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Study some technical methods to organic rice production at Hanoi, Vietnam

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The studies were carried between 2010 and 2011 in Myduc districts, Hanoi. This research included 3 experiments to study the effects of: (a) burying rice straw incorporated with microbial products, (b) application rates of composted manure and Songgianh microorganism and (c) organic foliar fertilizers. Bacthom 7 rice variety was used as the model crop plant. Randomized complete block design with three replicates was employed in the experiments. The results indicated that, burying rice straw with bio-plant microbial product increased the yield significantly (45.5 ta/ha in spring and 40.5 ta/ha in autumn) over the treatment in which microbial products were not incorporated (38.9 and 36.5 ta/ha, respectively). The treatment with 15-20 ton/ha composted chicken manure combined with 0.5-2.5 ton/ha Songgianh microorganism was found to be the most effective with respect to grain yield. Among the organic foliar fertilizers applied, ChelaxLayO organic-foliar fertilizer significantly increased spikelets/panicle and grain yield. The above findings were applied successfully in demonstration model that increased rice quality with protein (6.9), starch (78%) and economical effectiveness of organic rice production; decreased NO_3^- residue content, as well as improve soil fertility

Key words: burying rice straw, composted manure, Songgianh microorganism fertilizer, organic foliar, Bacthom 7 rice.

INTRODUCTION

Rice is the staple food for more than half of the world's population. The crop influences the livelihood and economies of several billion people, and for hundreds of millions it is the only thing between them and starvation [1]. Vietnam is a tropical country that is located in South-East Asia and it has an annual average temperature of about 30°C. This condition has made soil to be susceptible, have low organic matter content and give rise to high nutrient loss. Although, the total area under agriculture was 10126.4 thousand hectare from the total land surface area, rice grown land accounted for 4120.2 thousand hectare only [2]. To meet the demand for foods and vegetables, various types of pesticides and fertilizers are used in Vietnam in an increasing trend. According to the Department of Agriculture, Vietnam has initiated the application of chemical pesticides for crop protection since the 1960s. Although, approximately 34,000 tons of pesticides were imported into Vietnam in the year 2000; this figure does not include approximately 15 million tons of highly toxic pesticides illegally imported and sold in the market [3]. The pesticide consumption is increasing by 10-20% per year. The use of the pesticides leads to loss of biodiversity, decline in the flora of arable cropping system [4], reduction in the quality of products and affect human's health. Therefore, to enhance the quality and safety of agricultural products by maintaining ecological balance, Vietnam has been promoting organic farming including organic rice cultivation.

Organic farming is "an integrated farming system which involves the consideration of both technical (soil, agronomy, weed, and pest management) and economic aspects (input, output, and marketing) as well as human health" [5]. Although in Vietnam, the area under certified organic farming is on the increase, the lack of research to educate the farmers of techniques of organic rice cultivation has been identified as a major drawback in this context.

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The objective of this study is to develop some technical solutions for organic rice production in Hanoi. Techniques such as burying rice straw, applying composted manure with Songgianh microorganism and spraying organic foliar fertilizers are some of the technical solutions for organic rice production and it is expected that farmers that engaged in organic rice production can get higher yields of better quality and more economical gains.

MATERIALS AND METHODS

Experimental site: The site for the research was Myduc, Hanoi where the soil properties has medium nitrogen, phosphorus and potassium contents, organic matter content were low with 2% and has light acid with pH= 4.76

Experiment 1: Effect of burying microbial product incorporated with rice straw on growth and yield of Bacthom 7 rice variety

The experiment was arranged in a randomized complete block design (RCBD) with three replicates. 6 ton/ha of rice straw was buried at 20cm depth with supporting microbial products. A basal application of 12 tons of composted chicken manure and 1.5 tons of Songgianh microorganism fertilizer /per ha) was made in spring whereas 10 and 2 ton/ha respectively were added in autumn. In spring season, there were 2 treatments (control and *bio-plant* microbial product treatment) with 4 replications while in autumn season there were 3 treatments (control, *bio-plant* and *tricoderma* microbial product treatments) with 3 replications. Other techniques were conducted according to SRI principle (transplanting with young seedling, distance between rows was 20 cm, distance between plants was 20 cm, water control).
Materials used are: *Bio-plant* microbial product which includes a range of microorganisms like *bacillus, clostridium, stromyes, achoromobacter, aerobacter, nitrobacter, nitrosomonas, pseudomonas* 10^9(CFU/ml); *useful fungus are aspegillus, fusarium, polyporus, rhizopus* 10^9(CFU/ml). *Tricoderma*microbial product used have nitrogen content 4%; Phosphorus (P_2O_5) 3%; Potassium (K_20) 3%; CaO: 10%; MgO: 2%; (B, Cu, Zn, Mn, Fe, Mo) 300ppm; Fungus *trichoderma*: 10^8 CFU/g; Bacillus: 10^8 CFU/g.

Experiment 2: Determination of the level of composting chicken and Songgianh microorganism fertilizer to Bacthom7 variety

This experiment with two factors was also laid out in RCBD with three replications in Myduc. Experimental treatments includes combination of three levels of composting chicken manure (P1, P2, P3) and three levels of Songgianh microorganism fertilizer (S1, S2, S3). Combination treatments include S1P1, S1P2, S1P3, S2P1, S2P2, S2P3, S3P1, S3P2, S3P3. In spring season P1, P2, P3 was 10, 15, 20ton/ha and 5, 10, 15 ton/ha in autumn season respectively. The corresponding S1, S2, S3 was 1500, 2000, 2500 kg/ha in spring and 500; 1500, 2500 kg/ha in autumn. Base of experiment was spraying complex nutrition every 10 days/time from the first tending.
Materials used are: Songgianh microorganism fertilizer of organic content ≥ 15%; P2O5 ≥ 1,5%; Ca ≥ 1%; Mg ≥ 0,5%; S ≥ 0,2%. Microorganism population includes: *aspergillus* sp: 1.106 CFU/g*, azotobacter and bacillus*: 1.106 CFU/g. Composted chicken manure with pH= 8.7; nitrogen, phosphorus and potassium content was 0.94, 1.54, 0.85 respectively

Experiment 3: Effectiveness of organic foliar-fertilizers to yield of Bacthom 7 variety

The experiment was arranged in RCBD with 3 replications. Base of experiment is 12 ton of composted chicken manure and 1.5 ton of Songgianh microorganism fertilizer/ha in spring; while that in autumn was 10 and 1.5 ton/ha respectively. In spring, there were 5 treatments: spraying fresh-water (as a control), chelax lay O, chelax suger express, chelax rice and complex nutrition. In autumn season, 3 treatments were done: chelax lay O, chelax rice and complex nutrition. Spraying of foliar-fertilizers were started at tillering stage with 4ml/360m^2 and every 10 days per time.
Materials used are: chelax lay O (16% organic from seaweed, 10% amino axit. C), chelax sugar express (67% monosacarit, 1.66% L-Cystein, 0.33% axit folic), chelax rice (5% Zn, 3,3% MgO, 5% S). Complex nutrition was extracted from banana, papaya, water spinach, mugwort, fish with mollase according to 1/1 ratio in a month before using [6].

Demonstration model: The model of organic rice production was carried out in a total of 1.5 ha of 15 households in Myduc in both seasons of 2011. This field is free of the traces of inorganic fertilizers because the field had not been used for the past 5 seasons.

Observational Measurements: Soil properties before and after the experiment (after 2 and 4 seasons of organic rice cultivation) includes total N, P_2O_5, K_2O, Organic cacbon, pH_{KCl}:

- Total nitrogen was determined by Kjeldahl method [7]
- Total phosphorus was determined by Ascorbic Acid method [8]
- Total potassium was determined by the K concentration by flame photometric method [8]
- OM: Walkley-Back method [9]
- pH was determine by pH meter machine
- Microorganism population was determine by diluting in a specialized semi-solid culture medium, after which the number of colony were counted at 3 concentrations in succession (KOCH method).

Grain yield and yield components: The following are the methods used to analysis the bio-chemical properties of rice: Protein (Kjeldahl method) [7]; Starch (hydrolysis method by HCl 5% acid); Cellulose (Kürschner-Hanack) [10]; Vitamin B1 (fluorescence method); NO^-_3 (spectrophotometer method).

The economical effectiveness measurements of organic and non-organic rice production are as follow:

Total variable cost (TVC) = ∑ of cost of all variable inputs = cost of land preparation + cost of fertilizer + cost of human labour + cost of other inputs

Return above variable cost (RAVC) = Gross return – total variable cost (Where Gross return = returns from grain + return from straw)

Benefit cost ratio analysis (B/C ratio) = Gross margin/Total variable cost

Statistical analysis: The data were calculated by ANOVA using IRRISTAT 4.0 software. Significant means were separated by using LSD at 0.05 level of significant.

RESULTS AND DISCUSSIONS

Effectiveness of rice straw burying with microbial products on Bacthom 7 variety

Burying with different bio-products led to minute/no difference in growth measurements of Bacthom 7 rice, except from dry matter content which the highest content of 22.46g/hill belong to treatment buried with *tricoderma* product (Table 1). Both in spring and autumn seasons, there were significant difference in grain yield between treatments buried with microbial products and without product. In spring season, the grain yield of burying with bio-plant product was 45.5ta/ha while that of without product was only 38.9ta/ha (Table 2) and that in autumn was 40.5 and 36.5ta/ha respectively. The results of different yield could be explained as the cumulative effects of straw incorporation over the years which led to greater net nitrogen mineralization, an increase in microbial biomass nitrogen and greater recovery of ^{15}N in the soil after 1 year application by Bird [11]. After 3 years (from 1996-1999), the treatments in-which straw was rolled or incorporated showed higher grain yields for every year when compared to that in-which the straw was burned or baled.

Determination of the level of composted chicken and Songgianh microorganism fertilizer to Bacthom 7 variety

Table 3 shows that when calculating the separation effect of each factor, the level of Songgianh microorganism fertilizer of 2 ton/ha in spring and 1.5 ton/ha in autumn were the most suitable; and for composted chicken manure, the level of 10 ton/ha in spring and 15 ton/ha in autumn gave the highest yield with significant differences to other levels. Interaction effect of the levels of 20 ton/ha of composted chicken manure and 2.5 ton/ha of microorganism fertilizer in spring and respective 15 ton/ha and 0.5 ton/ha in autumn gave the highest yield in comparison with other interactions. The application of organic manures and microorganism increased the nitrogen uptake by rice and also, increased fertility of the soil was shown by an increase in organic carbon content and total nitrogen after rice harvest. In their research, Hartwig and Ammon [12] also found enhanced soil organic carbon due to manuring. Saha *et al*. [13] found that organic manure and bio-fertilizers also release their nutrients throughout the growth period. Increase in the soil organic carbon also enriches the microbial flora of the soil, which is a viable reason for the increased grain yield in this research.

Effectiveness of organic foliar-fertilizers to Bacthom 7 variety

Solu *et al*. [14] as well as Kenbaev and Sade [15] reported that foliar application of different micronutrient significantly increased in the number of panicles per hill and the number of spikelet per panicle. In this study, the results showed that panicle numbers per hill and spikelet numbers per panicle of Bacthom 7 variety are significantly different by different foliar fertilizer treatments. The highest panicle number recorded is ChelaxLayO, followed by complex nutrition treatments, while the lowest was recorded is control without spraying foliar (Table 4). However different foliar fertilizer treatments did not produced effect on filled grain percentage and 1000-grain weight of Bacthom 7 rice. Spraying organic foliar fertilizers increased grain yield of Bacthom 7 in comparison to not spraying organic foliar fertilizers (control) (Table 5).

The results of organic rice production demonstration model

From Table 6, the results showed that the return above variable cost is 24,980,000VND/ha in spring season and 27,057,000VND/ha in autumn and farmers are getting 0.84 and 1.14 in average over their investment of one VND. While the figure of TVC of non-organic production only gave 13,352,000VND in spring and 15,625,000VND in autumn. B/C ratio was 0.62 and 0.77 for both seasons respectively. In his research, Raj [16], reported that the organic rice production was found to be 3.15 Mt/ha which is considered to be higher than national average. In Figure 1, the B:C ratio of organic rice production was found to be 1.14 in autumn because of the acceptable high organic rice price of customers.

In the results of rice bio-chemical characteristic analysis presented in Table 7, the bio-chemical quality of organic rice is no remarkable difference comparing to

Table 1. Effect of burying straw to growth of Bacthom7 variety.

Treatment	Height plant (cm)		Leaf area (m^2leave/m^2soil)		Dry matter (g/hill)	
	Spring	Autumn	Spring	Autumn	Spring	Autumn
Control	108.8[a]	118.18[a]	2.5[a]	2,53[a]	22.2[b]	20.98[c]
Bioplant	113.4[a]	120.13[a]	4.5[a]	3,58[a]	25.9[a]	24.29[a]
Tricoderma	-	122.05[a]	-	3.35[a]	-	22.46[b]
$LSD_{0.05}$	8.6	4.88	2.4	0.78	3.5	1.15
CV%	3.5	1.8	11.2	11	6.6	2.3

Note: Means in the same column denoted by the same letter are not significantly different from each other at P = 0.05.

Table 2. Effect of burying straw to yield and yield components of Bacthom 7 variety.

Treatment	Panicles/hill		Spikelets/ Panicle		Filled grains (%)		1000-grain weight (g)		Grain yield (ta/ha)	
	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut
Control	5.75[a]	5.87[b]	176[a]	169[b]	85.2[a]	92.6[b]	17.1[a]	18.1[a]	38.9[b]	36.5[b]
Bioplant	6.5[a]	6.2[ab]	199[a]	172[a]	88.8[a]	96.4[a]	17.6[a]	18.3[a]	45.5[a]	40.5[a]
Tricoderma	-	6.4[a]	-	170[ab]	-	93.4[b]	-	18.0[a]	-	38.0[ab]
$LSD_{0.05}$	2.14	0.24	56	2.9	7.7	1.73	0.5	0.77	0.64	2.61
CV%	11.1	1.7	14.5	0.8	4.0	0.8	1.3	1.9	6.8	3.0

Note: Means in the same column denoted by the same letter are not significantly different from each other at P = 0.05.

Table 3. Grain yield of Bacthom 7 variety when applying combination levels of composted chicken manure and microorganism fertilizer.

Factors		Grain yield (ta/ha)	
		Spring season	Autumn season
	S1	39.56[b]	39.10[b]
S	S2	40.5[a]	39.61[a]
	S3	42.84[a]	39.59[a]
$LSD_{0.05}$		2.23	0.15
	P1	40.69[a]	38.71[c]
P	P2	40.99[a]	39.07[b]
	P3	41.28[a]	41.21[a]
$LSD_{0.05}$		2.23	0.15
	S1P1	35.88[d]	37.59[bc]
	S1P2	39.96[bcd]	38.74[bc]
SxP	S1P3	42.85[b]	40.99[ab]
	S2P1	39.95[bcd]	39.10[bc]
	S2P2	38.24[cd]	38.68[bc]
	S2P3	43.53[b]	39.75[bc]
	S3P1	37.92[cd]	39.44[bc]
	S3P2	40.8[bc]	39.78[bc]
	S3P3	49.79[a]	42.90[a]
$LSD_{0,05}$		3.87	2.64
CV%		5.50	3.8

non-organic rice, but the amount of NO_3^- residue in organic rice production was 3 times less than that in non-organic production. Protein content was higher in organic rice (6.9gr/100gr) than non-organic (6.4gr/100gr). The striking data was that after 4 seasons of cultivation, organic soil measurements changed remarkably where the organic

Table 4. Effect of organic foliar-fertilizers to yield components of Bacthom7 variety.

Treatment	Panicles/hill		Spikelets/panicle		Filled grains (%)		1000grain-wt (g)	
	Spr	Aut	Spr	Aut	Spr	Aut	Spr	Aut
Water (Đ/C)	6.8[b]	-	119[c]	-	78.1[d]	-	17.3[a]	-
CHELAX Lay O	8.0[a]	5.7[a]	152[a]	166[a]	87.4[a]	94.8[a]	17.5[a]	17.3[a]
CHELAX Sugar express	7.3[b]	-	129[b]	-	83.8[c]	-	17.3[a]	-
CHELAX Rice	6.9[b]	5.3[b]	129[b]	157[b]	77.2[d]	95.6[a]	17.1[a]	17.2[a]
Complex nutrition	7.2[b]	5.4[b]	134[b]	160[ab]	84.8[ab]	94.9[a]	17.4[a]	17.3[a]
$LSD_{0.05}$	*0.6*	*0.2*	*9.8*	*6.10*	*3.23*	*0.97*	*0.6*	*0.13*
CV%	*4.1*	*5.1*	*3.9*	*3.7*	*2.1*	*1.0*	*1.9*	*0.7*

Table 5. Effect of organic foliar-fertilizers to grain yield of Bacthom7 variety.

Treatment	Potential yield		Grain yield	
	Spr	Aut	Spr	Aut
Water (Đ/C)	42.63	-	37.73[d]	-
CHELAX Lay O	62.83	46.33	50.50[a]	38.20[a]
CHELAX Sugar express	48.90	-	43.40[c]	-
CHELAX Rice	46.70	41.63	42.63[c]	34.62[c]
Complex nutrition	50.47	43.21	46.33[b]	36.10[b]
$LSD_{0.05}$			2.34	1.2
CV%			2.8	3.2

Table 6. Economical effectiveness of organic rice and non-organic rice production.

Measurements	*Unit: thousand VND/ha*			
	Spring season		Autumn season	
	Organic	Non-org	Organic	Non-org
Total variable cost (TVC)	29,789	21,648	23,773	20375
Gross return (GR)	54,769	35,000	50,830	36,000
Grain yield (tạ)	5.0	5.04	3.91	4.5
Price (kg)	13	10	15	10
RAVC	24,980	13,352	27,057	15,625
B/C ratio	0.84	0.62	1.14	0.77

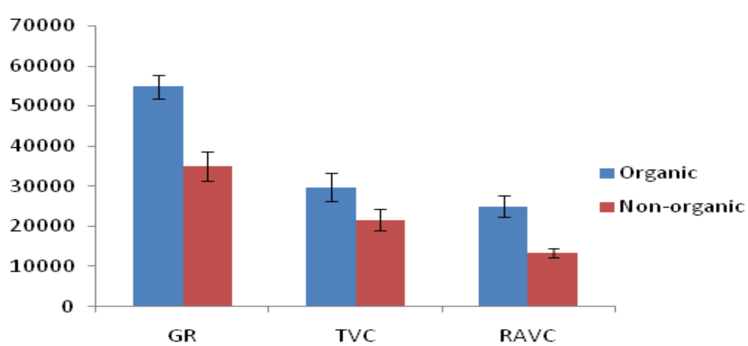

Figure 1: Diagram for gross total, return above variable cost, total variable cost organic and non-organic production in spring season.

Table 7. The results of bio-chemical measurements of organic and non-organic rice.

Measurement	Units	Organic	Non-organic
Protein	g/100g	6.9	6.4
Starch	g/100g	78	71
Cellulose	g/100g	1.1g	1.2
Water	g/100g	12.26	13.52
Vitamin B1	g/100g	0.063	0.06
NO_3^- residue	g/100g	1.6	4.2
Fe^{2+}	g/100g	0.65	0.6
Arsen (As)	mg/kg	0.33	-
Hg	mg/kg	0.046	-
Cacdimi (Cd)	mg/kg	0.74	-

Table 8. Soil measurements after 4 seasons practicing organic rice.

Sample	pH_{KCl}	OC (%)	N (%)	P_2O_5 (%)	K_2O (%)	Total aerobic microorganism (10^6CFU/g)	Total inaerobic microorganism (10^6CFU/g)
After 2 seasons practicing organic	5.16	1.60	0.24	0.73	2.55	5.42	1.43
After 4 seasons practicing organic	5.12	1.80	0.27	0.62	2.57	5.88	1.28

carbon, nitrogen content etc improved (Table 8).

Conclusion

In order to produce organic rice, it is necessary to bury rice straw with microbial products because this increased dry matter and grain yield in comparison with non-burying. The level of 15-20 ton/ha composted animal manure combination with 0.5-2.5 ton/ha Songgianh micro-organism fertilizer gave higher rice yield than other levels. Besides, spraying organic-forliar fertilizer also increased the number of spikelets/panicle and grain yield. Organic rice production not only increases the economical effectiveness (increased 87% in spring and 73% in autumn in comparison with non-organic rice production), but also improves soil fertility. Organic carbon content and total aerobic micro-organism population in soil increases significantly after 4 seasons organic cultivating.

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