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Research Article
Effectiveness of Organic Composts on the Growth and Production Yield of Organic Asparagus

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Abstract

Background and Objective: Since the chemical fertilizers were prohibited, the use of compost instead of chemical fertilizer was needed. This research project aims to study the type and rate of compost suitable for organic asparagus production by farmers in Koh Rang Sub-District, Chai Badan District Lopburi Province, Thailand. **Materials and Methods:** The production of organic asparagus is carried out under the control of the Department of Agriculture, Thailand. Using locally available agricultural materials to produce high-quality compost was investigated to increase production yield, quality of asparagus and improvement of soil properties. This research used a factorial randomized block design with the first factors being 3 types of composts. The second factors consist of no fertilizer added as control, chemical fertilizer and 5 rates of selected composts. **Results:** The results showed that rice straw compost had the ability to promote the yield of asparagus better than other materials such as peanut straw compost and bagasse compost. Rice straw compost at the rate of 6 tons/rai gave the cumulative number of shoots equivalent to chemical fertilizer application of 30 kg/rai according to the farmers' methods, which were 17.2±0.6 and 14.0±0.4 shoots/plant, respectively. **Conclusion:** The use of the rice straw compost resulted in an increasing amount of nutrient accumulation in the soil such as phosphorus and potassium affecting to stimulate asparagus yield.

Key words: Organic fertilizer, asparagus, rice straw, bagasse, compost, manure

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Asparagus is belonging to the important exported vegetable crop cultivation of Thailand. The productivity of asparagus has increased steadily. The high yield and quality of asparagus required the use of chemical fertilizer increasing costly production. Furthermore, it created environmental problems such as salt and hard soils. The loamy soils containing a high level of plant nutrients were also needed to increase the yield of asparagus.

Since organic agricultural practice prohibited the use of chemical fertilizers which was not environmentally friendly. Organic fertilizer was used as an alternative fertilizer instead of chemical fertilizer in organic agricultural systems and also used in the production of organic asparagus. Compost was an easily producing organic fertilizer that it could be produced in household[1]. Compost gave a benefit to farmers by reducing the amount of chemical fertilizer and cost when used in combination or single use. However, the result showed a lack of fertilizer which was easily accessible carbon and nitrogen. Organic materials especially agricultural waste contained a lot of carbon and nitrogen but they were not easy and fast enough in order to mineralize for the plants growth during critical periods[2]. To solve these problems, composts of organic agricultural wastes were needed. Composting was a process for beneficial appropriate obtaining from an ecological economic point of view. Crop residues were good material for plant nutrients and stability of agricultural green system[3]. Typical organic materials as by products from agriculture such as rice straw, bagasse and peanut straw were mostly deposited in the farm area or burned after harvest. Their organic materials were richer in organic carbon and nitrogen[4]. It was better to use them as raw materials to produce compost. There was some interaction between the type and rate of compost on the growth and yield of vegetable crops[5]. The application of bagasse compost on pakcoy plants was be able to stimulate plant growth and yields of pakcoy plants more than chicken manure and tobacco waste[6]. In other agricultural waste, rice straw compost was one of the organic fertilizers which were derived from fermented crop residues[7-9].

In this study, the plant nutrient content of different composts using each rice straw, bagasse, peanut straw, mix with dry cow dung was determined. Moreover, the application of composts was investigated in a field experiments to determine growth, the production yield of organic asparagus and changes in soil properties.

MATERIALS AND METHODS

Study area: The field works was located in Lopburi Province, with reference of latitudinal 15.3348168 and longitudinal 101.2552078, Thailand. It was characterized by hot and rain. The raining season was during July to October, while the hottest season was during April to May with an average temperature of 38°C. Formerly, the cultivated field work were sugar cane plantation and changed to asparagus (*Asparagus officinalis*) in the present. The size of field works was 1 rai (0.16 ha). The soils properties were analyzed before experiment. The field experiment was conducted during 2021-2022.

Composts: Multi-mix organic composts were done with 3 treatments consisting of treatment 1: Rice straw and cow dung, treatment 2: Bagasse and cow dung, treatment 3: Peanut straw and cow dung. The ratio of organic material and cow dung was 3:1. The windrow composting was done with 1.5×2.0×3 m (width×length×height). All treatments were composting for 1 month on the fieldwork with the addition of water each week to keep 50-60% moisture content and turning back the fertilizer pile once a week until finished composting. Matured composts from each treatment of multi-mix organic composts were determined to plant nutrients such as pH, electrical conductivity (EC), organic matter (OM), N, P and K and compared with the Department of Agriculture (DOA) quality standard of Thailand.

Experimental design and cultivation: This research used a factorial randomized block design with 4 replications. The first factors were 3 types of composts rice straw, peanut straw and bagasse at the rate of 6 tons/rai. The second factors consist of no fertilizer added as control, chemical fertilizer and 5 rates of selected composts consisting of T1 (0 tons/rai), T2 (30 kg-chemical fertilizer, 15-15-15 NPK/rai), T3 (2 tons/rai), T4 (4 tons/rai), T5 (6 tons/rai), T6 (8 tons/rai), T7 (10 tons/rai). Note that one rai means 0.16 ha.

After 4 months of asparagus plantation, asparagus shoots were pre-harvested and weighted for the production yield. Each month, asparagus shoots were harvested. After three times harvests, the wet weight of all asparagus shoot was calculated.

Growth measuring: Data of growth as number of asparagus shoot, number of stems and stem length (cm) were determined every month. The stem length (cm) was measured by a transparent ruler.

Soil analysis: One kilogram of soil samples was air dried, grinded and sieved. Soil organic matter, total nitrogen was measured by using Kjedahl method[10]. Viable phosphorus was measured colorimetrically in the soil extract by using BrayII method[11]. Exchangeable potassium was measured by using an atomic-absorption spectrophotometer (Agilent Technology 200 series AA, Agilent, Santa Clara, CA 95051, United States)[12].

Statistical analysis: The growth and yield of asparagus data were statistically performed by one-way analysis of variance as standard procedure by using the free software of GNU PSPP version 1.6.2. The significance was calculated at a 5% significance level.

RESULTS AND DISCUSSION

Compost property: The matured composts made from 3 different agricultural waste materials in the local area that were rice straw, bagasse and peanut straw were collected for chemical analysis. The properties of each compost such as pH, electrical conductivity (EC), organic matter (OM), total nitrogen, total phosphorus (P_2O_5) and total potassium (K_2O) were analyzed. The results showed that the pH of matured composts was belonged to slightly alkaline with a range of 7.63-7.99. The electrical conductivity showed a low value of 4 dS m^{-1} without salinity (1.24-1.44 dS m^{-1}). For major elements, total nitrogen was in a range of 1.56-1.86%, total phosphorus was in a range of 0.79-1.14% and total potassium was in a range of 1.25-1.46%. Moreover, the quality of different types of compost from agricultural residues was close to each other in quality of compost. The compost from rice straw and peanut straw showed high value of total nitrogen and total phosphorus than the compost from sugarcane bagasse. Whereas, the total potassium content of bagasse compost was higher than rice straw compost and peanut straw residue. The result revealed that rice straw compost seems to give the highest plant nutrient, especially, total nitrogen and phosphorus. Furthermore, the organic matter content of rice straw compost showed the highest value of 47.03% when compared to other compost. From the overall results, it is indicated that 3 composts from different agricultural wastes were in accordance with the quality standard of solid organic fertilizer of DOA, Thailand (Table 1). Considering the quality of all 3 compost formulas, it was found that they were good quality compost and could be used in the production of organic asparagus.

Effect of different composts on growth and yield of asparagus: The experiments in fieldwork were investigated at Koh Rang Sub-District Area, Chai Badan District, Lopburi Province. The area was shallow soil with a soil depth of about 50 cm from the topsoil. The water source for cultivation was groundwater. The soil properties before the experiment found that the pH was 7.74, the electrical conductivity was 3.45 dS m^{-1} which was not saline and the organic matter content was 0.75% which was quite low, total nitrogen content was 0.06% (low), useful phosphorus 92.97 mg kg^{-1} (very high) and exchangeable potassium 93.12 mg kg^{-1} (high).

According to the analysis of soil before the experiment, organic matter was low (0.75%). The application rate recommended for low organic matter content at 6 tons/rai was recommended to use in this experiment. To estimate the suitability of compost for organic asparagus production, 6 tons/rai of all 3 compost were applied to the fieldwork. Growth data of asparagus that were plant height, plant number and shoot number were collected for 4 months. The result showed that rice straw compost, bagasse compost and peanut straw compost, had no effect on plant height in each month of asparagus growth (Table 2). In the 4th month, asparagus showed a height of 21.6±0.3-22.3±0.6 cm. The

Table 1: Chemical analysis of compost from peanut straw, rice straw, bagasse and organic fertilizer standard of Department of Agriculture of Thailand

Type of compost	pH	EC (dS m^{-1})	OM (%)	Total N (%)	Total P_2O_5 (%)	Total K_2O (%)
Peanut straw	7.63	1.44	41.43	1.86	1.05	1.28
Rice straw	7.99	1.24	46.03	1.91	1.14	1.25
Bagasse	7.74	1.28	38.21	1.56	0.79	1.46
Department of Agriculture of Thailand Criteria	7.00	$\leq$10	>20	$\geq$1	$\geq$0.5	$\geq$0.5

Table 2: Asparagus growth and shoot production using each organic compost consisting of rice straw, peanut straw and bagasse after transplanting

	Plant height (cm)				Plant number				Shoot number				
Treatments	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	Total shoot
Rice straw	11.0±0.5^{a}	14.3±0.5^{a}	18.5±0.5^{a}	21.9±0.0^{a}	1.0±0.0^{a}	1.0±0.0^{a}	4.6±0.3^{a}	7.0±0.5^{a}	0	1.0±0.1^{a}	8.1±0.6^{a}	8.1±0.5^{a}	17.2±0.6^{a}
Peanut straw	11.1±0.3^{a}	16.0±0.1^{a}	17.6±0.6^{a}	22.3±0.6^{a}	1.0±0.0^{a}	1.0±0.0^{a}	2.6±0.1^{b}	7.3±0.4^{a}	0	1.0±0.0^{a}	6.2±0.2^{b}	2.4±0.1^{b}	9.6±0.5^{b}
Bagasse	11.8±0.6^{a}	15.6±0.3^{a}	18.3±0.3^{a}	21.6±0.3^{a}	1.0±0.0^{a}	1.0±0.0^{a}	3.6±0.^{1ab}	5.6±0.5^{b}	0	1.0±0.1^{a}	5.1±0.4^{b}	2.1±0.3^{b}	10.0±0.4^{b}

Data are shown as the Mean±1 SD, derived from four independent replicates, M1: 1 months, M2: 2 months, M3: 3 months and M4: 4 months, numbers accompanied by the same superscripted letter in the same column show that they are not significantly different and significance was calculated at 5% significance level

plant number was equal to 1 plant in all compost until 2nd month and the plant number start to increase in 3rd and 4th month. The maximum plant number was found in treatment with peanut straw compost (7.3 plant) and followed by rice straw compost (7.0 plant). However, compost in which was prepared from organic matters such as rice straw stimulated the shoot number of the asparagus an with accumulated value of 17.2±0.6 whereas, compost prepared from each bagasse and peanut straw showed lesser than those with the same value of 10.0±0.4 and 9.6±0.5, respectively. This study implied that compost prepared from rice straw improved the growth and yield of asparagus. This result according to other researchers that organic composts have a positive effect on vegetative growth[13,14]. Organic composts were a good nutrient source to improve soil properties by increasing organic matter, improving soil's physical and chemical properties[15-17]. Organic fertilizer prepared from fermented manure and rice husk charcoal was able to increase the height of the areca nut[18]. Rice straw compost containing humic substances could not only alter soil chemical properties but also effectively increased available phosphorus, soil pH, CEC of clay, C-organic and decrease exchangeable aluminium[19]. Ibrahim and Abd El- Kader[20] also reported that using 75% chemical fertilizers in combination with rice straw compost was able to improve vegetative growth and seed yield of bottle gourd plants.

Optimization on the rate of rice straw compost on growth and yield of asparagus: The previous experiment showed that rice straw compost was suited for stimulated growth and yield of asparagus. This experiment aims to optimize the rate of rice straw compost that is suitable to improve the growth and production yield of organic asparagus. The control treatment without fertilizer applied (T1) and chemical fertilizer (T2) were conducted together with rice straw compost at the rate of 0, 2, 4, 6, 8 and 10 tons/rai (T3-T7, respectively). The compost was used for optimization in the asparagus field. The result showed that rates of rice straw compost application affected the asparagus plants number due to the different amounts of nutrients in each rate of organic compost. The compost rate of 6 tons/rai stimulated a number of asparagus plants with the highest value of 4.6±0.3 and 7.0±0.5 plants within 3 and 4 months after plantation, respectively. Furthermore, control treatment and chemical fertilizer treatment showed a low or equal number of plants compared to the application of rice straw compost at any rate. The accumulation of asparagus shoots showed the highest with the value of 17.2±0.6 shoots per plant when using rice straw compost at the rate of 6.0 tons/rai. Those accumulated shoot was similar to the total asparagus shoot when using chemical fertilizer with 30 kg/rai. However, all rates of rice straw compost have no effect to stimulate the increase of asparagus plant height. This result was supported by the report of Warman[1] that fresh beef manures and age manures (compost) had a positive effect similar to chemical fertilizer on asparagus yield. Pang and Letey[2] also reported that rice straw compost was able to stimulate the effect on cocoa seedlings. Utilizing high rates of compost resulted in high organic matter content, total nitrogen content and exchangeable potassium supply into the soil. The addition of compost is not only to be a source of plant nutrients but also helps to raise the fertility of the soil. Noteworthy, the use of rice straw composes higher than 6 tons/rai showed decreasing plant number and total shoot number of asparagus (Table 3). Although, the use of combined chemical fertilizer and compost more increases plant growth and production[21,22] but current experiment could not use any chemical including chemical fertilizer because of organic asparagus.

Change of soil properties: The soil samples were collected at 2nd and 4th month after transplantation. The general soil properties were analyzed to state the change of soil properties during the experiment as shown in Table 4. The soil pH was slightly decreased in all treatments compared to the initial soil (7.74) before experiments on the 2nd month (range from 5.83-6.84) and increased to a neutral pH range on the 4th month (7.22-7.68). Surprisingly, the electrical conductivity of all treatments slightly increased in the 2nd month to be saline in the 4th month of all treatments excluding the control treatment. The application of a high rate of rice straw compost tends to increase soil electrical conductivity. The organic matter content of all treatment with rice straw compost applied was increased when compared to initial soil on the 2nd month and decreased on the 4th month, respectively. Control treatment and chemical fertilizer treatment were slightly decreased organic matter content from the 2nd to 4th month while a drastic decrease found in the treatment with 2 and 4 tons/rai of rice straw compost was applied. The application of rice straw compost tended to keep high organic matter content in the soil after the experiment. Since soil organic matter plays an important role in soil properties including biological properties by acting as carbon and energy source of heterotrophs in the soil, the drastic decrease of organic matter content occurred to microbial activity and affected to the fertility of the soil. The application of a high amount of compost could compensate for the loss of soil organic matter from microbial activity. The nutrient status of the soil after the experiment was focused on major plant

Table 3: Asparagus growth and shoot production using rice straw compost at various rates after transplanting

	Plant height (cm)				Plant number				Shoot number				
Treatments	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	Total shoot
T1	11.8±0.2^{a}	15.7±0.3^{a}	18.1±0.8^{a}	21.3±0.7^{a}	1.0±0.0^{a}	1.0±0.0^{a}	2.0±0.1^{c}	3.3±0.2^{c}	0	1.0±0.0^{b}	3.9±0.4^{c}	4.3±0.3^{c}	9.2±0.4^{c}
T2	11.5±0.5^{a}	16.1±0.1^{a}	18.8±0.1^{a}	21.6±1.3^{a}	1.0±0.0^{a}	1.0±0.0^{a}	2.3±0.2^{c}	3.0±0.1^{c}	0	2.1±0.3^{a}	6.9±0.5^{a}	5.3±0.3^{b}	14.3±0.4^{a}
T3	11.5±0.5^{a}	16.0±0.2^{a}	17.7±0.2^{a}	21.8±0.4^{a}	1.0±0.0^{a}	1.0±0.0^{a}	3.0±0.0^{b}	4.0±0.3^{b}	0	0.6±0.1^{c}	3.9±0.2^{c}	2.8±0.1^{d}	7.3±0.2^{c}
T4	11.5±0.5^{a}	15.4±0.5^{a}	18.4±0.5^{a}	22.7±0.4^{a}	1.0±0.0^{a}	1.0±0.0^{a}	2.0±0.0^{c}	3.3±0.2^{c}	0	0.3±0.1^{c}	5.1±0.3^{bc}	4.2±0.2^{c}	9.6±0.3^{c}
T5	11.0±0.5^{a}	14.3±0.5^{a}	18.5±0.5^{a}	21.9±0.0^{a}	1.0±0.0^{a}	1.0±0.0^{a}	4.6±0.3^{a}	7.0±0.5^{a}	0	1.0±0.1^{b}	8.1±0.6^{a}	8.1±0.5^{a}	17.2±0.6^{a}
T6	11.5±0.5^{a}	15.8±0.6^{a}	18.0±1.0^{a}	21.6±0.3^{a}	1.0±0.0^{a}	1.0±0.0^{a}	3.0±0.0^{b}	4.3±0.3^{b}	0	1.0±0.0^{b}	6.1±0.4^{b}	5.2±0.3^{b}	12.3±0.4^{bc}
T7	11.6±0.3^{a}	15.3±0.6^{a}	18.6±1.1^{a}	22.0±1.0^{a}	1.0±0.0^{a}	1.0±0.0^{a}	3.0±0.1^{b}	5.0±0.3^{ab}	0	1.3±0.2^{b}	6.3±0.5^{b}	5.0±0.4^{b}	12.6±0.5^{bc}

Data are shown as the Mean±1 SD, derived from four independent replicates, M1: 1 months, M2: 2 months, M3: 3 months and M4: 4 months, numbers accompanied by the same superscripted letter in the same column show that they are not significantly different and significance was calculated at 5% significance level

Table 4: Soil properties at 2 months (M2) and 4 months (M4) after asparagus transplanting

	pH		EC (dS m^{-1})		OM (%)		Total N (%)		Avai. P (mg kg^{-1})		Exch. K (mg kg^{-1})	
Treatments	M2	M4	M2	M4	M2	M4	M2	M4	M2	M4	M2	M4
T1	6.19^{a}	7.68^{a}	4.73^{a}	4.53^{bc}	0.77^{b}	0.69^{ab}	0.06^{a}	0.05^{a}	77.69^{b}	62.67^{c}	93.36^{b}	90.70^{c}
T2	5.83^{b}	7.34^{a}	4.95^{a}	6.03^{a}	0.68^{b}	0.64^{b}	0.06^{a}	0.05^{a}	73.77^{b}	85.84^{b}	95.64^{b}	91.70^{c}
T3	6.42^{a}	7.31^{a}	4.64^{a}	5.13^{b}	0.79^{b}	0.46^{b}	0.06^{a}	0.07^{a}	70.56^{b}	65.45^{c}	109.33^{b}	86.47^{c}
T4	6.48^{a}	7.27^{a}	2.86^{c}	5.80^{ab}	1.16^{a}	0.46^{b}	0.07^{a}	0.07^{a}	107.54^{a}	93.23^{b}	142.76^{b}	136.58^{b}
T5	6.80^{a}	7.22^{a}	3.42^{b}	7.38^{a}	1.12^{a}	0.77^{ab}	0.09^{a}	0.07^{a}	110.21^{a}	91.07^{b}	292.28^{a}	161.22^{b}
T6	6.82^{a}	7.25^{a}	4.61^{a}	4.05^{c}	1.68^{a}	0.98^{ab}	0.10^{a}	0.0^{a}	133.81^{a}	111.17^{a}	347.89^{a}	185.15^{b}
T7	6.84^{a}	7.22^{a}	3.74^{b}	5.19^{b}	1.99^{a}	1.77^{a}	0.11^{a}	0.08^{a}	161.75^{a}	138.00^{a}	370.51^{a}	323.52^{a}

EC: Electrical conductivity, OM: Organic matter, N: Nitrogen, Avai. P: Available phosphorus and Exch. K: Exchangeable potassium, numbers accompanied by the same superscripted letter in the same column show that they are not significantly different and significance was calculated at 5% significance level

nutrients. Total nitrogen was rapidly decreased on the 2nd month for control and chemical fertilizer at the rate of 2 and 4 tons/rai while the higher rate than those found slightly high level. This result showed an insufficient nitrogen in the above treatment to support asparagus growth and confirmed that 6 tons/rai of rice straw compost suits organic asparagus production. However, the total nitrogen of all treatments still decreased in the 4th month. This result can be used to recommend the farmer supply more nitrogen sources to asparagus during this period such as liquid organic fertilizer with high nitrogen content or adding more compost over many periods of time. Available phosphorus and exchangeable potassium revealed the decrease in the 2nd and 4th months. Control treatment, chemical fertilizer and rice straw compost at the rate of 2 tons/rai showed lower available phosphorus and exchangeable potassium than those when compared to an initial soil. Moreover, the application of rice straw compost from 6-10 tons/rai showed the remaining available phosphorus and exchangeable potassium higher than the initial soil. From overall, the result indicated that the application of compost required to add many time to the soil along with the growth of asparagus and nitrogen seem to be the critical factor limiting the growth and production yield of asparagus. The high rate of compost leads to the high accumulation of soil organic matter, available phosphorus and exchangeable potassium. Resman *et al.*[23] also reported that the compost fertilizer could improve physical, chemical, biological properties in term of pH, moisture, total N, total P, organic matter and C/N ratio when applied to infertile soils.

The limitation of utilizing compost for organic asparagus production was the number of macro nutrients which may not be enough to meet the requirement of the plant. Therefore, compost should be applied several times at a high rate for supplied the plant requirement. For compost production, farmers may have a shortage of certain plant residues as raw materials for composting during the growing season.

CONCLUSION

Different compost made from local agricultural waste, rice straw, peanut straw and bagasse gave the plant nutrient status passed according to the quality standard of DOA, Thailand. It was suitable to use for organic asparagus production. The rice straw compost at the rate of 6 tons/rai was suitable to stimulate the growth and yield of asparagus. At this rate, asparagus showed a high plant number and total shoot number when compared to chemical fertilizer application. The application of rice straw compost also improved the fertility of the soil by increasing the high accumulation of soil organic matter, available phosphorus and exchangeable potassium in the soil. The results imply that rice straw compost can be used for all kinds of crops.

SIGNIFICANCE STATEMENT

Treatment of rice straw compost has a significant effect on organic asparagus shoot accumulation. The highest yield of the asparagus shoot was found when adding 6 tons/rai of rice straw compost into the asparagus field. The novelty of this study relates to the treatment for organic asparagus and rice straw compost effect.

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