DEVELOPMENT OF PROTECTED CULTIVATION FOR VEGETABLES IN INDONESIA

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ABSTRACT

Open field vegetable production is the most common cultivation method practiced by farmers in Indonesia. Although the tropical climate condition allows the production of vegetables in the open field throughout the year, this sector is under pressure to increase production due to the problems faced such as heavy rainfall, wind and various damaging pests and diseases. Climate change phenomenon that often causes extreme temperature and rainfall invariability may have also increased the uncertainty of vegetable production and quality. Protected cultivation is an alternative of vegetable growing that may alleviate many of the problems prevail in the open field. Compared to open field vegetable production, some advantages of using protected cultivation method are its potentiality to increase yields, have better product quality, extend harvest time, and reduce the use of fertilizers and pesticides. Although in some parts of Indonesia, farmers have already produced some vegetables under protected cultivation, the development of this cultivation method is still underdeveloped. In general, they use simple protected structures made from bamboo with plastic covering materials on top and screen materials for sidewall. Crops commonly grown in these greenhouses are sweet pepper, beef tomato, cherry tomato, and leafy-vegetables. A collaborative research project (Hortin Project 2003-2010) between Indonesia and the Netherlands had initiated research and development activities on vegetable growing under protected cultivation. Based on the survey carried out in the beginning of the project, it was indicated that compared to other vegetable crops, sweet pepper was the main crop cultivated under protected cultivation. Therefore, research and development activities in the project were focused on the improvement of sweet pepper production techniques under plastic house conditions. Besides introducing new structure or construction for protected cultivation, other important issues such as growing techniques, nutrient use efficiency and pesticide use reduction were also studied and the results were disseminated to farmers.

INTRODUCTION

The vegetable sector is considered as one of key agro-industries for nutrition security, income generation, livelihood improvement and national development in Indonesia. However, vegetable consumption in Indonesia is still low, i.e. 40 kg per capita per year in 2014. This figure is far from the FAO recommendation of 65 kg per capita per year. With the increase of urbanization, population growth and income, demand for vegetables is expected to increase substantially during coming decades. Demand of fresh vegetables in Indonesia was estimated to increase from 5.6 million ton in 2000 to 8.4 million ton in 2013. In 2014, vegetable production area was 1.1 million hectares, of which about 300-400 ha was under protected cultivation. Based on these figures, there is still room for increasing vegetable production in open field as well as under protected conditions in the country.

In Indonesia, most vegetable crops are grown in the open field. The tropical climate condition allows the production of vegetables throughout the year. The production of vegetables in the open field, however, faces many problems. In the rainy season, vegetable growing in the open field is severely hampered by heavy rainfall, which is often carrying a large quantity of water in a short period of time. Therefore, the vegetable crops grown in the open field are often partly or entirely destroyed. The climate condition in the rainy season is also often not suitable for growing the vegetable crops due to the increase in humidity and this condition enhance the development of many diseases. In the dry season on the contrary, the open field vegetable growing could be affected by strong wind and also pests, which usually develop mostly in the dry season. Other problem includes the impacts of climate change, which could have adverse impacts on vegetable growing in the open field. A review of different countries shows that climate change can decrease the production and quality of the yields significantly (Suwandi et al. 2013; Setyanto et al. 2013). Climate change has caused changes in seasons and rainfall in Indonesia. Some vegetable farmers in some areas have been discussed about the abnormality of seasons (Syaukat 2011). In Indonesia in general, the dry season is occurred from April to September and the rainy season is occurred from October to March. The extreme climate changes occurred in 2010 to 2013 is the
continuous rainy season without any dry season. The significant impacts of climate change includes a decrease in productivity due to drought or prolonged rain, the higher temperatures increase the chance of pest activity or lead to new pests, and increased heat stress effect on fruit size and pollination, so the quality of the product decreases (Suwandi et al. 2013). More recent changing in seasons was also occurred in West Java in 2015 and 2016. During 2015, only dry season was occurred and during 2016, only rainy season was occurred and this caused the farmers have to sift their time of planting and in many cases, farmers failed to harvest their vegetables.

Protected cultivation is a technique of vegetable growing that may alleviate many of the problems related to growing vegetables in the open field. This technique comprises every form of physical protection of the plant, with the primary goal of controlling climate factors, which are detrimental to the development of the plant. Compared to open field vegetable production advantages of using structures for protected cultivation for vegetable production are higher yields, better product quality, extended harvest period, reduction of fertilizers and pesticides use (FFTC 1999; Robinson 1991). Other advantages include a more efficient use of fertilizer and pesticide, the possibility to apply biological control and a better planned crop production (Baudoin and Von Zabeltitz 2002).

There is an increase demand for vegetable products, which are cultivated under protected cultivation in the recent years. The better quality of vegetable products produced from protected cultivation than those produced in open field is the cause of the increased demand for vegetables produced under protected cultivation. However, the availability of quality vegetable products has not been able to meet the needs of consumers. This is due to the production of vegetables under protected cultivation are still very limited and underdeveloped. In order to increase the production of quality vegetables in Indonesia, it is necessary to develop vegetable production technology under protected cultivation in tropical conditions such as in Indonesia so as to meet the needs of domestic consumers and also potential for export market.

RECENT DEVELOPMENT OF PROTECTED CULTIVATION FOR VEGETABLE FARMING

Greenhouse Structure
Protected cultivation for vegetable production in the developed countries has been developed to the stage as the major technique for vegetable production. In the tropical countries such as in Indonesia, however, the technique of vegetable growing under protected cultivation is still need to be developed. In some areas of West Java, vegetable growing under protected cultivation has been practiced for several years since the 1990s. Some vegetable crops such as sweet pepper, beef tomato, cherry tomato, cucumber and leafy vegetables like lettuce, packcoco and kailan had been grown under simple protected cultivation. However, the development of vegetable growing under protected cultivation is still very slow since then. Research collaboration between Indonesia and the Netherlands (Wageningen University and Research - WUR) in the Hortin Project (2003-2010) had initiated research and development activities on vegetable growing under protected cultivation. The potentials and constraints of existing vegetable growing under protected cultivation were identified through exploratory survey and workshop in the beginning of the project. The 2003 exploratory survey and workshop conducted indicated that compared to other vegetable crops, sweet pepper was the main vegetable cultivated under protected cultivation. Almost all sweet pepper farmers in Indonesia used plastic house made from bamboo for the construction (Gunadi et al. 2003; 2007). Therefore, the research in the project activities was focused on the production techniques of sweet pepper under plastic house conditions.

In Indonesia, a plastic house made from bamboo is the common standard structure used by most farmers. The plastic house made from bamboo is relatively cheaper than that made from other materials such as wood and metal; besides the bamboo material is easily available in most of the area in Indonesia. However, the bamboo plastic house is considered has a heavy structure that reduce a lot of light intercepted in the plastic house therefore also reducing the yields of crops grown under this structure. Other disadvantages of using bamboo greenhouse include increasing temperature inside the greenhouse and its moderate life span. In order to improve the bamboo plastic house commonly used by farmers, a new structure of greenhouse has been introduced in some areas in West Java. The new structure of greenhouse i.e. wood-metal plastic house of which the supporting poles were made from wood and the roof construction was made from metal. This wood-metal plastic house improved the light transmission and therefore also increased the yields of crops grown in this type of greenhouse. Research results to compare two types of plastic houses indicated that the wood-metal type plastic house intercepted 12.6% of light higher than that in the traditional bamboo plastic house. Fruit weight and fruit number per plant of sweet pepper grown at the wood-metal plastic house were higher than those of sweet pepper grown at the bamboo plastic house (Gunadi et al. 2008; 2013; Maaswinkel and Gunadi, 2009).

Beside the structures, other important factors for vegetable production under plastic house are related to production techniques in order to increase the production and the quality of products. Information and knowledge of the production techniques obtained by the farmers were still very limited. The information for the
improvement in cultural practices, including growing techniques, nutrition, irrigation, pest and disease control, and planting media are still lacking. Under tropical condition, the production techniques have to be developed as simple as possible so that these techniques will appropriate and suitable for the conditions and the farmer needs. In general, the farmers used manual irrigation using plastic hose for sweet pepper grown under plastic house. Simple drip irrigation was introduced to these sweet pepper farmers. The simple drip irrigation introduced to the farmers could increase the water use efficiency compared to the manual irrigation. This simple drip irrigation could also reduced the labor so that reduced the cost for labor and the more important factor of using the simple drip irrigation was the increase of the yields of sweet pepper due to the better nutrient use by the crops and reduce leaching of nutrients. The cost of production per plant using the drip irrigation system is higher compared to that of the manual irrigation system (US$ 0.84 vs. US$ 0.67). But because the yield of sweet pepper per plant using the drip irrigation system is higher than that with the manual irrigation system (2.19 kg vs.1.98 kg), the return of the system using drip irrigation is better than that of the manual irrigation system (Gunadi et al. 2007).

The higher quality type of plastic house used by limited farmers is made fully from metal for the supporting poles and arches with covering materials of plastic for roof and screen materials for sidewall (Figure 1). This type of greenhouse has a relatively long life span and used by limited bigger farmers for high quality of vegetable crops such as sweet pepper, strawberry, beef tomato, cucumber and some leafy-vegetables. Other types of structure of protected cultivation used by some farmers include netting house and rain shelter. Netting house was used to grow some vegetables such as hot pepper either in both highland and lowland areas. The use of this netting house in hot pepper grown in the highland could increase the hot pepper yields for more than 100% and reduced the pesticide application by 73% and therefore increase the farmer profit (Gunadi and Sulastri 2013; Moekasan et al. 2015). The use of netting house in hot pepper grown in the lowland reduced the pest and disease infestation by 12-28% so that reduced also the pesticide application by 95% (Moekasan and Prabaningrum 2012). Rain shelter in some highland areas was still limited and used for tomato cultivation. This rain shelter could protect the tomato crops from heavy rainfall in short period of time especially in the rainy season. The tomato grown in this rain shelters had a higher yields and also better quality compared to those grown in the open field.

Figure 1: Traditional bamboo plastic house (left) and modified wood-metal plastic house (right)

Production Technique
As indicated by most farmers’ cultivated vegetable crops using protected cultivation, information and knowledge of vegetable growing under protected cultivation was still limited. The farmers were not aware of a government extension program on protected cultivation in plastic houses. Almost all farmers obtained the knowledge of the production techniques from the agricultural store, where they buy their inputs. Unfortunately, transferring the technology by this method resulted in very limited knowledge transferred to the farmers. The farmers were interested in knowledge transfer by extension programmes on protected cultivation in plastic houses, especially on cultural practices and on control of pests and diseases. In the Hortin project, research on production techniques of growing vegetable crops especially sweet pepper was carried out and the results were disseminated to farmers. The experiment to determine the effect of plant population and technique of fruit and side shoot selection indicated that the plants grown with high population (8.3 stems per m²) had significant higher total fruit weight than that of crops grown with low population (6.7 stems per m²) (Gunadi et al. 2013). Related to growing media, sweet pepper plant grown in rice husk gave higher either fruit weight or fruit number per plant than those grown in perlite (Gunadi et al. 2008). In terms of technique of side shoot pruning and fruit selection, similar total yields were obtained between the two techniques, but the introduced side shoot pruning
and fruit selection technique gave significant higher weight of fruit >200g per m² compared to those of the conventional technique applied by most farmers. This experiment suggest that in order to obtain more sweet pepper fruit of >200g, the introduced pruning system should be applied (Gunadi et al. 2013).

Other experiment to determine the effect of stem number per plant and media container indicated that the sweet pepper plants with 4 stems had 3 kg.m⁻² lower yields compared to plants with 2 or 3 stems per plant. The yields of fruits > 200g in plants with 4 stems were also lower compared to the yield of plants with 2 and 3 stems per plant. No significant differences in terms of yield of fruits > 200g were found between plants with 2 stems and with 3 stems per plant, however the 3 stems system was more efficient in the use of seed compared to the 2 stems system. The 3 stems system only used two third of seeds of the 2 stems system. In terms of media container, the plants grown on polybag tended to have a higher total yield and yield of fruits > 200g compared to yield of plants grown on slab, however, the differences were not significant. Production of sweet pepper using 3 stems per plant and polybag container could be recommended as alternatives in growing sweet pepper (Gunadi et al. 2015). Other experiments to compare the number of stem indicated that the plants grown with three stems per plant gave higher total yield and yield of class >200 g up to 9.3 and 9.1%, respectively, than those grown with two stems per plant (Gunadi et al. 2011). In order to confirm the previous experiment, the response of four sweet pepper varieties to different stem number per plant was conducted. The results indicated that plants grown with 3 stems per plant gave highest total yields and yield of class >200 g compared to plants grown with 2 and 4 stems per plant. In average, the total yields of plants grown with 3 stems per plant were 19% higher than those of plants grown with 2 stems per plant and 15% higher than those of plants grown with 4 stems per plant. The total yields were not significantly differed between varieties. The results can be used as a recommendation in variety selection and growing technique of sweet pepper grown under plastic house (Gunadi 2016).

Many pests and diseases were reported to attack the crops. Thrips was the most important pest in terms of estimated potential yield loss (10 to 60%). Because of a lack of knowledge on efficient pest and disease control, pesticide use is high. Most farmers routinely spray, often with a mix of several pesticides to increase efficiency of labor and costs. This causes not only the increase in production costs and the decrease of product quality, but also the increase of pesticide residues on the fruits, which is the most important factor considered for export. Often, the sweet pepper product is rejected due to the high levels of pesticide residue. Farmers who want to export are only allowed to use a limited number of pesticides. In order to reduce the pesticide application, biological controls of thrips using a predatory mite (Amblyseius swirskii) and a predatory bug (Orius laevigatus) were introduced in 2009. However only A. swirskii could survive under the tropical plastic house condition and this predator could reduce the thrips population in the plastic house and therefore reduced the insecticide application up to 35%. Other important pest control strategy disseminated to farmers was the spraying technique. The recommended spraying technique could reduce the insecticide application by reducing the spraying volume and increase the effectiveness in controlling the insect pests. Thus, the products for export market were accepted in the importing country such as Singapore due to the lower pesticide residues.

CONCLUSIONS

Many farmers have practiced the protected vegetable cultivation in Indonesia; however, the advances in structure development and crop management for protected cultivation are still limited. High cost for advanced types of greenhouses has led farmers to use simple plastic house constructed with locally available and cheap materials such as bamboo to fit their local conditions and needs. However, the simple greenhouse structure made from bamboo has many disadvantages such as reduced light transmission due to heavy structure, increased greenhouse temperature, and relatively short life span. Although new greenhouse structure has been introduced to farmers but the use of this new structure is still very limited. Attention needs to be given to improving the greenhouse structure adaptive and appropriate to farmer needs and tropical climate conditions, including cheap and long lasting plastic covers.

In order to increase the development of vegetable production under protected cultivation for domestic and export markets, apart from structure improvement, several areas of crop management under protection still need to be developed and integrated. They include innovative cropping systems, selection of varieties suitable for protected conditions and consumers, improved cultural practices, integrated soil and water management, and integrated pest management. On top of these, the protected cultivation of vegetables needs to be properly linked with other stages of supply chain such as packaging, storage, processing, distribution and marketing to ensure quality and safety of the products from protected cultivation.

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