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Effects of Biological and Chemical Fertiliser on Growth and Yield of Glutinous Corn Production

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Abstract: A field experiment was undertaken to determine the effects of biological fertiliser (Bokashi) with chemical fertiliser (NPK 15:15:15) on the growth and yield of glutinous corn cultivation in Roi-Et province, Northeast Thailand. Four treatments were compared consisting of T_1 (control), T_2 (4.8 kg NPK 15:15:15), T_3 (Bokashi 19.2 kg) and T_4 (4.8 kg NPK 15:15:15 + Bokashi 9.6 kg). Yield of ears without husks under all treatments increased between 16-108% when compared to the control. Application of Bokashi alone showed 16% increased yield of ears without husks over the control. However, in terms of statistical data, the total yield of ears was similar to those found in control. Moreover, plant height, plant diameter and area of the largest leaves were insignificant at a confidence level of 95%. Excluding labor costs, the maximum net return (25.92 US$) was obtained in T_4 which corresponding with the highest total yield of ears without husks (182.78±13.85 kg). The total yield of ears without husks obtained in T_4 was statistically at par with T_2 (165.02±7.60 kg) and yield of ears obtained in T_4 and T_2 were 107.89 and 87.69% over control. Even yield of ears and percentage net return obtained from Bokashi was less than those found from chemical fertiliser alone but taking into account chemical fertiliser cost, which is ten times higher than biological fertiliser, the soil amendment with Bokashi may be a practicable alternative for the poor farmers who own degraded farmlands may be unable to afford the cost of chemical fertiliser. Moreover, organic farming with effective microorganisms technology is simple, sustainable, economically viable, beneficial for farmers' livelihoods and environmentally friendly.

Key words: Biological fertiliser, chemical fertiliser, Bokashi, confidence level, Roi-Et province

INTRODUCTION

Corn has been a major economic crop in Thailand and there is approximately 1.28-1.44 m'ha of land devoted to corn. This results in a yield of 3-4 m't of corn each year. The extensive corn production and poor farm management systems have resulted in soil erosion, depletion of soil nutrients and soil exhaustion (Dahal, 1993). A major constraint to crop production in Northeast Thailand is the low soil organic matter content and biological activity. Chemical fertilisers are significant to succor nutrients in soil. Heavy doses of chemical fertilisers and pesticides are commonly used in order to enhance corn yields. Approximately 50% of crop yield increment has been promoted by chemical fertilisers (FAO, 1989; NFDC, 1989). Death and suffering from chemical fertilisers 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 fertiliser has resulted in nitrous oxide production and denitrification activity near the soil surface (Yamauchi, 1995).

The conventional method of building up soil organic matter is through the application of manures such as farmyard manure and various compost preparations (Lopez-Real, 1990). Effective Microorganisms (EM) is a mixed microorganism culture which consists of lactic acid bacteria, yeast, fermenting fungi, actinomycetes and photosynthetic bacteria (Higa, 1998). EM is widely used as a beneficial microbial inoculum for making Bokashi (biological fertiliser) 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 (Karim *et al*., 1992; Sangakkara *et al*., 1995). In Thailand, EM technology is applied in different domains such as cultivation, animal husbandry and environmental treatment. Presently, attraction in organic farming is increasing in Thailand and this interest has been promoted by the Thai government. Organic agriculture in Thailand needs to be highly efficient, sustainable, economically viable, address farmers' livelihoods, environmentally friendly and the food produced should be safe to consumers. Therefore, the fertility improvement of cultivated soils has to be derived from available biomass and build up biological activity of the soil by using EM in the form of compost (Bokashi). In this regard, nature farming with EM technology is an attractive option that is simple and affordable to average Thai farmers.

Heavy and continuous use of pesticides may accelerate serious negative effects on farmers' health, depletion of soil organic matter, nutrient deficiency in soil, crop yield reduction and increase cultivation cost. Therefore, this research was undertaken to examine the effect of EM application on growth and yield of glutinous corn cultivation and its economic consequences. It is expected that the findings of this study will help to develop appropriate glutinous corn cultivation management techniques Northeast Thailand.

MATERIALS AND METHODS

These field experiments were carried out at Huai Ang, Amphur Srisomded, Roi-Et province in Northeast Thailand.

Block preparation: Soil was ploughed one time each week for 2 weeks before glutinous corn was cultivated. Glutinous corn was cultivated in a Randomized Complete Block Design of 12 blocks with three replications of each treatment. Each block size was 6.4x8 m and there were 128 plants in each block. Glutinous corn was grown with 50 and 80 cm row to row and line to line spacing, respectively.

Biological fertiliser (Bokashi) preparation: Bokashi was prepared from cattle manure, rice bran, crushed paddy huskand extended EM solution. Extended EM solution was prepared by 5 mL of EM+10 mL of molasses +1985 mL of dechlorinated water and kept in the shade at room temperature in order to ferment for 2-4 days after mixing. Bokashi was mixed and sprayed with extended EM solution until the moisture content of the mixture material increased to 50%. Bokashi was ready to use after 14-21 days fermentation.

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

Treatment 1: Control (without fertiliser)
Treatment 2: 4.8 kg block^{-1} of NPK 15:15:15 (Chemical fertiliser)
Treatment 3: 19.2 kg block^{-1} of biological fertilisers (Bokashi)
Treatment 4: 4.8 kg of NPK 15:15:15+9.6 kg of Bokashi block^{-1}

Chemical fertiliser and biological fertiliser were incorporated one week before sowing and then added on day 20 and 40 after sowing. All treatments of glutinous corn cultivation were harvested on day 49 after sowing.

Data analysis: The glutinous corn growth and yield data from each treatment was collected on the same day to determine the following parameters:

1. Glutinous corn height (cm) was measured on day 21, 28 and 35 after sowing.
2. Diameter of glutinous corn plant (cm) was measured on day 21, 28 and 35 after sowing.
3. Area of the largest leaf (cm^2) was measured on day 21, 28 and 35 after sowing (Ofori *et al*., 1987).
4. Yield (kg) of ears without husks from each treatment was determined on day 49 after sowing.
5. Field cost of production for each treatment was evaluated and compared.
6. The data was analyzed using SPSS for Windows XP (SPSS, 1977).
7. Nitrogen content was examined by Buurman *et al.* (1996).
8. Potassium content was examined by Tan (1996) (modified method).
9. Phosphorus content was examined by Buurman *et al*. (1996).

RESULTS

Soil and Bokashi composition: Soil samples before sowing and Bokashi composition were evaluated by Kasetvisai Agricultural Extension Office in Roi-Et province. The soil was acidic (pH 4.1), sandy and low nutrient content (total nitrogen 0.009%, available phosphorus 0.002%, available potassium 0.001%). While, the bokashi contained 1.12% total nitrogen, 0.24% available phosphorus, 1.06% available potassium and pH 6.75.

Glutinous corn height, diameter of plant, area of the largest leaf and yield of ears without husks: Glutinous corn height, diameter of glutinous corn plant and area of the largest leaf were measured on day 21, 28 and 35 after sowing. However, yield (weight) of ears without husks from each treatment was determined on the day of harvesting (49 days after sowing). From the experiment it was found that T_2 and T_4 gave insignificant differences in plant height, plant diameter, the area of the largest leave and the total weight of ears without husks at a confidence level of 95% (Table 1-4). However, T_1 and T_3 showed almost significant difference in plant height, the area of the largest leave and the total weight of ears without husks to those found in T_2 and T_4. The total yield of ears without husks of T_2 and T_4 were 182.78 and 165.02 kg, respectively, which were higher than the T_1 (87.92 kg) and T_3 (101.98 kg) (Table 4).

Field cost (US$) production of glutinous corn cultivation: The most important cost for cultivation of glutinous corn for Thai farmers is the cost of fertiliser. In Thailand, chemical fertiliser (NPK 15:15:15) costs 0.26 $ per kg while Bokashi (biological fertiliser) is equivalent to one tenth of the cost of chemical fertiliser (0.026 $ per kg). The percent net return for farmers is dependant not only on cost of fertiliser but also on yield of glutinous corn ears and the unit price of corn (0.15 $ per kg). Excluding labor costs, economic analysis of yield data shown in Table 5 that the maximum net return increase over control (96.51%) was achieved in the T_4, while 78.17% increase in the T_2. T_3 contributed the lowest cost of fertiliser (0.50 $) but yield of ears, farmer income and net return were less than those found in T_2 and T_4.

Table 1: Effect of Bokashi and chemical fertiliser on glutinous corn height

Treatments	Average glutinous corn height (cm) 21 days	28 days	35 days	Average glutinous corn height (cm)
T_1	78.29±8.93^a	89.26±7.71^a	101.14±4.13^a	89.56±11.43^a
T_2	100.93±7.07^{bc}	110.91±7.10^b	130.28±8.17^b	114.04±14.92^{ab}
T_3	86.96± 6.57^{ab}	98.86±9.82^{ab}	115.26±9.74^{ab}	100.36±14.21^{ab}
T_4	106.37±12.79^c	117.63±13.02^b	130.79±14.98^b	118.26±12.22^b

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

Table 2: Effect of Bokashi and chemical fertiliser on diameter of glutinous corn plants

Treatments	Average diameter of glutinous corn plant (cm) 21 days	28 days	35 days	Average diameter glutinous corn plant (cm)
T_1	3.46±0.22^{NS}	3.56±0.29^{NS}	4.71±0.62^{NS}	3.91±0.69^{NS}
T_2	4.05±0.34	4.04±0.36	5.11±0.57	4.39±0.62
T_3	3.87± 0.32	4.04±0.21	4.99±0.48	4.30±0.68
T_4	4.51±0.53	4.44±0.31	5.37±0.46	4.77±0.52

NS=Not Significantly different

Table 3: Effect of Bokashi and chemical fertiliser on the area of the largest leaf

Treatments	Average area of the largest leaf (cm^2) 21 days	28 days	35 days	Average area of the largest leaf
T_1	162.41±10.11^a	266.24±41.31^a	293.13±31.30^a	241.26±19.42^a
T_2	269.58±38.16^b	360.32±33.84^b	408.76±33.05^b	357.44±52.97^b
T_3	208.75±19.82^a	288.24±25.02^a	329.87±35.18^a	275.62±29.29^a
T_4	289.82±29.84^b	383.85±31.93^b	435.91±35.62^b	369.86±32.13^b

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

Table 4: Effect of Bokashi and chemical fertiliser on the total yield of ears without husks per block

Treatments	Total yield of ears without husks per block (kg)	% increase over control
T_1	87.92±12.08^a	-
T_2	165.02±7.60^b	87.69
T_3	101.98±13.03^a	15.99
T_4	182.78±13.85^b	107.89

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

DISCUSSION

Yield of ears without husks under all treatments increased between 16-108% when compared to the control. Maximum total yield of ears without husks (182.78 kg) was obtained in T_4. However, yield of ears without husks of T_4 were insignificant and close to those found in T_2 (NPK). Even application of Bokashi alone showed a 15.99% increased yield of ears but in terms of statistical data the total yield of ears is similar to those found in the control. Therefore, T_4 was inadequate to make a difference in yield of ears when compared with application of NPK alone (T_2). T_3 did not show significant effects in promoting corn yield might be a result of the soil properties which are acidic, dry, sandy and a low nutrient content. Such soils are inappropriate for glutinous corn growth. Moreover, a slow degraded material property of Bokashi which may have caused the minerals and availability of plant nutrients to only gradually be released into the soil via the fermentation process (Parr and Hornic, 1995). The effectiveness of nutrients contribution from Bokashi relied on the soil properties, activities of ammonium and nitrification oxidative microbes in soil. The nutrients released from Bokashi into the soil cannot be predicted in immature and profound soils where the microbes cannot grow (Yamada *et al*., 1996).

Even yields of ears and percentage of net return obtained from Bokashi are less than those found from chemical fertiliser alone but these values ranged between 12-16% over the control. Since heavy use of chemical fertiliser may deteriorate the nutrient base, biological activity and depletion of the soil's natural fertility (Yamauchi, 1995). Presently, Thailand is concerned about promoting more organic farming systems since they are free of chemical fertilisers and pesticides, environmentally friendly, address farmers' livelihoods and emphasize utilization of on-farm resources by recycling waste into useful organic matter. In addition, the present cost of chemical fertiliser (NPK 15:15:15) is ten times higher than Bokashi (biological fertiliser). Hence, under the potential constraint of chemical fertiliser cost and the benefits of organic farming systems, poor farmers who own degraded farmlands may consider using more EM technology in the future.

Table 5: Comparative economic analysis among various treatments

Treatments	Total yield of ears per block (kg)	Total cost of fertiliser per block (US$)	Farmer income (US$)	Net return (US$)	% of net return increase over control per block
T_1	87.92	-	13.19	13.19	-
T_2	165.02	1.25	24.75	23.50	78.17
T_3	101.98	0.50	15.30	14.80	12.20
T_4	182.78	1.50	27.42	25.92	96.51

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