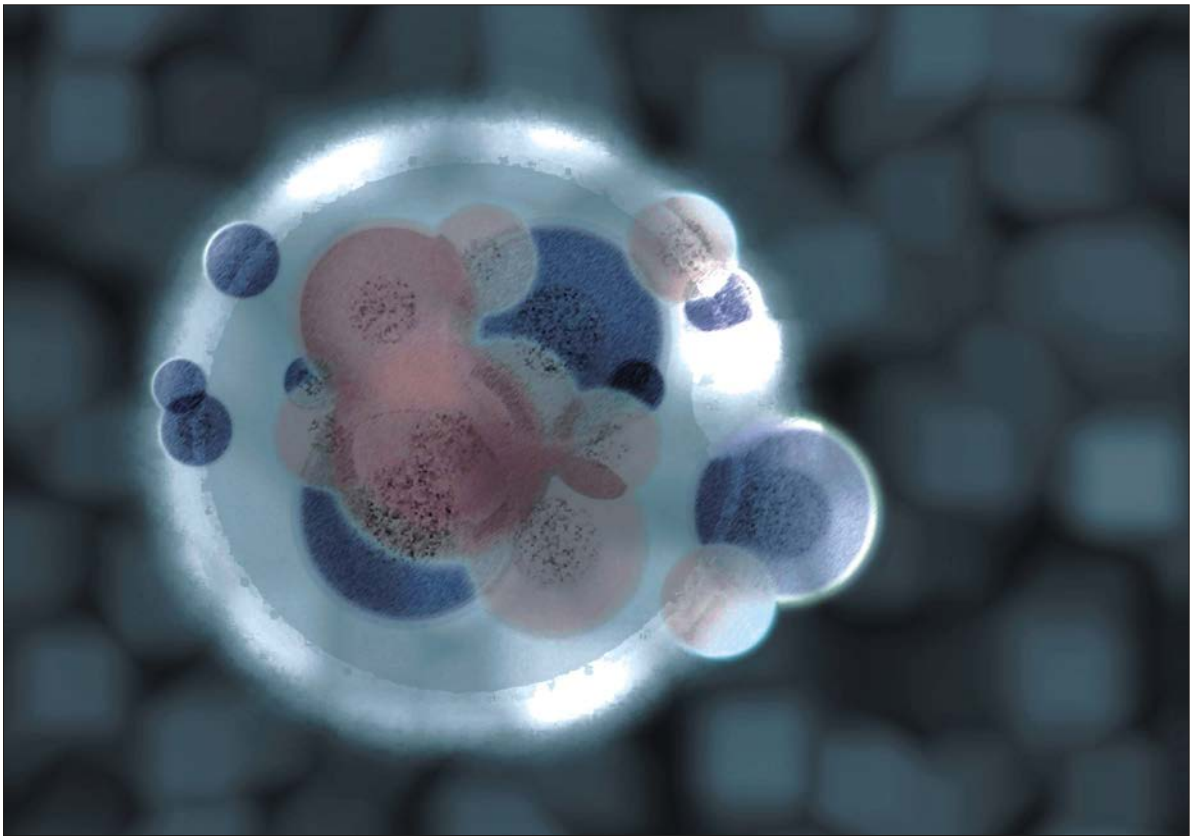

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Effects of Biological and Chemical Fertilizers on Growth and Yield of Shallot (*Allium cepa var. ascolonicum*) Production

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Abstract: A block experiment was undertaken to determine the effects of biological and chemical (NPK 15:15:15) fertilizers on the growth and yield of shallot cultivation in Mahasakham University, Mahasarakham province, Northeast Thailand. Six biological fertilizers were developed from BBF (basically biological fertilizer: 45 g cattle manure + 45 g rice bran + 20 mL of molasses + 10 mL of EM + 10 L of dechlorinated water) and used in this experiment. Chemical and biological fertilizers showed insignificant at a confidence level of 95% on the growth and yield of shallots. Increasing biological and chemical fertilizers concentration in this experiment had no significant effect on shallot growth and yield. Except control (without fertilizer), average shallot total weight with leaves and number of leaves per plant in all treatments were ranged between 9.885-12.024 g and 19.095-21.840 leaves, respectively. Average shallot total weight with leaves and number of leaves per plant obtained in this experimental were coincided to the Thai market standard. Growth and yield of these shallots showed significant different to the control (5.525 g of weight and 15.625 leaves per plant). Supplemented golden apple snails (*Pomacea canaliculat*) into BBF provided higher NO_3^- contents (4.28-4.68%). However, the high content of nitrate in biological fertilizer did not show significant effects in promoting shallot growth and yield. Under taking into account chemical fertilizer cost, which is ten times higher than biological fertilizer, the soil amendment with biological fertilizer may be a practicable alternative for the poor farmers who own degraded farmlands may be unable to afford the cost of chemical fertilizer.

Key words: Biological fertilizer, chemical fertilizer, confidence level, Mahasarakham province

INTRODUCTION

Shallot (*Allium cepa var. ascolonicum*) is an important alliaceous crops and it has been a major economic vegetable in Thailand. There is approximately 16,757 ha of land devoted to shallot especially in the northeast and north of Thailand. This results in a yield of 0.224 million tons of shallot each year. The extensive shallot production and poor farm management systems have resulted in soil erosion, depletion of soil nutrients and soil exhaustion. A major constraint to shallot 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 shallot yields. Approximately 50% of crop yield increment has been promoted by chemical fertilizers[1,2]. 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[3]. Presently, Thailand is concerned about promoting more organic farming systems since they are free of chemical fertilizers and 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 (NPK 15:15:15) is ten times higher than biological fertilizer. 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 study was undertaken to examine the effect of biological fertilizer on growth and yield of shallot cultivation. It is expected that the findings of this study will help to develop appropriate shallot cultivation management techniques in the Northeast of Thailand.

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MATERIALS AND METHODS

This study was carried out for 45 days at Mahasarakham University, Mahasarakham Province in Northeast Thailand.

Block preparation: Soil was ploughed one time and left for a week before shallot was cultivated. Shallot was cultivated in a Randomized Complete Block Design of 45 blocks with three replications of each treatment. Each block size was 0.5 x 0.6 m and there were 20 plants in each block. Shallot was grown with 10 and 10 cm row to row and line to line spacing, respectively.

Biological fertilizers preparation: Basically Biological Fertilizer (BBF) was prepared by mixing 45 g cattle manure, 45 g rice bran, 20 mL of molasses, 10 mL of EM and 10 L of dechlorinated water. This biological fertilizer was kept in the shade at room temperature in order to ferment for 2-4 days after mixing and ready to use after 14-21 days fermentation.
Six formulation of biological fertilizers were prepared as follows:

Formula 1: BBF + 45 g crushed paddy husk
Formula 2: BBF + 45 g crushed paddy husk + 45 g golden apple snails (*Pomacea canaliculat*)
Formula 3: BBF + 45 g corn straw + 45 g refined rice bran
Formula 4: BBF + 45 g corn straw + 45 g refined rice bran + 45 g golden apple snails
Formula 5: BBF + 45 g crushed paddy husk + 45 g refined rice bran
Formula 6: BBF + 45 g crushed paddy husk + 45 g refined rice bran + 45 g golden apple snails

Treatment design: Twelve treatments (each treatment has 3 blocks) were evaluated in this experiment as follows:

T_1: 300 g block^{-1} of biological fertilizer formula 1
T_2: 450 g block^{-1} of biological fertilizer formula 1
T_3: 300 g block^{-1} of biological fertilizer formula 2
T_4: 450 g block^{-1} of biological fertilizer formula 2
T_5: 300 g block^{-1} of biological fertilizer formula 3
T_6: 450 g block^{-1} of biological fertilizer formula 3
T_7: 300 g block^{-1} of biological fertilizer formula 4
T_8: 450 g block^{-1} of biological fertilizer formula 4
T_9: 300 g block^{-1} of biological fertilizer formula 5
T_{10}: 450 g block^{-1} of biological fertilizer formula 5
T_{11}: 300 g block^{-1} of biological fertilizer formula 6
T_{12}: 450 g block^{-1} of biological fertilizer formula 6
T_{13}: 75 g block^{-1} of NPK 15:15:15 (Chemical fertilizer)
T_{14}: 100 g block^{-1} of NPK 15:15:15 (Chemical fertilizer)
T_{15}: Control (without biological fertilizer)

Each biological and chemical fertilizers were incorporated one week before cultivation and then added on day 15 and 30 after cultivation. All treatments of shallot cultivation were harvested on day 45.

Data analysis: The shallot growth and yield data from each treatment was collected on the same day to determine the following parameters. Height of the highest and lowest leaf (cm) were measured on the day of harvesting. Number of leaves and total weight (g) with leaves per plant from each treatment were determined on day 45. Statistical analysis: the data was analyzed using SPSS for Windows XP[4]. Nitrogen, Potassium and Phosphorus content were examined by Buurman *et al.*[5], Tan [6] and Buurman *et al.*[5], respectively.

RESULTS

Soil and Biological fertilizer composition: The values of pH, P_2O_5 and K_2O were not much different in all six biological fertilizers. The P_2O_5 and K_2O were ranged between 0.24-0.45% and 1.06-1.86%, respectively (Table 1). For nitrogen contents, the formula 2, 4 and 6 showed higher NO_3^- concentration than those found from the formula 1, 3 and 5. This may be caused by golden apple snails have been incorporated into the BBF. Nitrogen contents in biological fertilizers was ranged between 2.12-4.68%. Therefore, the nitrogen concentration is equivalent to 6.36-14.04 g block^{-1} when 300 g of biological fertilizer was applied. This amount is equal to 212-468 kg ha^{-1} and increased to 318-702 kg ha^{-1}, when 450 g of biological fertilizer was used per block. For 300 g block^{-1} of biological fertilizer, the lowest and highest amount of P_2O_5 and K_2O supplemented into the soil were equivalent to 24 and 45 kg ha^{-1} and 106 and 186 kg ha^{-1} respectively. When 450 g block^{-1} of biological fertilizer was added into the soil the lowest and highest amount of P_2O_5 and K_2O were increased to 36 and 67.5 kg ha^{-1} and 159 and 279 kg ha^{-1}, respectively.

Height of the highest and lowest leaf, number of leaves and total weight with leaves per plant: Shallot height, number of leaves and total weight with leaves per plant were measured on the day of harvesting (45 days after cultivation). The average height of the lowest and highest leaf were ranged between 5.625 – 6.150 and 22.568 – 28.300 cm, respectively. From the experiment it was found that all treatments gave insignificant differences in the height of the lowest leaf at a confidence level of 95% (Table 2). However, the height of the highest leaf of all treatments showed almost significant difference to the control (Table 3).

Table 1: Soil and biological fertilizer composition

Sample	pH	NO_3^- (%)	P_2O_5 (%)	K_2O (%)
Soil	5.4	0.01	0.05	0.02
Formula 1	6.20	2.12	0.24	1.06
Formula 2	6.54	4.68	0.45	1.86
Formula 3	6.43	2.17	0.31	1.24
Formula 4	6.57	4.53	0.39	1.67
Formula 5	6.22	3.67	0.29	1.77
Formula 6	6.58	4.28	0.37	1.80

Table 2: Effect of fertilizers on the average height of the lowest leaf

	Average height of the lowest leaf (cm)	
Fertilizer	Fertilizer 300 g block^{-1}	Fertilizer 450 g block^{-1}
Formula 1	5.838±1.709	5.758±1.793
Formula 2	6.080±2.289	5.810±1.808
Formula 3	6.150±1.783	5.845±1.509
Formula 4	5.625±1.856	5.647±1.991
Formula 5	5.735±1.877	5.777±1.816
Formula 6	5.898±2.346	6.075±2.258
75g of NPK 15:15:15	5.960±2.489	
100 g of NPK 15:15:15	6.184±1.298	
Control	5.768±1.661	

Table 3: Effect of fertilizers on the average height of the highest leaf

	Average height of the lowest leaf (cm)	
Fertilizer	Fertilizer 300 g block^{-1}	Fertilizer 450 g block^{-1}
Formula 1	25.303±3.367^{bc}	27.330±3.212^{ab}
Formula 2	27.315±3.976^{ab}	28.300±3.806^{ab}
Formula 3	27.770±2.876^{ab}	27.413±3.662^{ab}
Formula 4	24.698±5.537^{bcd}	27.340±3.861^{ab}
Formula 5	24.055±7.937^{cd}	27.378±3.302^{ab}
Formula 6	26.882±2.899^{ab}	27.457±3.044^{ab}
75 g of NPK 15:15:15	28.210±2.976^{ab}	
100 g of NPK 15:15:15	27.620±3.676^{ab}	
Control	22.568±2.511^{c}	

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

Table 4: Effect of fertilizers on the average total weight with leaves per plant

	Average total weight with leaves per plant (g)	
Fertilizer	Fertilizer 300 g block^{-1}	Fertilizer 450 g block^{-1}
Formula 1	10.075±0.662^{a}	11.000±0.707^{a}
Formula 2	11.970±0.184^{a}	11.875±0.884^{a}
Formula 3	11.125±0.177^{a}	11.425±0.530^{a}
Formula 4	9.885±0.210^{a}	10.625±0.177^{a}
Formula 5	11.125±0.530^{a}	10.875±0.530^{a}
Formula 6	11.295±0.302^{a}	10.425±0.106^{a}
75 g of NPK 15:15:15	11.852±0.970^{a}	
100 g of NPK 15:15:15	12.024±0.830^{a}	
Control	5.525±0.591^{b}	

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

Except control, average shallot total weight with leaves and number of leaves per plant in all treatments were ranged between 9.885-12.024 g and 19.095-21.840 leaves, respectively (Table 4 and 5). These results showed significant different to the control (5.525 g of weight and

Table 5: Effect of fertilizers on the average number of leaves per plant

	Average number of leaves per plant	
Fertilizer	Fertilizer 300 g block^{-1}	Fertilizer 450 g block^{-1}
Formula 1	20.150±0.828^{a}	21.125±0.774^{a}
Formula 2	19.095±0.929^{a}	19.600±0.879^{a}
Formula 3	21.752±0.864^{a}	21.150±0.704^{a}
Formula 4	20.000±0.728^{a}	19.450±0.749^{a}
Formula 5	19.800±0.722^{a}	21.575±0.736^{a}
Formula 6	21.300±0.931^{a}	19.525±0.777^{a}
75 g of NPK 15:15:15	20.670±0.634^{a}	
100 g of NPK 15:15:15	21.840±0.976^{a}	
Control	15.625±0.532^{b}	

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

15.625 leaves per plant). Moreover, average shallot total weight with leaves and number of leaves per plant obtained in this experimental were coincided to the Thai market standard.

DISCUSSION

Even maximum average total weight with leaves per plant (12.024 g) was obtained from 100 g of chemical fertilizer. However, the average total weight with leaves was insignificant and close to those found in all six biological fertilizer treatments. Application of chemical and biological fertilizers showed higher growth and yield than control. Average shallot total weight with leaves and number of leaves per plant under all treatments increased approximately 2 times when compared to the control. Control did not show significant effects in promoting shallot yield might be a result of the soil properties which are acidic, dry and a low nutrient content. Such soils are inappropriate for shallot growth. Increasing biological and chemical fertilizers concentration, 300 to 450 g block^{-1} and 75 to 100 g block^{-1}, respectively. had no significant effect on shallot growth and yield. It may have been caused by shallot has a shorter growth cycle (45 days cultivation period), better tolerance to disease and drought stresses[7]. Therefore, three times supplemented with the lowest amount of biological (300 g block^{-1}) and chemical (75 g block^{-1}) fertilizers during cultivation may sufficient for shallot growth.

The amount of nitrogen needed in plant is depended on soil organic matter content, crop uptake and yield levels[8]. Nitrogen uptakes by onion crop is vary between 50-300 kg ha^{-1} and the amount of nitrogen responses also vary from place to place[9]. Supplemented golden apple snails into BBF provided high NO_3^- content. Therefore, the NO_3^- contents in biological fertilizer formula 2, 4 and 6 was approximately 2 times higher than those found in formula 1, 3 and 5. However, high content of NO_3^- in formula 2, 4 and 6 showed insignificant effects in promoting shallot growth and yield. This might be caused by a slow degraded property of golden apple snails which may have caused the availability nitrogen of plant nutrients to only gradually be released into the soil via the fermentation process. The effects of NO_3^- contents in six biological fertilizers on growth and yield of shallot was investigated and compared with chemical fertilizer. It was found that the highest concentration of nitrate (702 kg ha^{-1}) in biological fertilizer did not show significant effects in promoting shallot growth and yield than chemical fertilizer. The results from this experiment confirm those of Wiedenfeld[10], who found no additional yields benefit from applying N rates higher than 84 kg ha^{-1} and average N uptake efficiency less than 10%. Hayashi and Hatano[11] also calculated that the N leached annually from an onion field could correspond to 58% of applied N.

Potassium uptake in onion is more equivalent to Nitrogen[12,14]. In this experiment, the amount of Potassium supplied by 300 g $block^{-1}$ of biological fertilizers is ranged between 106-186 kg ha^{-1}. These values fall in the range of Nitrogen uptake rates, thus the availability of Potassium from the least amount of biological fertilizer was sufficient for shallots growth. Phosphorus is important for root development and Phosphorus uptake rates in shallots is depended on its diffusion and concentration near their roots[15]. In Malaysia, approximately 5 kg ha^{-1} of Phosphorus has been uptake for a yield of 6.6 ton ha^{-1} shallots grown on peat soil[16]. However, Phosphorus uptake rates in onion may varied between 15-52 kg ha^{-1}[13,17,18]. In this experiment, the amount of Phosphorus supplied by 300 g $block^{-1}$ of biological fertilizers for shallots growth is ranged between 24-45 kg ha^{-1}. These values fall in the range of Phosphorus uptake rates, thus the availability of Phosphorus from the least amount of biological fertilizer was sufficient for shallots growth.

Presently, the most important cost for cultivation of shallot for Thai farmers is the cost of fertilizer. In Thailand, chemical fertilizer (NPK 15:15:15) costs 0.26 $ per kg while biological fertilizer is equivalent to one tenth of the cost of chemical fertilizer (0.026$ per kg). Even, the effectiveness of nutrients contribution from biological fertilizer relied on the soil properties, activities of ammonium and nitrification oxidative microbes in soil. The nutrients released from biological fertilizer into the soil cannot be predicted in immature and profound soils where the microbes cannot grow[19]. In addition, heavy use of chemical fertilizer may deteriorate the nutrient base, biological activity and depletion of the soil's natural fertility[3]. 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. Furthermore, organic farming technique is simple, sustainable, economically viable, beneficial for farmers' livelihoods and environmentally friendly.

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