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Effect of Dried-grass Fermented Fertilizer on Growth and Yield of Chinese Kale (*Brassicaoleracea*) Production

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Abstract: A field experiment was undertaken to determine the effects of dried-grass fermented fertilizer on growth and yield of Chinese kale cultivation in Surin province, Northeast of Thailand. Two dried-grass fermented fertilizers were developed from chopped dried-grass : rice bran : cattle manure (v/v/v) in the ratio 1:1:1 (formula 1) and 2:1:1 (formula 2) + 20 ml of molasses + 10 ml of EM + 10 lit of dechlorinated water and used in this experiment. Twenty-one treatments were compared consisting of T_{1-3} (control), T_{4-6} and T_{13-15} (500 g block^{-1} of dried-grass fermented fertilizer formula 1 and 2, respectively), T_{7-9} and T_{16-18} (700 g block^{-1} of dried-grass fermented fertilizer formula 1 and 2, respectively), T_{10-12} and T_{19-21} (1000 g block^{-1} of dried-grass fermented fertilizer formula 1 and 2, respectively). Higher growth and yield of Chinese kale under all treatments increased between 2-5 times when compared to the control (without fertilizer). In terms of statistical data, average Chinese kale total weight with leaves and number of leaves per plant obtained from dried-grass fermented fertilizer were significant at a confidence level of 95 % to the control. Increasing dried-grass fermented fertilizer concentration in this experiment had no significant effect on average number of leaves per plant. Except control, average Chinese kale total weight with leaves and number of leaves per plant in all treatments were ranged between 11.16-26.21 g and 4.00-5.37 leaves respectively. However, average Chinese kale total weight with leaves and number of leaves per plant obtained in this experimental were not coincided to the Thai market standard. Under taking into account chemical fertilizer cost, which is ten times higher than ordinary biological fertilizer, the soil amendment with dried-grass fermented fertilizer may be a practicable alternative for the poor farmers who own degraded farmlands and unable to afford the cost of chemical fertilizer for growing Chinese kale.

Key words: dried-grass fermented fertilizer, dechlorinated water, confidence level, Surin province

INTRODUCTION

Chinese kale (*Brassica oleracea* var. *alboglabra* O. Kunze) is one of the major economic leafy vegetable in Thailand and in the year 2006 there is approximately 0.38 million hectares of land devoted to Chinese kale. This results in a yield of 3.4 million tons of Chinese kale each year. The extensive Chinese kale production and poor farm management systems have resulted in soil erosion, depletion of soil nutrients and soil exhaustion. A major constraint to Chinese kale production in Northeast Thailand is the low soil organic matter content and biological activity. Chemical fertilizers are significant to succor nutrients in soil. Heavy doses of chemical fertilizers and pesticides are commonly used in order to enhance Chinese kale yields. Approximately 50% of crop yield increment has been promoted by chemical fertilizers[2,6]. Death and suffering from chemical fertilizers and pesticides of the farmers is a critical problem in Thailand. These problems arose from a general lack of knowledge of agro-chemical application and safety use procedures. In addition the over use of inappropriate inorganic nitrogen fertilizer has resulted in nitrous oxide production and denitrification activity near the soil surface[4].

Effective microorganisms (EM) is a mixed microorganism culture which consists of lactic acid bacteria, yeast, fermenting fungi, actinomycetes and photosynthetic bacteria[4]. EM is widely used as a beneficial microbial inoculum for making Bokashi (biological fertilizer) and the use of EM helps to increase crop yields by enhancing soil fertility, conserve the soil productivity, improve biological properties and also physical amelioration of soil structures[5,8]. In Thailand, EM technology is applied in different domains such as cultivation, animal husbandry and environmental treatment. Presently, Thailand is concerned about promoting more organic farming systems since they are free of chemical fertilizers and

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pesticides, environmentally friendly, address farmers' livelihoods and emphasize utilization of on-farm resources by recycling waste into useful organic matter. Attraction in organic farming is increasing in Thailand and this interest has been promoted by the Thai government. In addition, the present cost of chemical fertilizer is increasing cooperative with the oil price. Hence, under the potential constraint of chemical fertilizer cost and the benefits of organic farming systems, poor farmers who own degraded farmlands may consider using more organic farming in the future. Therefore, this research was undertaken to examine the effect of dried-grass fermented fertilizer on growth and yield of Chinese kale cultivation. It is expected that the findings of this study will help to develop appropriate Chinese kale cultivation management techniques in the Northeast of Thailand.

MATERIALS AND METHODS

These block experiments were carried out at Surin Province in the Northeast of Thailand.

Block Preparation: Soil was ploughed two time and left for a week before Chinese kale was cultivated. Chinese kale was cultivated in a randomized complete block design of 21 blocks with three replications of each treatment. Each block size was 1.0 x 1.0 m and there were 9 plants in each block. Chinese kale was grown with 30 and 30 cm row to row and line to line spacing, respectively.

Dried-grass Fermented Fertilizers Preparation: Two dried-grass fermented fertilizers were prepared as follows:

Formula 1: Mixing chopped dried-grass : rice bran : cattle manure in the ratio 1:1:1 (v/v/v) and added 10 lit of dechlorinated water, 10 ml of EM and 20 ml of molasses.

Formula 2: Mixing chopped dried-grass : rice bran : cattle manure in the ratio 2:1:1 (v/v/v) and added 10 lit of dechlorinated water, 10 ml of EM and 20 ml of molasses.

Both of these two dried-grass fermented fertilizers were kept in the shade at room temperature in order to ferment for 14 days after mixing and ready to use after 21 days fermentation

Treatment Design: Twenty-one treatments were evaluated in this experiment as follows:

Treatment 1-3 Control (without dried-grass fermented fertilizers)

Treatment 4-6 500 g block^{-1} of dried-grass fermented fertilizer formula 1

Treatment 7-9 700 g block^{-1} of dried-grass fermented fertilizer formula 1

Treatment 10-12 1000 g block^{-1} of dried-grass fermented fertilizer formula 1

Treatment 13-15 500 g block^{-1} of dried-grass fermented fertilizer formula 2

Treatment 16-18 700 g block^{-1} of dried-grass fermented fertilizer formula 2

Treatment 19-21 1000 g block^{-1} of dried-grass fermented fertilizer formula 2

Each dried-grass fermented fertilizers were incorporated one week before cultivation and then added on day 15 and 30 after cultivation. All treatments of Chinese kale cultivation were harvested on day 45 after sowing.

Data Analysis: The Chinese kale growth and yield data from each treatment was collected on the same day to determine the following parameters:

1. Number of leaves were counted on the day of harvesting.
2. Total weight (g) per plant from each treatment was determined on day of harvesting.
3. Statistical analysis: the data was analyzed using SPSS for Windows XP (http://www.spss.com).
4. Nitrogen content of dried-grass fermented fertilizers and soil was examined by Buurman *et al*.,[1]
5. Potassium content of dried-grass fermented fertilizers and soil was examined by Tan[12].
6. Phosphorus content of dried-grass fermented fertilizers and soil was examined by Buurman *et al*.,[1].

RESULTS AND DISCUSSION

Soil and Biological Fertilizer Composition: Soil samples before planting and each dried-grass fermented fertilizers composition were evaluated (Table 1). The values of pH and NO_3^- were not much different in two dried-grass fermented fertilizers. Nitrogen contents in biological fertilizer formula 1 and 2 were 1.309 and 1.365 %, respectively. Therefore, the nitrogen concentration in dried-grass fermented fertilizer formula 1 and 2 is equivalent to 6.545 and 6.825 g block^{-1} or 65.45 and 68.25 kg ha^{-1} when 500 g of dried-grass fermented fertilizer was applied, respectively. This amount is increased to 91.63 and 95.55 kg ha^{-1} or 130.90 and 136.50 kg ha^{-1} when 700 and 1000 g of dried-grass fermented fertilizer was applied per block, respectively.

For phosphorous contents, the dried-grass fermented fertilizer formula 1 showed lower P_2O_5 concentration (0.344 %) than those found from the formula 2 (0.740 %). Therefore, the phosphorous concentration in dried-grass fermented fertilizer formula 1 and 2 is equivalent to 1.72 and 3.7 g block^{-1} or 17.20 and 37.00 kg ha^{-1} when 500 g of biological fertilizer was applied, respectively. This amount is increased to 24.08 and 51.80 kg ha^{-1} or 34.40 and 74.00 kg ha^{-1} when 700 and 1000 g of dried-grass fermented fertilizer was applied per block, respectively. For potassium contents, the fertilizer formula 2 showed higher K_2O concentration (1.138 %) than those found from the formula 1 (0.860 %). Therefore, the potassium concentration in dried-grass fermented fertilizer formula 1 and 2 is equivalent to 4.30 and 5.69 g block^{-1} or 43.00 and 56.90 kg ha^{-1} when 500 g of dried-grass fermented fertilizer was applied, respectively. This amount is increased to 60.20 and 79.66 kg ha^{-1} or 86.00 and 113.80 kg ha^{-1} when 700 and 1000 g of dried-grass fermented fertilizer was applied per block, respectively.

Number of Leaves and Total Weight with Leaves per Plant: Number of leaves and total weight with leaves per plant were measured on the day of harvesting (45 days after cultivation). Except control, average Chinese kale total weight with leaves and number of leaves per plant in all treatments were ranged between 11.16 – 26.21 g and 4.00 – 5.37 leaves respectively (Table 2 and 3). These results showed significant different to the control (5.80 g of weight and 3.12 leaves per plant). However, average size of Chinese kale obtained in this experimental was small and it was not coincided to the Thai market standard.

Discussion: Application of both dried-grass fermented fertilizers showed higher growth and yield than control. However, increasing dried-grass fermented fertilizers concentration from 700 to 1000 g block^{-1} had no significant effect in promoting growth and yield of Chinese kale. Even the maximum average total weight with leaves per plant (26.21 g) was obtained from biological fertilizer formula 2 but this value was insignificant and close to those found in dried-grass fermented fertilizer formula 1. Chinese Kale is a leafy vegetable thus it requires moderate amounts of fertilizer which rich in nitrogen content. However, the amount of nitrogen needed in plant is depended on soil organic matter content, crop uptake and yield levels[9]. Nitrogen uptakes by Chinese Kale is vary between 200-500 kg ha^{-1} and the amount of nitrogen responses also vary from place to place. Yield and average size of Chinese kale obtained in this experimental were less than the normal Thai market standard (average total weight approximately 100 g per plant) might be result from poor soil properties, low nutrients released from dried-grass fermented fertilizer and small amount of dried-grass fermented fertilizer was added into the cultivated soil. Low fertility may promote nutrient deficiencies that result in yellowing (nitrogen deficiency). The mineralization of nitrogen and its availability to plants varies greatly, depending on the nitrogen source, the temperature, humidity, texture of the material and microbial activity. Brassica crop requires nutrients in varying quantities to support optimal growth and reproduction. Nitrogen is the nutritional element that most cultivated crops need in the greatest amounts

Table 1: Soil and dried-grass fermented fertilizer composition

Sample	pH	NO_3^- (%)	P_2O_5 (%)	K_2O (%)
Soil	5.4	0.061	0.003	0.008
Formula 1	6.20	1.309	0.344	0.860
Formula 2	6.54	1.365	0.740	1.138

Table 2: Effect of dried-grass fermented fertilizers on the average number of Chinese kale leaves per plant

Fertilizer	Average number of leaves per plant		
	Fertilizer 500 g per block	Fertilizer 700 g per block	Fertilizer 1000 g per block
Formula 1	4.00 ± 0.29^{b}	5.14 ± 0.39^{b}	4.86 ± 0.22^{b}
Formula 2	4.23 ± 0.16^{b}	5.00 ± 0.12^{b}	5.37 ± 0.31^{b}
Without fertilizer		3.12 ± 0.21^{a}	

Means ± SD in each column with different superscripts indicate statistical differences (P<0.05)

Table 3: Effect of dried-grass fermented fertilizers on the average total weight with leaves per plant

Fertilizer	Average total weight with leaves per plant (gm)		
	Fertilizer 500 g per block	Fertilizer 700 g per block	Fertilizer 1000 g per block
Formula 1	11.16 ± 2.44^{b}	23.94 ± 2.87^{c}	21.93 ± 3.80^{c}
Formula 2	13.80 ± 2.67^{b}	24.35 ± 3.53^{c}	26.21 ± 2.71^{c}
Without fertilizer		5.80 ± 2.67^{a}	

Means ± SD in each column with different superscripts indicate statistical differences (P<0.05)

Brassica crop uses it to form proteins, chlorophyll, protoplasm and enzyme[3]. Suphachai *et al*., (2006) suggested that the fertilizer efficiency of Chinese kale was best at the nitrogen fertilizer rate of 156 kg ha^{-1}. Therefore, poor growth of Chinese kale obtained in this study might be resulted from nitrogen deficiency since the highest amount of nitrogen content (1000 g $block^{-1}$) of biological fertilizer formula 2 supplemented in this experiment is equivalent to 136.50 kg ha^{-1}. The results from this experiment confirm those of Gibson and Whipker (2000), who found higher growth of *Brassica oleracea* var. *acephala* L. when fertilized with nitrogen at 250 ppm (mg L^{-1}) than 100 ppm.

Phosphorus is important for root development and Phosphorus uptake rates in Chinese Kale is depended on its diffusion and concentration near their roots. Phosphorus and Potassium require in *Brassica oleracea* var. *acephala* L. are less than Nitrogen. The N:P:K ratio uses for growth of Chinese kale is 2:1:1 or 3:2:1 therefore Potassium and Phosphorus uptake by Chinese Kale are vary between 100-250 kg ha^{-1}. In this experiment, the amount of Potassium and Phosphorus supplied by 1000 g $block^{-1}$ of biological fertilizers is ranged between 86.00-113.80 and 34.40-74.00 kg ha^{-1}, respectively. These values fall under the normal range of Potassium and Phosphorus uptake rate, thus the availability of Potassium and Phosphorus from the highest amount of dried-grass fermented fertilizer supplied into the cultivated soil were insufficient for Chinese Kale growth. However, application of both dried-grass fermented fertilizers showed higher growth and yield than control. Average Chinese Kale total weight with leaves per plant under all treatments increased approximately 2-5 times (11.16-26.21 g) when compared to the control (5.80 g). Control did not show significant effects in promoting Chinese Kale yield might be a result of the soil properties which are acidic, dry and a very low nutrient content. Such soils are inappropriate for Chinese Kale growth. Increasing dried-grass fermented fertilizer from 700 to 1000 g $block^{-1}$ had no significant effect on Chinese Kale growth and yield. It may have been caused by Chinese Kale has a shorter growth cycle (45 days cultivation period) and the two times supplemented with dried-grass fermented fertilizer (350 and 500 g $block^{-1}$ each time) during cultivation may not provided sufficient nutritional for Chinese Kale growth. The dried-grass fermented fertilizer formula 2 contained two times of mixing chopped dried-grass than dried-grass fermented fertilizer formula 1. Supplemented more chopped dried-grass provided high Phosphorus and Potassium content. However, high content of Phosphorus and Potassium in dried-grass fermented fertilizer formula 2 showed insignificant effects in promoting Chinese Kale growth and yield. This might be caused by a slow degraded material property of dried-grass fermented fertilizer which may have caused the minerals and availability of plant nutrients to only gradually be released into the soil via the fermentation process[7]. The effectiveness of nutrients contribution from dried-grass fermented fertilizer relied on the soil properties, activities of ammonium and nitrification oxidative microbes in soil. The nutrients released from dried-grass fermented fertilizer into the soil cannot be predicted in immature and profound soils where the microbes cannot grow[13].

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