0.59 moderate	

Notes: *) leaf nutrient status sees Embelton, et. Al (1973), and for soil, see Bogor Soil and Agroclimate Research Institute (2002), Chapman (1967)

Table 3 shows that the moderate available micronutrients in the soil may correspond with the optimum status in the leaf tissue; except for the Cu status that was low, although in soil that was moderate. This fact indicates that although the trees in this orchard were depressed, the trees free from green disease. As reported elsewhere (Satriadarsa, 1994) one of the symptoms of that pathogen is Cu and Zn deficiency.

(b) The depressed bearing fruits citrus orchard

The cultivar of the sample orchard belongs to the "Keprok-Siem", that was 6 years old, grown in plant distance of 4 x 6 meters, in a land formerly used as rice field. The drainage system had been constructed properly, with canal's size of 1.0 x 1.5 x 0.65 m, in such a way so its built a block with 10 to 15 trees each.

Trees in this orchard have relatively the same canopy type that is umbrella, which is classified as ideal for Siem cultivar (Akyas, 2000). The canopy structure is given in Table 4 that categorized in three classes based on fruit size.

Table 4. The canopy structure and its correspond Fruit-size of the depressed bearing trees (*Citrus reticulata* Balnco, cuvar. " Keprok-Siem") 6 years old.

Fruit-size	Angel of Branch First Order (^{0})	Length of reproductive twig (cm)	Diameter of reproductive twig (cm)	Length of vegetative twig (cm)	Diameter of vegetative twig (cm)
Medium	61.7±2.1	11.0±0.8	0.25±0.02	7.8±0.8	0.20±0.01
Small	66.3±3.2	12.5±1.2	0.23±0.02	7.0±0.4	0.17±0.01
Very Small	60.6±4.8	11.8±0.8	0.21±0.01	4.8±1.7	0.15±0.02

The reproductive twig diameter (RTD) may correlate with fruit size; the group of trees with medium fruit size has larger RTD than group of trees with very small fruit size. Further the Table shows that the very small fruit size has smaller vegetative twig diameter. All those characters demonstrate the depressed condition of the orchard. The larger fruit that reach by this orchard is only medium size. These facts have strengthened the statement above, that this orchard was exhausted, due to over exploitation. That is why the nitrogen content in all three fruit size criteria subsists in excessive status, whereas in the soil is low (Table 5).

Table 5. The macronutrient content and its status in soil and in leaf tissue of the depressed bearing fruit trees(*Citrus reticulata* Balnco*,* cuvar. " Keprok-Siem")

Tree with fruit-size;		Macro nutrient content (%) and status*)				
		N	P	K	Ca	Mg
Medium	leaf	3.53 excessive	0.53 excessive	1.49 high	5.76 optimum	1.32 excessive
	soil	0.19 low	0.10 very high	0.07 very high	1.42 high	0.64 high
Small	leaf	3.54 excessive	0.51 excessive	1.29 high	6.34 excessive	1.18 excessive
	soil	0.20 low	0.09 very high	0.08 very high	1.59 high	0.88 high
Very Small	leaf	3.34 excessive	0.47 excessive	1.15 high	5.90 excessive	1.34 excessive
	soil	0.19 low	0.07 very high	0.08 very high	1.51 high	0.73 high

Notes: *) leaf nutrient status sees Embelton, et. Al (1973), and for soil, see Bogor Soil and Agroclimate Research Institute (2002), Chapman (1967)

One of their efforts to push the trees to reach maximum yield is to restrict the nitrogen in their fertilizer program, which cause the decrease of the formation of the new flushes. In turn, the restriction of new flushes means the decrease in sink capacity. Further it cause the accumulation of nitrogen in leaf tissue, as can be seen in Table 5.

Table 6. The micro nutrient content and its status in soil and in leaf tissue of the depressed bearing fruit trees(*Citrus reticulata* Balnco*,* cuvar. " Keprok-Siem")

Tree with fruit-size;		Micro nutrient content (ppm)			
		Fe	Cu	Zn	B
Medium	leaf	6 optimum	211 excessive	10 deficiency	101 optimum
	soil	57591 very high	89 very high	80±4 deficiency	134 very high
Small	leaf	8 optimum	250 xcessive	8 deficiency	123 optimum
	soil	56368 very high	85 very high	81 deficiency	123 very high
Very Small	leaf	94 optimum	262 excessive	24 deficiency	137 optimum
	soil	56884 very high	87 very high	77 deficiency	134 very high

Notes: *) leaf nutrient status sees Embelton, et. Al (1973), and for soil, see Bogor Soil and Agroclimate Research Institute (2002), Chapman (1967)

Note that the process of nitrogen accumulation in leaf tissue is just the same with the process that happens in non-bearing fruit trees, although the cause is not the same. The die back of the flush in the non bearing fruit orchard is caused by Ca deficiency, whereas the decreasing new flushes in bearing fruit orchard is caused by unbalance fertilizer practice.

The problem with micronutrient is Zn deficiency in the soil, correspond with its status in leaf tissue, as shown in Table 6. The next is the Cu that shows excessive status in leaf tissue. The micronutrients Fe and Boron subsist very high in the soil correspond with optimum status in leaf tissue. Yields are likely to be reduced by Zinc deficiency, although studies on oranges indicate that yield not increased by increasing zinc above 16 ppm (Embelton, 1963, Labanauskas and Puffer, 1964).

Conclusion

The diagnosis above leads to the recommended corrective measure (therapy) as follows.

The main cause that depresses the first orchard type is the impaired root system due to the poor aeration following the poor drainage. The corrective measure has to be focused on re-construct the waterworks that permit good drainage and good aeration. Calcium deficiency cannot be corrected by adding more Ca to the fertilizer program. The fertilizer program have to be directed to push the growth more vegetative and permit no fruit first by reducing the dosage of phosphor and potassium, coupled with some correction on canopy structure.

The condition of the second orchard type is exhausted; the tree have become stunted, the rate of growth decrease, the leaf undersize, and the fruit quality decrease. Corrective measure has to be focused on revitalizing this exhausted tree. The point is how the dormant bud can be activated to become new healthy flush.

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