Innovation of chili and shallot technology in supporting to development of horticultural commodities of dry land with dry climate (case study in Sugian Village, Sambelia Subdistrict, East Lombok District)

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Abstract. Horticultural technology innovation is needed for agricultural development to fulfil nutrition and increase economic value. The research objectives were (1) Obtaining data on the socio-economic characteristics of agriculture on dry land, (2) Analyzing vegetable farming on dry land and (3) Identifying potential development of vegetables on dry land with a dry climate. The number of respondents was 31 peoples. Application of low external input technology for intercropping chili with shallots on dry land, carried out with farmer groups and extension workers on co-operators farmer lands. The results showed that intercropping between chili and tobacco was feasible with feasibility level of the R/C ratio was 3.01. Through this technology, the chili productivity was 10.67 t ha⁻¹ and there is an additional of the yield of shallots one crop with the productivity of 17.33 t ha⁻¹ of wet bulbs. Average productivity per ha for cayenne pepper is 6-7 t ha⁻¹, while the average wet bulb productivity was 15 t ha⁻¹ for sub-optimal land. This means that the application of horticultural technology on dry land can increase the productivity of cayenne pepper and shallots by 64.1 and 15.53%, respectively. Intercropping between chili and shallot is the best choice for chili cultivation on dry land.

1. Introduction

Dry land in Indonesia has and will continue to have a strategic role in supporting long-term development towards sustainable bio-industrial agriculture. The strategic role of dry land is shown, by the potential for a large area, the opportunity to increase added value through the development of commercial commodities (plantations, horticulture and livestock), can compensate for agricultural production because the land is degraded and because of land conversion [1]. In this regard, the Agency for Agricultural Research and Development provides various supports with available technology.

The availability of dry land in Indonesia is at 144.47 million ha. The area of dry land with the potential for agricultural development is at 62.64 million ha of acid dry land and 7.76 million ha of dry climate dry land [2]. Acid dry land can be found in Sumatera, Borneo, Java and Papua, while dry land with dry climate is located in Bali, West Nusa Tenggara, East Nusa Tenggara, Sulawesi and Maluku. In general, dry land farmers in East Lombok District are classified with low economic and have low education, so that access to education is still difficult to obtain [3]. Farmers on dry land are often included
in the category of smallholders and need support to manage their land. The role of technology becomes important to increase productivity and quality of results. Vegetable farming in dry land has a limiting factor in the form of water availability. Soil conditions on dry land are very sensitive to erosion during the rainy season, although the intensity of the rain does not last long [4].

Water management is the main key in increasing land productivity on dry climate dry land while maintaining its sustainability aspects, including aspects of managing nutrients and organic matter and preventing erosion [2]. The development of horticultural commodities in dry/rain-fed land can be considered as an option due to its high economic value and can be used by rural communities to fulfil their nutritional needs in the form of vitamins and minerals and other functional compounds from vegetables and fruits. Technologies that can be developed include: varieties, low external input technology and environmentally friendly pest control. ATECU’s biopesticide formulation consists of cow urine, neem and kipahit leaves and liquefied palm sugar. All ingredients and fermented for the next 15 days can be used to control the attack of plant pests.

On the other hand, horticultural technological innovations, especially vegetables and fruit, are sufficiently available. Management of water resources for vegetable/fruit farming on dry land is very important. For agricultural development on dry land, vegetable commodities can be an option for household consumption to fulfil nutrition and have high economic value, so that it can support the improvement of farmers’ welfare. The research objectives were: (1) Obtaining data on the socio-economic characteristics of agriculture on dry land, (2) Knowing the potential for developing horticultural technology on dry land, (3) Analyzing the intercropping of chili and tobacco in dry land with dry climate. This study is necessary because at that location there will be development and escorting of superior horticultural technology in the dry land, the results of which can be used to determine the introduction of appropriate, suitable and profitable technology for the land.

2. Materials and methods

2.1. Time and place
This research was conducted on March to December 2018 in Sugian Village, Sambelia Subdistrict, East Lombok District, West Nusa Tenggara Province.

2.2. Data collection
This research utilized primary and secondary data. The primary data was taken with a method of surveying on the form of an interview based on a questionnaire. Secondary data obtained from the central bureau of statistics of East Lombok is used as supporting data. The number of respondents was 31 farmers who determined purposively.

Secondary data were obtained from East Lombok statistical data. Primary data were obtained through a baseline survey. Interviews were conducted with 31 respondents who were determined deliberately, namely farmers who intercropped chili and tobacco (existing).

To see the potential for the horticultural technology development, a pilot was carried out on the application of low external input technology using ATECU biopesticide for intercropping chili with shallots on dry land, which was carried out with farmer groups and extension workers on co-operators farmer lands. The cayenne pepper used is the local variety and the IAARD variety, namely the Prima Agrihorti variety and the shallots used are the Trisula variety.

2.3. Analysis
Data analysis was carried out in a descriptive qualitative manner to describe (1) data on the socio-economic characteristics of agriculture on dry land, (2) to analyze the intercropping of chili and tobacco on dry land using the R/C ratio analysis, (3) knowing the potential for developing horticultural technology in a dry land with a dry climate.
3. Results and discussion

3.1 General description
Almost all respondent farmers grow chilies with an intercropping system with smallholder tobacco. To find out the level of understanding of the respondent farmers on chili cultivation techniques, it can be seen from the length of farming experience. This can be seen from the majority of farmers' experiences in chili farming for less than 10 years (38.71%), between 10 to 20 years (45.16%) and more than 20 years (16.13%). The land area owned by farmers ranges from 5,000 to 10,000 m². The majority of land owned by farmers is less than 5,000 m² (45.16%). The grouping of respondent farmers based on land area and length of experience can be seen in table 1.

Table 1. General description of farming

| Working Length Experience as a Farmer (years): | Number of Farmers (person) | Percentage (%) |
|-----------------------------------------------|-----------------------------|----------------|
| - <10                                         | 12                          | 38.71          |
| - 10-20                                       | 14                          | 45.16          |
| - >20                                         | 5                           | 16.13          |
| Total                                         | 31                          | 100.00         |
| Farming size of Chili (m²):                   |                             |                |
| - <5,000                                      | 14                          | 45.16          |
| - >5,000-7,500                               | 11                          | 35.48          |
| - >7,500-10,000                              | 5                           | 16.13          |
| Total                                        | 31                          | 100.00         |
| Intercropping                                 | 31                          | 100.00         |

Source: processed primary data

3.2 Respondents’ characteristics
Between one farmer and another farmer has different characteristics. This can be seen from age, education level, farming status, cultivation experience, area of land cultivated for cultivation and land ownership status. Characteristics of respondent farmers are useful to determine the effect of farming decisions. Respondent farmers are generally between the ages of 28 and 67 who are grouped into 5 age groups. Based on age grouping, the majority of farmers are 28 to 47 years old (58.06%). The grouping of respondent farmers by age and percentage can be seen in table 2.

Table 2. The age group of respondents

| Age Group (years old) | Number of Farmers (person) | Percentage (%) |
|-----------------------|----------------------------|----------------|
| 18 – 27               | 6                          | 19.35          |
| 28 – 37               | 9                          | 29.03          |
| 38 – 47               | 9                          | 29.03          |
| 48 – 57               | 5                          | 16.13          |
| 58 – 67               | 2                          | 6.45           |
| Total                 | 31                         | 100.00         |

Source: processed primary data

According to Burhansyah [5] and Obeyelu et al. [6] that one of the factors that influence technology adoption is education. In addition, the role of agricultural extension agents is also a significant variable.
affecting technology adoption and an increase in the frequency of extension also increases technology adoption and the quality of extension workers. The role of extension workers in the willingness of farmer groups to adopt horticultural technology innovations is very important, because extension workers can help the process of adopting innovation that takes place especially in the research location, so that the extension process that occurs in these areas can be an example of the application of good and targeted extension techniques [7]. The level of education of the respondents in detail can be seen in table 3.

Table 3. The education level of respondents

| Education      | Number of Farmers (person) | Percentage |
|----------------|----------------------------|------------|
| Primary        | 14                         | 45.16      |
| Junior High    | 4                          | 12.90      |
| Senior High    | 8                          | 25.81      |
| S1             | 3                          | 9.68       |
| Non-educated   | 2                          | 6.45       |
| Total          | 31                         | 100.00     |

Source: processed primary data

Sugian village, Sambelia subdistrict is one of the chili production centers in East Lombok Regency and makes chili as the main commodity cultivated by local farmers. The main livelihood of most of the respondent farmers is farmers (80.65%), while the side livelihoods include traders, farm laborers and fishermen (19.35%). The livelihoods of the respondents can be seen in table 4.

Table 4. The main job of respondents

| The Main Job    | Number of Farmers (person) | Percentage |
|----------------|----------------------------|------------|
| Farmer         | 25                         | 80.65      |
| Trader         | 1                          | 3.22       |
| Fisherman      | 1                          | 3.22       |
| Others         | 4                          | 12.90      |
| Total          | 31                         | 100.00     |

Source: processed primary data

Table 5. The reason respondents cultivated chili and tobacco

| Reason of Chili farming | Percentage | Reason for Tobacco farming | Percentage |
|-------------------------|------------|----------------------------|------------|
| The harvesting period is short | 6.45       | The harvesting period is short | 9.00       |
| Disease resistant       | 6.45       | Disease resistant           | 16.13      |
| Production higher       | 64.52      | Production higher           | 45.16      |
| Longer shelf-life production | 22.58     | Longer shelf-life production | 12.90      |
| Market preference       | 41.94      | Market preference           | 38.71      |
| market availability     | 6.45       | market availability         | 38.71      |
| Others:                 |            | Others:                    |            |
| high price              | 3.23       | high price                 | 3.23       |
| Easy plant maintenance  | 6.45       | Easy plant maintenance      | 12.90      |
| Good quality            |            | Good quality               | 6.45       |

Source: processed primary data

In general, land ownership status for chili and tobacco cultivation is self-owned land (52%), leased land (25.8%) and pawned (22.58%). The majority of respondent farmers planted seeds from local varieties (100%) and other types of plants planted were the Kasturi tobacco (93.56%), while the rest
planted rice, corn, peanuts and pineapples (6.44%). The reason for farmers to plant local varieties of chilies based on ranking (the highest 3) is because the yield is higher, preferably the market and the results are resistant to storage. Meanwhile, the reasons for planting the muskrat variety of tobacco are due to higher yields, preferability of the market and short harvest life. The detailed reasons can be seen in table 5.

3.3 Pest and disease control
The kind of pests that attack plants in chili and tobacco plantation areas are ground worms, snails, fruit caterpillars, fruit flies, armyworms. The intensity of fruit fly pests to attacking plants was 35%, 40% of leaf miner flies, 40% of fruit caterpillars. As a result of leaf miner fly attacks, the risk of yield loss was 30% for fruit caterpillars, 15% and peach aphids at 15%. Types of diseases that attacked chili plants were anthracnose fruit rot, curly leaves, sooty dew, leaf spot. The percentage of attacks by leaf curl disease and sooty dew was up to 100%. If you have started to rain frequently, you can be sure that many diseases will start to attack with a very high attack rate. This has been going on for a long time and farmers have not been able to solve this problem. Control of plant pests was carried out by chemical means. Before spraying crops, farmers always observe and apply the pesticide according to the recommended dosage and the type of pest/disease that attacks.

3.4 Irrigation
Water supply technology for dryland irrigation has been developed, but from this technology, it is necessary to evaluate the appropriate technology and according to land conditions, including soil, water and climate, as well as farmers. Therefore, it is necessary to know in advance the characteristics of the land and the conditions of the farmers so that the selected technology was truly effective and can be adopted by farmers [8]. The technique of supplying water with the use of an irrigation pump was an alternative to meet the needs of irrigation water on dry land, however, the use of a pump will not necessarily provide benefits to farmers. In cultivating chili and tobacco, the respondent farmers do not use an irrigation system. The need for water for watering, farmers use boreholes built by the government.

3.5 Farming analysis
The main obstacles that hinder the adoption of horticultural commodity technology on dry land include the lack of support from the availability of adequate irrigation infrastructure, the level of knowledge and skills of farmers in managing horticultural commodities is relatively low, the level of farmer participation is relatively low and the low ownership of business capital owned by farmers.

The yield sales system was often carried out by respondent farmers by weighing all yields and paying in cash. The harvest was sold to middlemen and most of the places were sold at home and a small part was in the fields. The farm production costs were the total costs incurred by the respondent farmers in implementing the intercropping of local cayenne pepper with tobacco, includes fixed and variable costs. The overall costs incurred by the respondent farmers in the study area was presented in table 6.

| Table 6. The Analysis of Intercropping between chili and existing tobacco |
|---------------------------------------------------------------|
| Type                          | Total (IDR)  |
| Total Production Cost         | 20,813,000   |
| Income                        | 62,587,500   |
| Revenue (B - A)               | 41,774,500   |
| R/C Ratio (B/A)               | 3.01         |

Source: processed primary data

Farm income/profit was the difference between revenue minus production costs. Based on the table, the average income received by large scale farmers of 0.5 ha was IDR 62,587,500, while the costs incurred were IDR 20,813,000, so the income received by farmers was IDR 41,774,500. The feasibility
level of the R/C ratio was 3.01, meaning that for every IDR 1 spent, IDR 3.01 was received. This means that intercropping farming between chilies and tobacco in the research location was feasible. In line with the research of Aini et al. [9], that the ratio of farming income with an intercropping pattern between chili and traditional tobacco was 13.34 times greater than that of smallholder tobacco monoculture farming.

When planting tobacco was at the same time as planting chilies, three months later it was harvesting tobacco, one month later was harvesting chili. In one month, farmers can harvest 4 times. The harvest period for chilies was approximately three months (depending on weather conditions). Usually when entering the rainy season there was always a decrease in production, because various diseases appear and begin to attack, causing crop failure. This indicates that the R/C ratio is less than 1, so that the farming experiences a loss (not feasible).

Intercropping between chili and tobacco has long been practiced by the majority of farmers on dry land, because it is profitable. However, some important drawbacks to watch out for are too much tobacco population it can result in decreased chili productivity, due to reduced flowering and competition in water use. This has the potential to increase pest and disease attacks because the pests and diseases of chili and tobacco originate from the same host, especially the yellow virus. The presence of high pest and disease attacks increases the input use of chemicals which results in a decrease in land quality. This has worsened the condition of the land, which required improvement of the adequacy of soil nutrients. Therefore, a review is needed by improving cropping patterns and crop management.

3.6 Potential development of chili and shallot technology in dry land

The characteristics of dry land are land that naturally has problems, namely limited water and high air temperature so that it takes extra effort to make it productive cultivation land [8]. One of the research and development programs for dry land management technology innovation for chili and shallot commodities that have been carried out at the research site is by applying low external input technology which is applied to the intercropping cultivation of chilies and shallots, namely the application of compost and NPK, as well as control plant pests using ATECU biopesticide which is applied based on the control threshold in the demonstration plot area.

In the chili monoculture system in the field, the mortality rate of chili plants at the beginning of planting was relatively high. Chili plants in growth require shade for adaptation. High air temperature causes a low percentage of living chili plants. Intercropping chilies with tobacco is thought to be able to overcome the mortality rate of chili plants at the beginning of planting in the field, but on the other hand it can preserve diseases that attack and become endemic in the planting area, because plant pests (OPT) that attack chili and tobacco plants from OPT sources the same one.

Vegetative and production characters of shallot and chili intercropping on dry land showed good plant performance and large tuber size. The appearance of shallots planted in the demonstration plot is shown in figure 1.

Figure 1. Display of shallots planted on the demonstration plot
According to Mulyono et al. [10], the yield of shallot for one planting was obtained 356.5 kg, which is equivalent to the productivity of 17.33 t ha$^{-1}$ of wet tubers. Meanwhile, the prediction of chili productivity was calculated based on: (number of fruits + number of flowers) x fruit weight x plant population per ha x 60%. Setiawati and Hudaya [11], Setiawati et al. [12] reported that a two-one cropping system could increase productivity by 52.58%. The results of the calculations are presented in figure 2. The highest results occurred in the Prima Agrihorti treatment (11.45 t ha$^{-1}$) followed by the intercropping treatment of chili + shallots (10.67 t ha$^{-1}$), chili monoculture (7.08 t ha$^{-1}$) and intercropping chili + tobacco 3.37 t ha$^{-1}$.

![Figure 2. The prediction of chili productivity in Lotim 2018 [10]](image)

The cultivation of intercropping shallot and chilies with the innovative technology of the Horticultural Research and Development can be used as an alternative technology innovation besides the intercropping of tobacco and chilli which has the potential to be widely developed in dry land. Technological improvements by using low input which are environmentally friendly is an agricultural system that uses nutrients and pesticides from biological and natural sources, without using agrochemicals, it can reduce irrigation water pollution from heavy metals and reduce production costs due to the use of synthetic fertilizers and pesticides.

Technological innovation for dry land management through the intercropping of shallots and chilies still needs to be developed, in addition to improving technological innovations that are already available, but also to replace technological innovations that are deemed insufficient to answer existing problems or not following current conditions, such as plant varieties, it is necessary to develop various varieties of plants that can adapt to climate change. Nutrient management technology innovations need to be continuously developed towards more efficient use of fertilizers.

4. Conclusions
The main obstacles that hinder the adoption of horticultural commodity technology on dry land include the lack of support from the availability of adequate irrigation infrastructure, the level of knowledge and skills of farmers in managing horticultural commodities is relatively low, the level of farmer participation is relatively low and the low ownership of business capital owned by farmers. The feasibility level of intercropping between chilies and tobacco of the R/C ratio was 3.01, meaning that for every IDR 1 issued, IDR 3.01 was received. However, during certain planting periods (it often rains) there was a drastic decrease in the yield of chili peppers was indicated that the R/C ratio was less than 1 (not feasible), because the attack rate of disease was very high. Intercropping between chilies and shallots was the best choice for cultivating chili plants in dry land and is capable of producing a productivity of 10.67 t ha$^{-1}$ and one-time shallot yield with a productivity of 17.33 t ha$^{-1}$ of wet tubers. Average productivity per ha for chili it is 6 to 7 t ha$^{-1}$, while the average wet bulb productivity is 15 t ha$^{-1}$ for sub-optimal land. This means that the application of horticultural technology on dry land can increase the productivity of chili by 64.1% and shallots by 15.53%.
To overcome the mortality rate of chili plants at the beginning of planting in the field was given shade to the chili plants. High air temperature caused a low percentage of living chili plants. The intercropping of chilies with tobacco was thought to be able to overcome the mortality rate of chili plants at the beginning of planting in the field, but on the other hand, it could preserve diseases that attack and become endemic to the planting area, because of plant pests (OPT) attack chili and tobacco plants from pest sources same.

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