Orchardists' Needs for the Development of Technology and Innovation

Suwanna Sayruamyat[1] Suwanna Praneetvatakul[2*] Kampanat Vijitsrikamol[3]
Chakrit Potchanasin[4] Nithicha Thamthanakoon[5] and Piyatat Pananurak[6]
[1, 2*, 3, 4, 5] Faculty of Economics, Kasetsart University
[6] Knowledge Network Institute of Thailand

(Received: September 10, 2020; Revised: November 10, 2020; Accepted: February 8, 2021)

Abstract

This article aims to summarize the situation of problem and barriers, and to explore the need for technology and innovation in the production of fruit orchards. The study analyzed by a survey of 295 farmers and data from in-depth interviews with 31 farmers following the 5-Whys concept. The results show that the most important problem is climate variability, which cause the problems of plant pathology, insect pest and low rate of flowering. For these reasons, fruit planters require to develop accurate climate forecasting technology at the field level, easy-to-use and inexpensive technology for soil quality and soil nutrient analysis, new varieties resistant to climatic variability, plant pathology and insect pest. Moreover, the size of the production area and the type of fruit trees affect different levels of the above problem indicating the different technological requirements. This study suggests that the developed technologies should vary to suit different both plated area and types of fruit trees leading to modern agriculture effectively.

Keywords: 1) Fruit Production 2) Technology 3) Innovation 4) Need Assessment

---

[1,5] Lecturer, Department of Agricultural and Resource Economics

[2*] Associate Professor, Department of Agricultural and Resource Economics; E-mail: suwanna.p@ku.th

[3, 4] Assistant Professor, Department of Agricultural and Resource Economics

[6] Senior Project Manager

This research got the fund from Thailand Science Research and Innovation (TSRI) under the project of technology-driven approaches for the development of orchards.

Introduction

Fruits are agricultural products that are important to the Thai economy. With the topography and climate suitable for production, Thailand can produce tropical fruits all year round, as many as 57 species, with an area of approximately 6.58 million rai (3.7% of the country's agricultural area). The total yield is approximately 11.25 million tons per year. The fruit trees with the highest production growth rate during 2010–2018 consisted of bananas, coconuts, durians, pomelos, and longans. The types of fruit trees with the highest yields were longan, durian, mango, coconut, banana, mangosteen, grapefruit, tamarind, and lychee, respectively (Department of Agriculture Extension, 2018, pp. 2-5).

During the years 2013–2017, the growth rate of fruit yield value was 2.29% per year. In 2017, the export value of fruits and products was ฿142,609 million, accounting for 10.52% of the total export value of agricultural sector (after natural rubber and rice and their products), which increasing in both quantity and value (Office of Agricultural Economics, 2018, pp.27-30). Because of increasing demand from abroad, fruit prices increased during that period. Orchard owners decided to expand the growing area. As a result, they were facing production problems such as labor shortages, and the variability of the global climate, etc. These problems required the introduction of modern production technology or innovation to solve the problem and to increase the productivity of sustainable fruit production. This could develop the farmer's abilities dealing with various risks for farmers as well. However, there are 57 types of Thai fruits. Each fruit had a different production process. Moreover, problems and obstacles that arise during the process were also different. It is very important to know the root of the problems farmers face, leading to the urgency of choosing technology development or innovation that meets the orchard farmers' needs.

This research therefore focuses on the survey of farmers to analyze the current situation, problems and needs for development of technology and innovations that support Thai orchard production. The finding would provide important information to prioritize technology and innovation development for fruit production. Furthermore, this research finding would advocate developing technology and innovation for Thai fruit production in order to transfer to modernize agriculture in the future effectively.

Literature Review

5 Whys technique

Lopez-Vega, Tell, and Vanhaverbeke (2015, p. 126) said that innovative developments could not be developed from existing manufacturing processes. It was necessary to develop new knowledge that combines science from many fields. The problem must be clearly stated and include determining the target area and knowing the correct process. Innovation acquisition might be through experimentation, accumulated experience, and new perspectives. Therefore, to study the need for technology or innovation of orchard owners, it was necessary to analyze problems and obstacles of fruit production in order to find the root of the problem before considering technology to help solve the problem. The process of analyzing the problem is very important. As Albert Einstein said, once said, “If I were given one hour to save the planet, I would spend 59 minutes defining the problem and one minute resolving it” (Spradlin, 2012, p. 84).

To analyze the real cause of the problem, it was necessary to know the root cause of the problem through asking the question 'Why...' when given the first answer and asking the question 'why' four more times in order to delve further into it. Five Why questions will help stimulate information and reasons to explain getting to the root of the real problem. However, this technique has limitations because the root cause of the problem can have more than one. Thus, using the 5-Whys questioning technique requires experience in considering each step of cause and effect to determine the root cause of the problem as much as possible. Using the 5-Whys technique, it may be possible to ask fewer than or more times, depending on in what order the root cause can be identified. Not only business applied 5-Whys, World Health Organization (2011, pp. 102-104) but also promote this technique to accurate Root Cause Analysis of various diseases precisely.

To conclude, 5-Whys technique is necessary analysis through an in-depth interview. It provides an overview of problems, obstacles and needs for technology and innovation development for fruit production as the starting point in order to determine the extent of finding the root of the real problem.

Related Literature

As a result of fruit market expansion, technology has been developed to increase fruit productivity supporting the growth of tropical fruit consumption demands such as bananas, papayas, and mangos. Yahia (2006, pp. 2) suggested that climate change technology was critical for tropical fruit production; there was a critical need for in-depth research increasing the commercial use of such technology. In addition to technology, location or even the style of landscaping was also important to increase the quality of fruit production as well. Sritongchuay, Kremen and Bumrungsri (2016, pp. 274-276) found that the distance between orchards such as rambutan, mango and durian, the cave site and forest area did not affect the pollination quality of mango and durian. But it significantly affected the pollination quality of rambutans. These results indicated that mixed fruit orchard production reduced the risk of crop damage caused by pests and pests better than monocultures. Farm managers need to implement proper garden management methods as each fruit variety has different needs, both in terms of soil, fertilizing, watering management and so on, which growers must be aware of the problems and needs of technology and innovation for each type of fruit production. In Indonesia, one of the tropical fruit-producing countries, they explored problems and research approaches in cash crops (such as bananas, mangos, mangosteens, and durians), as well as potential fruit trees (such as papaya, rennet, watermelon, and breadfruit), with a focus on species development, ecosystem management and plant protection to increase the potential of their fruit production (Mansyah and Sutanto, 2020, p.1). However, this type of research was still scarce in Thailand. It is often researched specifically on fruit with high economic value, such as longan and durian, whereas crops with economic potential such as pomelo and coconut must be explored the problems and needs for technological development and innovation as a guideline for further research and development of Thai fruit trees in the future as well.

Research Methodology

This research uses primary data from a survey of the needs for technological development and innovation of orchard farmers. It was based on an online structured questionnaire and an applied snowball sampling survey. The quantitative analysis focused on 9 types of fruit from 295 orchard farmers including 128 durian farmers, 98 mangosteen farmers, 76 bananas farmers, 64 mango farmers, 46 aromatic coconut farmers, 29 longan farmers, 19 grapefruit farmers, 18 tamarind farmers, and 11 lychees farmers. Some respondents produced more than one type of fruit. To deal with 9 types of fruit orchards, which had large production area and economic potential. The study conducted in-depth interviews with 31 farmers who had experience in using technology to produce fruit trees. These specific farmers were recommended by experts. In the durian and mangosteen cases, 6 farmers from Chanthaburi Province and 11 farmers from Chumphon Province were interviewed. For mango, we interviewed 4 four members of Nam Dok Mai mango farmers group in Nakhon Ratchasima Province. Moreover, we interviewed a banana farmer from Pathum Thani Province, 5 aromatic coconut farmers from Samut Sakhon Province, 2 longan farmers from Samut Sakhon Province, and 2 grapefruit farmers from Nakhon Pathom Province.

The survey instrument was divided into two parts: Part 1 questioned the problems, obstacles and needs of technology development and innovation in the past 5 years (2014-2019). Assessments of problems, obstacles, and technology needs were divided into 16 areas: 1) seed shortage 2) seed quality 3) soil quality 4) flowering 5) plant disease management 6) insect pest management 7) Weed management 8) Labor shortage 9) Quality and proficiency of labor skills 10) Watering 11) Pruning 12) Harvest 13) Climate variability 14) GAP standardization 15) production grading and 16) production price information. Each aspect assessed the level of problems and obstacles by using 5-category scales: least/no problem, low, moderate, very, and most. For more flexibility in answering questions and obtaining more measurement frequency information, the study explored the need based on fruit production activities, including breeding, soil quality examination and soil nutrient testing, fertilization, watering, flower budding, pruning, plant diseases/pests, harvest, post-harvest care, agricultural waste management and climate forecast information with a 5-point rating scale that fruit farmers want to develop. Part 2 consisted general information of farmers, including gender, age, highest level of education, type of orchard, planting area size, and experience in production.

Problem analysis used the data obtained from the orchard farmer survey to analyze problems and obstacles in fruit production preliminary statistical values such as mean. Then assessed the level of problems and obstacles at 3 levels: low-level with an average score of not more than 1.67 points, medium level with an average score of between 1.68 to 3.34 points, and high level with an average of more than 3.35 points. Then tested the difference of the average of problems and obstacles in fruit production between 4 groups of farmers: very small (production area ≤5 Rai), small (production area 5.01 to 10.00 Rai), medium (production area 10.01 to 25.00 Rai) and large (production area ≥ 25 Rai) by analyzing the variance test (ANOVA). And then discussed the results of the analysis with the in-depth interview data using the 5-Whys technique to participate in the analysis of the survey results. The 5-Whys technique has four steps as follows:

Step 1 Write a specific problem on a paper. The conceptual framework will be systematic, structured, easy to explain and allows the questioner to set the goals of the solution appropriately.

Step 2 Begin with the question "Why is this problem happening?" and write the answer on a piece of paper and keep asking this question until you get a satisfactory answer.

Step 3 From the second step, if the exact cause cannot be analyzed. Instead, go back to step 1 and change the original question to be more specific.

Step 4 After receiving the answer from the question. Use the answers above to analyze the cause of the problem including identifying the risk that there are factors contributing to the problem. Then find the connection or relationship of the factors that cause the risk to the problem.

For need assessment of technology development and innovation, this study ranked the needs according to the fruit production process. Then analyze with preliminary statistics such as frequency and percentage, and then test the relationship between technology development requirements and each aspect of innovation with farmer groups according to production area size and type of fruit produced by Chi-square test.

The survey and questionnaires in this research were approved for research in accordance with the Human Research Ethics Code No. COE62/055 from the Research Standard Department and Kasetsart University Development Institution.

Results

Preliminary data of 295 fruit orchard farmers, 61.3% male, mean age 49.9 years, 47.4% graduated with a diploma/bachelor's degree (45.7% secondary school or less and 6.7% postgraduate). Their average experience in orchard 17.2 years. There was 35.6% single fruit production and 64.4% of mixed fruit production. Respondents produced 128 durians, 98 mangosteens, 76 bananas, 64 mangos, 46 aromatic coconuts, 29 longans, 19 grapefruits, 18 tamarinds and 11 lychees, and 60 other fruit trees such as jackfruit, rambutan, champada, and maprang. santol etc. Overall, the average orchard area was 24.6 rai, divided into 4 groups: 68 very small (22.7%), 83 small (28.5%), 67 medium (22.7%), and 77 large cases (26.1%).

From the survey, the overall problem situation for fruit orchard farmers was climate variability. It is a major problem and obstacle that affects fruit production at a high level, followed by the management of plant diseases and pests. Other problems included flowering, labor shortages weed management, soil quality, watering, harvesting, price information, grading, establishing GAP standards, seed quality pruning and seed shortage as moderate problem. No problems were assessed at a low level (Table No. 1).

When considering the results of problem assessment by size of production area, it was found that the top 3 problems with high mean among orchards with very small areas were plant disease management problems, very in line as well as the problem of climate variability, while the problem of pest management was in the middle level.

The top problems that small-sized orchards faced were climate variability at high levels. Pest management, plant disease and pest management problems were at moderate level.

The top three problems with high averages among medium-sized orchards were climate variability, plant disease management, and pest management problems. All 3 problems were assessed at high criteria.

The top three problems with high averages among large-sized orchards were climate variability and pest management problems as well as other groups. Both problems were assessed at a high level. The third problem was plant disease management with moderate criteria.

When testing the difference of the average of problems and obstacles in fruit production between the four sized orchards. It found that the problems that differed clearly between the groups were the shortage of seedlings, harvest, climate variability, GAP standardization, product grading, and production information at 95% confidence intervals. For seed quality, watering and pruning problems were a statistically significant difference at 90% confidence interval.

According to Table No. 1, it indicated that sapling scarcity and seed quality were issues for very small-sized than others. For pruning, harvesting, GAP standardization, and product grading issues, they were major problems in medium- and large-sized.

While the average of soil quality problems, flower settling, plant disease management pest management, weed management, labor shortage, quality, expertise and skills of workers were no difference in size (Table No. 1).

According to needs and demand for technological developments and innovations, the results showed that technologies and innovations that require improvement in more than 50 % of the survey respondents was accurate climate forecasting technology (66.8%), followed by technology for quality inspection and measurement of soil nutrients (55.9%), assisted flowering technology (55.3%), breeding (53.6%), watering system (52.2%), respectively.

Considering orchard areas, it found that farmers with very small areas suggested developing climate forecasting technology the most (67.2%), followed by breeding, and information about the situation of plant epidemics/pests which were the same proportion of demand (58.2%).

For small orchards, they suggested developing climate forecasting technology (71.4%), followed by breeding (63.8%) and flowering (56.0%), respectively.

Table No. 1 Problems and obstacles in fruit production classified by orchard size

Types of problems and obstacles	Overall	Average score of problems				F-test
		Very small	Small	Middle	Large	
1. Sapling scarcity	2.0	2.4	1.9	1.9	1.8	4.67***
2. Sapling quality	2.4	2.8	2.4	2.3	2.3	2.33*
3. Soil quality	2.7	2.7	2.7	2.6	2.6	0.08
4. Flowering	3.0	2.9	2.8	3.0	3.2	1.96
5. Plant disease management	3.4	4.0	3.0	3.4	3.3	1.49
6. Pest management	3.3	3.2	3.1	3.4	3.5	1.65
7. Weed management	2.8	2.8	2.6	3.0	2.7	1.82
8. Labour shortage	2.9	2.7	2.8	3.1	3.1	1.73
9. Quality and expertise labour skills	3.0	2.8	2.8	3.1	3.1	2.06
10. Watering	2.7	2.6	2.4	2.9	2.8	2.24*
11. Trimming	2.4	2.4	2.2	2.6	2.4	2.35*
12. Harvesting	2.7	2.6	2.4	3.1	2.9	3.98***
13. Climate variability	3.7	3.4	3.4	3.9	4.1	4.82***
14. GAP Standard	2.5	2.4	2.2	2.7	2.6	8.98***
15. Product grading	2.6	2.5	2.3	2.9	2.8	2.80**
16. Price information	2.7	2.6	2.3	3.0	2.9	5.08***

Note: < 1.67 = Low level; 1.68 – 3.34 = Moderate level; > 3.35= High level

*** p < 0.01; ** p < 0.05; *p < 0.1

For medium-sized orchards, the most asked to develop technology for quality and nutrient testing in the soil, followed by watering, and flowering, respectively.

When testing the relationship between the need for technology development and innovation of each type and group of production area sizes, it found that it was necessary to develop technology and innovation in three areas that were significantly related to the size of the orchard including quality and nutrient testing in the soil (χ^2_{soi}= 11.10; $p < 0.05$), plant breeding (χ^2_{var}= 7.80; $p < 0.05$), and post-harvest (χ^2_{posth}= 10.67; $p < 0.05$). Whereas the need for technology development and other innovations is not related to the size of the orchard (Table No. 2).

The need for technology development and innovation of each group according to fruit tree types, consisting of durian, mangosteen, banana, mango, coconut, longan, lychee, grapefruit, tamarind were as follows:

Table No. 2 Proportion of technology development needs and innovation of fruit orchard farmers classified by orchard size in 2019 (Unit: Cases)

Lists	Overall n = 295	Very small n = 68	Small n = 83	Middle n = 67	Large n = 77	χ^2
Plant breeding	157	39	52	34	32	7.80**
Soil quality and soil nutrient testing	164	27	45	42	50	11.10**
Fertilizing	120	25	29	32	34	3.34
Watering	153	31	35	40	47	8.44**
Flowering	162	35	44	39	44	0.89
Trimming	63	13	21	15	23	5.92
Weather forecasting	197	45	61	38	53	4.90
News about plant epidemics/pests	139	38	40	28	33	3.45
Harvest	132	27	36	30	39	1.84
Post-harvest	93	28	31	20	14	10.67**
Agricultural waste management	67	19	21	14	13	2.99

Note *** $p < 0.01$; ** $p < 0.05$; *$p < 0.1$

Durian

A survey of 142 durian farmers found that durian farmers asked to develop technology and innovation in irrigation the most (60.5%), followed by soil quality and soil nutrient testing (58.4%), and climate forecasting accuracy (57.0%), respectively. Twenty-three very small durian farmers needed technology for information on plant/pest epidemics situation, breed, and harvesting technology in the same proportion (60.8%). Because the orchard size of this group was very small, high-yielding varieties were needed as well as being resistant to disease and insects. The results from in-depth interviews with durian farmers informed that the group of farmers with a very small area faced labor shortages and high labor costs for harvesting. The availability of technology to facilitate harvesting would support to reduce production costs for them in another way.

The most technology that 28 small farmers needed was climate forecasting technology (67.8%), followed by soil quality and nutrient testing (60.7%) and flowering (57.1%). A group of 39 medium-sized farmers needed technology or innovation in irrigation the most (66.7%), followed by flowering (61.5%), soil quality and soil nutrient testing, and fertilizing at the same proportion at 53.8%. Meanwhile, 52 large farmers needed technology or innovation to monitor soil quality and soil nutrients the most (69.2%), followed by irrigation (67.3%) and an accurate climate forecasting system (61.5%), which was more than small orchards. According to the large orchard, they spent large amounts of money to maintain the soil and to set up a watering system that was suitable for lifetime plant requirements. Especially, watering was an important factor in off-season durian production, which was part of an important production management plan. For the needs of quality and nutrient testing in the soil, data from interviews revealed that orchard owners did soil inspection once a year before fertilizing. They randomly dogged the soil within the orchard at three points and sent the sample soil to the agricultural sub-district officer. This process took at least two weeks before the results were known. If there is a development of technology or innovation that makes soil quality inspection easier and can be done it by the owner at the conversion. Moreover, the technology should be inexpensive in cost; it will help durian farmers to make soil management and fertilization more effective to meet the needs of durian trees.

Mangosteen

A survey of 108 mangosteen growers needed watering system technology, and soil quality and soil nutrients testing in equal proportions (63.8%), followed by flowering technology (60.1%).

When considering separate groups, it was found that a very small group of 10 gardeners needed technology for irrigation and flowering 70.0% and information about plant/pest epidemic situation 60.0%. A group of 25 small farmers most wanted improvements in climate forecasting (68.0%), followed by soil quality testing and soil nutrient testing (64.0%). Thirty-three middle-orchards and 40 large orchards wanted the same technology. They needed water supply, soil quality and soil nutrient testing and flowering with more than 50% of the demand in all three issues, which was consistent with the results of the level of problems and obstacles in the water supply of large gardens at a high level more than any other group, especially a small orchard group that assessed the level of water problems at a moderate level.

In addition, the results of in-depth interviews with mangosteen farmers revealed that they needed technology that helps in harvesting. Due to the current mangosteen harvesting situation was labor intensive. If there is a high yield in some years, the harvest cannot be harvested in time. Their mangosteen was damaged and could not be sold.

Banana

Eighty-eight banana-producing farmers needed watering technology at most (61.3%), followed by weather forecasting (59.0%), soil quality and soil nutrient testing (55.6%). When considering the separate groups, it showed that 23 very small orchards needed weather forecasting (78.2%), followed by postharvest management (56.5%) and information reports on epidemic situation (65.2%), respectively.

For 33 small banana plantations and 14 medium banana plantations, they needed the same technology as watering systems, soil quality and soil nutrient testing, and flowering. While 18 large banana plantations required technology for soil quality and soil nutrient testing, the most, followed by watering and weather forecasting.

Commercial banana production requires a lot of water. This corresponds to the results of the assessment of the problem level of watering. The middle and large orchards scores were 3.4 and 3.2 points, respectively, which were higher than the very small group and the small group assessed at 2.1 and 2.3 points, respectively. For soil quality inspection and soil nutrient testing, the information obtained from the in-depth interviews showed that although bananas can be grown in all regions of Thailand, the plot must be managed according to clay set. Each clay set required a different amount of nutrients to match the standard. The problem of soil quality was an important problem for middle-class orchards according to 3.4 points of problem assessment, which was higher than other groups. Moreover, in case of banana production under contracts with private companies, the company would test soil quality before production. But the soil testing was very low in general because soil quality testing takes time, as mentioned in the case of durian.

Aromatic coconut

The result of 53 coconut orchard survey, divided into 11 very small farmers, 18 small farmers, 14 medium farmers and ten large planters, found that they needed to improve the weather forecasting the most (66.0%), followed by soil quality and soil nutrient testing, and information on plant/pest epidemic situation 58.4%. When considering the group by production area, each group had a corresponding demand.

Climate change directly affected coconut orchard management. From an in-depth interview, farmers commented that warmer temperatures resulted in low humidity conditions. It was a key factor in increasing pests (the average problem level for all groups was 3.4 points) leading to the second source of need being for information on plant/pest epidemic situation. If the weather forecast was more accurate and received timely information, it would help to manage the coconut plantation easier. The next demand was soil quality and soil nutrient testing technology. Over 50% of very small and small orchards needed. There was still a need to develop coconut breeding to be more disease resistance. Large orchards required technology or innovations supporting in harvest process. Because it required skilled labour and labour costs were high compared to other production costs.

Longan

The results of 33 longan farmers (4 very small farmers, 12 small farmers, 6 medium farmers and 11 large farmers) indicated that all groups needed a lot of improvement in weather forecasting (81.8%). For other needs, each group wanted different needs. The small orchard wanted flowering and harvesting (58.3%). The medium orchard wanted flowering and soil quality and soil nutrient testing (66.7%). According to problem and obstacle assessments, flowering technology was consistent with the assessment of both small and medium orchards at 3.0 and 3.3 points. Large orchards needed watering and harvest technology (72.7%).

Lychee

A survey of 13 orchard owners, divided into two very small, two small, five medium, and four large orchards, found that all groups of lychee farmers wanted soil quality and soil nutrients (76.9%), except for small gardeners who did not have this requirement, followed by flowering, and weather forecasting at

69.2%, especially the medium and large orchards. However, the result was the opinions of only two small orchard owners. Other groups wanted flowering technology of flowering, which was an important problem for all groups because the results of the assessment of problems and obstacles of flowering rate were in the range of 3.0-3.5 points, and the next demand was harvest technology.

Pomelo

The survey of 21 pomelo orchards was divided into eight very small, five small, five medium and three large orchards. All groups of orchards (except large size) wanted improvements in weather forecasting (80.9%), a key issue in orchard management. Although the assessment results of the problem level of climate change were moderate. However, from orchard viewpoints on climate change, farmers must adapt to cope with weather situation. If weather forecasting systems could be accurate at the plot level, it would be useful for orchard management. The next need was in flowering (76.1%), which was a major problem and obstacle for all groups, especially the large group of farmers who assessed the level of problem at a high level. Moreover, it was also needed new varieties that be resistant to plant disease and technology for soil quality and soil nutrient testing

Tamarind

The survey results of 13 tamarind farmers, divided into one very small gardener, two small gardeners, six medium gardeners and four large gardeners, found that each group needed different technology. Small orchards required improved fertilization and postharvest technology. Very small and medium and large orchards needed harvesting technology the most (76.9%), followed by weather forecasting (61.5%). This corresponds to the results of the assessment of the problem level at a high level.

According to the results of the survey on the need for development of technology and innovation for fruit production classified by type and size of orchards, it showed that the demands for technology were not much different. This corresponds to the need for technology and innovation for fruit production presented in the overall development of technology in four areas, including fertilizing, watering, weather forecasting and agricultural waste management.

In Table No. 3, mangosteen grower group related to the need for technology development in six areas: plant breeding, soil quality and nutrient testing, fertilizing, watering, weather forecasting and agricultural waste management.

Banana grower group related to the need for technology development in three areas: flowering post-harvest, and agricultural waste management.

Mango growers related to the need for technology development in three areas: fertilizing, weather forecasting, harvest, and watering.

Coconut grower group related to the need for technology development in two areas: the situation of plant epidemics/pests, and agricultural waste management.

Table No. 3 The need for technology development and innovation of orchards classified by type of fruit.

Lists	Durian n = 142	Mangosteen n = 108	Banana n = 79	Mango n = 72	Coconut n = 53	Longan n = 33	Lychee n = 13	Pomelo n = 28	Tamarind n = 13
Plant breeding	70 (χ^{2}=1.69)	48 (χ^{2}2=5.27**)	39 (χ^{2}=0.64)	44 (χ^{2}=2.38)	29 (χ^{2}=0.05)	12 (χ^{2}=4.24**)	5 (χ^{2}=1.18)	21 (χ^{2}=5.89**)	6 (χ^{2}=0.27)
Soil quality nutrient testing	83 (χ^{2}=0.90)	69 (χ^{2}=4.74**)	41 (χ^{2}=0.59)	38 (χ^{2}=0.30)	31 (χ^{2}=0.21)	19 (χ^{2}=0.05)	10 (χ^{2}=2.50)	17 (χ^{2}=0.32)	5 (χ^{2}=1.61)
Fertilizing	72 (χ^{2}=11.40***)	57 (χ^{2}=10.33***)	31 (χ^{2}=0.09)	22 (χ^{2}=4.04**)	19 (χ^{2}=0.62)	9 (χ^{2}=2.76*)	5 (χ^{2}=0.02)	8 (χ^{2}=1.87)	8 (χ^{2}=2.45)
Watering	86 (χ^{2}=8.29***)	69 (χ^{2}=9.86***)	45 (χ^{2}=1.12)	31 (χ^{2}=2.96*)	24 (χ^{2}=1.12)	13 (χ^{2}=2.31)	5 (χ^{2}=0.97)	13 (χ^{2}=0.36)	6 (χ^{2}=0.17)
Flowering	80 (χ^{2}=0.22)	65 (χ^{2}=1.91)	32 (χ^{2}=9.04***)	44 (χ^{2}=1.47)	29 (χ^{2}=0.001)	20 (χ^{2}=0.48)	9 (χ^{2}=1.12)	18 (χ^{2}=1.09)	6 (χ^{2}=0.42)
Trimming	32 (χ^{2}=0.22)	27 (χ^{2}=1.34)	21 (χ^{2}=1.75)	18 (χ^{2}=0.75)	15 (χ^{2}=1.85)	6 (χ^{2}=0.22)	3 (χ^{2}=0.02)	10 (χ^{2}=3.79)	3 (χ^{2}=0.02)
Weather forecasting	81 (χ^{2}=11.70***)	63 (χ^{2}=5.47*)*)	52 (χ^{2}=0.0)4)	59 (χ^{2}=9.87**)*)	35 (χ^{2}=0.0)1)	27 (χ^{2}=3.78*)	9 (χ^{2}=0.03)	20 (χ^{2}=0.30)	8 (χ^{2}=0.16)
News about plant epidemics/pests	62 (χ^{2}=1.31)	46 (χ^{2}=1.40)	37 (χ^{2}=0.003)	33 (χ^{2}=0.06)	31 (χ^{2}=3.35***)	12 (χ^{2}=1.72)	4 (χ^{2}=1.45)	12 (χ^{2}=0.22)	4 (χ^{2}=1.45)
Harvest	70 (χ^{2}=2.29)	44 (χ^{2}=1.10)	31 (χ^{2}=1.32)	23 (χ^{2}=6.31**)	24 (χ^{2}=0.007)	17 (χ^{2}=0.68)	7 (χ^{2}=0.45)	11 (χ^{2}=0.37)	10 (χ^{2}=5.69**)

Table No. 3 (Continued)

Lists	Durian n = 142	Mangosteen n = 108	Banana n = 79	Mango n = 72	Coconut n = 53	Longan n = 33	Lychee n = 13	Pomelo n = 28	Tamarind n = 13
Post-harvest	40 (χ^2=1.42)	31 (χ^2=0.62)	34 (χ^2=6.62**)	19 (χ^2=1.16)	15 (χ^2=0.31)	10 (χ^2=0.02)	3 (χ^2=0.44)	9 (χ^2=0.005)	4 (χ^2=0.003)
Agricultural waste management	24 (χ^2=5.26**)	16 (χ^2=6.05**)	27 (χ^2=8.07***)	17 (χ^2=0.04)	17 (χ^2=3.22*)	10 (χ^2=1.21)	1 (χ^2=1.74)	6 (χ^2=0.02)	4 (χ^2=0.50)

Note: The numbers in parentheses are the Pearson Chi-square for the correlation test between individual needs and groups of farmers. *** $p < 0.01$; ** $p < 0.05$; * p <

Longan grower group related to the need for technology development in two areas: plant breeding, fertilizing, and weather forecasting.

Pomelo grower group related to the need to develop specific breeding technologies and tamarind grower group related to the need to develop specialized harvesting technology. While lychee growers have no relationship with the need for technology development in any field.

Conclusion and Discussion

The major problem affecting fruit orchards was climate variability, which was an important cause of plant diseases, and pest outbreaks as well as low flowering rates. The problem of plant disease and pest infestation in fruit production was severely influenced on both product and fruit trees, depending on the type of disease and pest. For example, banana production in Africa uses genetic engineering to address banana diseases to enhance agriculture and improve Africa's food security (Tripathi, et al., 2017, pp. 37-38).

Other issues such as soil quality, water supply, harvesting, fruit price information, grading, establishing GAP standards for seed quality, pruning, and seed shortage, were problems that affected fruit production at a moderate level. This was in line with the results of the survey on the need for technology development and innovation for fruit production. All groups demanded to develop technology for weather forecasting to be as accurate as possible and can be predicted at the orchard level. In general, fruit growers followed the news about the weather forecast including outbreaks of plant diseases and pests, through television and social media. Although some tracked through mobile applications, it was still not accurate because it was an area-level that directly affected the rate of low flowering. Some farmers demanded climate-tolerant breeding including information on outbreaks of plant diseases and pest situations that caused yields to not be as expected quickly. These problems were common among Taiwanese fruit growers. Joe-Air et al. (2013, pp. 323-325) developed a web-based integrated pest management system in coconut plantations that utilizes wireless sensor networks for precision agriculture. The data was sent to mobile phones and computers for remote control. This allowed the orchard owner to know the current situation, which helps in planning and managing plant diseases and pests in time before they are damaged. However, this system required historical data to be assessed as well. Precision agriculture concept tracking systems greatly reduce the damage caused by infestations of plant diseases and pests.

For the difficulty of soil nutrient analysis, it must develop to be easy to use and affordable.

Orchard size affected the need for different technologies as well. Very small and small orchards wanted new plant breeding to be more climate-tolerant, and plant diseases and pest resistance. This technology will enable effective orchard management and improve fruit quality. For large chards, watering was a problem more than medium and small groups. As the plot was large, it demanded an efficient irrigation system suitable for each plant's lifespan. Each fruit tree was produced using technology and innovation that was unique according to fruit type. When considering the overall technology needs in various fields, the needs were in the same direction. Thus, technology development should have a variety of applications supporting different fruits and production sizes.

Reserch Suggestion

The results indicated that (1) the government should have urgent policies to research and develop technologies or innovations that mitigate production problems, climate variability, plant disease and pest management, and the quality and expertise of workers. Researchers should develop technology for weather forecasting at the orchard level as quickly as possible because it is an important cause of fruit production management at present. Next is soil testing technology that helps analyze soil nutrients easier and inexpensively. Because at present, when farmers want to check the nutrients in the soil, they must send the sample to the agricultural district for testing, which takes time to know the results. Therefore, it cannot be utilized in fertilizing in the current production cycle. (2) The Ministry of Agriculture and Cooperatives should increase the research budget on fruit breeding in order to develop a variety of fruit tree species and can resist disease and pests to support climate change. (3) Future technology should be easier to use than current technology and to be utilized in accordance with the needs of the fruit orchard farmers. The development process should involve fruit orchard farmers to share their opinions and test prototypes. Their information will facilitate researchers tracking real problems or obstacles and guiding them to develop suitable technology for orchard management. Farmers participating in the test should include small, medium, and large orchards. (4) To achieve widespread use of technology, in the development of technology, the average cost incurred in implementing a new technology should not exceed the average cost of the technology or production process currently in use.

Acknowledgments

The author would like to thank the research fund from Thailand Science Research and Innovation (TSRI) under the project of technology-driven approaches for the development of orchards and thanks to all farmers for the extremely useful information.

Bibliography

Department of Agriculture Extention. (2018). **Statistic Report for Agricultural Production: Perennial Crop "Fruit"**. Retrieved December 25, 2018 from Department of Agricultural Extension: http://production.doae.go.th

Joe-Air , J., Tzu-Shiang , L., En-Cheng , Y., Chwan-Lu , T., Chia-Pang , C., Chung-Wei , Y., et al. (2013). Application of a web-based remote agro-ecological monitoring system for observing spatial distribution and dynamics of Bactrocera dorsalis in fruit orchards. **Precision Agric**, 14(3), 323-342.

Lopez-Vega, H., Tell, F., and Vanhaverbeke, W. (2015). Where and how to search? Search paths in open innovation. **Research Policy**, 45(2016), 125-136.

Mansyah, E. and Sutanto, A. (2020). Tropical Fruit Research and Development Programs of Indonesian Tropical Fruits Research Institute (ITFRI). **IOP Conf. Ser.: Earth Environ. Sci**, 583(1), 1-4.

Office of Agritural Economics. (2018). **Agricultural Economic Outlook 2018 and Trend in 2019.** Bangkok: Office of Agricultural Economics, Thailand.

Spradlin, D. (2012, September 1). Are You Solving the Right Problem? **Harvard Business Review**, 84-93.

Sritongchuay, T., Kremen C., and Bumrungsri, S. (2016). Effects of Forest and Cave Proximity on Fruit Set of Tree Crops in Tropical Orchards in Southern Thailand. **Journal of Tropical Ecology**, 32(4), 269-279.

Tripathi, L., Atkinson, H., Roderick, H., Kubiriba, J., and Tripathi, J. N. (2017). Genetically Engineered Bananas Resistant to Xanthomonas wilt Disease and Nematodes. **Food and Energy Security**, 6(2), 37-47.

World Health Organization. (2011). **WHO patient safety curriculum guide: multi-professional edition.** Malta: World Health Organization.

Yahia, E. M. (2006). Modified and Controlled Atmospheres for Tropical Fruits. **Stewart Postharvest Review**, 5(6), 1-10.