Aceh tomato farmers and the application of tomato cultivation technology

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Tomatoes are one of the most widely cultivated agricultural products in Aceh Province and are one of the livelihoods of some farmers. The purpose of this study is to describe the development of the latest tomato planting technology in the world and develop tomato planting techniques in Aceh. This study uses a quota sampling survey technique with 40 respondents and descriptive analysis methods. The results of this study indicate how to use technology for tomato cultivation in Aceh Province is still relatively simple. We found that tomato growers in Aceh are generally small scale. Their production level is low, their education level is low, selling prices fluctuate, and pest management uses chemicals. The application of tomato cultivation technology in Aceh Province is still lagging. The adoption of technologies such as greenhouses, trends in organic tomato production, the use of organic fertilizers, and the use of the latest agricultural tools and machinery do not yet exist. The active role and guidance of the government, non-governmental organizations and academics are essential in efforts to increase the adoption of technology for tomato farmers in Aceh.

1. Introduction

Tomato is one of the many agricultural commodities cultivated in Indonesia, especially Aceh Province. Tomato (*Lycopersicum esculentum* Mill) is one of the most widely cultivated agrarian products in the tropics. It has high nutritional value as well as a source of vitamins and minerals [1]. Tomato plants can grow well in the dry season when getting adequate irrigation. Tomatoes can grow in cold air, with temperatures at night ranging from 10˚C - 20˚C and temperatures during the day ranging from 19˚C - 29˚C. Temperatures that are too high will cause damage due to the blazing sun, while temperatures that are too low will cause growth disturbances [2].

Aceh Province is one of the regions that contribute as a producer of tomato commodities. Tomato plants live in the highlands and lowlands. Bener Meriah Regency and Central Aceh District are among the largest tomato producers in Aceh Province. Tomato production in Bener Meriah Regency and Central Aceh District fluctuates every year. Excessive production of tomatoes from other regions, pests, and diseases cause fluctuations in tomato production. Despite increasing production fluctuations, tomato farmers in Aceh Province continue farming because it is one of their livelihoods to make ends meet.

The technology of tomato cultivation in Aceh Province is still relatively simple compared to the growing tomato cultivation technology at present. Tomato cultivation in Aceh still uses plastic mulch to maintain soil moisture, processing land using tractors, and handling pests using chemical pesticides. Changing the trend of tomato production to organic has been widely applied in other countries such as China and Mexico. Growing organic tomatoes currently using greenhouses as shade, fertilizing manipulations, breeding, and tomato domestication, using organic fertilizers, and handling pests and diseases using organic pesticides. Tomato farmers in Aceh Province have not implemented organic cultivation and are still using standard technology. Therefore the purpose of this study is to describe the
development of the latest tomato cultivation technology in the world and evaluate tomato planting techniques in Aceh.

2. Literature Review

Tomato cultivation in Aceh Province still uses simple technology. Tomatoes are even planted in soil media and often experience crop failures caused by pests and diseases. Limited land production also resulted in reduced tomato production. One of the breakthroughs in farming today is without using soil media known as hydroponic cultivation. The use of greenhouses and chemical nutrient solutions is needed to carry out hydroponic tomato cultivation. However, the limited technology and ability of tomato farmers in Aceh have made this technological innovation not yet applicable. Farmers have used rice husk as a medium for growing tomatoes, but the results did not have a significant change in growth and yield. [3]

Compared to other tomato-producing regions, the condition of tomato cultivation in Aceh Province is still lagging. The lack of research on tomato cultivation in Aceh Province has made farmers feel the impact. A lot of research is needed or recommendations from related parties so that tomato farmers can increase the yield of tomatoes.

The current trends in urban China consume fresh vegetables purchased in greenhouses. Chinese people recognize the importance of environmental protection and food security so that the production and consumption activities of agricultural products have shifted to organic production systems. Activists, scientists, and other policy [4] makers have introduced organic cultivation [4]. Organic production trend makes agricultural activities pollution-free. The main driver of adopting pollution-free agriculture is to ensure high product quality and high prices [5]. According to a survey in China's Jiangxi province, the price of pollution-free vegetables is more elevated than traditionally produced vegetables that use chemicals [6].

In the production of organic tomatoes, different farming steps are used to control pests, actions such as trap color plates are carried out. Besides, farmers also use small amounts of bio-pesticides, not chemical pesticides that can damage soil conditions. The use of bio-pesticides is still considered good because farmers only use a little bio-pesticide for the needs of tomato plants. Another advantage of bio-pesticides is pesticides do not accumulate on plant parts and in the soil so that it does not interfere with the health of environment and humans [7].

China has implemented greenhouse technology. Greenhouses are used to protect plants from environmental conditions that are detrimental and manipulate the environment that is suitable for plants to increase crop yields. Plants planted in greenhouses can produce throughout the year with higher production quality than plants built on open land. In recent years, technological advances for agricultural commodities using greenhouses have been used by China [8].

Mexico seeks to improve the efficiency of resources and infrastructure in cultivating tomatoes. They develop technology training and technical assistance to farmers. The results of these actions will increase product productivity and quality, and increase the competitiveness of Mexican tomatoes in the global market.

Increased tomato productivity and quality in Mexico have started since the Free Trade Agreement (NAFTA) with the United States and Canada, which has a positive effect on tomato production. But other factors that can make tomato production better are like stopping the use of vague tomato varieties, promoting greenhouses, producing and developing biotechnology. Organic tomato production innovation is a response to the environmental impact on conventional production, which has many adverse effects on the environment [9].
3. Research Methodology

Study Area
The places of this research are Bener Meriah Regency and Central Aceh. Research carried out June 2018 - July 2018.

Sampling Technique
The sampling technique in this study was using the Quota Sampling technique. Quota sampling is a technique used to determine a sample of a population that has specific characteristics until the desired number (quota) is fulfilled [10]. In this study, the selection of samples by setting certain quotas for participation. After sampling fulfills the quota, data are collected [11]. The sample of this research is tomato farmers who have been planting tomatoes for more than one year. The location of the farm is under the research area with high tomato production.

Data collection and analysis
Data collection methods in this study used a questionnaire containing questions to obtain data and information from respondents. Researchers interview farmers. Interview results were analyzed using descriptive statistics in the form of tables and graphs.

4. Results

Tomato plants (Lycopersicum esculentum Mill) can grow in two categories of regions. Tomato plants in the highlands (> 900 masl) and lowlands (<500 masl). Tomatoes in the highlands will require a relatively lower temperature than in the valleys. When conducting business in cultivation, farmers must pay attention to several things such as temperature, altitude associated with sunlight, rainfall, humidity, and varieties obtained by regional characteristics [12].

The condition of the Bener Meriah Regency and Central Aceh Regency located in the highlands makes tomato plants grow well. Farmers in both districts besides working as tomato growers also become coffee farmers. The choice of tomato plants as a cultivation competition is due to the relatively short harvest time and supporting essential requirements. Tomato cultivation in two districts still uses simple technology. The following table is a description of the results of interviews with farmers:

| Variable                      | Minimal  | Maximum       | Average       |
|-------------------------------|----------|---------------|---------------|
| Land Area (Ha)                | 0.13     | 1             | 0.33          |
| Selling Price of Tomato (IDR)| Rp 150/kg| Rp 17.500/kg  | Rp 4.581/kg   |
| Income (IDR)                  | Rp 1,500,000 | Rp 100,000,000 | Rp 16,880,000 |
| Background Education          | Primary School (2 people) | Bachelor (5 people) | Senior High School (33 people) |

The area of tomato owned by tomato farmers in the field of Bener Meriah Regency and Central Aceh Regency is still relatively small. The smallest land area owned by farmers is 0.13 ha with a maximum area of 1 ha. The small amount of farming land owned by farmers makes the cultivation of tomatoes not run optimally. Many tomato yields will be supported if the maximum land area will increase production yields and increase farmers' profits.

The selling price of tomatoes often fluctuates. Tomatoes are perishable agricultural commodities that do not last long. Fluctuations in the selling price of tomatoes significantly affect the income of farmers. Although the selling price often fluctuates, farmers grow crops to meet market demand, albeit on a small scale [13]. Farmers' income can increase if they try to add value to tomatoes or produce processed products. However, compared to transforming it into specific products, tomato farmers prefer to sell...
fresh tomatoes directly in the market, especially small farmers who lack funds [14]. Besides being caused by lack of funds, farmers also do not have enough knowledge to process tomatoes into specific products.

The profits of farmers from tomato farming are still relatively low. Not all farmers get the maximum benefit. Small land area, inappropriate use of technology at the time of cultivation, low selling prices of tomatoes at harvest, and a small amount of production are the cause. The maximum profit is very beneficial for further cultivation activities because the procurement of tomato production inputs is relatively expensive.

The education level of tomato farmers in Bener Meriah and Central Aceh Districts is quite good. Although the total respondents, some farmers have an elementary school educational background. The level of education will influence the mindset of farmers in making decisions. Having adequate knowledge will facilitate farmers in receiving information about the latest innovations and technologies [15].

The limited information obtained by farmers makes tomato cultivation based on the experience of farmers. The current technology of tomato cultivation is still traditional. The processing of farming land is already using a tractor, but some farmers who have limited capital choose to cultivate the land using hoes. Farmers have used plastic mulch to maintain soil moisture, and in addition to preserving soil moisture, mulch also aims to repel pests that attack tomatoes. Reflection of sunlight on the plastic mulch during the day makes the pests that attach to the stem, or the tomato leaves will fall.

Farmers deal with pests and diseases that attack tomatoes using chemicals. Pesticides and fungicides used by farmers are sprayed on tomato plants regularly. If pest and disease attacks increase, the intensity of spraying and the dose of chemicals also increase. This maintenance method not only prevents damage to the environment.

In addition to pest attacks such as caterpillars, fruit borer in tomatoes, massive pest attacks also attack tomato land in the region. Appropriate actions overcome significant pests that attack tomato lands such as pigs, monkeys, and mice. Farmers handle pigs by hunting. Meanwhile, to prevent monkey attacks, tomato land is given a fence around the business land, either a living wall using protective plants or wire fences. Prevention of rat pests is overcome by trapping in every corner of the area. Prevention of pest attacks is still traditionally carried out due to the absence of the latest information regarding the use of technology to deal with pest attacks.

Factors that influence tomato production are tomato adaptation to the season, fruit type, plant habits, fertilization, soil texture, pruning, planting, insects, weeds, and disease control. Tomato production is very dependent on the weather. Improper weather will cause damage and crop losses. For farmers to overcome this problem, farmers must choose varieties that are resistant to certain seasons, such as using seeds that are suitable for soil conditions. Also, farmers should use herbicides that are suitable for the needs of weeds, spraying to treat pests and diseases, pruning, tying tomatoes with ropes, and watering [16].

Based on 2017 FAO data [17], the highest tomato production is China then received by India and Turkey. Most of the tomato production, originating from, China, has a large land area and uses the latest technology. Tomato farming activities in China have supported trends of organic output.

| No | Country | Total Production(Ton) |
|----|---------|-----------------------|
| 1  | China   | 59,514.773            |
| 2  | India   | 20,708.000            |
| 3  | Turkey  | 12,750.000            |
| 4  | USA     | 10,910.990            |
| 5  | Egypt   | 7,297.108             |
| No | Country   | Total Production(Ton) |
|----|-----------|-----------------------|
| 6  | Iran      | 6.177.290             |
| 7  | Italy     | 6.015.868             |
| 8  | Spain     | 5.163.466             |
| 9  | Mexico    | 4.243.058             |
| 10 | Brazil    | 4.230.150             |
| ...| ...       | ...                   |
| 21 | Indonesia | 962.856               |

The advantage of tomato cultivation in China is the use of chemical controls for handling pests and diseases less because it focuses more on treating biological controls. Pest and disease control using biological controls must ensure that farmers get information about it. With the example of the use of biological controls, this will improve the quality of farmers' production. Reduced use of chemical pesticides will reduce residues in the environment. The Chinese government has developed a program that promotes natural enemies with additional information for farmers to use more biological controls. This sustainability program is very effective in developing biological control for small scale in China. This program can be more intensive if combined with the use of glass to manipulate the environment [18].

![Greenhouse technology in China](image1.png)

Figure 1. Greenhouse technology in China [19]

The latest technology like Greenhouse has environmental impacts such as increasing global temperatures. The newest technology, such as Greenhouse has globally preferred ecological effects. Then it is crucial to analyze the effect of the environment. Life Cycle Analysis (LCA) is a tool to analyze the environmental impact of a product at all stages in its life cycle, including extraction of resources,
production of materials, parts of products and products themselves; transport, use, and disposal either through recycling or final disposal. The use of LCA to: (a) analyze the origin of environmental impacts, such as global warming, acidification, eutrophication, human toxicity, air toxicity, soil toxicity associated with certain products; (b) comparing factors to improve product; (c) product design new; and (d) choose between a comparable number of results [20].

The cultivation of tomatoes is inseparable from the disruption of pest attacks. Pest attacks in the form of insects, mainly migrant pests, will appear every time there is an increase in temperature and rapid rates of population growth and migration. As a result of climate change, migrant pests colonize new habitats. This is the result of a progressive increase in carbon dioxide in the atmosphere and direct impacts on pest species (accumulation of carbon dioxide effects) and indirectly (through interactions with other environmental factors) [21]. Tuta Absoluta is a destructive tomato pest originating from South America. After early detection in eastern Spain in 2006, it quickly invaded various other countries. If farmers do not take control measures, then pests can cause an 80-100% yield of tomato production in a greenhouse or tomatoes grown in open land [22].

China, as the first producer of tomatoes in the world, is ranked 10th as the exporting country. Mexico as a tomato exporting country because the selling price of Mexican tomatoes is higher than China. The following table shows the data of the world’s tomato exporting countries:

| No | Country      | Total Production (Ton)                                      |
|----|--------------|------------------------------------------------------------|
| 1  | Mexico       | $2.3 billion (24.5% of total tomato exports)               |
| 2  | Netherlands  | $1.9 M billion (20.8% of total tomato exports)             |
| 3  | Spain        | $1.1 million (11.9% of total tomato exports)               |
| 4  | Morocco      | $686.8 million (7.4% of total tomato exports)              |
| 5  | Canada       | $411.7 million (4.5% of total tomato exports)              |
| 6  | France       | $369.8 million (4% of total tomato exports)                |
| 7  | United States| $325 million (3.5% of total tomato exports)                |
| 8  | Turkey       | $289.9 million (3.1% of total tomato exports)              |
| 9  | Belgium      | $284, 1 million (3.1% of total tomato exports)             |
| 10 | China        | $207.3 million (2.2% of total tomato exports)              |
| ...| ...          | ...                                                        |
| 82 | Indonesia    | $240,000 (0.003% of total tomato exports)                  |

Based on data from world’s top exporters [23], Indonesia is 82nd for tomato export activities in 2018. Limited tomato commodities to be enlarged because the tomato products produced do not meet world market requirements. To increase the export value of tomatoes, Indonesia needs to improve the quality of products such as using superior seeds and cultivate organic tomatoes that are free of pesticides. This effort is very important because the current trend of the tomato trade is organic and quality tomatoes. Mexico is the country that ranked first in tomato export activities. Tomatoes are one of Mexico's most famous export commodities, with the country's tomato sector responsible for 18.7% of Mexico's agricultural export revenues. The tomato sector's increased productivity in Mexico is defined as an increase in the results of the adoption of new technologies or practices in the industry, or through improvements in existing technologies and practices. The tomato sector seems to be an excellent
candidate for public and private research and development, investment, and productivity improvement efforts [24].

Although recently an increase in planting area has been reported, the growth rate is low like tomatoes. Tomato-producing regions such as Sinaloa and Baja California continue to shift from open-field production to protecting production, using fewer total areas while increasing yield. To get good quality export tomatoes, some producers from Sinaloa produce tomatoes in the states of Michoacán, Jalisco, and Queretaro to have access to summer exports after winter. These countries also orient some of their production of fancy tomato production. Smaller producer countries such as Nuevo Leon in the northern part of Mexico are increasing protected agricultural production [25].

Protected agricultural activities in Mexico make producers increasingly aware of the benefits of production, quality, pest control, and reduced risk exposure to climate change. The Mexican government introduced this protected agricultural production method to rural areas as a form of social development. The main horticultural products produced by applying this technology are tomatoes (70 percent), paprika (16 percent), cucumbers (10 percent), and the rest products such as flowers, chili, berries, and papaya.

The typical tomato attack in Mexico is Tuta Absoluta, which is the same as pests that attack tomatoes in China. The handling of Tuta Absoluta pests in Mexico is to do a biocontrol program by releasing inundative parasitoid. Besides manipulating fertilizers using organic fertilizers can suppress Tuta Absoluta pest attacks.

The main factors that influence technology adoption are assets, vulnerabilities, and institutions. Limited assets, such as land, education, or equipment, will limit the process of technology adoption. More attention is needed, and that means more attention is needed from further studies and technological development efforts that require few assets. Decision-makers also need to be aware that the technology built on assets owned by poor farmers is more likely to be adopted.

5. Discussion

Tomato cultivation in Indonesia still uses traditional land. The owners of tomato gardens are mostly tomato farmers themselves, and the rest are others who use the area to grow tomatoes. Tomato planting in Bener Meriah and Central Aceh still does not use the latest technology such as greenhouses. There is a difference in the quality of the tomatoes produced when compared to China and Mexico. China, as the largest tomato producing country in the world, has implemented "smart farming" to do tomato cultivation. The use of greenhouses as a place to grow tomatoes makes production more controlled.

Smart Farming in China in addition to using greenhouses also considers the quality of tomatoes, reducing the use of chemical pesticides and drugs making tomato-oriented organic tomato production. Harvesting arrangements according to needs, so tomato stock in China is always enough. The marketing of organic tomatoes is more desirable because people's lifestyles have changed to a healthy lifestyle by reducing the consumption of vegetables that contain pesticides.

Although China involves the largest tomato producing country in the world, Mexico, as the largest exporting country has also implemented smart agriculture using greenhouses. The government also initiated agriculture in Mexico by introducing protected production methods such as demanding tomato quality, controlling pests, and reducing risks arising from climate change. Mexico and China have supported technology that can increase tomato production so that it can compete with world markets. In addition to being controlled by the government, greenhouse planting is also carried out by private parties such as companies that run agricultural businesses. Tomato cultivation with technology can genetically engineer the tomatoes themselves. Tomato plants that use technology can set the harvest period, the level of fruit maturity, and packaging that is under safety standards.

Besides the role of government, the part of the private sector in tomato cultivation is also essential. The Chinese National Cereal, Oil and Food Corporation (COFCO) was founded in 1949 to import and export foodstuffs. Besides being profitable, COFCO is also a leading company in agriculture, especially tomatoes. As a COFCO company, it targets not only the domestic market but also foreign exchange. The domestic commodity investment model is the same as that of other countries working with COFCO.
Mexico, like a tomato exporting country, also has an institution that supports tomato cultivation. The Mexican Government implemented an inversion known as the Capitalization and Investment Fund (FOCIR) to support agricultural activities, where FOCIR manages seven internal private equity funds totaling more than $500 million, with more than 30 investments in rural projects. The United States is one of the importers of tomatoes from Mexico. One of Mexico's tomato gardens is in the Queretaro Agropark, a greenhouse with a production yield of 60 kg per square meter. FOCIR finances investments to build greenhouses and install land to connect heating and cooling equipment. Funding for 11 companies (10 Mexican and one Dutch) in Agropark Queretaro is a private cooperative and a Mexican government agency, FOCIR. The 11 companies pay for general services but can be supported by independent companies.

6. Conclusion

Based on the results of the study, it can be concluded that the activity of tomato cultivation in Aceh Province is still relatively simple in the use of technology. Farmers use chemical pesticides and non-organic fertilizers because they do not have the information to use environmentally friendly materials such as organic pesticides and organic fertilizers. The technology of tomato cultivation in Aceh Province is still far behind. Even though it has used plastic mulch, sprayers, and tillage using a tractor. The technology currently in use is still conventional, but when compared to China and Mexico the technology used is far behind such as the use of greenhouses, fertilization manipulation, handling pests and disease using organic materials. In order for farmers to adopt technology, especially in the cultivation of tomatoes in Aceh, the role of the government, NGOs and academics is needed to provide information and introduction on the use of the latest technology so that the Province of Aceh can produce quality tomatoes thereby increasing farmers’ incomes.

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