Research article

The Effectiveness of Different Net-coverings on Production Yield of Chinese mustard (*Brassica juncea*) at Royal University of Agriculture

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Abstract Cambodia, among other nations in South East Asia, is a developing country that relies on its agricultural sector. More than 70% of the population farms rice is a staple crop and vegetables as a secondary crop for domestic demand and consumption. In 2013, Cambodia produced only 40-50% of the domestic demand for vegetables and the shortage was filled by imported vegetables from neighboring countries including Vietnam and Thailand. The shortage is caused by a number of factors including that vegetables are cultivated in small quantities and farmers lack funds to support improvements in crop cultivation that are necessary to address climate change, poor irrigation systems, disease outbreaks, and particularly crop destruction by pests. For instance, in 2016 crops in some provinces of Cambodia were damaged by Spodpter spp. Other insects also cause crop destruction which prompts farmers to change chemical pesticides to control additional pests. Using chemical methods to control the variety of pests that destroy Cambodian crops is not a viable long-term solution because it affects the health of both producers and consumers, the environment, and the microorganisms that are useful for cultivating high quality crops. The net-house is an installation structure using high quality mosquito netting that tolerates weather. It is suitable for growing vegetables and other crops because it creates a barrier between pests and crops to prevent damage. Using a net-house is an effective way to reduce pesticide use in vegetable production. It is also reported that net-houses have other benefits such as preventing weeds, reducing soil moisture loss, depleting sunlight, increasing yields and providing safe food. This research study has two aims (1) to assess the effects of different shapes of net-houses on growth and yield of Chinese mustard, and (2) to study the economic efficiency of growing Chinese mustard in differently designed net-houses. Experiments were conducted in triplicate using Randomized Complete Block Design. Treatments included standard net-house, covered-ridge net-house and open field as a control. Analysis revealed that using net houses increased the yield and economic efficiency of growing Chinese mustard and that the degree of benefit was affected by the design of the net house. Based on the results, recommendations are made about the most suitable method for growing high quality, pesticide-free Chinese mustard.

Keywords net-house, IPM, humidity, soil erosion, Chinese mustard

INTRODUCTION

Cambodia is a country located in tropical region with a monsoon wind, which is separated into the main two seasons: dry season and rainy season from May to October, and the dry season from November to April. This climate conditions that cause the cultivation of almost all types of crops grow well. Especially, most of vegetables commonly cultivated in lowland areas along rivers and other lowland areas. In that, vegetable crops with short harvesting time, such as mustard, are also cultivated. Due to the increase in demand for vegetables, local farmers cannot supply to import vegetables from neighboring countries such as Vietnam, Thailand, etc. These causes urge farmers to find ways to produce high-yield vegetables. The population is growing rapidly, which is why food demand is increasing every year. To solve these problems, scientists and technicians have tried to study new techniques to increase food production to meet daily needs (Nai, 2005).

Many of these foods, such as rice, wheat, corn, beans, sesame, and all kinds of vegetables, including Chinese mustard is a crucial crop to the people, Cambodian prefer to grow and take it as a vegetable to eat, or take it to cook for food and as supported substances such as protein, vitamins and other minerals and has been widely grew in all of Cambodia, especially along the river and other provinces. Farmers often grow as small and medium scale to supply families and markets with no technical limitations to increase yields. As a researcher for Chinese mustard grows well and no pests destroy and get better yields, we have to practice which techniques are relatively easy to spend little bit and get high yields to apply these techniques to farmers and to make their family life better (Chanchhaya, 2006).

The Net-house is an installation, which be built with large surface of net that allows plants to grow well and be environmentally-controlled to allow for better plant growth. In addition, the net-house has many roles: reduce weed, reduce the loss of soil moisture, reduces soil erosion, prevent sunlight, reduces the damaging as strong winds, increase yield and food safety to reduce soil erosion, and it is easy to harvest crops, use of nets is a good way to reduce the use of pesticides in the production of vegetable crops (Dany, 2010).

Chinese mustard is a type of vegetable that prefers to grow and eat because it has many benefits and is a crop that is resistant to hot and rainy those have same to the type of variety. In addition, Chinese mustard has no longevity of cultivation, farmers are often grown in vegetable gardens, family or farm produce for marketing in all seasons. Chinese mustard is a leafy vegetable that can contribute to the nutritional content and can be processed according to the need for cooking, or boiling and mixing with other vegetables or eating raw shoots of young leaves, as well as pickled mustard. Besides, it can be extracted deliciously and dried so that it can be stored for a long time. On the other hand, about 20-30% of Chinese mustard seeds can be refined as cooking oil and good quality (Vanarith, 2005).

OBJECTIVES

The objectives of this experiment were (1) to assess the effects of different shapes of net-houses on growth and yield of Chinese mustard and (2) to study the economic efficiency of growing Chinese mustard in differently designed net-houses.

METHODOLOGY

The Chinese mustard grown in front faculty of Agricultural Engineering in Royal University of Agriculture, Cambodia, in two seasons, rainy and dry season during academic year 2016-2017. The experiment was designed in a randomized block design with selection two models of net use and outside as Control. There were 3 treatments in this experiment as shown in Table 1 below. For each treatment was done in three replicates of which one plot containing 3 m^2 (1 m x 3 m) and all plots of this experiment were 27 m^2.

Treatment

- 1.T1: Opened-type (Control treatment)
- 2.T2: Net-house (7 m x 4.50 m x 3.40 m)
- 3.T3: Cover-bed net (3 m x 1 m x 1.5 m)

Fig. 1 Net-house

Fig. 2 Covered-bed net

After 12 days of germination stage, Chinese mustard plants were transplanted with a distance of 0.01 m × 0.01 m between rows and plants, respectively.

The Chinese mustard plant soil was sandy silt, pH 7, humus 0.8, containing total Nitrogen (0.21%), total Phosphorous (0.08%), total Potassium (0.90%), total Carbon (0.156 mil/100 g soil), a C/N of 5, with Organic Matter 0.26% (GDA, 2016). Net-house has installed same size (7 m x 4.50 m x 3.40 m) with three net-house for three replicates on flat land located different places. Covered-bed net has installed each bed with size (3 m × 1 m × 1.5 m) with three replicates to cover on each bed as well. The white net was used in this experiment and those were used same net for all net-house with mesh (32*32). For outside, is conventional method that has no covering or Control treatment. Chinese mustard were harvested manually when they had reached proper stage through cutting root, data collection was determined on number of insects, weight of weed, branch of plants, leaf area, weight per plant, and total weights. On economic analysis was determined on gross profit that took from calculation of total income minus total cost of Chinese mustard production. Below were some formulas to calculate economic cost in Chinese mustard production.

Formula GP=TI – TC, and
TC=TFC + TVC

Where: GP = Gross profit (US$)
TI = Total income (US$)
TC = Total cost (US$)
TFC = Total fix cost (US$)
TVC = Total variable cost (US$) (Farris et al, 2010).

Data as subjected to analyze of variance in Statistix 8 app. If interactions were significant, they we used explain the data. If interactions were not significant, means have separated with Tukey test.

RESULTS AND DISCUSSION

The Net-house and outside growing were determined in growth rate to analysis completely, as result shown that each data in Table 2. In addition, ANOVA determined that Covered-bed, type of growing and their two-way interactions had a significant effect on all measured characteristics of Chinese mustard interaction between different types of growing in net (Table 1).

Table 1 ANOVA table of Net-house Experiment on growing rate and total yield

	Mean Square				
S.O.V	Replicate	Treatment	Error	Total	CV (%)
d.f	2.00	2.00	4.00	8.00	
Insects (n/cm^2)	0.39	104.93	0.56		4.55
Weeds (g)	1773.88	11686.98	463.34		23.91
Branch/Plant	0.14	0.82	0.37		6.11
Leaf area (cm^2)	202.82	850.38	18.38		3.50
Plant height (cm)	13.72	88.94	3.51		7.16
Weight per plant (g)	98.98	1844.26	58.41		10.89
Total weight (t/ha)	0.94	64.12	2.02		10.59

*Note: S.O.V. = Sources of Variance; d.f. =degree of freedom; CV. = coefficient of variance; ns, ***, **, * non-significant and significant at P≤ 0.001, P≤ 0.01 and P≤ 0.05 respectively*

Table 2 Treatment of each replicates of chili yield and total yield characteristics

Treatments	Insect (N/cm^2)	Weigh of weed (g)	Number of leaf (N/plant)	Leaf area (cm^2)	Plant height (cm)	Weigh per plant (g/plant)	Weigh per square meter (t/ha)
T1	23.28a	113.69	9.39	109.61c	20.74c	51.25c	9.10c
T2	13.44b	90.08	10.24	116.45b	26.19b	61.06b	12.90b
T3	12.67c	66.27	10.33	141.58a	31.63a	98.25a	18.30a
Meaning	***	ns	ns	**	**	**	**
F-value	186.73	3.64	2.20	46.26	25.30	31.57	32.07
P-value	0.0001	0.1257	0.2268	0.0017	0.0054	0.0035	0.0034
CV	4.55	23.91	6.11	3.50	7.16	10.89	10.56

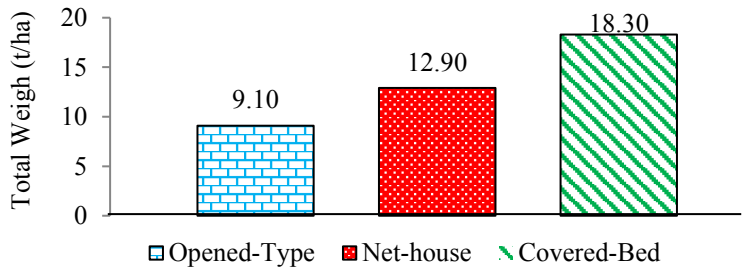

Fig. 3 Total weight of all treatments in t/ha

For production cost, Chinese mustard production costs have calculated AVERAGE of total weight per bed with 3 m^2 (1 m x 3 m) through first and second season. At first season of Opened-type, Net-house, and Covered-ridge weights per bed are 2.97, 3.87, and 5.49 kg/bed. In the table was separated costs into 2 types that were fixed cost and variable cost.

Table 3 Production Cost Analysis on each treatment in dollars ($)

Production cost	Formula	Opened-type	Net house	Covered-ridge
Fixed cost (FC)				
Irrigated tank(280 L) (5 years)	20 $ / 5 years / 4 times / 3 places	0.3333	0.3333	0.3333
Water sprayer	3 $ / 3 years / 8 times	0.375	0.375	0.375
Net (Mesh size=32)	29.40 $ for small and139.93 $ for net house (period 5years up and 8times)	-	0.5830	0.735
Wood posts	(9 post x 5 $) / 7 years / 8 times	-	0.0835	-
Wood bar	(13 bars x 5 $) /3 years / 8 times / 6 plots	-	0.45	-
Bamboo	3 $ / 2 years / 8 time	-	-	0.1875
Cable	10 $ / 500 m / 8 times	0.0025	0.0025	0.0025
Variable cost (VC)				
Land preparation	(5 $ / 162 m^2) x (1 time)	0.0102	0.0102	0.0102
Seeds or variety	1 $ / 2 times	0.5	0.5	0.5
Chemical fertilizer	40 $ / 50 kg / 5 times	0.16	0.16	0.16
Water for irrigation	(35 days) x 3 L x 2 times x 0.5/1000	0.105	0.105	0.105
Cow manure	2.5 $ / 100 kg / 30 times	0.0008	0.0008	0.0008
Power tiller renting	2.5 $ / 162 m^2 / 1time	0.0154	0.0154	0.0154
Weed cleaning cost	(5 $ / 27 ridges) x 3 times	0.5555	0.5555	0.5555
Installation cost	(10 $ / 27ridges / 6 beds)	-	0.0617	0.0617
Yields				
Weight	(0.91 kg/m^2, 1.29 kg/m^2, 1.83 kg/m^2) x 3	2.97	3.87	5.49
Total cost (TC)				
Include labor force		2.0578	3.2360	3.0420
Not include labor force		0.5555	0.6172	0.6172
Total income (TI)	Price x kg (1 kg = 2 $)	5.9400	7.7400	10.9800
Profit	Total income (TI) - TC	3.8822	4.5040	7.9380
Include labor force		3.8822	4.5040	7.9380
Not include labor force		5.3845	7.1228	10.3628

On the result, number of insects shown that much insects treatment was T1=23.28 N/cm^2, and least insects was T3=12.67 N/cm^2 which be used covered-bed net had a significant 0.1% with CV=4.55% and P-value = 0.0001. For leaf area, the biggest size treatment was T3=141.38 cm^2 and the smallest size treatment was T1= 119.61 cm^2 had a significant 1% with CV=3.50% and P-value = 0.0017. In addition, plant height of each treatment had a significant 1% with CV=7.16% and P-value = 0.0054 shown that the tallest treatment was T3=31.63 cm and the shortest treatment was T1=20.74 cm. Also, weight per plant of each treatment had a significant 1% with CV=10.89% and P-value=0.0035, treatment which be heaviest was T3=98.25 g/plant and lightest treatments was T1=51.25 g/plant. For weight per plant of each treatment had a significant 1% with CV=4.71%, heaviest treatment of weight per plant was T2=129.85 g per plant and lightest weight per plant was T0=95.45 g per plant. Furthermore, total weight of all treatments were significant 0.1% with CV=10.56% and P-value = 0.0034, which be heaviest was T3 = 18.30 t/ha and lightest was T1 = 9.10 t/ha. Otherwise, number of leaf and weight of weed were not significant.

Refer to data calculation in Table 3 was shown that income of each treatment are opened-type (US$ 5.94/bed), net house (US$ 7.74/bed), and covered-ridge is US$ 10.98/bed. In addition, treatment which be more profit is T3 (US$ 7.93/bed), next is net-house (US$ 4.50) and last treatment is opened-type got US$ 3.88/bed.

According to compare on the growth rate of Chinese mustard (Table 2), we were recorded on some data such as plant height, leaf area. ANOVA of these factors had shown that three factor were not same on some reasons such as soil of experiment plots, closing net-house doors and wind flow.

Total weight had obtained by grower be good thing to get such weight of Chinese mustard, so after ANOVA Table 2 and total weight of all treatments were significant 0.1% with CV=10.56% and P-value = 0.0034, which be heaviest was T3 = 18.30 t/ha and lightest was T1 = 9.10 t/ha (Fig. 3). After this research, result observation was proved that some reasons can be good for this study such as soil moisture on covered-bed treatment. we have observed some frogs and yellow tree frogs

those are nearby covered-bed treatment. According optimal condition of frog lifecycle is shown that proper humidity to live is 97.80% and temperature is 27.5 ^{0}C (Lannoo et al, 2005).

CONCLUSION

For the net-house and outside application in two seasons on Chinese mustard yield be effective and well than another treatment no need net. It makes Chinese mustard grow well and obtain high yield as well. Covered-bed application can keep humidity in soil, reduced pest on vegetable, reduce soil erosion and prevent the crop from heavy rain and insects destroying. And according to the results, where the criterion for net-house selection and its application rate is based on total yield as total weight, then the following net regimes can be recommended: T3=18.30 t/ha stand for covered-bed net-house was obtained highest yield and got highest profit (US$ 7.93 per bed) in this experiment and next suitable was T5=4.50 t/ha with profit was US$ 3.88 per bed.

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I have tried hard and soul to gather all relevant documents regarding this subject. I do not know how far I am able to do that. Furthermore, I do not claim all the information in this manuscript is included perfectly. There may be shortcoming, factual error, mistaken opinion which are all mine and I alone am responsible for those but I will try to give a better volume in future.

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