

References

- Agropedia. 2010. Deficiency symptom & their remedies remedies in citrus. [Online]. Available: <http://agropedia.iitk.ac.in/?q=content/deficiency-symptoms-their-remedies-citrus>. [September 23, 2011]
- Aimrun, W., M.S.M. Amin and A. Gholizadeh. 2010. Spatial Variability of Irrigation Water Percolation Rates and Its Relation to Rice Productivity. Am. J. Applied Sci., 7: 51-55.
- Anderson R. M., A.P. Marcos, E.C. Marcelo and M. Mario. 2002. Dolomite Lime's Reaction Applied on the Surface of a Sandy Soil of the Northwest Paraná, Brazil. Brazilizn Archives of Biology and Technology. Vol.45, No.2 : pp. 219- 222.
- Ankerman, D. and R.Large. 2001. A&L Agricultural Laborites Agronomy Handbook. A&L Agric. Lab., Richmond, VA.
- Bhuwarodom, S. 2004. Plant Nutrient Management and Improvement of Fertilizer Efficiency for Durian Orchard. The Final Report. Funded Thailand Research Fund (TRF). Bangkok. 147 p. (In Thai)
- Boonyakiat, D. 2005. Plant physiology. Department of Horticulture. Faculty of Agriculture, Chiang Mai Univ. 230 p. (In Thai)
- Brady, N.C. and R. R. Weil. 2002. The Nature and Properties of Soils. 13th Edition. Prentice Hall, New Jersey, USA. 960 p.

- Chang, W.N. and J.B. Peterson. 2003. Citrus Production : A Manual for Asian Farmers. FFTC Publication. 97 p.
- Chanwijit, P., T. Radanachales. and N. Supakumnerd. 2008. Use of Plant Nutrient Balance for Improvement of Yield and Quality of Sai Num Phung Tangerine Fruits : Estimation of the Suitable Position of Citrus Leaf Sample for Collection of Plant Samples for Plant Nutrients Analysis. J. Agric. 24(2): 117-124. (In Thai)
- Chiang Mai Agricultural Office. 2009. Situation of Tangerine Production in Chiang Mai Province in 2008/2009. [Online]. Available:
http://chiangmai.doe.go.th/reports/Report_tangerine%202552.pdf
 (November 2, 2010). (In Thai)
- Chowpaka, N. 1999. Soil Series in Northern Region and Central Highland of Thailand: New Soil Taxonomy. 1998. Technical Document no.444. Division of Soil Survey and Classification Land Development Department. (In Thai)
- Chuong, H.V. 2008. Multi-criteria Land Suitability Evaluation for Crops Using GIS Community Level in Central Vietnam. Proceeding of 4th International Symposium on Geoinformatics for Spatial Infrastructure Development in Earth and Allied Sciences. Hanoi , Vietnam.
- Comes, T., M. Hiete, N. Wijngaards, and M. Kempen. 2009. Intergrading Scenario-Based Reasoning into Multi-Criteria Decision Analysis. Proceedings of the 6th International ISCRAM Conference-Göteborg, Sweden.
- Darby, H.M., A.G. Stone, R.P. Dick. 2006. Compost and manure mediated impacts on soilborne pathogens and soil quality. Soil Sci. Soc. Am.J. 70: 347-358.

- Department of Soil Survey and Classification. 1999. Manual of Soil Suitability classification for Economic Crops of Thailand. Technical Document No. 453, Land Development Department, Ministry of Agriculture and Cooperatives. 2nd ed.
- Duffera, M., and W. P. Robarge. 1999. Soil Characteristics and Management Effects on Phosphorus Sorption by Highland Plateau Soils of Ethiopia. *Soil Sci. Soc. Am.J.* 63(5): 1455-1462.
- Durbach, I. and T. Stewart. 2003. Integrating Scenario Planning and Goal Programming, *Journal of Multi-Criteria Decision Analysis*. 12(4-5): 261-271.
- Eck, H.V. and P.W.Unger. 1985. Soil profile modification for increasing crop production. *Advance in Soil Science*. Vol.1. pp. 66-100. Springer-Verlag New York Inc. Texas.
- Ekasingh, M., T. Kaewmuongmoon and C. Sumhem. 2006. A multi-criteria analysis decision support system. *Proceeding of Multiple Cropping Center Seminar for 2006*. Nov. 22-23 2006. Green Lake Resort, Chiang Mai. (In Thai)
- ERDAS. 2001. Using Expert Classifier: ERDAS IMAGINE Expert Classifier Overview. ERDAS Incorporation: USA.
- ERSI. 2007. ArcGIS: A Complete Integrated System. ArcGIS v.9.2. Environmental Systems Research Institute (ESRI). [Online]. Available <http://www.esri.com> [August 29, 2010]
- Fang district, Agricultural office, 2008. Agricultural Development plan for 2008-2010: Mae Soon Sub District. Fang District, Chiang Mai Province. 28 p. (In Thai)

FAO. 2001. Water Relations and Water Management of Citrus.[Online]. Available:

<http://www.fao.org/landandwater/aglw/cropwater/citrus.stm#yield>

[November 10, 2010]

Food & Fertilizer Technology Centre (FFTC). 2003. Fertilizer Management for

Citrus Orchards. [online]. Available <http://www.agnet.org/library/bc/52006>

[August 3, 2011]

Foth, H.D. and B.G. Ellis. 1997. Soil Fertility. 2nd Edition. CRC Lewis Publishers.

New York, USA. 289 p.

Glinski, J. and J. Lipice. 1990. Soil Physical Conditions and Plant Roots. CRC Press,

Inc. Boca Raton, Florida.

Halvin, J.L., J.D. Beaton, S.L. Tisdale and W.L. Nelson. 2005. Soil Fertility and

Fertilizers: An Introduction to Nutrient Management. 7th Edition. Prentice

Hall, New Jersey, USA. 515 p.

Hardy, S. 2004. Growing Lemons in Australia-a Production Manual. [Online].

Available: <http://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/lemon-manual> [November 2, 2010]

He, Z. L., D.V. Calvert, A. K. Alva, D. J. Banks and Y. C. Li. 2003. Threshold of

Leaf Nitrogen for Optimum Fruit Production and Quality in Grapefruit. Soil

Sci. Soc. Am.J.67: 583-588.

- Helmke, P.A. and L. Sparks. 1996. Lithium, sodium, potassium, rubidium and cesium. In Sparks, D. L., A. L. Page, P. A. Helmke, R. H. Loeppert, P. N. Soltanpour, M. A. Tabatabai, C. T. Johnston and M. E. Summer. SSSA. Book Series: 5 Method of Soil Analysis Part 3 Chemical Method. pp. 551-574. SSSA and ASA. Madison.
- Kaosumain, Y., C. Sritontip, and S. Changjeraja. 2002. Problem Solving of Longan Tree Declined syndrome: Relationship Between the Levels of Plant Nutrients in the Soil and in the Trees and the Longan Tree Declined Syndrome. Final Report. The Thailand research Fund. Bangkok. 146 p.
- Kitjaideaw, A. 1998. Efficacy of Antagonistic Microorganisms for the Protection of Tangerine Root Rot Caused by *Phytophthora parasitica* (Dastur.). Ms. Thesis. Faculty of Agriculture. Kasetsart University. 124 p. (In Thai)
- Koo, R.C.J., C.A. Anderson, D.A. Callvert, I. Stewart, D.P.H. Tucker and H.K. Wutscher. 1984. Recommended Fertilizers and Nutritional Sprays for Citrus. Bulletin 536-S University of Florida, Agricultural Experiment Station, Florida. 168 p.
- Kuaparakone, U., M. Promin, S. Wichitranun and P. Pitukpriwan. 1999. Production and Propagation of Disease Free Citrus Root Stocks. Division of Plant Pathology and Microbiology. Department of Agriculture, Ministry of Agriculture and Cooperatives. Bangkok. pp. 47-59. (In Thai)
- Land Development Department. 1997. Upland soil. Report of the study on Database Development for Soil Management for Cash Crop Cultivation According to the Group of Soil Series and the Linkage with Soil Database of Land Development. Book II. Ministry of Agriculture and Cooperatives. (In Thai)

- Land Development Department. 1997. Lowland soil. Report of the study on Database Development for Soil Management for Cash Crop Cultivation According to the Group of Soil Series and the Linkage with Soil Database of Land Development. Book I. Ministry of Agriculture and Cooperatives. (In Thai)
- Land Development Department. 2007. Soil group no. 62. [online]. Available <http://www.ddd.go.th/gisweb/webchaingrai/soilgroup/62.htm> [August 1, 2010]
- Malczewski, J. 1999. GIS and Multi-criteria Decision Analysis. New York: John Wiley & Sons, Inc.
- Malczewski, J. 2006. GIS-based Multicriteria Decision Analysis: A Survey of The Literature. International Journal of Geographical Information Science. 20(7): 703-726.
- Maneepong, S., N. Buranapong, N. Suwannung, N. Churnim, P. Sanchan, P. Lekkong, W. Srabua, S. Boonsuk, S. Lipimongkorn and S. Putornraj. 2005. Research report: Soil and Plant Analysis laboratory Network. Thailand Research Fund. Bangkok. (In Thai)
- Menge, J.A. Strategies to control *Phytophthora cinnamomi* root rot of avocado. [online]. Available: [online]. Available: <http://commserv.ucdavis.edu/CESanDiego/bender/p%20cinnamomi%20root%20rot.htm> [July, 11, 2011]
- Mengel, D. 1995. Root Growth and nutrient uptake. Agronomy Department, Purdue University. West Lafayette, IN 47907-1150. [online]. Available: <http://www.agry.purdue.edu/ext/pubs/AGRY-95-08.pdf> [July, 22, 2011]

- Namrungsai W., S. Wichitranon, S. Lertwathanakiat. J. Manussakorn, T. Sangudom, S. Sakuntengtrong, N. Ditkrajun and S. Pukdee. 2007. Problem Solving for the People Affected by Over Usage of Chemicals in Mandarin Orchards at Fang, Mae Ai and Chai Prakarn Districts, Chiang Mai Province. [online]. Available: <http://it.doa.go.th/refs/index.php> [October, 22, 2010]
- Naqvi, S. A. M. H. .2004.. Diagnosis and management of certain important fungal diseases of citrus diseases of fruits and vegetables. Vol. I. pp. 247-290. Kluwer Academic Publishes.
- Noling, J.W. 2003. Citrus Root Growth and Soil Pest Management Practices. [online]. Available <http://edis.ifas.ufl.edu/ch008> [June 24, 2011]
- Novozamsky, R., J. van Eck, Ch. van Schouwenburg and I. Wallinga. 1974. Total nitrogen determination in plant material by means of the indophenol blue method. *Neth. J. agric. Sci.* 22: 3-5.
- Nunan, N., M. A. Morgan and M. Herlihy. 1997. Ultraviolet absorbance (280 nm) of compounds released from soil during chloroform fumigation as an estimate of the microbial biomass. *Soil Biol. Biochem.* 30: 1599-1603.
- Obreza, T.A. and M.E. Collins. 1999. Common Soils Used for Citrus Production in Florida. [online] Available <http://edis.ifas.ufl.edu/pdffiles/SS/SS40300>. [December 2, 2010]
- Obreza, T. A., and M. E. Collins. 2002. Common Soils Used for Citrus Production in Florida. [online]. Available: <http://edis.ifas.ufl.edu/SS403> [July, 14, 2011]
- Obrega. T.A. and K.T. Morgan .2008. Nutrition of Florida Citrus Trees. 2nd Edition. [online]. <http://edis.ifas.ufl.edu/pdffiles/SS/SS47800.pdf> [July, 20, 2011]

- Office of Agricultural Economic. 2002. Orthophoto map at scale 1: 4000. Thai National AGRIS Centre. Ministry of Agriculture and Cooperatives. (In Thai)
- Office of National Standard of Agricultural Products and Food. 2009. National Standard of Agricultural Products and Food. 14-2550: Madarin. Ministry of Agriculture and cooperatives. 15 p. (In Thai)
- Onprapai, T. and C. Santhasup. 2009. Soil and Water Resources Suitable for The Production of Sai Nam Pueng mandarin. The Progress Report. Faculty of Agriculture. Chiang Mai University. Funded Thailand Research Fund (TRF). 133 p. (In Thai)
- Onprapai, T. and C. Santhasup. 2010. Soil and Water Resources Suitable for The Production of Sai Nam Pueng mandarin. The Final Report. Faculty of Agriculture. Chiang Mai University. Funded Thailand Research Fund (TRF). 230 p. (In Thai)
- Ounpo, P. 2005. Some Physical and Biochemical Changes of Declined Tangerine. Ms. Thesis, Faculty of Agriculture. Chiang Mai University. 144 p. (In Thai)
- Priestley, C. A., Treharne, K. J., & Lenz, F. (1988). Effects of Low Oxygen on Photosynthesis, Translocation and Growth in Green Pepper (*Capsicum annum*). *Annals of Botany*, 61(2), 159-167.
- Panomtaranichagul, M. 2008. Soil and Water Management for Sustainable Agricultural System. 1st Ed. Faculty of Agriculture. Chiang Mai University. 487 p. (In Thai)
- Paradornnuwat, A. 2009. Report of The First Meeting on Development of Citrus Research Project. April 1st 2009. Faculty of Agriculture. Chiang Mai University. (In Thai)

- Pereira, W.E., D.L. Siqueira., M. Puiatti., C.A. Martinez., L.C.C.S. Salomao and P.R. Cecon. 2003. Growth of Citrus Rootstocks Under Aluminum Stress in Hydroponics. *Sci. agric.* 60(1): 31-41.
- Pingali, P.L., M. Hossain and R.V. Gerpacio. 1997. Asian rice bowls: the returning crisis?. International Rice Research Institute (IRRI). pp. 85.
- Polex M. 2007. Citrus bacterial canker disease and Huanglongbing (Citrus Greening). ANR Publication 8218. [online]. Available: <http://ucanr.org/freepubs/docs/8218.pdf> [October, 22, 2011]
- Putijun, W. 2005. General Physiology. Oadian Store. Bangkok. 384 p.
- Ribeiro, R.V., E.C. Machado and M.G. Santos. 2005. Leaf Temperature in Sweet Orange Plants Under Field Conditions: Influence of Meteorological Elements. *Rev. Bras. Agrometeorol.* 13: 353-368.
- Ribeiro, R. V. and E. C. Machado. 2007. Some aspects of citrus ecophysiology in subtropical climates: re-visiting photosynthesis under natural conditions. *Braz. J. Plant Physiol.* 19(4):393-411.
- Royal Thai Survey Department. 2010. Digital elevation model (DEM). Center of the Map. Bangkok. (In Thai)
- Saaty, T.L. 1980. The Analytic Hierarchy Process, McGraw Hill Company, New York.
- Saaty, T.L. 2003. Decision-making with The AHP : Why is the principal eigenvector necessary. *European Journal of Operation Research* 145: 85-91.
- Sadudee, s. and R. Jeerwipah. 2005. Fruit splitting of Shokun (*Citrus reticulata* cv.Shokun) in southern Thailand and problem solving by Ca and B spraying. *Songklanakarin Jour.* 27(4):720-730. (In Thai)

- Sasiprapa, W., A. Buntrapiwat, W. Namreungsri, K. Paotong, S. Atichard, M. Promin, J. Jatisatien, K. Linwatana, S. Tunjarearn and V. Vongwai. 2007. Using remote sensing for citrus decline identification [Online]. Available: <http://it.doa.go.th/refs/index.php> [October 9, 2010]
- Sittigul, C., A. Akarapisan, M. Kongchuensin, K. Sookchaoy, P. Nualbunrung, P. Chi Ai and P. Suriyapromchai. 2005. Important Disease and Insect Pest Management of Citrus and Restoration of Deteriorated Orchards in Northern Region by Slightly Efficient Management of Pest, Soil Fertilizer and Water Project. The Final Report. Faculty of Agriculture. Chiang Mai University. Funded Thailand Research Fund (TRF). 345 p. (In Thai)
- Srisaart, A. 2003. Eight Experts of Citrus Orchard. Bangkok. Intermedia Naka Co. 138 p. (In Thai)
- Srithongchai, W. 2010. Restoration of Citrus Orchard by Using Disease Free Citrus Varieties. [online]. Available: <http://esc.agritech.doe.go.th/webpage/e-book/rok-orange.pdf> [October, 12, 2011]
- Sruamsiri, P., A. Bhromsiri, S. Srichuwong, J. Tayutivutikul, A. Akrapisarn, D. Naphrom, K. Kunasakdakul, C. Boonchitsirikul, T. Pankasemsuk, A. Shutsrirung, C. Santasup, Y. Janbang and W. Kumpuen. 2008. Chiang Mai sweet tangerine competitiveness. The Progress report. Faculty of agriculture. Chiang Mai Univ. Funded the Department of Foreign Trade, Ministry of Commerce. 257 p. (In Thai)

- Sruamsiri, P., A. Bhromsiri, S. Srichuwong, J. Tayutivutikul, A. Akrapisarn, D. Naphrom, K. Kunasakdakul, C. Boonchitsirikul, T. Pankasemsuk, A. Shutsrirung, C. Santasup, Y. Janbang and W. Kumpuen. 2009. Sai Num Phung Tangerine : Technology for fruit quality and marketing. 1st Edition. Wanida Printing. Chiang Mai. 116 p. (In Thai)
- Storey, R and M.T. Treeby. 2000. Seasonal changes in nutrient concentrations of Navel orange fruit. *Scientia Horticulturae*. 84:67-82.
- Suit. R.F. and L.C. Knorr. 1949. Progress Report on Citrus Decline. Florida State Horticultural Society. pp. 45-49.
- Supakumnerd, N., P. Leartrat, S. Suwankatenikom. 2005. Research Project Estimation of Plant Nutrient Requirement of Citrus by Plant Analysis. The Final Report. Bangkok : Office of Thailand Research Fund. 102 p. (In Thai)
- Suwanawong, S. 2001. Analysis of Plant Nutrients in Leaf Samples. Kasetsart Univ. Publishing. Bangkok. 141 p. (In Thai)
- Timmer, L.W., L.W. Duncan. 1999. Citrus Health Management. St. Paul, Minnesota : American Phytopathological Society. vi, 197 p.
- Timmer, L.W., Grancy, S.W. and Graham, J.H. 2000. Compendium of Citrus Disease. 2nd ed. APS Press, St. Paul, Minnesota, USA. 92 p.
- Verchot, L. V., Dutaur, L., Shepherd, K. D., & Albrecht, A. 2011. Organic matter stabilization in soil aggregates: understanding the biogeochemical mechanisms that determine the fate of carbon inputs in soils, understanding the biogeochemical mechanisms that determine the fate of carbon inputs in soils.



Vineela, C., Wani, S. P., Srinivasarao, C., Padmaja, B., & Vittal, K. P. R. (2008).

Microbial properties of soils as affected by cropping and nutrient management practices in several long-term manurial experiments in the semi-arid tropics of India. *Applied Soil Ecology*, 40(1), 165-173.

Virunrat, V., A. Bhromsiri, C. Santasup, and T. Onpraphai. 2011. Soil properties, fertilizer management by farmers and plant nutrients status in the leaves of “Sai Nam Pueng” mandarin : Mae Soon sub-district, Fang district, Chiang Mai province case study. Proceeding of the 2nd National Soil and Fertilizer Conference. 11-13 May 2011, Mae Jo University, Chiang Mai. Thailand. pp. 232-242. (In Thai)

Wallinga, I. , W. V. Vark, V. J. G. Houba and J. J. Vander Lee. 1989. Soil and plant Analysis A Series of Syllabi: Part 7 Plant Analysis Procedures. Department of Soil Science And Plant Nutrition. Wageningen Agricultural University, Netherland. 263 p.

Wiwatwongwana. P. 2003. Soil Chemistry. 1st Edition. Chiang Mai Pimsuai Publishing House. 273p. (In Thai)

World Fertilizer Use Manual; Citrus(Citrus spp., ect) 1992 [online]. Available:

<http://www.fertilizer.org/ifa/publicat/html/pubman/citrus.thm> [June, 12, 2011]

Appendixes

Appendix A

Questionnaire for study of some factors affecting reduction of mandarin cultivated orchards in Mae Soon sub district

Objective : This questionnaire is used in order to study of the farmer practices for mandarin orchard management in Mae Soon sub district with the aim to clearly identify the factors affecting productivity declination of the mandarin trees. The hypothesis is that the problem in each area will be different according to the differences among the mandarin cultivated areas. Once the real problem is identified the suitable problem solving can be applied. The information obtained from this study will be useful for the farmers who want to cultivate mandarin trees in the new area for planning of cultivation schedule in advance.

The questionnaire consists of 4 parts.

Part 1 General information of the farmer who fill up the questionnaire.

Part 2 General information about the orchard.

Part 3 Orchard management information.

Part 4 Evaluation of the orchard status.

Part 5 The test : How do you manage the soil in the orchard?

Please kindly answer the questionnaire according the real fact. The data obtained will be kept secretly and used for research only. Thank you for your kind cooperation in answering the questions and providing your useful opinion.

Miss Vassana Viroonrat

Mobile phone 084-8049247

1) General information of the farmer

- 1.1 First name.....Family name.....
- 1.2 Address.....Moo.....Sub-district.....
- 1.3 Telephone no.
- 1.4 Age.....year
- 1.5 Level of highest education.....Specialized field.....
- 1.6 Major career ☐ Mandarin orchard
- ☐ Others.....

2) Information about mandarin orchard

- 2.1 Location of the orchard
- ☐ Mu.....Mae Soon sub district
- ☐ Mu.....Sub-district.....District.....
- 2.2 Age of mandarin trees.....year.
- 2.3 Orchard history
- ☐ Used to be litchi orchard ☐ New area ☐ Paddy field
- ☐ Other crops specified.....
- 2.4 Total area.....rais Total no. of mandarin trees.....trees
- If you have more than orchard please provide the details for the other orchards
- Second orchard area.....rais, Total no. of tree.....trees
- Third orchard area.....rais, Total no. of tree.....trees
- 2.5 Location of the orchard
- ☐ Unwounded by mandarin orchards
- ☐ The orchard nearby is still productive
- ☐ Abandon orchard
- ☐ The orchard is far away from the major mandarin cultivated area and it is close to the forest or the area cultivated with the other crops

2.6 Topographic condition of the orchard

☐ Highland ☐ Foothill

☐ Paddy field

2.7 Land preparation of the orchard

☐ Bedding

☐ No bedding

2.8 mostly used planting material

☐ Grafting

☐ cv. troyer

☐ cv. cleopata

☐ Air layering

☐ Other.....

2.9 Availability of water used in the orchard

☐ Sufficient all year second

☐ Insufficient solving problem by.....

2.10 Normal irrigation schedule

☐ Once a day for a period of.....hr.

☐ Twice a week each for.....hr.

☐ Once a week for a period ofhr.

☐ a week each forhr.

2.11 Source of irrigated water for the orchard

☐ Huoy Nam Uoon

☐ Huoy Nam Dung

☐ Mae Soon river

☐ Others.....

2.12 Methods of irrigation in the orchard

☐ High pressure sprinkle pressurelb/in

☐ Mini sprinkle pressure lb/in

☐ Rain fed

☐ Sun face irrigation

☐ Others.....

2.13 Type of soil in the orchard

- ☐ Clayey ☐ Loam ☐ Sandy ☐ Other

3) *Soil management in the orchard.*

3.1 Have you ever check soil quality of your orchard?

- ☐ Yes ☐ No

3.2 Fertilizer usage in your orchard

- ☐ Only chemical fertilizers ☐ Only organic fertilizers
☐ Both element and organic fertilizers

3.3 Application of manure or compost in the orchard

- ☐ No application because.....
☐ Application at approximatelykg/tree
☐ Seldom ☐ Every other year ☐ Every year.....times/year

3.4 Do you use mulching under the tree canopy?

- ☐ Yes because.....
☐ No because.....

3.5 Criteria use for fertilizer application in your orchard

- ☐ Experience
☐ Recommendation by dealer of fertilizer distributes
☐ Text book, Agricultural Journal
☐ Information from the experienced farmers or adjacent orchard
☐ The result of soil testing ☐ Others

3.6 Fertilizer grade which you used regularly can be answers more than 1 item

- ☐ 46-0-0 ☐ 15-15-15 ☐ 13-13-21
☐ 0-46-0 ☐ 0-0-60 ☐ 15-0-0
☐ 0-52-34 ☐ Other grades.....

3.7 Rate of chemical fertilizer application for mandarin trees

☐ 1 kg/tree/M☐ 0.2 kg/tree/M☐ 0.5 kg/tree/M☐ kg/tree/M

3.8 Have you ever adjusted your soil pH?

☐ Yes liming material used is☐ Quick lime☐ marl☐ dolomite☐ others.....☐ No

3.9 Are there any mandarin trees in your orchard showed plant nutrient deficiency symptom?

☐ Yes☐ No

Occurred symptom

☐ The older leaves have yellow color towards the apex with a inverted V shaped area remaining green at the base☐ The leaves are small, having yellow mottle with green veinal area☐ Splitting fruit☐ Other symptoms.....☐ None

3.10 When do you apply foliar spraying ?

☐ When the trees show nutrient deficiency symptom☐ Spraying to prevent nutrient deficiencies**4) Evaluation of the status of mandarin orchard**

4.1 Present status of the orchard

☐ Not productive, the orchard has be collapsed☐ Still productive for at least 2-3 more years☐ Productive and provide good fruit production continuously

4.2 Cause of orchard failure (can answer more than one item)

- ☐ No skill to produce mandarin ☐ Insufficient of water
☐ Root rot ☐ Greening disease
☐ Limit of fertilizer application ☐ Other.....

4.3 approximate fruit yield

Yield (period)	No : of basket (3kg/basket)		
	2010	2009	2008
In season fruit yield (Dec-Jan)			
1 st off season fruit yield (Feb)			
2 nd off season fruit yield (Mar)			
3 rd off season fruit yield (July-Aug)			

4.4 In 2010 was there any problem on immature fruit with the red point symptom?

- ☐ Yes approximately.....% of the total yield
☐ No

4.5 Do you have the unhealthy mandarin trees in your orchard?

- ☐ Yes distribution pattern of unhealthy trees in the orchard
 - ☐ Border (adjacent to deteriorating orchard)
 - ☐ Spreading from the central area of the orchard
 - ☐ Patchy distribution throughout the whole area
 - ☐ Other pattern☐ No

4.6 If your orchard is collapsed what is your plan for the next career?

- ☐ Mandarin cultivation
- ☐ Agriculture but changing the crop by expecting to grow.....
- ☐ Change the career to.....
- ☐ Do not know what to do

4.7 previous situation of your mandarin production

- ☐ Gained profit in the year
- ☐ Lost profit in the year.....
- ☐ Zero gain
- ☐ No information

5) *The test "How do you manage the soil in your orchard ?"*

Concept : check only one correct answer

5.1 Concept for fertilizer application to mandarin trees

- ☐ Based on available input cost
- ☐ Use high dose in order to get more fruit yield
- ☐ Based on the requirement of the trees
- ☐ Follow the information labeled on fertilizer bag

5.2 How is your ideal soil for mandarin cultivation?

- ☐ Sandy soil with very good drainage
- ☐ Clayey soil with very good water holding capacity
- ☐ Loamy soil with good drainage
- ☐ Lateritic gravel soil with rapid water percolation

5.3 Which item is not the usefulness of manure/compost?

- ☐ Soil aggregate formation resulting in better soil structure
- ☐ Soil microbial food
- ☐ Improving the growth of root system resulting in healthy root
- ☐ Increasing of plant nutrients and can be used as the alternative source of chemical fertilizer

5.4 If your soil is strong acidic how do you apply lime to get the highest effectiveness?

- ☐ Mixing lime with chemical fertilizer and then immediately broadcast into the soil
- ☐ Mixing lime with compost or manure, then thoroughly mix into the soil following with irrigation
- ☐ Patchy application of lime on the soil surface
- ☐ Apply urea fertilizer and then broadcast lime on top – urea fertilizer

5.5 What is the suitable pH of water used for mixing with insecticides or foliar fertilizer?

- ☐ Do not know this information before
- ☐ I know the suitable pH but cannot know how to the problem
- ☐ I know and I will use commercial acetic acid to acidity water high pH
- ☐ I know if the water is acidic the pH should be adjusted to neutral

5.6 Criteria that you use insecticide spraying

- ☐ Spraying according to spraying schedule (every 3 days/every 7 days/every 10 days)
- ☐ Randomly check the number of insect pest. Use insecticide spraying if 1-3 insect pests were found.
- ☐ Spraying when insect damage was found
- ☐ Consider climatic condition and environment before spraying and use insecticide spraying when 1-5 insect pests were found

5.7 The most dangerous disease in your orchard

- ☐ Canker
- ☐ Root rot
- ☐ Fungal disease at the point of the fruits
- ☐ Greening disease

Please draw roughly the map of your orchard



Appendix B

Table Appendix 1 Soil properties of soil series

soil series	name series	soil group	soil texture	level soil	Horizon A			drainage	runoff	permeability	soil depth (cm)
					%sand	%silt	%clay				
Mt-sIB	Mae Taeng	29B	sl	Ap(A)-Bt	59.3	25.1	15.6	well	moderate to rapid	moderate	75-100
Mt-sIC	Mae Taeng	29C	sl	Ap(A)-Bt	59.3	25.1	15.6	well	moderate to rapid	moderate	75-100
Mt-clD	Mae Taeng	29D	sl	Ap(A)-Bt	59.3	25.1	15.6	well	moderate	moderate	75-100
Bg-clD	Ban Chong	19	cl	Ap(A)-Bt	40.1	25.1	34.8	moderate	moderate to rapid	moderate	75-100
Kp-silA	Kamphaeng Phet	33	l	Ap(A)-Bt	51.8	38.5	9.7	moderate well	moderate to rapid	moderate	>100
Don-silA	Dong Yang En	33	sil	Ap(A)-Bt	15.5	70	14.5	poorly	rapid	slow	>100
Don-silB	Dong Yang En	33B	sil	Ap(A)-Bt	15.5	70	14.5	poorly	rapid	slow	>100
Pe-sIC/d5	Phetchabun	36C	sl	Ap(A)-Bt-Btc-(Cr)	63.2	22.9	13.9	well	slow	rapid	50-75
Sg-sIA	Sai Ngam	38	sl	Ap(A)-Bt	60.3	29.2	10.5	well	slow	rapid	>100
Li-gclD	Li	47D	sic	Ap(A)-Bt-Cr	9.2	50	40.8	poorly	rapid	slow	25-50
Ph-sicIA	Phan	5	sicl	Apg-Btg-Btgv	21	48.5	30.5	poorly	rapid	slow	>100
Hd-str-sicIA	Hang Dong	5	sic	Apg-Btg	2.3	43.7	54	poorly	rapid	slow	>100
Wch-sicIA	Wang Chomphu	5	l	Ap(A)-Bss-Ck	33.9	38.5	27.6	moderate	moderate to rapid	moderate	75-100
Pe-sIB	Phetchabun	36B	sl	Ap(A)-Bt-Btc-(Cr)	63.2	22.9	13.9	well	slow	rapid	50-75
SC	Slope Complex	62						rapid	rapid	slow	25-50

Table Appendix 2 Risky classification of factors contributing to root rots each orchard

No.	owner	slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	total porosity (% by volume)	pH	organic matter (%)	total score	risky level
1	Mrs.Jansom YaJai	0-5	Pe-sIC/d5	well	<590	1.29	51.59	5.95	2.59	0.50	3
2	Mr.Charoen Tanomsin	0-5	SC	well	590-740	1.12	57.21	6.57	4.17	0.43	2
2	Mr.Charoen Tanomsin	12-20	SC	well	590-740	1.12	57.21	6.57	4.17	0.22	1
2	Mr.Charoen Tanomsin	5-12	SC	well	590-740	1.12	57.21	6.57	4.17	0.27	1
3	Mr.Chamnong Tummakunkaew	0-5	Pe-sIC/d5	well	<590	1.37	46.34	5.64	2.45	0.60	3
4	Mr.Saokaew Jitrawong	0-5	Pe-sIC/d5	well	<590	1.32	49.09	6.18	3.17	0.48	2
5	Mr.Jai Aetama	0-5	Pe-sIC/d5	well	<590	1.26	52.31	6.04	3.07	0.46	2
5	Mr.Jai Aetama	0-5	Don-silB	poorly	<590	1.26	52.31	6.04	3.07	0.62	4
6	Mr.Ming Lungkana	0-5	SC	well	590-740	1.22	52.52	5.71	3.00	0.48	2
6	Mr.Ming Lungkana	12-20	SC	well	590-740	1.22	52.52	5.71	3.00	0.28	1
6	Mr.Ming Lungkana	5-12	SC	well	590-740	1.22	52.52	5.71	3.00	0.33	1
7	Mr.Krisorn Tontang	0-5	Don-silB	poorly	<590	1.32	49.38	5.77	2.34	0.70	4
8	Mr.Jomreang Kumpat	0-5	Don-silB	poorly	<590	1.34	47.41	5.01	2.65	0.77	5
9	Mr.Intorn Keawsuriya	0-5	Don-silB	poorly	<590	1.49	40.05	5.82	1.38	0.80	5
10	Mr.Winit Saisahingkarn	0-5	Don-silB	poorly	<590	1.41	46.40	5.40	1.79	0.87	5
11	Mr.Wai Bungkomnate	0-5	Don-silB	poorly	<590	1.32	49.00	5.73	2.37	0.70	4
12	Mr.Tae wongsai	0-5	Don-silB	poorly	<590	1.28	49.47	5.50	2.65	0.66	4
13	Mr.Kom Srila	0-5	Pe-sIC/d5	well	<590	1.16	54.64	5.96	2.48	0.51	3
13	Mr.Kom Srila	0-5	Don-silB	poorly	<590	1.16	54.64	5.96	2.48	0.68	4
14	Mrs.Yupin Intatar	0-5	Don-silB	poorly	<590	1.31	48.97	6.13	2.92	0.64	4
15	Mr.Sawang Wongkat	0-5	Don-silB	poorly	<590	1.20	53.60	6.05	2.74	0.62	4

No.	owner	slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	total porosity (% by volume)	pH	organic matter (%)	total score	risky level
16	Mr.Sawang Wongkat	0-5	Don-silB	poorly	<590	1.30	52.07	6.75	2.17	0.66	4
17	Mrs.Ratana Intatar	0-5	Don-silB	poorly	<590	1.25	51.61	6.28	2.90	0.62	4
18	Mr.Yanyong Chaiwut	0-5	Don-silB	poorly	590-740	1.29	46.98	5.33	2.17	0.81	5
19	Mr.Kumpun Yana	0-5	Don-silB	poorly	<590	1.26	51.16	5.00	2.27	0.76	5
20	Mr.Jitti Pipatpittayasakul	12-20	Li-gclD	poorly	590-740	1.27	49.35	5.12	3.54	0.51	3
20	Mr.Jitti Pipatpittayasakul	5-12	Li-gclD	poorly	590-740	1.27	49.35	5.12	3.54	0.56	3
21	Mr.Tae wongsai	12-20	Li-gclD	poorly	590-740	1.32	49.98	4.80	3.14	0.59	3
21	Mr.Tae wongsai	5-12	Li-gclD	poorly	590-740	1.32	49.98	4.80	3.14	0.64	4
22	Mr.Kumpun Yana	12-20	Li-gclD	poorly	590-740	1.31	50.04	5.76	3.03	0.46	2
22	Mr.Kumpun Yana	5-12	Li-gclD	poorly	590-740	1.31	50.04	5.76	3.03	0.51	3
23	Mr.Boonmee Kaewsingkum	0-5	Don-silB	poorly	590-740	1.29	49.14	5.48	3.34	0.73	4
23	Mr.Boonmee Kaewsingkum	0-5	Don-silB	poorly	<590	1.29	49.14	5.48	3.34	0.75	5
23	Mr.Boonmee Kaewsingkum	5-12	Don-silB	poorly	590-740	1.29	49.14	5.48	3.34	0.57	3
23	Mr.Boonmee Kaewsingkum	5-12	Don-silB	poorly	<590	1.29	49.14	5.48	3.34	0.59	3
24	Mr.Thanom siti	0-5	Don-silB	poorly	590-740	1.29	48.39	3.98	3.27	0.77	5
24	Mr.Thanom siti	0-5	Li-gclD	poorly	590-740	1.29	48.39	3.98	3.27	0.77	5
25	Mr.Artit Sujai	0-5	Mt-silC	well	590-740	1.41	46.11	6.08	2.59	0.55	3
25	Mr.Artit Sujai	0-5	Don-silB	poorly	590-740	1.41	46.11	6.08	2.59	0.71	4
26	Mr.Luan Yavilart	0-5	SC	well	590-740	1.29	50.91	5.36	2.16	0.58	3
26	Mr.Luan Yavilart	0-5	Li-gclD	poorly	590-740	1.29	50.91	5.36	2.16	0.74	5
26	Mr.Luan Yavilart	5-12	SC	well	590-740	1.29	50.91	5.36	2.16	0.42	2
26	Mr.Luan Yavilart	5-12	Li-gclD	poorly	590-740	1.29	50.91	5.36	2.16	0.59	3
27	Mr. Son Charoenchep	0-5	Mt-silC	well	590-740	1.29	48.09	5.34	2.25	0.58	3

No.	owner	slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	total porosity (% by volume)	pH	organic matter (%)	total score	risky level
27	Mr. Son Charoenchep	0-5	SC	well	590-740	1.29	48.09	5.34	2.25	0.58	3
27	Mr. Son Charoenchep	0-5	Li-gclD	poorly	590-740	1.29	48.09	5.34	2.25	0.74	5
27	Mr. Son Charoenchep	5-12	Li-gclD	poorly	590-740	1.29	48.09	5.34	2.25	0.59	3
28	Mr.Somkiat Wongta	0-5	Mt-sIC	well	590-740	1.33	50.68	5.66	1.72	0.52	3
29	Mr.Boonmee Wongchai	5-12	Mt-sIC	well	590-740	1.29	50.72	5.31	2.48	0.42	2
30	Mr.Choochert Chaisu	0-5	Mt-sIC	well	590-740	1.19	53.63	5.26	3.75	0.55	3
30	Mr.Choochert Chaisu	0-5	Bg-clD	moderate	590-740	1.19	53.63	5.26	3.75	0.63	4
30	Mr.Choochert Chaisu	5-12	Mt-sIC	well	590-740	1.19	53.63	5.26	3.75	0.40	2
31	Mr. Bumpot Doawee	0-5	Bg-clD	moderate	590-740	1.19	55.67	4.44	3.87	0.67	4
31	Mr. Bumpot Doawee	5-12	Bg-clD	moderate	590-740	1.19	55.67	4.44	3.87	0.52	3
32	Ms. Renu Paodoapan	0-5	Li-gclD	poorly	590-740	1.25	50.01	6.24	4.60	0.58	3
33	Mr.Montree Wongroy	0-5	Don-silB	poorly	<590	1.27	49.61	5.49	2.78	0.75	5
33	Mr.Montree Wongroy	5-12	Don-silB	poorly	<590	1.27	49.61	5.49	2.78	0.59	3
34	Mr.Srima Jittrawong	12-20	SC	well	590-740	1.02	59.14	4.55	3.34	0.40	2
34	Mr.Srima Jittrawong	5-12	SC	well	590-740	1.02	59.14	4.55	3.34	0.45	2
35	Mr.Aumnui WongJun	12-20	Li-gclD	poorly	590-740	1.21	52.76	4.18	3.48	0.56	3
35	Mr.Aumnui WongJun	5-12	Li-gclD	poorly	590-740	1.21	52.76	4.18	3.48	0.62	4
36	Mr.Chamrat Tejakeaw	0-5	Bg-clD	moderate	590-740	1.24	53.43	5.02	3.42	0.64	4
37	Mr.Sunit Sang Ai (#1)	0-5	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.66	4
37	Mr.Sunit Sang Ai (#1)	12-20	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.46	2
37	Mr.Sunit Sang Ai (#1)	20-35	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.46	2
37	Mr.Sunit Sang Ai (#1)	5-12	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.51	3
38	Mr.Sukit Sang Ai	0-5	Bg-clD	moderate	590-740	1.14	54.72	3.86	3.54	0.67	4

No.	owner	slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	total porosity (% by volume)	pH	organic matter (%)	total score	risky level
38	Mr.Sukit Sang Ai	12-20	Bg-clD	moderate	590-740	1.14	54.72	3.86	3.54	0.47	2
38	Mr.Sukit Sang Ai	5-12	Bg-clD	moderate	590-740	1.14	54.72	3.86	3.54	0.52	3
39	Mrs.Ratana Potijan	0-5	Bg-clD	moderate	590-740	1.14	54.43	5.52	3.65	0.55	3
39	Mrs.Ratana Potijan	5-12	Bg-clD	moderate	590-740	1.14	54.43	5.52	3.65	0.40	2
40	Mrs.Wassana Sittima	5-12	Bg-clD	moderate	590-740	1.08	58.71	5.34	3.50	0.49	3
41	Mr.Sunit Sang Ai (#2)	12-20	Bg-clD	moderate	590-740	1.02	61.44	4.48	4.31	0.47	2
41	Mr.Sunit Sang Ai (#2)	20-35	Bg-clD	moderate	590-740	1.02	61.44	4.48	4.31	0.47	2
41	Mr.Sunit Sang Ai (#2)	5-12	Bg-clD	moderate	590-740	1.02	61.44	4.48	4.31	0.52	3
42	Mr. Ruruong Doawee	0-5	Mt-slC	well	590-740	1.36	47.78	4.49	1.45	0.65	4
42	Mr. Natee Intawong	0-5	SC	well	590-740	1.36	47.78	4.49	1.45	0.65	4
43	Mr. Natee Intawong	0-5	SC	well	590-740	1.06	67.56	4.30	4.59	0.58	3
43	Mr. Natee Intawong	12-20	SC	well	590-740	1.06	67.56	4.30	4.59	0.37	2
43	Mr. Natee Intawong	12-20	Bg-clD	moderate	590-740	1.06	67.56	4.30	4.59	0.46	2
43	Mr. Natee Intawong	20-35	SC	well	590-740	1.06	67.56	4.30	4.59	0.37	2
43	Mr. Natee Intawong	20-35	Bg-clD	moderate	590-740	1.06	67.56	4.30	4.59	0.46	2
43	Mr. Natee Intawong	5-12	SC	well	590-740	1.06	67.56	4.30	4.59	0.42	2
43	Mr. Natee Intawong	5-12	Bg-clD	moderate	590-740	1.06	67.56	4.30	4.59	0.51	3
44	Mr. Taworn Mungjai	0-5	Li-gclD	poorly	590-740	1.38	43.80	5.13	2.71	0.81	5
44	Mr. Taworn Mungjai	12-20	Li-gclD	poorly	590-740	1.38	43.80	5.13	2.71	0.61	4
44	Mr. Taworn Mungjai	5-12	Li-gclD	poorly	590-740	1.38	43.80	5.13	2.71	0.66	4
45	Mr. Uoonruan Punya (#1)	12-20	Li-gclD	poorly	590-740	1.33	47.93	6.39	4.82	0.40	2
46	Mr. Uoonruan Punya (#2)	0-5	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.61	4
46	Mr. Uoonruan Punya (#2)	12-20	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.41	2

No.	owner	slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	total porosity (% by volume)	pH	organic matter (%)	total score	risky level
46	Mr. Uoonruoan Punya (#2)	20-35	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.41	2
46	Mr. Uoonruoan Punya (#2)	5-12	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.46	2
47	Mr. Boontum Punsurin	12-20	Li-gclD	poorly	590-740	1.21	50.15	4.92	3.06	0.56	3
47	Mr. Boontum Punsurin	20-35	Li-gclD	poorly	590-740	1.21	50.15	4.92	3.06	0.56	3
47	Mr. Boontum Punsurin	5-12	Li-gclD	poorly	590-740	1.21	50.15	4.92	3.06	0.62	4
48	Mr. Kummoon Taladkeaw (lowland)	0-5	Don-silB	poorly	<590	1.28	49.17	4.20	2.47	0.80	5
49	Mr. Tawechai Kotrakul	0-5	Pe-sIC/d5	well	<590	1.29	49.68	5.47	2.14	0.60	3
50	Mr. Kummoon Taladkeaw (sloping land)	12-20	Li-gclD	poorly	590-740	1.19	55.27	6.60	3.42	0.40	2
50	Mr. Kummoon Taladkeaw (sloping land)	5-12	Li-gclD	poorly	590-740	1.19	55.27	6.60	3.42	0.45	2

Appendix 3 Risky classification of factors contributing to nutrient lost though leaching and runoff each orchard

No.	Owner	Slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	porosity (% by volume)	pH	organic matter (%)	total score	risky level
1	Mrs.Jansom Yajai	0-5	Pe-sIC/d5	well	<590	1.29	51.59	5.95	2.59	0.50	3
2	Mr.Charoen Tanomsin	0-5	SC	well	590-740	1.12	57.21	6.57	4.17	0.43	2
2	Mr.Charoen Tanomsin	12-20	SC	well	590-740	1.12	57.21	6.57	4.17	0.22	1
2	Mr.Charoen Tanomsin	5-12	SC	well	590-740	1.12	57.21	6.57	4.17	0.27	1
3	Mr.Chamnong Tummakunkaew	0-5	Pe-sIC/d5	well	<590	1.37	46.34	5.64	2.45	0.60	3
4	Mr.Saokaew Jitrawong	0-5	Pe-sIC/d5	well	<590	1.32	49.09	6.18	3.17	0.48	2
5	Mr.Jai Aetama	0-5	Pe-sIC/d5	well	<590	1.26	52.31	6.04	3.07	0.46	2
5	Mr.Jai Aetama	0-5	Don-silB	poorly	<590	1.26	52.31	6.04	3.07	0.62	4
6	Mr.Ming Lungkana	0-5	SC	well	590-740	1.22	52.52	5.71	3.00	0.48	2
6	Mr.Ming Lungkana	12-20	SC	well	590-740	1.22	52.52	5.71	3.00	0.28	1
6	Mr.Ming Lungkana	5-12	SC	well	590-740	1.22	52.52	5.71	3.00	0.33	1
7	Mr.Krisorn Tontang	0-5	Don-silB	poorly	<590	1.32	49.38	5.77	2.34	0.70	4
8	Mr.Jomreang Kumpat	0-5	Don-silB	poorly	<590	1.34	47.41	5.01	2.65	0.77	5
9	Mr.Intorn Keawsuriya	0-5	Don-silB	poorly	<590	1.49	40.05	5.82	1.38	0.80	5
10	Mr.Winit Saisahingkam	0-5	Don-silB	poorly	<590	1.41	46.40	5.40	1.79	0.87	5
11	Mr.Wai Bungkomnate	0-5	Don-silB	poorly	<590	1.32	49.00	5.73	2.37	0.70	4
12	Mr.Tae wongsai	0-5	Don-silB	poorly	<590	1.28	49.47	5.50	2.65	0.66	4
13	Mr.Kom Srila	0-5	Pe-sIC/d5	well	<590	1.16	54.64	5.96	2.48	0.51	3
13	Mr.Kom Srila	0-5	Don-silB	poorly	<590	1.16	54.64	5.96	2.48	0.68	4
14	Mrs.Yupin Intatar	0-5	Don-silB	poorly	<590	1.31	48.97	6.13	2.92	0.64	4
15	Mr.Sawang Wongkat	0-5	Don-silB	poorly	<590	1.20	53.60	6.05	2.74	0.62	4

No.	Owner	Slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	porosity (% by volume)	pH	organic matter (%)	total score	risky level
16	Mr.Sawang Wongkat (#2)	0-5	Don-silB	poorly	<590	1.30	52.07	6.75	2.17	0.66	4
17	Mrs.Ratana Intatar	0-5	Don-silB	poorly	<590	1.25	51.61	6.28	2.90	0.62	4
18	Mr.Yanyong Chaiwut	0-5	Don-silB	poorly	590-740	1.29	46.98	5.33	2.17	0.81	5
19	Mr.Kumpun Yana (lowland)	0-5	Don-silB	poorly	<590	1.26	51.16	5.00	2.27	0.76	5
20	Mr.Jitti Pipatpittayasakul	12-20	Li-gclD	poorly	590-740	1.27	49.35	5.12	3.54	0.51	3
20	Mr.Jitti Pipatpittayasakul	5-12	Li-gclD	poorly	590-740	1.27	49.35	5.12	3.54	0.56	3
21	Mr.Tae wongsai	12-20	Li-gclD	poorly	590-740	1.32	49.98	4.80	3.14	0.59	3
21	Mr.Tae wongsai	5-12	Li-gclD	poorly	590-740	1.32	49.98	4.80	3.14	0.64	4
22	Mr.Kumpun Yana (sloping land)	12-20	Li-gclD	poorly	590-740	1.31	50.04	5.76	3.03	0.46	2
22	Mr.Kumpun Yana (sloping land)	5-12	Li-gclD	poorly	590-740	1.31	50.04	5.76	3.03	0.51	3
23	Mr.Boonmee Kaewsingkum	0-5	Don-silB	poorly	590-740	1.29	49.14	5.48	3.34	0.73	4
23	Mr.Boonmee Kaewsingkum	0-5	Don-silB	poorly	<590	1.29	49.14	5.48	3.34	0.75	5
23	Mr.Boonmee Kaewsingkum	5-12	Don-silB	poorly	590-740	1.29	49.14	5.48	3.34	0.57	3
23	Mr.Boonmee Kaewsingkum	5-12	Don-silB	poorly	<590	1.29	49.14	5.48	3.34	0.59	3
24	Mr.Thanom siti	0-5	Don-silB	poorly	590-740	1.29	48.39	3.98	3.27	0.77	5
24	Mr.Thanom siti	0-5	Li-gclD	poorly	590-740	1.29	48.39	3.98	3.27	0.77	5
25	Mr.Aritit Sujai	0-5	Mt-sIC	well	590-740	1.41	46.11	6.08	2.59	0.55	3
25	Mr.Aritit Sujai	0-5	Don-silB	poorly	590-740	1.41	46.11	6.08	2.59	0.71	4
26	Mr.Luan Yawilart	0-5	SC	well	590-740	1.29	50.91	5.36	2.16	0.58	3
26	Mr.Luan Yawilart	0-5	Li-gclD	poorly	590-740	1.29	50.91	5.36	2.16	0.74	5
26	Mr.Luan Yawilart	5-12	SC	well	590-740	1.29	50.91	5.36	2.16	0.42	2
26	Mr.Luan Yawilart	5-12	Li-gclD	poorly	590-740	1.29	50.91	5.36	2.16	0.59	3
27	Mr. Son Charoenchep	0-5	Mt-sIC	well	590-740	1.29	48.09	5.34	2.25	0.58	3

No.	Owner	Slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	porosity (% by volume)	pH	organic matter (%)	total score	risky level
27	Mr. Son Charoenchep	0-5	SC	well	590-740	1.29	48.09	5.34	2.25	0.58	3
27	Mr. Son Charoenchep	0-5	Li-gclD	poorly	590-740	1.29	48.09	5.34	2.25	0.74	5
27	Mr. Son Charoenchep	5-12	Li-gclD	poorly	590-740	1.29	48.09	5.34	2.25	0.59	3
28	Mr.Somkiat Wongta	0-5	Mt-slC	well	590-740	1.33	50.68	5.66	1.72	0.52	3
29	Mr.Boonmee Wongchai	5-12	Mt-slC	well	590-740	1.29	50.72	5.31	2.48	0.42	2
30	Mr.Choochert Chaisu	0-5	Mt-slC	well	590-740	1.19	53.63	5.26	3.75	0.55	3
30	Mr.Choochert Chaisu	0-5	Bg-clD	moderate	590-740	1.19	53.63	5.26	3.75	0.63	4
30	Mr.Choochert Chaisu	5-12	Mt-slC	well	590-740	1.19	53.63	5.26	3.75	0.40	2
31	Mr. Bunpot Doawee	0-5	Bg-clD	moderate	590-740	1.19	55.67	4.44	3.87	0.67	4
31	Mr. Bunpot Doawee	5-12	Bg-clD	moderate	590-740	1.19	55.67	4.44	3.87	0.52	3
32	Ms. Renu Paodoapan	0-5	Li-gclD	poorly	590-740	1.25	50.01	6.24	4.60	0.58	3
33	Mr.Montree Wongroy	0-5	Don-silB	poorly	<590	1.27	49.61	5.49	2.78	0.75	5
33	Mr.Montree Wongroy	5-12	Don-silB	poorly	<590	1.27	49.61	5.49	2.78	0.59	3
34	Mr.Srima Jittrawong	12-20	SC	well	590-740	1.02	59.14	4.55	3.34	0.40	2
34	Mr.Srima Jittrawong	5-12	SC	well	590-740	1.02	59.14	4.55	3.34	0.45	2
35	Mr.Aumnui Wonglun	12-20	Li-gclD	poorly	590-740	1.21	52.76	4.18	3.48	0.56	3
35	Mr.Aumnui Wonglun	5-12	Li-gclD	poorly	590-740	1.21	52.76	4.18	3.48	0.62	4
36	Mr.Chamrat Tejakeaw	0-5	Bg-clD	moderate	590-740	1.24	53.43	5.02	3.42	0.64	4
37	Mr.Sunit Sang Ai (#1)	0-5	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.66	4
37	Mr.Sunit Sang Ai (#1)	12-20	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.46	2
37	Mr.Sunit Sang Ai (#1)	20-35	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.46	2
37	Mr.Sunit Sang Ai (#1)	5-12	Bg-clD	moderate	590-740	0.90	66.84	4.26	4.94	0.51	3
38	Mr.Sukit Sang Ai	0-5	Bg-clD	moderate	590-740	1.14	54.72	3.86	3.54	0.67	4

No.	Owner	Slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	porosity (% by volume)	pH	organic matter (%)	total score	risky level
38	Mr.Sukit Sang Ai	12-20	Bg-clD	moderate	590-740	1.14	54.72	3.86	3.54	0.47	2
38	Mr.Sukit Sang Ai	5-12	Bg-clD	moderate	590-740	1.14	54.72	3.86	3.54	0.52	3
39	Mrs.Ratana Potijan	0-5	Bg-clD	moderate	590-740	1.14	54.43	5.52	3.65	0.55	3
39	Mrs.Ratana Potijan	5-12	Bg-clD	moderate	590-740	1.14	54.43	5.52	3.65	0.40	2
40	Mrs.Wassana Sittima	5-12	Bg-clD	moderate	590-740	1.08	58.71	5.34	3.50	0.49	3
41	Mr.Sunit Sang Ai (#2)	12-20	Bg-clD	moderate	590-740	1.02	61.44	4.48	4.31	0.47	2
41	Mr.Sunit Sang Ai (#2)	20-35	Bg-clD	moderate	590-740	1.02	61.44	4.48	4.31	0.47	2
41	Mr.Sunit Sang Ai (#2)	5-12	Bg-clD	moderate	590-740	1.02	61.44	4.48	4.31	0.52	3
42	Mr. Rurung Doawee	0-5	Mt-sIC	well	590-740	1.36	47.78	4.49	1.45	0.65	4
42	Mr. Natee Intawong	0-5	SC	well	590-740	1.36	47.78	4.49	1.45	0.65	4
43	Mr. Natee Intawong	0-5	SC	well	590-740	1.06	67.56	4.30	4.59	0.58	3
43	Mr. Natee Intawong	12-20	SC	well	590-740	1.06	67.56	4.30	4.59	0.37	2
43	Mr. Natee Intawong	12-20	Bg-clD	moderate	590-740	1.06	67.56	4.30	4.59	0.46	2
43	Mr. Natee Intawong	20-35	SC	well	590-740	1.06	67.56	4.30	4.59	0.37	2
43	Mr. Natee Intawong	20-35	Bg-clD	moderate	590-740	1.06	67.56	4.30	4.59	0.46	2
43	Mr. Natee Intawong	5-12	SC	well	590-740	1.06	67.56	4.30	4.59	0.42	2
43	Mr. Natee Intawong	5-12	Bg-clD	moderate	590-740	1.06	67.56	4.30	4.59	0.51	3
44	Mr. Taworn Mungjai	0-5	Li-gclD	poorly	590-740	1.38	43.80	5.13	2.71	0.81	5
44	Mr. Taworn Mungjai	12-20	Li-gclD	poorly	590-740	1.38	43.80	5.13	2.71	0.61	4
44	Mr. Taworn Mungjai	5-12	Li-gclD	poorly	590-740	1.38	43.80	5.13	2.71	0.66	4
45	Mr. Uoonruan Punya (#1)	12-20	Li-gclD	poorly	590-740	1.33	47.93	6.39	4.82	0.40	2
46	Mr. Uoonruan Punya (#2)	0-5	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.61	4
46	Mr. Uoonruan Punya (#2)	12-20	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.41	2

No.	Owner	Slope (%)	soil series	drainage	elevation (m)	bulk density (g/cm ³)	porosity (% by volume)	pH	organic matter (%)	total score	risky level
46	Mr. Uoonruoan Punya (#2)	20-35	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.41	2
46	Mr. Uoonruoan Punya (#2)	5-12	Li-gclD	poorly	590-740	1.31	47.23	6.57	3.73	0.46	2
47	Mr. Boontum Punsurin	12-20	Li-gclD	poorly	590-740	1.21	50.15	4.92	3.06	0.56	3
47	Mr. Boontum Punsurin	20-35	Li-gclD	poorly	590-740	1.21	50.15	4.92	3.06	0.56	3
47	Mr. Boontum Punsurin	5-12	Li-gclD	poorly	590-740	1.21	50.15	4.92	3.06	0.62	4
48	Mr. Kummoon Taladkeaw (lowland)	0-5	Don-silB	poorly	<590	1.28	49.17	4.20	2.47	0.80	5
49	Mr. Tawechai Kotrakul	0-5	Pe-sIC/d5	well	<590	1.29	49.68	5.47	2.14	0.60	3
50	Mr. Kummoon Taladkeaw (sloping land)	12-20	Li-gclD	poorly	590-740	1.19	55.27	6.60	3.42	0.40	2
50	Mr. Kummoon Taladkeaw (sloping land)	5-12	Li-gclD	poorly	590-740	1.19	55.27	6.60	3.42	0.45	2

Appendix 3 Risky classification of factors contributing to nutrient imbalance each orchard

No	owner	pH	CEC (cmol/kg)	%OM	Avai.P (mg/kg)	Exch.K (mg/kg)	total score	risky level
1	Mrs.Jansom YaJai	5.95	9.47	2.59	226.08	68.80	0.57	2
2	Mr.Charoen Tanomsin	6.57	10.04	4.17	73.79	118.80	0.42	1
3	Mr.Chamnong Tummakunkaew	5.64	14.79	2.45	135.53	86.93	0.56	2
4	Mr.Saokaew Jitrawong	6.18	10.67	3.17	124.87	130.95	0.54	2
5	Mr.Jai Aetama	6.04	10.33	3.07	189.55	69.00	0.45	1
6	Mr.Ming Lungkana	5.71	8.21	3.00	126.34	162.02	0.66	3
7	Mr.Krisorn Tontang	5.77	7.01	2.34	327.50	63.00	0.61	2
8	Mr.Jomreang Kumpat	5.01	5.58	2.65	121.20	43.00	0.72	3
9	Mr.Intorn Keawsuriya	5.82	5.64	1.38	20.84	28.00	0.56	2
10	Mr.Winit Saisahingkam	5.40	5.64	1.79	47.85	59.00	0.67	3
11	Mr.Wai Bungkonnate	5.73	10.67	2.37	239.31	68.80	0.56	2
12	Mr.Tae wongsai	5.50	9.81	2.65	274.58	211.22	0.66	3
13	Mr.Kom Srila	5.96	9.41	2.48	177.79	79.16	0.61	2
14	Mrs.Yupin Intatar	6.13	9.93	2.92	229.02	128.36	0.59	2
15	Mr.Sawang Wongkat (#1)	6.05	10.96	2.74	265.77	84.34	0.45	1
16	Mr.Sawang Wongkat (#2)	6.75	9.47	2.17	87.76	81.00	0.54	2
17	Mrs.Ratana Intatar	6.28	11.13	2.90	132.59	93.00	0.45	1
18	Mr.Yanyong Chaiwut	5.33	4.67	2.17	179.26	70.00	0.76	4
19	Mr.Kumpun Yana (sloping land)	5.00	12.73	2.27	212.85	71.39	0.71	3
20	Mr.Jitti Pipatpittayasakul	5.12	8.84	3.54	489.20	138.72	0.77	4
21	Mr.Tae wongsai	4.80	9.47	3.14	384.83	237.12	0.88	5
22	Mr.Kumpun Yana (นาย)	5.76	8.56	3.03	312.80	237.12	0.66	3
23	Mr.Boonmee Kaewsingkum	5.48	10.50	3.34	94.00	57.00	0.67	3
24	Mr.Thanom siti	3.98	10.04	3.27	114.58	97.00	0.75	4

No	owner	pH	CEC (cmol/kg)	%OM	Avai.P (mg/kg)	Exch.K (mg/kg)	total score	risky level
25	Mr.Artit Sujai	6.08	7.07	2.59	112.01	112.00	0.50	1
26	Mr.Luan Yawilart	5.36	3.18	2.16	201.23	94.00	0.76	4
27	Mr. Son Charoenchep	5.34	9.19	2.25	166.03	92.00	0.76	4
28	Mr.Somkiat Wongta	5.66	6.90	1.72	234.90	80.00	0.61	2
29	Mr.Boonmee Wongchai	5.31	8.79	2.48	339.26	170.00	0.84	4
30	Mr.Choochert Chaisu	5.26	11.01	3.75	251.07	141.31	0.72	3
31	Mr. Bunpot Doawee	4.44	13.36	3.87	227.55	291.50	0.80	4
32	Ms. Renu Paodoapan	6.24	9.53	4.60	355.43	70.00	0.43	1
33	Mr.Montree Wongroy	5.49	10.21	2.78	199.62	81.00	0.67	3
34	Mr.Srima Jitrawong	4.55	12.62	3.34	109.44	286.32	0.83	4
35	Mr.Aumnui WongJun	4.18	12.22	3.48	177.05	275.96	0.83	4
36	Mr.Chamrat Tejakeaw	5.02	10.90	3.42	249.60	112.82	0.67	3
37	Mr.Sunit Sang Ai (#1)	4.26	14.44	4.94	373.07	335.52	0.76	4
38	Mr.Sukit Sang Ai	3.86	11.47	3.54	408.35	239.71	0.80	4
39	Mrs.Ratana Potijan	5.52	7.36	3.65	34.75	76.00	0.45	1
40	Mrs.Wassana Sittima	5.34	6.50	3.50	115.32	102.00	0.68	3
41	Mr.Sunit Sang Ai (#2)	4.48	10.67	4.31	315.74	755.02	0.80	4
42	Mr. Ruruong Doawee	4.49	5.81	1.45	140.31	459.81	0.95	5
43	Mr. Natee Intawong	4.30	6.27	4.59	233.43	317.39	0.81	4
44	Mr. Taworn Mungjai	5.13	8.90	2.71	358.37	677.33	0.81	4
45	Mr. Uoonruoan Punya (#1)	6.39	11.07	4.82	376.01	395.08	0.47	1
46	Mr. Uoonruoan Punya (#2)	6.57	6.90	3.73	383.36	322.57	0.55	2
47	Mr. Boontum Punsurin	4.92	11.07	3.06	312.80	441.69	0.83	4
48	Mr. Kumnoon Taladkeaw (lowland)	4.20	22.49	2.47	684.70	151.66	0.82	4
49	Mr.Tawechai Kotrakul	5.47	11.30	2.14	193.96	296.68	0.80	4

No	owner	pH	CEC (cmol/kg)	%OM	Avai.P (mg/kg)	Exch.K (mg/kg)	total score	risky level
50	Mr. Kumnoon Taladkeaw (sloping land)	6.60	13.42	3.42	211.38	433.92	0.54	2

Curriculum Vitae



Name	Miss.Vassana Viroonrat
Date of birth	March, 09, 1981
Academic background	1999-2002 B.S. (Agronomy), Chiang Mai University, Chiang Mai, Thailand 2004-2007 M.S. (Soil Science), Chiang Mai University, Chiang Mai, Thailand

