PROTECTED CULTIVATION TECHNOLOGIES FOR VEGETABLES PRODUCTION IN MALAYSIA

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ABSTRACT

Protected cultivation has traditionally been concentrated in the highland regions in Malaysia, where the environmental condition or climate is suitable for temperate crop, land is scarce and competitive agricultural production. The need to increase cultivation area and production of vegetables is in line with the National Agricultural Policy. Cultivation systems which are environment friendly while ensuring high productivity have been adopted by vegetable growers and gradually increasing in lowlands where more space is available for protected horticulture. In view of this, MARDI has developed various technologies in vegetable production which are aimed towards reducing some of the major problems in vegetable production such as pests and diseases, and low productivity. This paper describes the technologies of vegetable production under protective structures, namely, the rain-shelter and netted structure.

INTRODUCTION

In Malaysia, vegetables are cultivated to a much lesser extent compared to the major agricultural commodities such as rubber, oil palm, rice, cocoa, coconut and fruits. Nevertheless, the production area of vegetables in Malaysia has increased from 49,085 hectares in 2011 to 65,899 hectares in 2015 an increase of 34% over the period. The production volume has increased from 938,000 tons in 2011 to 1.373 million tons in 2015, an increase of 46% over the period. Malaysia exports vegetables valued at RM 1.097 billion while imports amount to RM 4.480 billion, giving a negative annual trade balance of RM 3.383 billion. The most common vegetables imported are onions, shallots, garlic, potatoes, carrots, cabbages, cauliflower and broccoli (Vegetables and Cash Crops Statistic, DOA, 2016). Most of the vegetables imported consist of temperate types and those that are not technically and economically viable to be produced in Malaysia. In general, the import of vegetables into Malaysia keeps on increasing. Due to hiking in cost of production in Malaysia, especially the labour and other input costs, the production cost of vegetables, in Malaysia keeps on increasing. With the trade liberalization, the importation of vegetables from the neighboring countries with cheaper cost of production such as Thailand, China and Indonesia will definitely increase.

Vegetables in Malaysia are commonly cultivated in open field production system, which involves heavy use of inputs and manual labour. In tropical lowland of Malaysia heavy rainfall, wind and various plant pests and diseases often damage the open field grown vegetables. Traditionally, farmers use high levels of pesticides and chemical fertilizers so as to achieve high yields and quality grades of produce. The emphasis on yields and high demand for food has contributed to wide and indiscriminate use of pesticides and chemical fertilizers. Long-term usage of these practices has taken its toll on the soil and environment, leading to environmental pollution. Meanwhile, protected cultivation has traditionally been concentrated in the highland regions in Malaysia, where the environmental condition or climate is suitable for temperate crop, land is scarce and competitive agricultural production. The need to increase cultivation area and production of vegetables is in line with the National Agricultural Policy. Increased production is anticipated to come from opening up new areas as well as increased productivity from existing farms. Cultivation systems which are environment friendly while ensuring high productivity, have been adopted by vegetable growers and gradually increasing in lowlands where more space is available for protected horticulture. In view of this, MARDI has developed various technologies in vegetable production which are aimed towards reducing some of the major problems in vegetable production such as pests and diseases, and low productivity. This paper describes the technologies of vegetable production under protective structures, namely, the rain-shelter and netted structure.
Protected Cultivation in Malaysia

Majority of the crops under protected cultivation was flowers with few being vegetables. Flowers are mainly grown under protected structures both in the highlands and lowlands. The cultivation of chrysanthemum under rains-shelter in Cameron Highlands had less than 1 t/ha per year erosion, which is about 80 times smaller than that in open vegetable farms. The results suggest that open vegetable farming in the highlands is not sustainable due to erosion (Midmore et al. 1996). It appears that cultivation of crops under rain shelter is more sustainable. In case of vegetable production, smallholders dominate the industry with most of them operate on smallholdings. In Malaysia, high value vegetables (e.g. chili, tomato, cauliflower, and broccoli) are planted under rain-shelters. Production under rain-shelter is more expensive than in open field cultivation, but is economically viable because it enables limitations of the climate to be overcome. In the lowlands the rain-shelter provides shade to the crops against effects of excessive solar radiation.

Main Purpose of Protected Cultivation

Reduce disease incidence which normally spread in the rain
In open field planting diseases become serious whenever it rains and a great deal of chemicals need to be used for their control. This is particularly so for the brassicas (cabbage, cauliflower, broccoli, Chinese cabbage, chinese kale and leaf mustard) and solanaceous vegetables (chilli, tomato and bell pepper). Among the commonly used chemicals are the ethylenebis dithiocarbamate (EBDC) fungicides such as mancozeb, zineb and maneb. These chemicals provide cheap means of control against various leaf diseases on the brassicas and against early blight, late blight, anthracnose and leaf rot on chilli and bell pepper. Chemicals, however, have not been completely effective and their excessive use often leads to high chemical residues in crops. Excessive EBDC fungicide residues on various vegetable crops have been reported in Malaysia (Cheah 1989). This has led to the rejection of some of Malaysia’s vegetable produce exported to Singapore. Planting under the rain-shelter can overcome these problems. The plastic roof of the rain-shelter protects the crop from rain water, reducing the incidence of diseases which normally spread during wet periods, thus keeping chemical usage to a minimum. Under the rain-shelter serious bacterial diseases like soft rot and black rot on cabbage can be reduced since the soil is not entirely wetted by the rain. Choanephora fruit disease and fruit anthracnose problems in chilli can be overcome without much fungicide sprays. The use of the drip system in irrigation and fertilization of crops under the rain-shelter further helps to check the spread of diseases.

Reduce damage from insects, pests and other predators
Pests are always serious problems in vegetable production especially in the open field. Major pests of the brassica vegetables are the Plutella, Hellula, Spodoptera and flea beetles while Heliolthes, Dacus spp., thrips, aphids and mites are chilli and bell pepper. Various insecticides are used to control these pests, some of the common ones being deltametrin, permethrin, profenofos, cypermetrin and propargit. However, there are no known chemicals that are truly effective most of these pests all the time. Farmers are known to spray their crops with insecticides twice or thrice weekly. This practice, though able to control the pests to a certain extent, is harmful and also uneconomical. This situation can be improved when crops are grown under rain-shelters fitted with insect-proof screen. The insect-proof screen of the rain-shelter prevents entry of most insect pests. The netting of mesh size 1.0 mm used for the screen is effective for the control of most major insect pests of the brassicas. Only one or two chemical sprays are all that are needed to control these pests which affect cabbage, cauliflower, broccoli and Chinese cabbage. For the short term leafy vegetables like leaf mustard and chinese kale insecticides may not be required at all. Tiny pests such as thrips, mites and aphids can still enter through the netting, affecting crops like chilli and bell pepper, needing chemicals to control them. However, any insecticide required is very much less than that normally practiced in the open field. In general, under the rain-shelter there is 50-90% reduction in insecticide usage compared to open field planting (Illias and Rezuwan 1997).

Weed Control
Under rain-shelters weeds are not a serious problem due to a lack of excessive moisture in the soil that would otherwise be made available by rain. Besides, the use of drip irrigation system only wets the root zone of the crop while keeping the rest of the area dry, thereby reducing weed growth. Weedicides are usually not necessary unlike in the open field where they are frequently necessary.
Increase yield, improve product quality, and preserve resources

Vegetables grown under rain-shelter can give high yields and quality produce. Year round production is also possible since most field operations are not hampered by wet weather conditions. Shading of 20-30% from full rays of the sun is beneficial to the crop, improving growth leading to high yield and quality produce. Vegetable produce from planting under rain-shelter will be low in pesticide residues or even pesticide-free. Normally, achieving all these goals requires a greater investment than in conventional open field cultivation, as well as more inputs per unit surface area.

Technologies under Protected Structure

Soil-based system with conventional fertilizer application

In the soil-based system vegetables are planted on raised beds using seedlings or direct seeding and fertilized with granular compound fertilizers. Beds are covered with plastic mulch to prevent weed growth and to conserve soil moisture. Irrigation is through the drip system. Compound fertilizers such as NPK 12:12:17:2+TE are applied around the plants while irrigation is through the drip system.

Soil-based system with fertigation

Plants grown on the raised soil beds are fertilized through a technique called fertigation. Fertigation is a process where nutrients required by plants are supplied through the irrigation system. The processes of irrigation and fertilizer application run concurrently through the drip irrigation system. The fertigation process can be practiced using simple methods without sophisticated equipments, or using complete computerized automated systems to control fertilizer formulation, time, duration and frequency of fertilizer application. Many vegetables can be grown using this system, such as cabbage, cauliflower, chilli and tomato. Fertigation is an effective tool to control placement, timing and type of fertilizer needed according to the soil fertility status and growth stage of the crop. This technology improves fertilizer use efficiency (FUE) and minimizes nutrient losses due to volatilization, leaching and fixation in less available forms.

Fertigation in the soilless system

Small acreage owned by many small growers may not allow them enough space for crop rotation as a way to combat pest problems. Since rainwater is excluded from the cropping area, salt buildup from repeated fertilizer application may be a potential threat for continuous cropping. Thus, container culture where crops were grown in pots, boxes or bags filled with soilless media come as a solution. In the soilless system, plants are grown in polybags containing growth media such as cocopeat or cocopeat + burnt padi husk. Polybags of size 28 cm x 38 cm are commonly used. The polybags are placed in appropriate planting distance rows under the rain-shelter structure and fertigation applied. As with fertigation in the soil-based system, this technique can be practiced using simple methods without sophisticated equipment, or using complete computerized automated systems to control fertilizer formulation, time, duration and frequency of fertilizer application. This technique is popular with fruit vegetables particularly chilli (Yasser et al. 2016), tomato, and melon. It can also be practiced for other vegetables such as cabbage and cauliflower. Table 1 shows yields of various vegetables grown under rain-shelters in the lowlands. Yields under netted structures are high and of good quality since they are free from damage due to pests and mechanical damage due to heavy rainfall.

Table 1. Comparison between yield of selected vegetables under rain-shelter and open field (t/ha)

<table>
<thead>
<tr>
<th>Vegetables</th>
<th>Rain-shelter (with side netting)</th>
<th>Rain-shelter (without side netting)</th>
<th>Open field planting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage (soil-based)</td>
<td>37</td>
<td>33</td>
<td>28</td>
</tr>
<tr>
<td>Cauliflower (soil-based)</td>
<td>12</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Tomato (soilless fertigation)</td>
<td>NA</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Chilli (soilless fertigation)</td>
<td>22</td>
<td>27.7</td>
<td>18</td>
</tr>
</tbody>
</table>

Organic production

Organic production is a system of farming which avoids the use of chemical fertilizers, pesticides, growth regulators, feed additives and other chemicals. Under the rain-shelter crops are grown organically on raised soil beds. The
practice of organic farming under the rain-shelter with side netting is more assured of success since the crop is protected from insect pests while disease incidences are reduced without total dependence on pesticides. Biopesticides, natural enemies and cultural/sanitation practices commonly employed in organic farming are more effective when used or carried out under rain-shelter structures.

**Hydroponics**

Hydroponics is particularly for the growing of leafy vegetables although fruit vegetables are sometimes grown. Hydroponics is free from soil contamination and is a promising cultivation method for tropical regions. It uses water and dissolved nutrients in a plastic trough or container. A trough made of plastic or opaque material which does not absorb heat and not rust can be used as container. Problems associated with hydroponic systems are wastes of growing media and liquid. Circulation of cultivation solution is essential but does not fully solve the liquid waste problem. Accumulated unused salts must be removed from the circulating liquid to prevent the salt concentrations from exceeding the acceptable range.

**Production Economics**

The use of protective structures, especially rain-shelters, in vegetable production involves high capital costs. The wooden type rain-shelter is cheaper in construction and may be within reach of most farmers. The galvanized iron tunnel type is more expensive and may become an obstacle to its adoption. However, it lasts longer, can withstand strong winds, and usually gives higher crop yield and quality. With the availability of cheaper local materials, the costs of these rain-shelters can be significantly reduced. Although expensive, the high yields and returns will make production under rain-shelters profitable.

**CONCLUSIONS**

Agriculture is highly dependent on environment, and it’s very difficult to get favorable climatic conditions for crop growth and development as per crop need. Fast climatic changes happening across the globe has changed climatic characteristics of a season, which has resulted in untimely rains and other fluctuations, raising the challenge to develop climate resilient technologies. Manipulation the climatic conditions by providing protection to the crops against climatic fluctuations and various other related stresses by restricting or minimizing the exposure of the crops to various adverse factors, which are high in open conditions. Production of vegetable crops under protected conditions provides high water and nutrient use efficiency under varied agro climatic conditions. However, protected cultivation technology requires careful planning and attention about timing of production and moreover, harvest time to coincide with high market prices e.g. rainy season, choice of varieties adopted to the off season environments, and able to produce economical yields of high quality produce. Protected vegetable cultivation technology is highly relevant under the era of changing climatic conditions and can be well adopted for not only supplying high quality vegetables in the markets but also stabilizing the huge fluctuations in market prices of fresh vegetables in almost every year in Malaysia. Regardless of where protected cultivation structures occur, the challenge is to develop a greenhouse product whose value in terms of yield, quality or consistency can justify the added cost of production in controlled environments.

**REFERENCES**

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