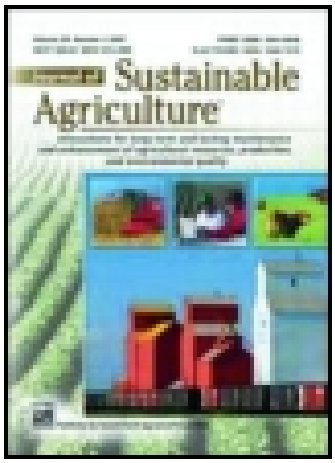

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Influence of EM Bokashi on Nodulation, Physiological Characters and Yield of Peanut in Nature Farming Fields

Yan Pei-Sheng [a b] & Xu Hui-Lian [b]
[a] Department of Plant Protection , Laiyang Agricultural University , China
[b] International Nature Farming Research Center , 5632 Hata, Nagano, 390-1401, Japan
[c] International Nature Farming Research Center , 5632 Hata, Nagano, 390-1401, Japan E-mail:
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RESEARCH NOTE

Influence of EM Bokashi on Nodulation, Physiological Characters and Yield of Peanut in Nature Farming Fields

Yan Pei-Sheng
Xu Hui-Lian

ABSTRACT. Effects of EM bokashi organic fertilizer on nodulation, physiological properties and yield of peanut plants were investigated in a nature-farming field. Compared to chemical fertilizer, EM bokashi fertilizer significantly increased both the nodule numbers per plant and fresh weight per nodule. The peanut plants fertilized with EM bokashi fertilizer also showed higher photosynthetic rate, transpiration rate and mesophyll conductance. Therefore, the vegetative and reproductive growth of peanut plant in EM bokashi treatment was promoted significantly. The shoot and root dry weights in EM bokashi treatment were significantly higher

Yan Pei-Sheng is Professor of Microbiology, Department of Plant Protection, Laiyang Agricultural University, China. He was Visiting Scientist, International Nature Farming Research Center, 5632 Hata, Nagano 390-1401, Japan.

Xu Hui-Lian is Senior Researcher of Crop Science, International Nature Farming Research Center, 5632 Hata, Nagano 390-1401, Japan (E-mail: huilian@janis.or.jp).

Address correspondence to: Dr. Yan Pei-Sheng, 65 Wenhua Road, Laiyang, Shandong 265200, China (E-mail: psyan@lyac.edu.cn).

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than those in chemical treatment. The total pod number and pod dry weight in EM bokashi fertilizer treatment were significantly higher than those in chemical fertilizer treatment. These results suggested that EM bokashi is an effective organic fertilizer in nature farming crop production.

KEYWORDS. EM bokashi, organic fertilizer, nodulation, physiological characters, peanut, sustainable agriculture

INTRODUCTION

Nature farming is a practice to cultivate crops without application of any synthetic chemicals and pesticides or any untreated manure and sewage, with application of only composts fermented using plant organic materials (Okada, 1987). It is similar to other versions of organic farming. However, nature farming goes beyond organic farming because it must satisfy the following five requirements: (1) it must produce safe and nutritious food to enhance the human health, (2) it must be economically and spiritually beneficial to both producers and consumers, (3) it must be sustainable and easily practiced by anyone, (4) it must conform to nature and protect the environment, and (5) it must produce sufficient food of high quality for an expanding world population (Higa, 1995). As more and more people begin to understand the need to respect the laws of nature in modern society, nature farming is receiving more attention from scientists, growers and governments.

Effective microorganisms (EM) technology has become an integral part of nature farming. This technology has been extended to a large number of countries throughout the world and beneficial results are being reported for a diverse range of environments under both laboratory and field conditions (Higa, 1995). EM contains predominant populations of lactic acid bacteria, yeast, actinomycetes, photosynthetic bacteria and other beneficial microorganisms that are mutually compatible and can co-exist in liquid cultures (Higa and Parr, 1994). EM are usually used as inoculant on plant seeds, in soils or sprayed on the plant leafs. Recently, an organic fertilizer called EM bokashi is used in nature farming crop production. EM bokashi is produced by anaerobic fermentation of rice bran, rice husk, rapeseeds oil mill sludge and fishmeal in

enclosed containers with EM added. It contains a large amount of propagated *Lactobacillus* and yeast, and intermediate metabolites like organic and amino acids at high concentrations. The total concentration of N is 45 g/kg with a C/N ratio of 10. Before application, N and P are almost in organic status, and the mineral N (NO_3^- + NH_4^+) and P are only 0.1% and 1% (Yamada, 1996). Some research results show that EM bokashi increases crop production of vegetables, rice and sweet corn (Iwahori, 1996; Iwashi, 1994; Fujita, 1997). In this research, we investigated the influence of EM bokashi on nodulation, some physiological properties and yield of peanut under nature farming conditions.

MATERIALS AND METHODS

Fertilizer Application and Peanut Planting

In this experiment, EM bokashi organic fertilizer was compared with a chemical fertilizer (N: P: K 15: 15: 15) (Japan Agricultural Company). EM bokashi was applied at 300 g/m^2. Chemical fertilizer was applied at 60 g/m^2, with the total N adjusted equivalent to that in EM bokashi.

Seeds of peanut (*Arachis hypogaea* L.) were sown on June 15, 2000 with a 25-cm plant distance and a 40-cm row distance. Two seeds were planted in each hole. The experimental plot was 42 m^2 with three replicates for each fertilizer treatment.

Nodulation, Plant Growth and Yield Analysis

At pod growing stage of 90 days after sowing, ten peanut plants from five holes in each replicate were sampled and brought back to the laboratory. The total nodules were removed from the roots, the nodule numbers and nodule fresh weight were recorded. About 130 days after sowing, another ten peanut plants were harvested as above. The shoot dry weight and root dry weight (dried at 80°C for 48h) were analyzed. The final pod number, fresh weight and dry weight were recorded.

Photosynthesis Measurement

The photosynthesis, stomatal conductance and transpiration were measured 84 days after sowing using the LI-6400 Portable Photosynthesis System (LI-COR Inc., Lincoln, NE, USA).

Statistical Analysis

All data were subjected to two-way analysis of variance (ANOVA). Least significant difference (LSD) test was used to compare the treatment means when the analysis of variance indicated significant treatment effects.

RESULTS AND ANALYSIS

Nodule Numbers and Fresh Weight

The nodule number on the main root consisted only of about 2.6-2.7% of the total root nodules; most of the nodules grew on the lateral roots (Table 1). The total nodule number in EM bokashi treatment was 77.8 per plant, which was 9.73% over that in chemical fertilizer treatment.

The fresh weights of nodules both per plant and per nodule on main root showed no significant difference between the two fertilizer treatments (Table 2). However, the fresh weights of nodules on lateral roots both per plant and per nodule in EM bokashi fertilizer treatment were significantly higher than those in chemical fertilizer treatment. The total fresh weights per plant and per nodule in EM bokashi fertilizer treatment were 18.6% and 9.9% higher, respectively, than those in chemical fertilizer treatment. These results suggested that EM bokashi could not only stimulate the colonization of rhizobia on peanut roots, but also promote nodule development.

TABLE 1. Effect of EM Bokashi on nodule number of peanut.

Treatment	Nodules on main root (No./plant)	Nodules on lateral root (No./plant)	Total Numbers (No./plant)
EM Bokashi	2.0 ± 0.4	75.8 ± 1.5	77.8 ± 1.9
Chemical	1.9 ± 0.7	68.9 ± 2.6	70.9 ± 3.2

TABLE 2. Effect of EM Bokashi on the fresh weight (FW) of peanut nodules.

Treatment	Nodule FW on main root		Nodule FW on lateral root		Total	
	g/plant	mg/nodule	g/plant	mg/nodule	g/plant	mg/nodule
EM Bokashi	0.04 ± 0.01	17.5 ± 1.0	1.12 ± 0.08a	15.0 ± 0.3a	1.15 ± 0.08a	15.1 ± 0.3a
Chemical	0.03 ± 0.01	18.0 ± 4.1	0.93 ± 0.04b	13.5 ± 0.2b	0.97 ± 0.04b	13.6 ± 0.1b

Physiological Properties

The photosynthetic rate (P_N) in plants given the EM bokashi fertilizer treatment was slightly higher than that in chemical fertilizer treatment (Table 3). This contributed to the higher mesophyll conductance (g_m) rather than the stomatal conductance (*gs*) (Table 3). The transpiration rate (*Tr*) in EM bokashi fertilizer treatment was also higher than that in chemical fertilizer.

Shoot and Root Development

At harvest stage, the shoot dry weight in EM bokashi fertilizer treatment was significantly higher than that in chemical fertilizer treatment (Table 4). The root dry weight in EM bokashi treatment was also significantly higher than that in chemical fertilizer treatment. These results suggested that EM bokashi could promote the vegetative growth of peanut.

Pod Number and Yield

The total pod number per plant in EM bokashi fertilizer treatment was significantly higher than that in chemical fertilizer treatment (Table 5). And more pods developed with two-seeds in the EM bokashi treatment. The pod number with two-seeds in EM bokashi fertilizer treatment was significantly higher than that in chemical fertilizer treatment, but the

TABLE 3. Effect of EM bokashi fertilizer on peanut physiological characters.

Treatment	P_N (μmol $m^{-2}s^{-1}$)	*gs* (mol $m^{-2}s^{-1}$)	*Tr* (mmol $m^{-2}s^{-1}$)	g_m (mmol $m^{-2}s^{-1}$)
EM bokashi	40.0 ± 0.19	0.70 ± 0.05	5.65 ± 0.26	0.185 ± 0.004
Chemical	38.5 ± 0.59	0.73 ± 0.03	5.41 ± 0.31	0.181 ± 0.002

TABLE 4. Shoot dry matter weight and root dry matter weight at harvest.

Treatment	Shoot DM (g/plant)	Root DM (g/plant)	Ratio of shoot DM to root DM
EM bokashi	41.1 ± 0.3 a	2.85 ± 0.25a	14.6 ± 0.2 a
Chemical	33.4 ± 0.6b	1.93 ± 0.01 b	17.3 ± 0.3 b

TABLE 5. Effects of EM bokashi on pod number and dry weight of peanut at harvest.

Treatment	Pod number (No./plant)			Pod dry weight (g/plant)		
	Two-seed	One-seed	Total	Two-seed	One-seed	Total
EM bokashi	32.9 ± 1.0a	10.5 ± 1.1a	43.4 ± 2.1a	61.8 ± 2.7a	10.2 ± 1.3a	72.1 ± 3.9a
Chemical	28.6 ± 2.7b	10.9 ± 0.2a	39.5 ± 2.6b	55.1 ± 5.7b	10.8 ± 0.7a	65.9 ± 5.7b

pod number with one-seed showed no significant difference between two treatments.

The total pod dry weight per plant in EM bokashi treatment was also significantly higher than that in chemical treatment. This was due to the higher dry weight of pods with two-seed, rather than the dry weight of pod with one-seed (Table 5). These results showed that EM bokashi fertilizer could significantly increase the peanut yield.

DISCUSSION

EM bokashi fertilizer has been used in nature farming systems for years in Japan. Other researchers' results showed that, with this kind of organic fertilizer, yields of sweet corn, paddy-rice and vegetables reached a similar or higher level to that with chemical fertilizers (Iwahori, 1996; Iwashi, 1994; Fujita, 1997). Hussain et al. (1995) also reported that EM could increase the yields of rice and wheat to 16.0% and 24.8%, respectively. The application of EM with organic manure together could increase the peanut yield 6.6%-10.1% compared with organic manure used only (Zhao, 1995). Our results suggested that EM bokashi organic fertilizer could increase the peanut pod yield to 9.4% over the chemical fertilizer. This resulted from increased total pod number and more pods with two seeds. In EM bokashi treatment, the peanut plants showed higher photosynthetic rate and transpiration rate compared with chemical fertilizer treatment. The results of other studies have indicated that, at late growing stage, sweet corn plants could absorb more nitrogen and phosphorus from the soil in organic fertilizer treatment than in chemical fertilizer treatment (Fujita et al., 1997; Xu, 2000). Balanced nutrition in soil of organic fertilizer treatment might enhance the photosynthesis and other physiological process as evidenced in peanuts in our study and by others (Xu, 2000). Thus, more photosynthetic products in EM

bokashi treatment should be supplied for the vegetative and reproductive growth.

The nodulation pattern was affected evidently by the EM bokashi fertilizer. Both the nodule numbers per plant and fresh weight per nodule in EM bokashi fertilizer treatment were higher than that in chemical fertilizer treatment. The difference of nodule number per plant in the two treatments might be due to the substances produced by the EM or decomposed from organic matter, which could stimulate the multiplication and invasion of rhizobia into the root. Zhao's result suggested that EM-soaked peanut seeds could increase the population of soil nitrogen-fixing bacteria (Zhao, 1995). Another reason was the full-developed root system in EM bokashi treatment, which provided more space for nodule formation. The larger nodules in EM bokashi treatment might be contributed to the well-developed roots and higher photosynthetic rate, which provided more nutrients and photosynthates for the nodule growth. In turn, the larger nodules had higher nitrogen fixation ability and more nitrogen was supplied for the peanut plant growth.

The results of this research suggested that the pod yield of peanut fertilized by the EM bokashi organic fertilizer could reach a higher level than that fertilized by chemical fertilizer. This shows a bright future for applications of EM bokashi organic fertilizer in nature farming system. As only 70% of the organic nitrogen in microbe-fermented organic fertilizer could be mineralized in one growing season (Yamada, 1996), more research should be conducted to find whether the higher amount of EM bokashi organic fertilizer application could result in a higher crop yield.

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