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On-Farm Effects of Drainage System on the Productivity of Chinese Cabbage (*Brassica pekinensis* L. Rupr.) of Farmers in Svay Rieng Province, Cambodia

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Abstract: The vegetable production in Cambodia has been plagued with poor productivity and broken chain, leaving the comparative advantage to the neighboring countries, namely Vietnam and Thailand. Poor soil condition during wet season has been significantly impacting the productivity of vegetable production in Cambodia which leads to an introduction of sub-surface drainage system at the root zone of Chinese cabbage under this paper. The aim of the experiment is to determine the possibility in increasing the effectiveness and productivity during wet season of Cambodian vegetable producers. The results of the experiment indicate positive improvement in terms of yield and growth of the Chinese cabbage at a rate of 24% and 34% for T2 and T3, respectively. There are, however, limited practicality and generalization for the research due to the controlling factors during the experiment and the detailed experimental setting which need further analysis, especially economic analysis and following up research work.

Key words: Chinese cabbage, sub-surface drainage system, vegetable production.

1. Introduction

Although the major occupation of the Cambodians is agriculture, the country is a net agricultural importer, giving the vegetable imports worth approximately USD200 million annually [1]. The heavy reliance of the country on neighboring countries (mainly Vietnam and Thailand) on vegetables is associated with the highly seasonal productions of Cambodian producers lasting for around only three months from late December to late March. The period is appropriate for vegetable production as the weather is relatively mild and dry [2]. Moreover, rice farmers are free from rice production and some of them opt to produce vegetables for additional income, causing the volume of vegetables reaching the peak while the price falls to the lowest one [3]. After the period, water becomes scare and soil becomes too dry whereas wet season faces the problem of too much rainfall, causing waterlogging, high pests, and diseases [2]. The discontinuous supply of the vegetables at stable volume has caused vegetable value chain broken and loss of competitiveness to the neighboring countries, namely Vietnam and Thailand. It is reported that local capacity for vegetable production could supply approximately 45% of the market demands and 70% are in the peak period of the production in dry season [4].

Drainage system provides substantial benefits to agricultural production which could contribute to (i) increasing of farm income; (ii) intensification and diversification of cropping; and (iii) generation of employment [5]. Proper management of irrigation practice could provide various benefits to crop production such as: extended crop season, increased yield, and improved aeration of root zone [6]. However, the development of drainage system has been lagging far behind the development of irrigation, leaving agriculture at high risk of losing productive lands to waterlogging and salinization [7]. There is no exception for Cambodia where the introduction of sub-surface irrigation system has been very limited and hardly found at any Cambodian farm. Unstable quantity at

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the supply side has been one of the reasons behind the loss of production competitiveness to the neighboring countries including: Vietnam and Thailand.

The experience from collaboration between Svay Rieng University with Svay Rieng Agricultural cooperatives (SAC) shows that vegetable producers are facing severe issues of waterlogging during wet season causing their production being least productive and delayed. The introduction of sub-surface drainage system is, therefore, essential to study, determining the potential contribution of drainage system, the sub-surface, to vegetable production within the province which could also be essential for other vegetable producers across the country.

2. Materials and Design

2.1 Site and Period

The experiment had been conducted in Svay Rieng Province, Cambodia with eight vegetable producers who are the members of SAC being conducted between November and December 2020 while the second trial was conducted between February and March 2021. The result being used for this research was only conducted for the first trial due to severe damage of the second trial. The production sites are located in six villages, four communes of the same district, Svay Chrom district, Svay Rieng province.

2.2 Design

Randomized Complete Block Design (RCBD) has been used as the design for the experiment, containing three treatments T1, T2 and T3 with three rows each (Fig. 1) and 8 farmers acting as the replication. The cabbages are grown on the raised bed with the polyvinyl chloride (PVC) pipe being buried underneath at the depth of 20 cm under the root zone of the cabbages. The pipes were sawed to make holes for water to drain to the nearby canal. There are a total of 28 blocks of 4 m^2, consisting of 8 replications (the farmers) and 3 treatments. Observation on growth and discussion on perception of farmers who involved with the experiment were also part of the study to obtain the added value of the experiment.

2.3 The Control

To ensure the conformity and variations among the farmers, the experiment controlled a number of factors including: the amount of fertilizer application and cultivation practices. Field monitoring had been conducted regularly to the experiment site to monitor the progress as well as the level of management of farmers. There are, however, limitations being observed with the practices of farmers which could not controlled because their experiences and practices are varied from one farmer to another.

2.4 Data Analysis

The results of the experiment were recorded using meter and weight meter to measure the weight and

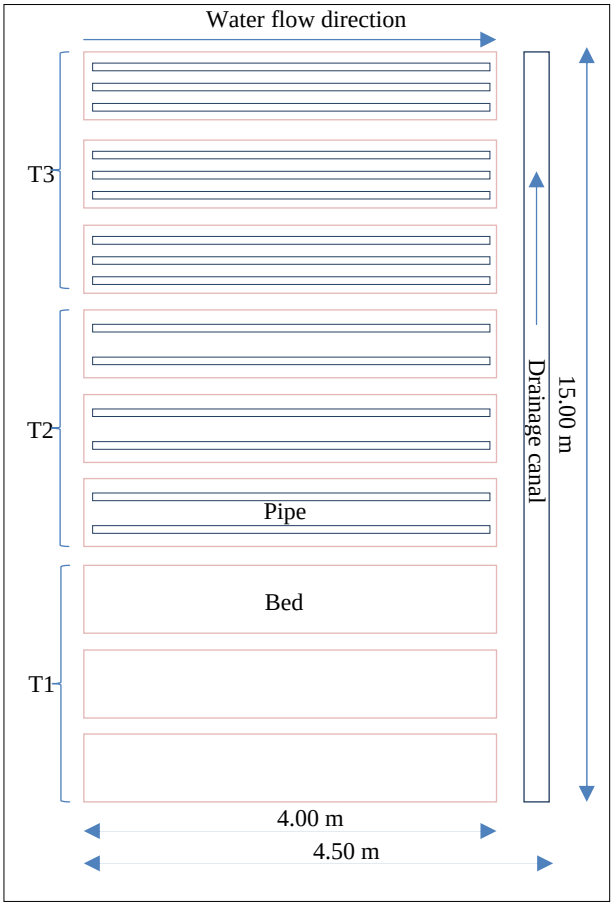

Fig. 1 Illustration of the experimental design for each farmer.

length of all parts of cabbages including: stem length, weight, leaf length and widths and weight of the cabbages. The analysis of the data used statistical package for social science (SPSS) in which General Linear Models with analysis of variance (ANOVA) for comparing different means of all data sets are the important part in the analysis. Prior to the analysis, the data were normalized to exclude the covariance being observed from the differentiation among farmers. The analysis data are the adjusted one which would not be the case for experiment being conducted at farms or station.

3. Results and Discussion

3.1 Effects on Growth

Seven key parameters were measured from the experiment of cabbage including: height, stem length, leaf width, leaf length, number of leaves, root length and productivity (weight of stem, leaf, and root). The result of the experiment is summarized as Table 1 below.

Table 1 Effects of on growth.

No.	Time	T1	T2	T3	*p*-value
1	Height				
1.1	Day 01 (cm)	10.44	10.39	10.41	0.944
1.2	Day 07 (cm)	14.55	14.75	15.30	0.053
1.3	Day 14 (cm)	20.19	20.87	21.44	0.016*
1.4	Day 21 (cm)	24.4	25.17	25.54	0.001**
1.5	Changes (cm)	13.96	14.78	15.14	0.004**
2	Stem length				
2.1	Day 01 (cm)	4.35	4.08	4.11	3.970
2.2	Day 07 (cm)	7.10	7.59	7.65	0.059
2.3	Day 14 (cm)	10.68	11.34	11.79	0.022*
2.4	Day 21 (cm)	15.02	15.54	15.75	0.001**
2.5	Changes (cm)	10.66	11.46	11.64	0.015*
3	Leaf width				
3.1	Day 01 (cm)	3.63	3.38	3.27	0.266
3.2	Day 07 (cm)	4.99	5.02	5.14	0.089
3.3	Day 14 (cm)	7.20	7.48	7.76	0.023*
3.4	Day 21 (cm)	10.55	10.83	10.95	0.001**
3.5	Changes (cm)	6.91	7.46	7.68	0.022*
4	Leaf length				
4.1	Day 01 (cm)	2.17	2.08	2.02	0.328
4.2	Day 07 (cm)	3.27	3.35	3.41	0.052
4.3	Day 14 (cm)	4.01	4.14	4.26	0.020*
4.4	Day 21 (cm)	4.67	5.04	5.40	0.007**
4.5	Changes (cm)	2.50	2.96	3.38	0.006**
5	No. of leaves				
5.1	Day 01 (cm)	4.38	4.39	4.40	0.990
5.2	Day 07 (cm)	7.55	7.65	7.66	0.052
5.3	Day 14 (cm)	10.81	10.95	11.07	0.013*
5.4	Day 21 (cm)	13.07	13.47	13.73	0.001**
6.6	Changes (cm)	8.70	9.09	9.33	0.028*
6	Root length				
6.1	Day 01 (cm)	2.56	2.50	2.63	0.624
6.2	Day 21 (cm)	11.73	13.15	13.70	0.001**
6.3	Changes	9.17	10.65	11.08	0.001**

* Significant with *p*-value < 0.05; ** significant with *p*-value < 0.01.

Table 2 Effects on productivity.

No.	Parameter	T1	T2	T3	*p*-value
1	Stem weight (g)	6.87	7.25	8.05	0.005**
2	Leaf weight (g)	97.62	124.15	131.70	0.002**
3	Root weight (g)	5.98	6.70	7.80	0.004**
4	Yield (t/ha)	26.12	32.85	34.94	0.002**

** Significant with *p*-value < 0.01.

Table 1 shows that the drainage system could make significant impact on the growth of cabbage. In overall, T3 is observed to be better than T2 and T1. However, T2 and T3 are slightly different from each other. At the time of transplanting, all parameters are statistically non-significant which is similar to the growth at day 7. However, the difference has become greater at day 14 with most of the parameters becoming significant with *p*-value less than 0.05. The increase of difference has been gradually developed, resulting in the *p*-value of less than 0.01 for all of the day 21 records. In addition, the level of changes for all parameters is statistically different.

3.2 Effects on Productivity

Stem, leaf and root weight and yield per hectare are measured and calculated from the experiment. The results from the experiment are provided in Table 2.

The findings show highly significant impact of drainage (T2) and (T3) on the yield of cabbage based on different designs of the drainage system. The figures indicate the more drainage systems could yield the better growth of Chinese cabbage. The growths of the cabbage are better at all directions: to the top, into the ground and the size of the vegetables.

3.3 Observation and Farmers' Perception

The second trial was severely impacted and damaged causing that the result from the second trial could not be used. There are however a few observations which could be made from the experiment. Firstly, the growth of the cabbage within the drainage zone (T2 & T3) has been observed to be more robust and resilient to both raining and draught. At the time of raining, the cabbage could continue its growth with less effect while during the time of draught, cabbage could maintain its freshness, possibly as a result of good aeration of the soil and less soil compaction after strong drop of the rain.

Farmers who involved in the experiment indicate their interest in participating in the experiment and applying the technique within their production but very much concern on the cost of the drainage pipe as it is still high cost while the ready-made drainage pipe is not yet available in the country at the moment.

3.4 Discussion

The effect of drainage on the yield of the Chinese cabbage has been significant, increasing at 26% and 34%, respectively for T2 and T3. However, there is limited possibility in making generalization since the controlling factors are inadequate including: the cultivation practices of farmers and effects of rainfall at different intensities across the most production period of the country. In addition, the yield from the experiment is slightly better than the one being conducted at Royal University of Agriculture with the yield of 28 ton/ha [8]. This would be more precise with full-control condition of experimentation which would be possible in making generalization into the actual condition of the country.

The experiment indicates high economic benefit for vegetable production. With the average changes of 26% and 34% difference comparing to T1 for T2 and T3, respectively, the economic benefits for farmers would be enormous. It is reported that the consumption of the vegetables in Cambodia is approximately 1,062 million tons per year [9]. This would translate into approximately 80 tons for the wet season production

for Cambodia. With the application of the drainage at the maximum scenario, the increase of vegetable production would possibly estimate at up to 20 million tons and 27 million tons, respectively for T2 and T3.

There is still another concern regarding the cost of sawing and the drainage pipe which is included in the production. A more detailed analysis on the cost and benefit of the production would help to make the drainage system more determined and applicable.

4. Conclusion

The introduction of sub-surface drainage system into the Chinese cabbage production could yield significantly difference from the traditional application even with bed raising. The application would bring in a more significant difference, if the ready-made drainage pipe could be manufactured or imported to reduce the cost of local-sawing for practical comparison for vegetable producers in the province as well as the country.

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