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Effect of effective microorganisms on composting characteristics of chicken manure

(Kesan 'mikroorganisma berkesan' terhadap ciri-ciri pembuatan kompos daripada tahi ayam)

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Key words: effective microorganisms, composting, chicken manure, *Bokashi*, ammonia

Abstrak

Keberkesanan penambahan mikroorganisma berkesan (EM) dan *Bokashi* dalam pembuatan kompos terhadap sembilan himpunan 'windrow' tahi ayam pedaging telah dikaji. Kajian dijalankan tanpa pengudaraan dan tanpa pertukaran nisbah C/N. Tiga perlakuan telah disediakan, iaitu kawalan, EM dan *Bokashi*. Produk EM terdiri daripada campuran mikroorganisma di dalam cecair yang mengandungi bakteria asid laktik yang dikultur di dalam pH 3.0–3.5. *Bokashi* juga mengandungi EM tetapi dalam bentuk campuran pepejal yang terdiri daripada dedak padi, sekam padi terbakar, habuk kelapa dan tahi ayam. Pembuatan kompos tersebut telah mengambil masa selama 7 minggu. Kehilangan lembapan ialah 50%. Kehilangan karbon pula ialah 9.0, 10.9 dan 9.2% manakala kehilangan nitrogen ialah 17.5, 18.8 dan 22.7% masing-masing untuk kawalan, EM dan *Bokashi*. Nilai pH meningkat daripada 6 pada mulanya kepada 9 pada akhir kajian. Kepekatan unsur-unsur lain termasuk logam berat meningkat selepas proses pembuatan kompos disebabkan kehilangan kandungan lembapan. Pengeluaran ammonia adalah paling tinggi pada perlakuan *Bokashi* pada hari ke-15. Penambahan EM tidak menyingkatkan tempoh kematangan kompos. Bukti yang menunjukkan penambahan EM dapat mengurangkan bau tahi ayam tidak diperoleh kerana ammonia masih dikeluarkan.

Abstract

A composting trial using nine windrow piles of broiler manure was conducted under non-ideal and non-aerated conditions without carbon/nitrogen adjustment to study the effect of effective microorganisms (EM) and *Bokashi* on composting process and ammonia emission. There were three piles per treatment, with the treatments being a Control, EM-treated and *Bokashi*-treated. The product EM was a mixture of microbial inoculum in a solution of lactic acid bacteria maintained at pH 3.0–3.5. EM was added in liquid form while *Bokashi* was also EM-inoculated but in a solid medium of rice bran, burnt rice hull, coconut coir dust and chicken manure. The compost took 7 weeks to stabilise. Moisture loss was about 50%. Carbon losses were 9.0, 10.9 and 9.2%, while nitrogen losses were 17.5, 18.8 and 22.7% respectively for control, EM-treated and *Bokashi*-treated composts. There was an increase in pH from 6 initially to 9 at the end of composting.

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Concentrations of other elements including heavy metals were increased at the end of composting due to loss of mass. Ammonia emission was highest in *Bokashi*-treated piles. Maximum ammonia emission was found at about 15 days of composting. The addition of EM did not shorten the composting period. Based on result of ammonia emission, there was also no evidence to suggest that EM addition reduces odour.

Introduction

In Malaysia, chicken manure is widely used as organic fertilizer for vegetable production. However, it is mainly applied to the soil in its raw form, causing nuisance complaints such as infestation of houseflies and malodour emission. Such problems can be overcome by using stabilized manure resulting from composting, which is defined as the biological decomposition of biodegradable solid waste under predominantly aerobic conditions to a state that is sufficiently stable for nuisance-free storage and handling and is satisfactorily matured for safe use in agriculture. However, during composting, gases such as ammonia are being emitted, particularly during the early stages.

Effective microorganisms (EM) is a mixture of microbial inoculums developed by Prof. Teruo Higa of Ryukyus University in Japan in the early 1980s. The culture contains 125 species (Higa 1993), mixed in a solution of lactic acid bacteria and maintained at pH 3.0–3.5. It was developed on the hypothesis that it is feasible to culture and maintain a mixture of microbes (photosynthetic, nitrogen fixing and lactic acid bacteria) and yeast together. The culture is stored under tightly sealed condition under room temperature. Under such conditions the microbes are claimed to be viable within 6 months to one year of storage.

The reported beneficial effects of EM include a) suppression of soil-borne pathogens; b) increased decomposition rate of organic waste; c) increased availability of mineralized nutrients to plants; d) enhancement of microbial activities; e) increased nitrogen fixation; f) reduced requirement of chemical fertilizer (Higa and Kinjo 1989; Higa and Wididana 1989; Lin 1989; Piyadasa et al. 1993). However, there has been some controversy over the effects of EM applications. The objective of this work is to determine the effect of EM application on the composting process and emission of ammonia during composting of chicken manure.

Materials and methods

Raw materials

Manure voided by broilers reared on raised-floor houses were collected and heaped into nine windrow piles of 1 m^3 in volume for each pile. The nine piles were arranged in two rows inside an unused chicken barn. The nine piles were randomly assigned to three treatments with three piles per treatment. The manure was not mixed with any other substrates.

Treatments

Treatment A was a control in which only the chicken manure was used for composting. It was sprayed with 1 000 mL of distilled water at commencement of experiment, and subsequently at weekly intervals. Treatment B was similarly treated except that EM solution of 1:1 000 mL was sprayed on the piles initially and weekly. Treatment C consisted of 1 m^3 of the chicken dung mixed with *Bokashi* at 1 kg initially and subsequently at weekly intervals. It was similarly sprayed with 1 000 mL of distilled water initially and subsequently once a week.

Bokashi was EM-inoculated compost made up of 15 kg chicken dung, 10 kg rice bran, 5 kg coconut coir dust, 2 kg burnt rice hulls, 15 mL EM, 15 mL molasses and 20 litres water. The ingredients were mixed in a rotating drum mixer. The *Bokashi* was kept in sacks for an average of 10 days prior to application.

Mixing and monitoring

The piles were mixed manually with a spade on alternate days during the first week and then every 3 days for 2 weeks and subsequently once a week. Temperature taken at 30 cm depth was recorded daily using a temperature gauge. All readings were taken prior to any mixing. The mean temperatures of each of three replicates were taken. Fortnightly samples were randomly taken from each replicate and composited for each treatment for chemical analysis.

Chemical analyses

About 100 g of each sample was ground in a laboratory grinder. Weighed samples were subjected to wet digestion before being determined for elemental content. Total nitrogen was determined using Flow Injection Analyzer. Determinations of P, Ca, K and Na were done by Inductively Coupled Plasma Optical Emission (ICP-OES). Heavy metals were determined by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Total carbon was analyzed using CHNS Analyzer (Perkin Elmer 2400). Determination of pH was carried out on alternate days, using the method described in FCQAO (1994).

Ammonia emission

In order to determine the effect of EM on ammonia emission, the ammonia content in the composts was estimated every 3 days using Gastec Analyzer Tubes. The tubes were inserted at 10 cm depth at the center of each pile and left there for exactly 30 min before reading the ammonia concentration indicated by colour change. All readings were taken prior to any mixing.

Results and discussion

Temperature changes

Typically, the temperature changes in compost parallels those of microbial populations. The initial change in temperature parallels the incubation stage. If conditions are appropriate, this stage is usually succeeded by an exponential rise in temperature. This is a consequence of the breakdown of the easily decomposable component of the waste. It is during this period that the microbial populations increase exponentially. Thereafter, the temperature begins to drop until it reaches the ambient level.

The daily changes in mean temperatures of the three piles of chicken manure are shown in *Figure 1*. Each temperature was the mean of three replicates. It can be seen that the curves for EM-treated as well as Control treatments are rather similar. Thus treatment of chicken manure by using EM in solution did not show any advantage over the control. However, the addition of *Bokashi* appeared to compost at a higher rate in that it showed a higher peak than the other two treatments. The inference could be: a) that EM were multiplying in the *Bokashi* and were having an effect; b) that the carbon sources provided by the *Bokashi* helped in the improvement of C/N ratio, albeit only by a little; c) that indigenous species were growing well in the *Bokashi* and they helped in improving the composting process.

It can be seen from *Figure 1* that there was hardly any lag phase in the curves, with temperatures of about 50 °C being attained after one day. This shows that composting had already begun in the manure underneath the chicken houses, indicating that indigenous species were already active. The process took about 7 weeks, a period considered too long for most farmers to go into compost making. Two reasons could be attributed to this length of time to reach compost maturity. One is the insufficient supply of oxygen in this method of passive aeration in windrow composting. Another is the low C/N ratio (less than 10) in the chicken dung. The ideal C/N ratio in classical literature is about 25. No attempts

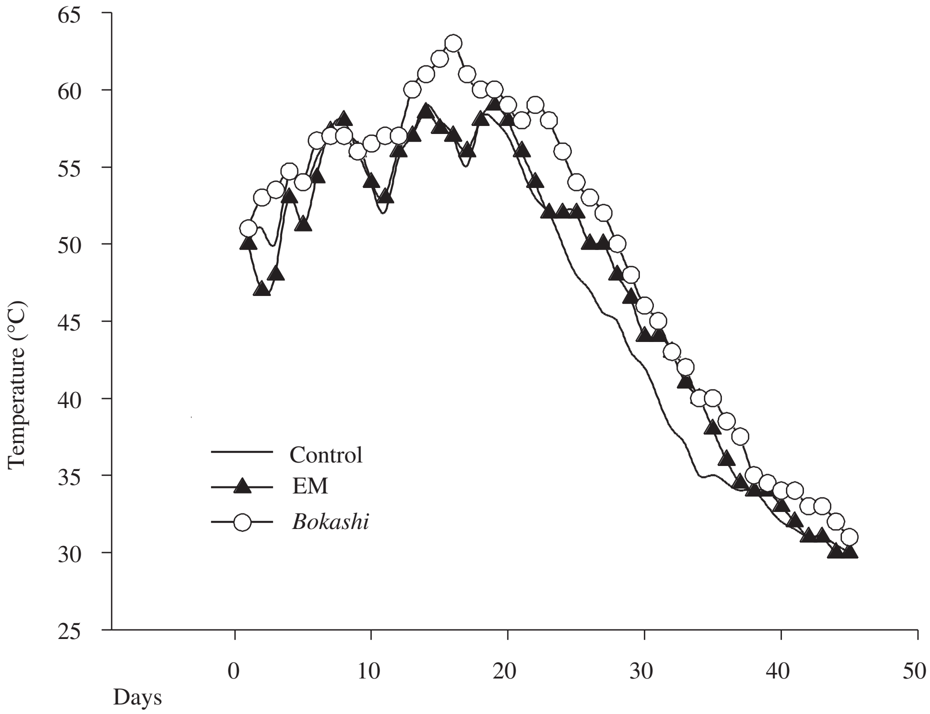

Figure 1. Effect of EM on temperature

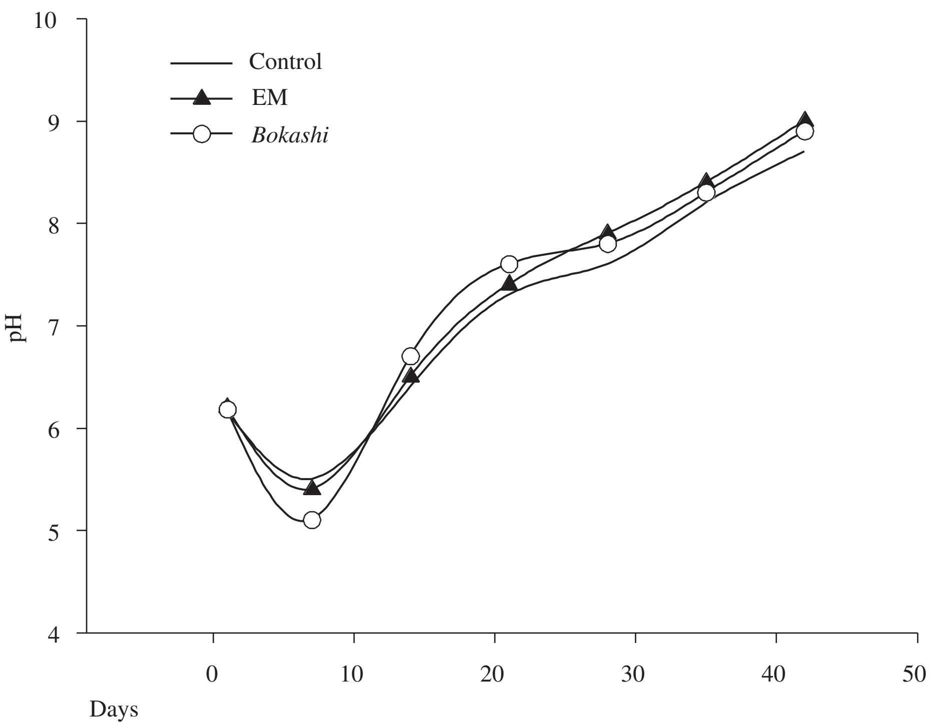

Figure 2. Effect of EM on pH of compost

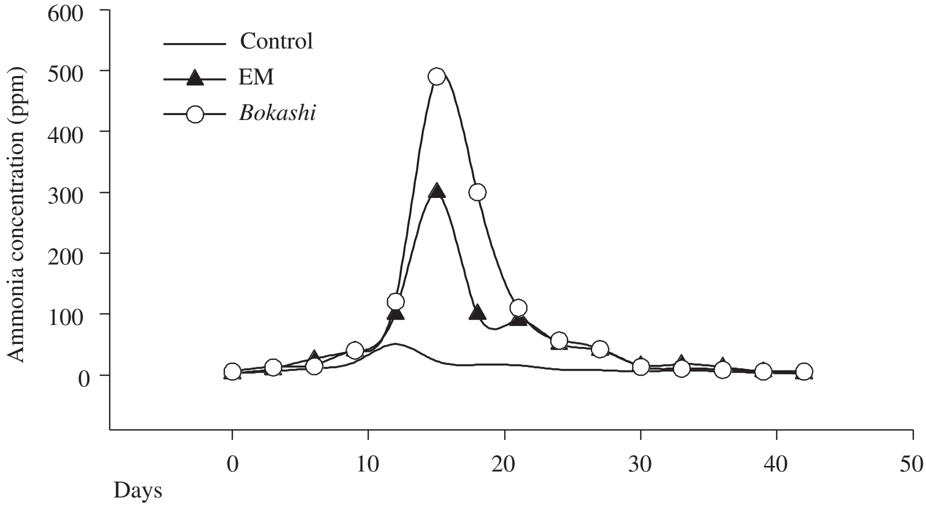

Figure 3. Effect of EM on ammonia emission

were made to increase this ratio by adding some carbon source, since the final user (usually vegetable farmers) always considered such addition as "adulteration" as the fertilizer value would decrease after plant residues have been added. Ong et al. (1996) found that in the treatment of poultry slaughter waste, EM had a positive effect when compared with the control. However, it was only as efficacious as indigenous species collected from sewage sludge.

pH changes

The pH of raw layer manure was in the region of 6. After 7 weeks it increased to about 9 *(Figure 2)*. In general, the pH initially decreased to about 5 for several days and then it rose steadily to about 9. Since microbiological investigation was not carried out, it is unclear whether EM did survive in the composts, as EM was cultured in a solution of lactic acid bacteria and maintained at pH 3.0 to 3.5. Reduction in pH was even less in the cases of EM-treated compost and the control. The initial drop in pH reflects the synthesis of organic acids, which serve as substrates for succeeding microbial populations. The subsequent rise reflects the utilization of the organic acids by microorganisms. Since there was a rise, it showed that the microbes were growing, and therefore the initial drop for a few days does not warrant any addition of lime.

Ammonia concentration

The ammonia emission was highest in *Bokashi*-treated piles, and it appears to be increasing with increase in temperature *(Figure 3)*. Ammonia may not be an indicator gas for odour since odour is emanated by a combination of fatty acids, amines, aromatics, inorganic sulphur and terpenes. It was singled out for estimation since it is generally accepted as being pungent to the human nose. As well, it is easy to estimate using the Gastec Analyzer Tubes. Ammonia emission is aggravated by the low C/N ratio at the commencement of composting (Zucconi and Bertoldi 1986). It was found to be high when the composting activity was high, as indicated by higher temperature. This is similar to the observation of Martins and Dewes (1992). It can be observed that ammonia emission was similar in all treatments at the beginning and towards the end of composting period.

Emission of ammonia can also be taken as a loss of nitrogen from the compost. This is further confirmed by analyses of compost samples as shown in *Table 1*. The loss of

Table1. Composition of poultry manure compost at various stages

	Week 1			Week 3			Week 5			Week 7		
	Ctr	EM	Bok	Ctr	EM	Bok	Ctr	EM	Bok	Ctr	EM	Bok
Water (g/kg)	662	656	641	582	567	538	427	460	479	327	331	319
C (g/kg)	288	303	294	265	278	256	250	263	241	226	240	237
N (g/kg)	32.5	33.6	34.4	30.5	29.6	28.8	29.2	28.4	27.5	26.8	27.3	26.2
C/N ratio	8.86	9.02	8.55	8.69	9.39	8.88	8.56	9.26	8.76	8.43	8.79	9.05
P (g/kg)	11.6	10.2	9.9	12.7	11.6	10.7	13.6	12.8	13.4	15.7	15.4	15.9
K (g/kg)	15.9	16.6	17.1	16.2	17.4	18.3	17.9	18.6	19.2	19.4	19.9	20.1
Ca (g/kg)	23.2	22.4	21.1	26.5	27.2	25.9	28.5	29.2	27.3	31.4	31.1	30.3
Mg (g/kg)	3.8	4.0	3.5	4.0	4.6	3.9	4.4	4.9	4.8	5.5	5.4	5.5
Fe (mg/kg)	120	124	113	127	129	119	131	132	121	133	134	125
Cu (mg/kg)	31	33	40	35	37	43	41	44	49	47	48	52
Zn (mg/kg)	90	88	86	92	90	89	95	92	97	97	95	99

Ctr = Control; EM = Effective Microorganisms; Bok = *Bokashi*

Table 2. Percentage losses of moisture, carbon and nitrogen at termination of composting

	Control	EM	*Bokashi*
Water	50.6	49.5	50.2
Carbon	21.5	20.8	19.4
Nitrogen	17.5	18.8	22.7

nitrogen is highest in *Bokashi*-treated piles *(Table 2).* Thus it can be inferred that addition of EM did not slow down the loss of nitrogen. The losses in nitrogen were similar in range to those found by Ong and Wan Hassan (1990). The amounts of nitrogen lost in gaseous form were not estimated in this trial. Even for the case of ammonia, the concentration was estimated only within a half-hour period. Kirchmann and Witter (1989) showed that, depending on C/N ratio and other factors, gaseous nitrogen losses of manure amounted to 9–44% of the total nitrogen over a period of 200 days. Factors that influence the emission of ammonia from animal manure are pH, NH_4^+/NH_3 equilibrium, mineralization of organic nitrogen compounds, C/N ratio, temperature, dry matter content and wind speed (Martins and Dewes 1992).

Nitrogen is also lost through leaching. In this trial, leachates were returned to the compost during mixing, but there has been a lot of concern regarding the danger that manure leachates pose to ground water. The work of Martins and Dewes (1992) showed that the greatest losses of nitrogen are through gaseous emission (46.8–77.4%) rather than through leachates. Of the gaseous emission, the greatest amount consists of ammonia. The most important factors influencing gaseous losses are the nitrogen content at the start of composting, temperature and heap rotation (Martins and Dewes 1992).

The higher content of nitrogen of *Bokashi* treatment at the start of composting would help to explain the greater nitrogen losses, since *Bokashi* itself was made up of several materials including chicken manure and rice bran. Hansen et al. (1990) found that during composting of poultry manure mixed with corncobs, carried out under ideal, aerated conditions, over 85% of the NH_3-N emitted occurs within the first three days. In this study, carried out under non-ideal and non-aerated conditions, the maximum ammonia emission appeared to be at about 15 days.

Changes in C/N ratio

In the cases of Control and EM treatment, the C/N ratio declined with time. This is expected, as the rate of carbon disappearance is normally higher than that of nitrogen. This was not the case in *Bokashi*-treated piles, in which nitrogen loss was exceptionally high. This was probably due to higher initial nitrogen content. Nitrogen losses were 17.5, 18.8 and 22.7%, respectively for control, EM and *Bokashi* treatments *(Table 2).* Prevention of this loss will have a significant effect on both odour emission and fertilizer value. A problem associated with the composting of poultry manure is that a large proportion of nitrogen contained in it is in the form of uric acid ($C_5H_4O_3N_4$). Of the total nitrogen, 60–70% is in the form of uric acid (Shuler et al. 1979). During composting, uric acid is first transformed to alloxan ($C_4H_2O_4N_2$) and then to urea (N_2H_4CO), and eventually to ammonia and carbon dioxide.

Changes in other elements

For elements other than carbon and nitrogen, there was a general increase in the concentration at the end of composting *(Table 1)*. The increases are expected. Owing to loss of mass, the compost materials were more concentrated after composting than before. The use of composite samples led to loss of opportunity to carry out analysis of variance. Composite samples were chosen in order to reduce variations, since it was the rate of change in composition in the progress of composting that was of concern. The nine piles of raw materials were collected over a period of 3 weeks. Due to unavailability of mixing equipment during the conduct of the experiment, the homogeneity of materials was questionable. Thus composite sampling was opted, since the main concern was the reduction rather than the absolute values, especially for nitrogen.

Conclusion

Under non-ideal and non-aerated conditions, a small-scale windrow composting trial using chicken manure without C/N adjustment showed that the process of stabilization required 7 weeks. Losses of moisture, carbon and nitrogen were approximately 50, 10 and 20% respectively. Addition of effective microorganisms (EM) and *Bokashi* did not shorten the composting period. Release of ammonia was highest in *Bokashi*-treated compost. Maximum ammonia release was found at 15 days. There was no evidence to suggest that EM addition reduces ammonia emission in the composting of poultry manure. At the level of application of *Bokashi* and EM (1 kg and 1 liter/m^3 respectively), composting was not enhanced.

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Adding maize straw to chicken manure composts can therefore increase the fermentation temperature and inhibit the growth of Proteobacteria. In general, these findings provide increased insig...Â It is therefore crucial to find an effective biosafety method for processing livestock manure. Composting can transform organic agricultural and industrial wastes into bio-fertilizers in an environmentally friendly way, and is a promising method for waste disposal (Bertoldi et al., 2014). During the composting process, microbial communities play an important role in the degradation of organic materials.Â Physicochemical Analysis of Chicken Manure Compost Samples. Compost is a self-heating habitat, in which temperature changes with time. Effect of effective microorganisms on composting characteristics of. chicken manure (Kesan mikroorganisma berkesan terhadap ciri-ciri pembuatan kompos daripada tahi ayam) H.K. Ong*, B.H. Chew* and M. Suhaimi* Key words: effective microorganisms, composting, chicken manure, Bokashi, ammonia.Â The objective of this work is to determine the effect of EM application on the composting process and emission of ammonia during composting of chicken manure. Materials and methods Raw materials Manure voided by broilers reared on raisedfloor houses were collected and heaped into nine windrow piles of 1 m3 in volume for each pile. The nine piles were arranged in two rows inside an unused chicken barn. Compost based on chicken manure can be a valuable. fertilizer because it contains a sufficient amount of nitrogen which is insufficient in many organic wastes. However, it is. advisable to use a co-substrate for effective composting of chicken manure. In this study, the chicken manure was co-. composted with organic fraction of municipal solid waste, sewage sludge (SS), food waste (FW), demoistened sewage sludge Comprehensive Utilization of Chicken Manure-Composting Chicken Litter. As we all know, Chicken manure is a kind of high quality organic fertilizer rich in various nutrients, including pure nitrogen (about 1.63%), phosphorus element (about 1.54%) and potassium element (about 0.85%). Before used as fertilizer in cropland, the chicken manure should be well decomposed so that the parasite, spawn and some germs existing in the chicken manure can be killed during the decomposition process.Â Too much water will cause impermeable effect and inhibit fermentation of the microorganism. There are a great diversity of auxiliary materials to choose, aiming at absorbing water from chicken manure. In general, auxiliary materials refer to saw powder, straw, peat carbon and so on. Effective microorganisms (EM) are various blends of common predominantly anaerobic microorganisms in a carbohydrate-rich liquid carrier substrate (molasses nutrient solution) of EM Research Organization, Inc., Studies have stated that Effective microorganisms (EM-A, EM-Bokashi) show no effect on yield and soil microbiology in field experiments as bio-fertilizer in organic farming.