Adaptation of cayenne pepper farmers (*Capsicum frutescens* L.) on climate change in Jelbuk Subdistrict Jember

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Abstract. Climate change becomes more difficult to predict. Thus, makes farmers no longer able to accurately predict planting season. The impacts are decreasing productivity and production of cayenne pepper which can cause farmers to suffer losses. Efforts to minimize these losses are carried out with appropriate adaptation actions according to the conditions of the cultivated land. This study aims to determine the adaptation made by cayenne pepper farmers in Jelbuk Subdistrict, Jember District because of climate change. The used analysed method is qualitative through structured interviews, observation, and documentation. The used sampling method is purposive. The results showed that in the last 10 years, cayenne pepper farmers have experienced climate change. These changes such as seasonal shifts, extreme rains, droughts, and changes in air temperature which have an impact on increasing attacks of plant-disturbing organisms. The adaptations carried out by cayenne pepper farmers are adjusting the planting season, adjusting plant types (using tolerant varieties and crop rotation), using mulch and adding organic fertilizer, adjusting the shape of the beds / mounds, adjusting spacing settings, improving irrigation channels (adjusting the depth of the canal), applying water-saving technology, applying integrated pest and disease management techniques, implementing an intercropping system, accessing information technology, and actively participating in agricultural extention and field schools.

1. Introduction

Horticultural commodities have a very important role in the economy of Indonesia. Jember District as one of the centers for producing cayenne pepper in East Java, spread over five subdistricts, one of which is Jelbuk. Based on data from the Central Bureau of Statistics of Jember District, the harvested area in 2016 and 2017 was reduced by 25.24% and 30.30%, respectively. Climate change is one of the factors causing the decline in cayenne pepper production. The fluctuations in harvested area, productivity, and production of cayenne pepper both in terms of quantity and quality are influenced by several factors, such as plant varieties, geographical conditions, cultivation techniques, and plant-disturbing organisms. Climate is closely related to weather changes and global warming can reduce agricultural production between 5–20% [1]. National Council on Climate Change [2] stated that agricultural sector is experiencing direct disruption due to climate change. Climate change has resulted in an increase in rainfall in certain areas and at the same time drought in others [3]. This climate change has an impact on farmers who can no longer predict the planting season accurately.
Efforts in respond to climate change are carried out through the use of low-emission varieties, the use of organic fertilizers, as well as adjustments to cultivation techniques through water and land management, and also socializing the importance of agricultural insurance. This can be obtained through the implementation of the Climate Field School (SLI). Based on information from the Department of Food Crops, Horticulture and Plantation, Jember District, Jelbuk is the only village that has received the Climate Field School (SLI) Activity Program in 2016 and the Cayenne Pepper Integrated Pest Management Field School (SLPHT) in 2017.

The existence of these two government programs are expected to change the behavior of cayenne pepper farmers who initially conventional to environmental friendly agriculture. So decrease in cayenne pepper productivity can be minimized. Therefore, it is necessary to have knowledge, take attitudes, and improve farmers' skills in minimizing the impact of climate change, so that farmers can minimize the factors that cause losses due to climate change. In addition, it is also necessary to study the impact of climate change on changes in farmer behavior, not only production but also the changes in farmer behavior should be studied qualitatively. Moreover, there are still few studies related to changes in farmer behavior.

2. Materials and methods
   2.1. Materials
   Climate change is the impact of global warming, in addition to increasing air temperature, it also has an impact on increasing the frequency of extreme climate events such as El-Nino and La-Nina. Climate change can have a positive impact on the agricultural sector, for example: helping the process of photosynthesis, increasing water availability and breaking the life cycle of pests. Climate change that has negative impacts include drought, flooding, washing of top soil layers, and increased pest attacks. The negative impact causes a decrease in planted area, crop failure, a decrease in production and productivity and a decrease in income which in turn reduces the level of welfare of farming families. Therefore, the negative impacts of climate change are considered more detrimental so that anticipatory steps are needed to minimize these negative impacts. Efforts to reduce the negative impact of climate change on cayenne pepper plants can be done with adaptive behavior that must be done by farmers. This research on the adaptive behavior of cayenne pepper farmers in Jelbuk Village, Jelbuk District, Jember District is expected to produce information about how cayenne pepper farmers make efforts to minimize the impact of climate change. The information obtained can be used as recommendations for consideration in formulating adaptation strategy policies and mitigation strategies by policy makers.

   2.2. Methods
   Descriptive qualitative was used as analyze method. This because the data collection and the analysis are more qualitative in nature. The descriptive method aims to understand the meaning behind the visible data. Social phenomena often cannot be understood based on what people say and do [4].

   Purposive sampling method was used to determine informants. According to Sugiyono [5], purposive sampling is a sampling technique with certain considerations. The key informants in this study were field officers (PPL and POPT) and the supporting informants in this study were the head of farmer group association. The used data collection methods are observation, interviews and documentation. Qualitative data analysis includes three components, namely data reduction, data presentation, and drawing conclusions or verification [6].

   The three main things that have been stated above are data reduction, data presentation and conclusion drawing/verification as something that exists before, during and after data collection. The three main things can be interpreted as a cyclical and interactive process.
3. Results and discussion

3.1. Cayenne pepper farmers’ behavior towards seasonal shifts
Farmers are aware of the shift in seasons marked by the natural conditions which they can feel. Such as changes in temperature, spring conditions, and rainfall. The time span of the shift of the seasons can also be described well.

As a response of farmers to face the climate change, they make several adaptations of appropriate technology. This knowledge is obtained both from agricultural extension workers, sharing between farmers and searching for information through internet. The attitude of farmers to the provision of this information is very positive. Farmers consider that this information can help maximize the implementation of cayenne pepper farming. This study supports previous research where the form of adaptation behavior to climate change carried out by farmers is by changing planting patterns, shifting planting time, and shifting harvest time [7,8].

3.2. Cayenne pepper farmers’ behavior in adjusting plant types
The application of cayenne pepper variety rotation is carried out by taking climate change into account. Generally, in the rainy season, farmers use bara and geni varieties so that the plants won’t be collapsed easily. During the dry season, farmers used arimbi varieties with a higher garden posture and resistance to drought stress. However, it is possible to use other chili varieties according to farmers needs. Farmers have realized the benefits of changing varieties, one of which is breaking the cycle of plant pests and diseases. Varieties of cayenne pepper that are commonly grown in Jelbuk Village are bara, sonar, seris and arimbi. Farmers have knowledge which varieties are suitable during rainy and dry season. Farmers can also explain about varieties such as bara and geni which have high production and are suitable during rainy season. Farmers can also explain about varieties such as bara and geni which have high production and are suitable during dry season. In addition to high production, these varieties are considered more resistant to disease. The use of cayenne pepper varieties is carried out selectively by farmers.

According to Bunyamin and Aqil [9], the use of high-yielding varieties, especially varieties that can minimize the effects of intraspecies and interspecies interactions will be beneficial. This is done as an effort to minimize losses due to climate change. In accordance with previous research, where farmers took adaptation actions by choosing new plant types with climate-oriented varieties [7,8,10].

3.3. Cayenne pepper farmers’ behaviour in using organic fertilizer
Farmers already use both solid and liquid organic fertilizer. Solid organic fertilizer is given from the beginning, precisely during soil tillage. While liquid organic fertilizer in the form of MOL (Local Microorganisms) is given either sprayed on plant leaves or sprinkled on plant roots. The addition of organic fertilizers is considered to be able to save the use of chemical fertilizers and is considered safer for the products and friendly to the environment. Farmers believe that organic fertilizers can help to increase crop fertility, environmentally friendly, and make crops safer for consumption. Arul and Xu [11] stated that synthetic fertilizers or inorganic fertilizers cause environmental pollution, health problems, and soil damage.

Changes in the adaptation behavior of farmers in Jelbuk Village to climate change by reducing the use of chemical fertilizers and combining chemical with organic fertilizers, both solid and liquid. This
statement supports previous research where farmers action to adapt climate change by using more environmental friendly fertilizer [7,12].

3.4. Cayenne pepper farmers behaviour in adjusting the shape and depth of beds/rolls

There are two kinds of beds or rolls carried out by farmers in Jelbuk, namely flat and semi-circular beds (mellok pao). Semi-circular beds are used during the rainy season. The aim is to make water go straight down to the beds or rolls. While flat beds are used during the dry season so that the given water can enter the planting hole and will not be wasted.

Kurnia et al. [13] supporting this research, where changes in adaptation behavior were carried out by cayenne pepper farmers in Jelbuk. Farmers initially made beds or rolls with the same shape and depth both in the rainy season and in the dry season. The existence of information through counseling and field schools as well as weather forecasting services makes farmers’ knowledge increase and change their behavior in adapting to climate change. Farmers obtain climate information through field schools, extension services, engage in social groups and follow weather forecast broadcasts in the mass media [8,10,12,14].

3.5. Cayenne pepper farmers behaviour in adjusting planting distance

Adjustment of distance is no less important in the implementation of cayenne pepper cultivation. The planting distance in the rainy season is wider than the dry season. The aim is to make environment condition around the plants not too humid so that air circulation can be smoother and sunlight can penetrate so that all plants get the same light.

Distance is one of the way to support availability of factors needed by plants and to optimize it [15]. In addition, the use of planting distance can have a major effect on plant growth, leaf shade due to changes in leaf structure, increase in plant height, decrease in the number of tillers, and number of branches [16]. The narrow planting distance results in competition for nutrients [17].

3.6. Cayenne pepper farmers behaviour in using silver black mulch

The use of silver black mulch provides many benefits. Besides being able to be used more than once, it can also suppress weed growth, reduce evaporation so that soil around the roots does not dry out quickly and can reduce the population of vermin under the leaf.

As stated by Ardhona et al. [18], the use of mulch in horticultural cultivation is to provide better environmental conditions for plant growth, where the soil structure remains loose, maintains soil moisture and temperature, reduces nutrient leaching, suppresses weeds, and reduce soil erosion. In addition, the use of silver black plastic mulch can increase chili yields and delay virus incidence [19].

3.7. Cayenne pepper farmers behaviour in lateral shoots pruning (pewiwilan)

One of the treatments which carried out by farmers is lateral shoots pruning. The aim is to make the plants taller and the plant crowns to be wider or the availability of productive branches becomes more, so that the production will increase. Farmers began to routinely conduct lateral shoots pruning because they already knew the benefits.

According to Firmanto [20], pruning of lateral shoots is done to reduce vegetative growth such as branch leaves, as well as stimulate generative growth and increase sunlight reception. The results of research Davis and Estes [21] stated that the number of branches on a chili plant will affect fruit quality.

The pruning treatment carried out on tomato plants affected the average weight of the fruit produced [22]. Research conducted by Sowlley and Damba [23] showed the same results on the size of the tomatoes produced. The results of this study indicate that pruning increases the size of the fruit produced compared to plants that are not pruned so that it can increase the selling value.
3.8. Cayenne pepper farmers behaviour in adjusting plant watering

Plant watering must be done by looking at land condition. Plant watering does not need to be done in rainy season as the soil already moist. But it still necessary to maintain irrigation channels so that the rainwater that falls does not stagnate around the plants. On the other hand, during the dry season, the watering system is no longer inundated or “leb” but use “shooting jerry cans”. This is done in addition to save water and also can be used at the same time for additional fertilization.

Research by Hilman et al. [24] also stated that there are several adaptation technologies adopted to face climate change, especially during the dry season. These technologies include efficient irrigation systems, namely drip irrigation and bulk irrigation. The purpose of irrigation is to provide additional water to rainwater, and to provide water to plants in sufficient quantities and when needed [25].

3.9. Cayenne pepper farmers behaviour in making molt and vegetable pesticides

Utilization of Local Micro Organisms (MOL) and vegetable pesticides is a form of adaptive behavior carried out by cayenne pepper farmers in Jelbuk Village, Jelbuk District. This is because in addition to making it easy to do, the raw materials to make it are also easy to obtain and of course farmers can be more efficient in farming costs. The use of MOL and botanical pesticides is not only healthy for plants and their products are safer for consumption, they are also considered environmentally friendly. In addition, if the plant is healthy, the yield or production will also increase.

The MOL solution contains macro and micro nutrients, and contains microorganisms that have the potential to decompose organic matter, and control plant pests and diseases, so they are good for use as biological fertilizers and organic pesticides. MOL can be used both as a decomposer, biological fertilizer and as an organic pesticide, especially as a fungicide [26,27], stated that the benefits of giving MOL showed positive results on the number of primary branches, number of leaves, wet weight of fruit, and dry weight of cayenne pepper (Capsicum frutescens L.).

3.10. Cayenne pepper farmers behaviour in handling plant pest organisms

An important factor that must be considered is the handling of Plant Pest Organisms (OPT) with the Principles of Integrated Pest Management (IPM). The principles of IPM carried out by cayenne pepper farmers in Jelbuk include conducting early observations in the cultivated plant area, cultivating healthy plants such as adding organic fertilizer, making mole and using vegetable pesticides. Apart from that, it is also hoped that the farmers will become IPM experts by planting refugia plants as natural enemies.

The application of IPM aims to reduce the use of chemical pesticides. In general, red chili farmers often use chemical pesticides as a preventive measure, by spraying 1–7 days after planting in the field. Farmers also carry out other strategies, including increasing the concentration and frequency of spraying during heavy attacks and changing the type of pesticide and mixing pesticides [28]

3.11. Cayenne pepper farmers behaviour in implementing intercropping pattern

The way to maximize land use to become more effective is by implementing intercropping system. Farmers not only plant cayenne pepper but also plant other crops. For example, the other crops could be tobacco, peanut, and sweet potato. This cropping pattern is intended so that farmers get additional production results from the area of cultivated land. Farmers who use an intercropping pattern usually do not use plastic mulch, this is done because the presence of other plants can suppress weed growth. Meanwhile, cayenne pepper farmers who use plastic mulch tend to choose a monoculture cropping pattern.

One of the determining factors for the success of intercropping is the arrangement of the planting distance. Setting a distance that is too narrow can result in competition between plants for the use of water, nutrients, air, and space by plants [29]. The advantages of using intercropping, namely growth resources such as light, water, nutrients become more efficient for each competitively intercropped plant in the level of canopy development, width and height of the canopy, adaptation to radiation conditions, and root depth [30,31].


4. Conclusions
Based on the research that has been carried out towards the impact of climate change on cayenne farmers behavior in Jelbuk, it can be concluded that there are eleven important points. These changes include farmers knowledge in seasonal shifts, adjusting plant types, using organic fertilizer, adjusting the shape and depth of beds / rolls, adjusting planting distance, using silver black mulch, lateral shoots pruning, adjusting plant watering, making mol and vegetable pesticides, handling plant pest organisms, also implementing intercropping pattern. Farmers get information related to behavioral adjustment to climate change through the climate field school, cayenne pepper integrated pest management field school, the results of information exchange between fellow farmers, extension service activities, and information from the internet. It is recommended that a program and socialization are needed both from the Department of Horticulture and Plantation of Jember District and from the BMKG regarding the impact of climate change on a sustainable basis. Government programs and policies in increasing the adaptive behavior capacity of cayenne pepper farmers through SLI and SLPHT programs should be implemented for farmers as a whole.

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