

THE MANUFACTURING AND APPLICATION OF ORGANIC COMPOUND FERTILIZERS

T.C. Juang
Department of Soil and Environment
National Chung Hsing University
Taichung, Taiwan, Republic of China

ABSTRACT

This Bulletin discusses several manufacturing processes for organic compound fertilizers overseas and in Taiwan. The different formulations of $N-P_2O_5-K_2O$ in the fertilizers are also reported. The yield response of different crops from the application of organic compound fertilizer reflects their superiority over organic fertilizers. Experiments also showed that the use of organic compound fertilizers improved the quality of tea and some orchard fruits.

INTRODUCTION

Early in the 1970s, a South African fertilizer company (Groeikrag Organic Fertilizers Co.) began to produce an organic fertilizer which contained guano and ammonium carbonate as the main ingredients. It was widely used by South African farmers (Botha 1982). In the United States, the Dickerson Composting Plant used sludge slurry composted together with coarse wood chips, with lime or rock phosphate added to the final product, depending on market requirements. The cost of the composting system was quite high, and the Dickerson plant suffered a net loss of U.S.\$7 million per 100,000 mt in 1982.

There are now many commercial compost plants in the United States, processing poultry wastes, corn residues, livestock manure, crop residues and sewage sludge. The average sale price of their compost was around US\$25-30/mt, plus US\$5 delivery cost. Most compost plants lose money, even when the products are used in plant nurseries or home gardens. If chemical N, P and K is added, the price can rise to US\$31-50/mt F.O.B.. These are known as "compost-NPK plus", or organic compound fertilizers. Sometimes the added NPK exceeds 38% of the total present in the compost.

In 1990, an activated sludge pasteurization process (ASP) was developed in South Africa.

The activated sludge was enriched with N and P (N:P = 11:18%) through natural aerobic and anaerobic digestion. The process made use of a continuous-flow pipe reactor, without the addition of any extra energy. Patents for the technology and its application have been granted in 23 other countries. The final product is used in liquid form, and the cost is about US\$30-45 per wet ton and US\$180/mt for the dried solids. An evaluation report has been submitted by Nell, van der Merwe and Barnard (Nell *et al.* 1990).

In Taiwan, the Taiwan Fertilizer Company (TFC) began to develop organic compound fertilizers in 1986. There are now seven formulated fertilizers on the market, each used for a different crop (see Table 1). The raw materials used for making compost or mixer include peat, guano, milled oil seeds, leather residues, activated sludge and bone meal. The formulation and quality is guaranteed. Prices are around US\$326-544/mt, which is 30-100% higher than the price of ordinary compost. Juang and Tsai have formulated a number of different compound organic fertilizers made from various organic wastes to which a small amount of NPK fertilizer has been added (Tsai 1995, Juang and Tsai 1996). It is intended to develop organic compound fertilizers for different crops from different formulations, based on crop nutrient requirements. The three main purposes of developing the use of organic

Keywords: Active Sewage Pasteurization (ASP), compost, Dickerson Sludge composting process, organic compound fertilizer, Taiwan

Table 1. Commercial organic compound fertilizer in Taiwan

Formulation					Crop
N	P ₂ O ₅	K ₂ O	MgO	Compost	
11	- 11	- 11		30	Orchards, vegetables and rice
5	- 10	- 10	- 5	30	
10	- 6	- 7	- 3	30	
15	- 3	- 7	- 3	30	
5	- 10	- 10	- 5	30	
5	- 15	- 15	-	30	
5	- 10	- 15	- 3	30	Tobacco

compound fertilizers in Taiwan are:

- To cut down the cost of applying compost (less compost is needed);
- To reduce nitrate pollution from chemical fertilizer; *and*
- To meet the different nutrient requirements of various crops.

There are more than 100 private compost factories in Taiwan, producing all kinds of organic fertilizers. Since they are not covered by official regulations, their quality control is generally poor. They tend to contain variable amounts of chemical N, P and K. The nutrient balance does not usually correspond to the needs of the crop, and they are generally sold for too high a price.

The following sections discuss the processes by which organic compound fertilizers are manufactured, both in Taiwan and abroad, and report on the yield or quality responses of crops from the application of these fertilizers.

MANUFACTURING PROCESSES FOR ORGANIC COMPOUND FERTILIZERS

Dickerson Sludge Composting Process

Coarse wood chips are spread out by a bucket loader in long rows with flattened tops. Tankers containing sludge slurry drive slowly along the rows, discharging slurry as they go. The slurry and wood chips are mixed roughly by a bucket loader, while a Cobey machine then picks up the mixture and forms it into a hollow square. At the same time, another operator prepares a bed of wood chips over slotted plastic pipes. The mixed material is then laid over the layer of wood chips, allowing proper removal of the air. A final layer of compost is laid over the top of the fresh material. Simple suction pumps of only 1/3 H.P are used to expel the

air from each unit. The air is pumped into a small compost heap to absorb any volatile odor. Temperatures in the compost heap rise to 70°C, or even 90°C, and all pathogenic organisms are destroyed. The material is screened after three weeks. The screening machine is movable, and has two rubber screens, the upper with 2-cm square holes, and the lower with 1 cm mesh. In smaller units, wire string screens are used. Coarse wood chips are used again for the composting process, since they facilitate aeration.

The final product is piled in heaps 7-10 m high, using a stacking conveyer. Lime or rock phosphate may be added, depending on market requirements. One plant produces 100,000 mt annually.

Active Sewage Pasteurization (ASP) Process

(Note: Patent granted in South Africa in 1989)

Water is removed from primary or digested sewage sludge by conventional methods until it is 15% solids. The concentrated sludge then enters a stainless steel pipe reactor. The retention time varies, depending on flow rate (Fig. 1), but ten minutes is normally sufficient. At the point where the sludge enters the reactor, anhydrous ammonia gas is injected into the sludge at a pressure of 100 - 300 kpa, although 200 kpa is typical.

As a result of the exothermic reaction between the ammonia and the sludge, the temperature in the reactor rises to 40°C - 50°C. The actual temperature depends on the pressure, the quantity of ammonia injected, and the flow rate. The pH is normally 11.6. Just before the sludge leaves the pipe reactor, concentrated phosphoric acid is pumped into the ammoniated sludge at a rate sufficient to reduce the pH of the mixture to 7.0. Depending on

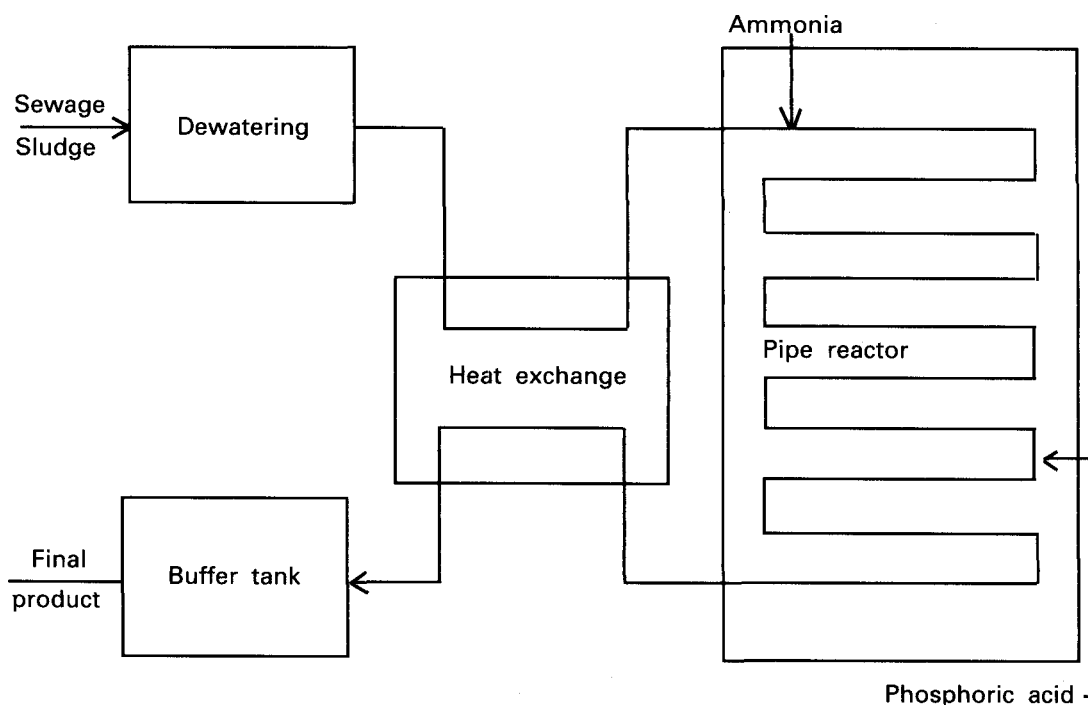


Fig. 1. Schematic Diagram of the ASP process

residual temperature and ammonia concentration, a further temperature rise to 65-75°C is obtained.

The treated sludge then enters a heat exchanger where heat is transferred to the incoming untreated sludge and/or ammonia. Pasteurization is achieved by a combination of pressure, temperature, pH and ammonia toxicity.

Pressure in the pipe reactor is controlled by throttling the outflow, while retention time is determined by the throughput rate. The final pH depends on the ratio of ammonia to phosphoric acid pumped into the system. Temperature control is less straightforward, since it depends on both the total amount of ammonia injected and the ratio of ammonia to phosphoric acid.

The end-product is a syrupy, gray to black liquid with a slight ammonia smell. The intensity of the smell is related to the pH, the concentration of free ammonia and the ratio between the ammonium phosphate species present. As more phosphoric acid enters the system, the ratio of di- to mono-ammonium phosphate decreases, with a simultaneous fall in the concentration of free ammonia, in pH and in the solubility of the ammonium phosphate.

The process can be carried out in a modular plant, each module having a daily capacity of 20 - 60 million liters.

TFC Special No. 4

The Taiwan Fertilizer Company (TFC) has manufactured a 8-8-3-50 (Compost) organic compound fertilizer, known as 'Special No. 4' or by its commercial trade name of "Humic Acid Organic Compound Fertilizer". The raw materials include peat, guano, and chemical nutrients such as urea, mono-ammonium phosphate, potassium sulphate, KOH and $Mg(OH)_2$. The manufacturing process is shown in Fig. 2. TFC Special No. 4 contains 12.0% humic acid and 50.0% organic matter, and has a pH of around 7. It is sold in both powder and granule forms. This fertilizer is suitable for use in orchards and tea plantations, and for vegetables, rice and flowers.

TFC Tobacco Organic Compound Fertilizers

In 1993, TFC developed two formulations of organic compound fertilizer, 5-15-15-30 and 5-10-15-3 (MgO)-30, specifically for tobacco. The raw materials include bone

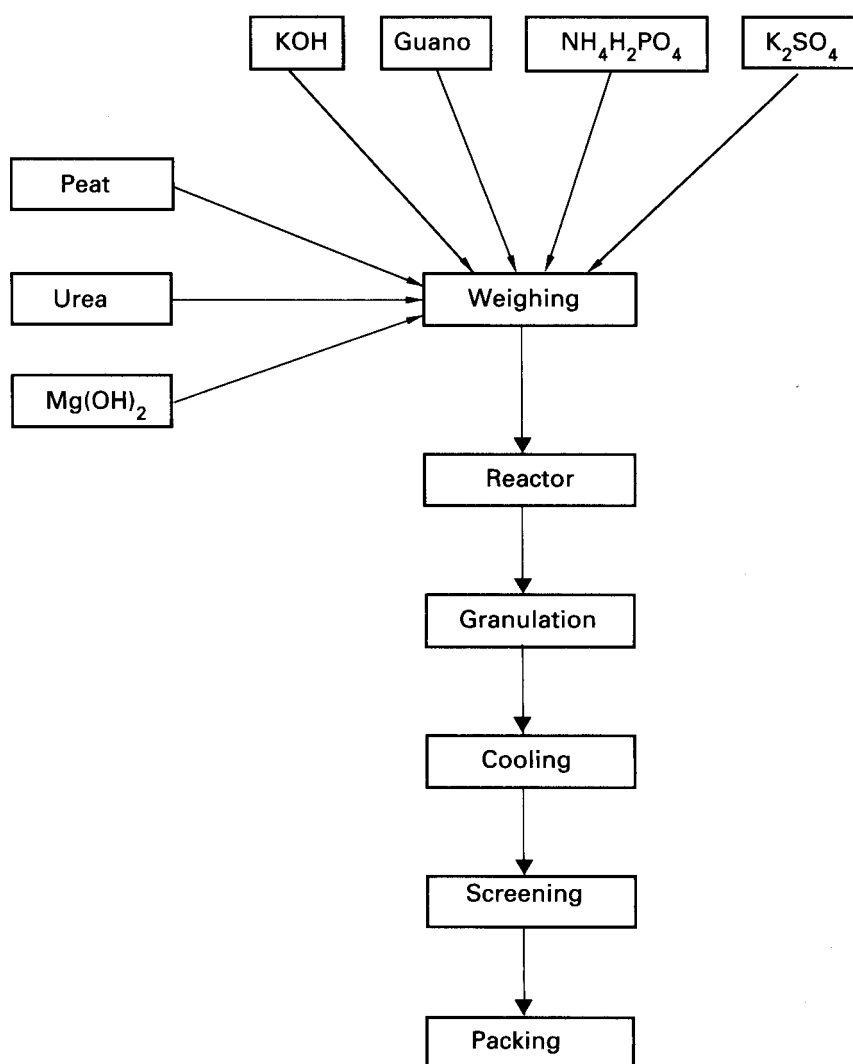


Fig. 2. Diagram of manufacturing process of TFC Special No. 4

meal, linseed and rapeseed meal, mono-ammonium phosphate, potash sulphate and urea. The production process is shown in Fig. 3. The 5-15-15-30 fertilizer is recommended for use in central and eastern Taiwan, and 5-10-15-3-30 for use in southern Taiwan. The fertilizer takes the form of rounded crystals. Another TFC organic compound fertilizer, 11-11-11, is widely recommended for use in orchards, tea plantations and vegetable farms. One of the raw materials of 11-11-11 is powdered leather scraps, which contain amino acids and ammonium-type nitrogen which may have some beneficial effects on crops.

Experimental Pilot Plant

A pilot organic fertilizer plant has been built at the Taichung District Agricultural Improvement Station in Taiwan (Tsai 1995). Here, organic fertilizer are being manufactured from different combinations of raw materials, with or without urea and superphosphate. The animal wastes include chicken, cattle and hog manure used as a primary source, to which is added sawdust, rice straw or mushroom compost (i.e. Compost which has been used for intensive production in mushroom houses.) In some cases, urea and superphosphate are added before composting. The manufacturing process is shown in Fig. 4. It follows a complete composting procedure. The compost is then screened, granulated, and finally packed.

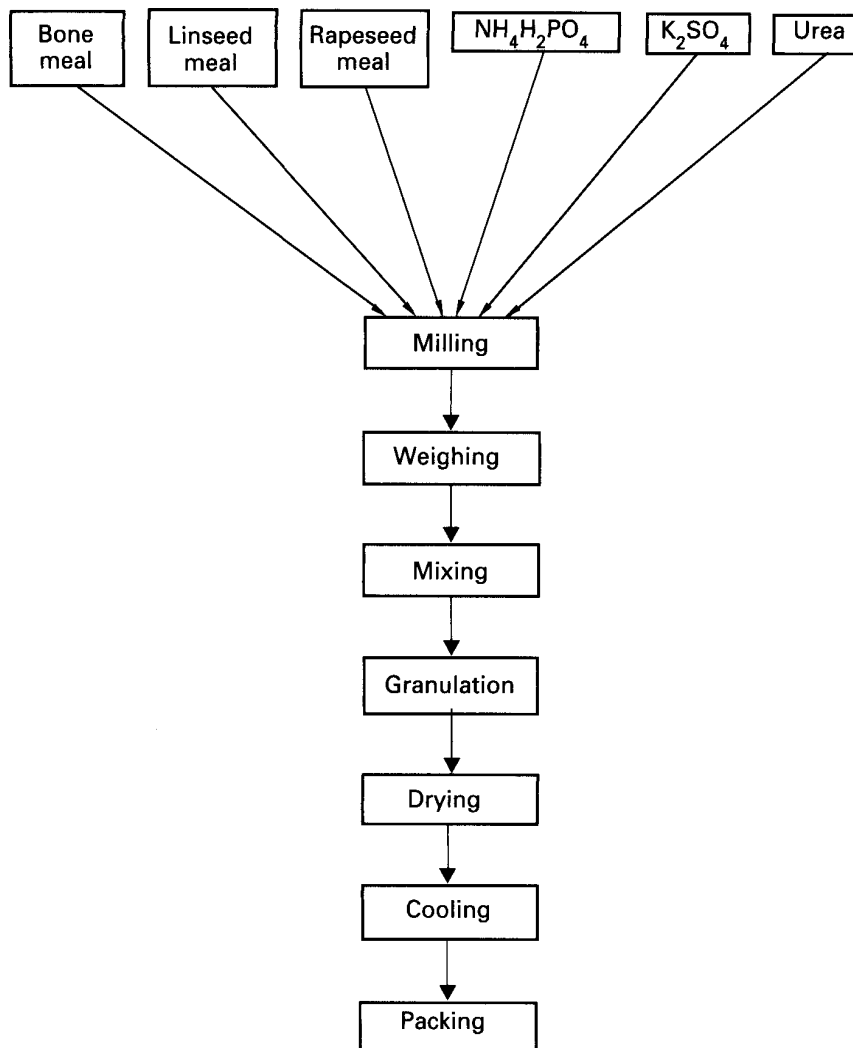


Fig. 3. Diagram of the manufacturing process for TFC tobacco organic compound fertilizer

CROP YIELD RESPONSES TO ORGANIC COMPOUND FERTILIZERS

Corn

The use of organic compound fertilizer in corn production is not economical, because the price for the crop is too low compared to the cost of the fertilizer. However, there are some reports that the use of fertilizer from the ASP process in South Africa produced yield increases in corn and tobacco of 20 - 30% (A. Fourie, personal communication 1992).

Tobacco

Experiments were conducted in three sites in Taiwan, in the center, east and south of the island, respectively. They compared the effect of two organic compound fertilizers and two chemical fertilizers on the spring and autumn tobacco crop. The organic compound fertilizers were made by the Taiwan Fertilizer Company (5:15:15 (30) and 5:10:15:3 (30)), while the NPK chemical fertilizers were 7:21:21 and 9:18:27. Both kinds of fertilizer were applied at N-levels of 40, 60 and 80 kg N/ha.

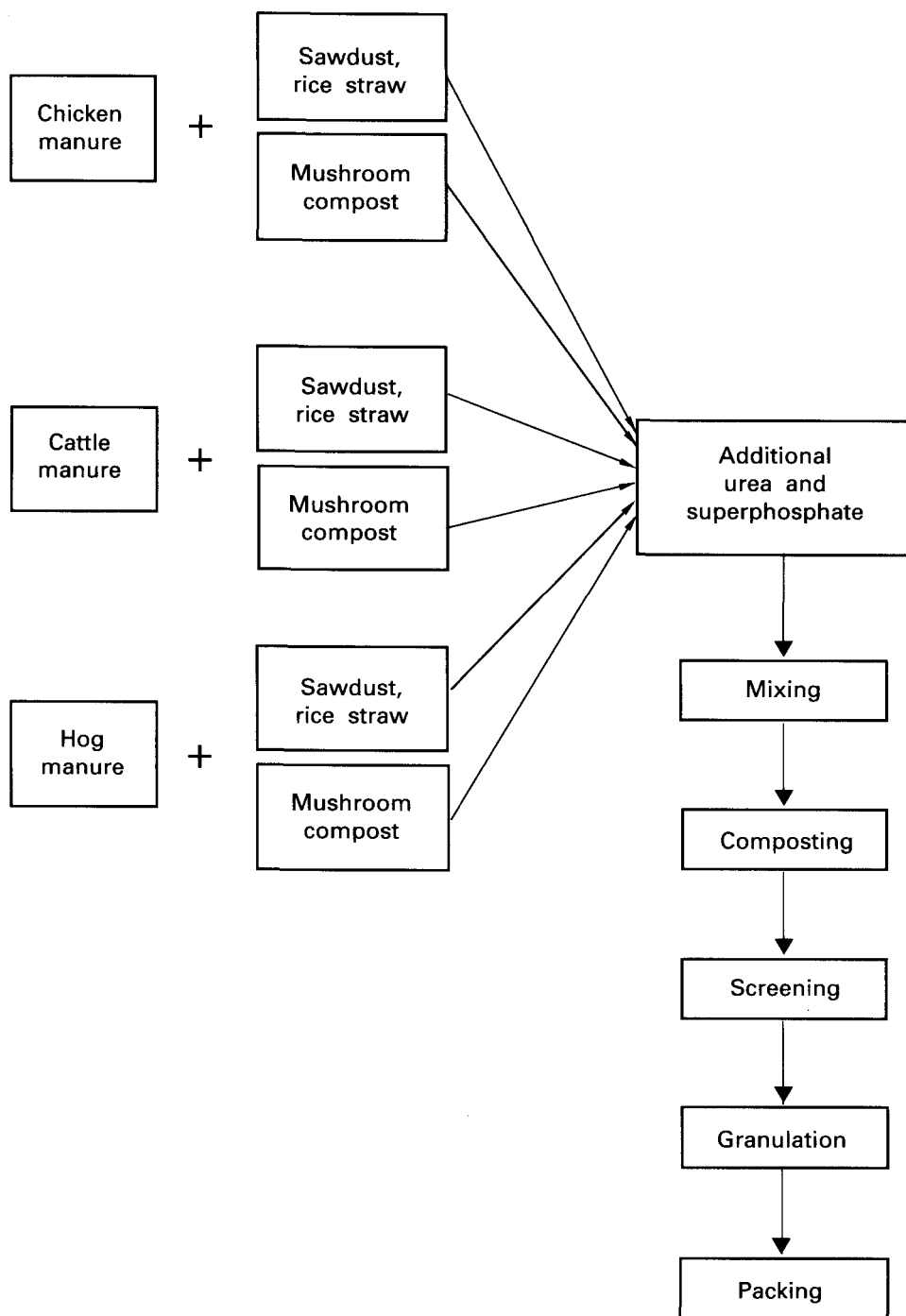


Fig. 4. Manufacturing process for organic compound fertilizer made from composted livestock manure.

	Treatment				Site 1		Site 2	
	N	P ₂ O ₅	K ₂ O	MgO (Compost)	April 9	April 20	May 25	Total
Chemical fertilizer	15	3	7	3(30)	217	90	144	361
Chemical fertilizer	10	6	7	3 + Special No. 1*	234	92	192	426
Organic compound fertilizer	10	6	7	2(30)	268	127	170	438
Organic compound fertilizer	15	3	7	3(30)	253	144	190	443

* Special No. 1: Organic compound fertilizer made by the Taiwan Fertilizer Company. N:P:K:Compost = 11.11.11.30

Table 2. Comparative yield of tea (g/plant) from the application of organic and inorganic compound fertilizers, Taiwan 1993

The results showed that in the first year, tobacco quality was better from the heaviest organic compound application in eastern Taiwan, but there was no significant difference in yield between the two fertilizer treatments. During the second year (1995-96), the organic compound fertilizer at a level of 60kg N/ha was found to give a higher net profit for autumn tobacco in Taichung. As one might expect, the yield increased with increasing N levels for both chemical and organic compound fertilizers. However, the use of organic compound fertilizers for tobacco production gave higher yields than chemical fertilizer at the same N levels, although this effect was not seen until the second year.

Tea

The Taiwan Tea Experiment Station conducted field trials on the effect of organic compound fertilizers in two sites in Taiwan in 1993. The results in tea yield (g/plant) are shown in Table 2. The yield increases from the use of organic compound fertilizer seems quite significant, especially in site No. 1. Tea to which organic compound fertilizer 10-6-7-2-30 had been applied appeared to have better flavor and fragrance.

Rice

Rice field experiments were conducted in three sites in the lowland plain of central Taiwan (Juang and Tsai 1996). The treatments were designed according to a formulation of 12-18-12 (40) for rice as follows:

All treatments of total N, P₂O₅ and K₂O maintained the same level of 120-180-120 levels. Application of compost assumed 50% available N in composted hog and chicken manure and mushroom wastes, and 25% available N in composted cattle manure and mushroom wastes. Chemical P and K fertilizers were added make up the insufficient P₂O₅ and K₂O in the compost treatments.

The results indicated that chemical fertilizers gave the highest rice yield (Table 3). They also showed that organic compound fertilizer gave higher yields than compost alone.

Citrus

Experiments carried out at the Taiwan Tea Experiment Station on Ponkan oranges in 1993, using organic and chemical compound fertilizers, found that the former gave a higher Brix, and in some cases a higher yield. Experiments on pommelo at the Tainan District Agricultural Improvement Station, Taiwan, gave similar results.

Vegetables

Some experiments on the use of organic, organic compound and chemical fertilizers for green onion have been carried out in Taiwan at the Hualian District Agricultural Improvement Station. Fertilizer applications were adjusted in order to make up the same level of N-P₂O₅-K₂O (180-100-160 kg/ha). These experiments are still at an early stage, but so far they have shown yields from plots with organic compound fertilizer to be higher than those with chemical fertilizer.

Similar results have been obtained with comparable experiments on lettuce, comparing chemical fertilizer treatment with two types of compost and three organic compound fertilizers. Although the highest yield was obtained with a compost treatment, the chemical fertilizer treatment gave a higher yield than the organic compound fertilizer or the other compost treatment.

CONCLUSION

Organic compound fertilizer may combine the best qualities of compost and chemical fertilizer, in a way which is cost effective and minimizes environmental pollution. However, the quality control of organic compound fertilizer and of compost are of critical importance. National standards for factories and for the quality and prices of products, should be set by the government, and included officially in Taiwan's Fertilizer Management Law.

Table 3. Effect of compound and organic fertilizers on rice yields at three lowland sites, central Taiwan

Treatment	Compost applied	Chemical fertilizer added			Site 1	Site 2	Site 3
		N	P ₂ O ₅	K ₂ O			
	mt/ha	kg/ha			Grain yield, mt/ha		
Chemical fertilizer	—	120	- 180	- 120	5.5(100)	9.4(100)	5.1(100)
Composted hog manure + mushroom wastes + chemical fertilizer	10	60	- 167	- 91	5.3(95)	7.5(80)	4.4(87)
Composted cattle manure + waste + chemical fertilizer	20	60	- 161	- 14	4.3(77)	7.2(76)	4.0(79)
Composted chicken manure + mushroom waste + chemical fertilizer	12	60	- 159	- 32	5.3(95)	7.9(85)	4.3(86)
Composted hog manure + mushroom waste	20	0	- 0	- 0	—	6.5(69)	4.4(87)
Composted cattle manure + mushroom waste	40	0	- 0	- 0	—	6.4(68)	4.3(85)
Composted chicken manure + mushroom waste	24	0	- 0	- 0	—	6.9(74)	3.7(72)

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