Research Article

Agronomic Traits and Fruit Quality of Pineapple with Different Levels of Chicken Manure Application

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Received September 5, 2013; Accepted November 11, 2013

Abstract

The responses of the pineapple (*Ananas comosus* (L.) Merr cv. Pattavia) grown in a fine-silty soil to various levels of chicken manure, in terms of plant growth, and fruit yield and quality, were investigated at a farm plantation in Petchaburi, Thailand. A randomized complete block design with 4 replications was used. Treatments were the chicken manure applied in levels equivalent to 0 (control), 3, 6 and 9 g nitrogen (N) plant^{-1}. The manure was manually and thoroughly mixed with the soils, which was incubated for 30 days prior to pineapple planting. Agronomic traits of the pineapple plants and chemical composition of the pineapple fruits were determined. Plant growth and fruit size were linearly increased ($p<0.05$) with the increased manure levels. Fresh fruit weight from the highest level of manure application was 60% higher than that of the control treatment. Similarly, citric acid and vitamin C contents were linearly increased ($p<0.05$) as the manure rates increased. It can be concluded that growth and yield of the pineapple positively respond to increased chicken manure application. In terms of productivity, the moderate application rate of chicken manure cannot yet be recommended because curvilinear response has not been detected in this study. Therefore, further study with respect to a wider range of application rate is required to find out the most appropriate rate.

***Key Words*:** *Ananas comosus*; Chicken manure; Plant growth; Yield; Fine-silty soil

Introduction

It has been reported that pineapple (*Ananuscomosus* (L.) Merr.) products were the third most important tropical fruit produced in the world, after banana and citrus (Malezieux and Bartholomew, 2003). Globally, similar to other food products, a demand for the pineapple products is substantially increasing worldwide. In general, farmers improve productivity of pineapple by intensifying their farming practices, mainly through increased use of synthetic fertilizers. However, a long term use of such fertilizers can degrade qualities of soils, which, in turn, results in a reduction in productivity of pineapple in long run. In addition, in terms of soil fertility and conservation, heavy use of synthetic fertilizers can induce soil impaction and acidification (Havlin et al., 2005).

Isuwan (2007) reported a notable reduction in soil fertility arising from repeated pineapple cropping on the same area. She also illustrated that, in Thailand, yield and quality of pineapple have diminished due to the degradation of soil quality. Alternatively, in order to improve soil fertility as well as to fulfill a demand for nutrients of pineapple plants, the application of organic fertilizers is one of the most effective methods to address soil problems (Maillard and Angers, 2013). Moreover, the application of animal excreta, including chicken manure, has been reported to increase soil organic matter and to provide trace elements to crops (Havlin et al., 2005 and Brar et al., 2013) and to some varieties of pineapple (Daramola et al., 2013; Lui et al., 2013 and Omotoso and Akinrinde, 2013).

This study examined the effects of chicken manure levels on the improvement in agronomic and production traits of pineapple grown in low fertility soils. Therefore, the objectives of this experiment were: (i) to determine the response of agronomic and production traits of pineapple to the increased application rates of chicken (layer) manure, and (ii) to evaluate the optimal level of manure application for pineapple plants grown in poor-quality fine-silty soils.

Materials and Methods

Location, Experimental Plot and Soil Property

The experiment was conducted at farmer's pineapple field in Petchaburi province, Thailand (12.90N; 99.63E), 190 km SSW of Bangkok. Soil samples were collected and subjected to chemical analysis before commencing the experiment. The chemical composition of the experimental soil is presented in Table 1. The soil was identified as fine-silty soil (Fine-silty, mixed, semiactive, isohyperthermic Typic Haplustalfs) and low fertility (Havlin et al., 2005). Therefore, before starting the experiment, soil property was improved by using green manure (*Crotolaria mucronata*). These plants were grown, tilled and subsequently allowed to decompose for 49 days, as described by Isuwan (2008). Significantly, soil fertility was improved after green manure application (Table 1).

Experimental Plan and Treatment

A randomized complete block design with 4 replications was used. Treatments were 4 rates of chicken manure application: 0 (control), 3, 6, and 9 g N plant^{-1}, equivalent to 0, 131.25, 262.50 and 393.75 kg N ha^{-1}, respectively. The incremental rates of manure application were set at equal interval

Table 1 Properties of the experimental soil before and after amendment with green manure

	Before amendment	After amendment*
pH	4.83	4.96
Organic matter (%)	1.092	1.351
Electrical conductivity (dS m^{-1})	0.466	0.454
Total nitrogen (%)	0.051	0.072
Available phosphorus (mg kg^{-1})	8.334	nd.[1]
Exchangeable potassium (mg kg^{-1})	47.82	nd.
Exchangeable calcium (mg kg^{-1})	141.6	nd.
Exchangeable magnesium (mg kg^{-1})	12.33	nd.

*49 days after green manure application;[1]nd.-not determined aiming at determining the optimal application levels in case of the quadratic response exists. Chicken manure was sampled and subjected to chemical analysis. Later, the manure was manually mixed with the soil. The mixture was incubated for 30 days prior to pineapple planting. Chemical composition of the manure is presented in Table 2.

Planting and Management

The pineapple suckers (cv. Pattavia) were treated with phos-ethyl-aluminium (80% WP) solution before transplanting. The suckers were planted at a spacing of 30×50×80 cm, which equals to the planting density of 45,000 plant ha^{-1}. The plants were fertilized with urea fertilizer (46-0-0) at the rate of 312.50 kg ha^{-1}, a month after planting. Also, obvious weeds were manually controlled 1 month after planting. Later, the plants were induced for flowering with calcium carbine (CaC_2), at 8 months after planting, at the rate of 1-2 g plant^{-1}, twice at 5 days interval.

Measurement of Agronomic Traits and Sampling

Agronomic traits of the pineapple, including plant widths and heights, at 6 month after planting, and fruit perimeters and lengths, at 9 and 11 month after planting and a week before fruit harvesting, were measured. Plant dry weights (inclusive root) were carried out by randomly sampling 3 plants plot^{-1}. They were cut into small pieces and subsequently dried in the force air oven at 60° C for 72 h to determine dry weight. Fruits were harvested at 13 months after planting. Fresh fruits were weighed and randomly sampled. Subsequently, they were subjected to chemical analysis.

Chemical Analysis

Soil samples were air-dried and ground to pass through a 2 mm sieve. Subsequently, pH (1:1, soil: water) (Mclean, 1982), electrical conductivity (ECe) (Richards, 1954), organic matter (OM) (Walkley, 1947), total nitrogen (Bremmer and Mulvaney, 1982), available phosphorus (Bray II) (Bray and Kurtz, 1945), exchangeable potassium, calcium and magnesium (Peech et al., 1947) were determined.

Manure samples were air-dried and analyzed for pH (1:10 of manure: water) (AOAC, 2000), electrical conductivity (ECe, 1:10 of manure: water) (Jackson, 1958), organic matter (Walkley, 1947), total nitrogen (Bremmer and Mulvaney, 1982), total phosphorus and total potassium (AOAC, 2000),

Table 2 Physical and chemical properties of experimental chicken manure

Items	Chicken manure	Criteria*
pH	8.21	5.5-8.5
Organic matter (%)	64.34	> 30%
Electrical conductivity (dS m^{-1})	6.83	< 6.0
Total nitrogen (%)	1.972	> 1.0%
Total phosphorus (%)	0.723	> 0.5%
Total potassium (%)	2.610	> 0.5%
Total calcium (%)	1.941	-
Total magnesium (%)	0.606	-
Total sulfur (%)	0.097	-
Moisture content (%)	11.34	< 35%
C/N ratio	16.32	< 20:1

*Criteria for organic fertilizer as legally announced by Department of Agriculture (2005) total calcium and total magnesium (AOAC, 1990a), moisture (Hesse, 1971), and C:N ratio (Anderson and Ingram, 1993).

Fruit samples were subjected to chemical analysis, including total soluble solids (AOAC, 1990b), total sugars (Hodge and Hofreiter, 1962), citric acid (AOAC, 1990b) and vitamin C (AOAC, 1990a).

Statistical Analysis

Data were subjected to analysis of variance. The response of pineapple to the increased rates of manure application was determined using pre-plan orthogonal polynomial analysis, including linear, quadratic and cubic trends (Muller and Fetterman, 2003).

Results and Discussion

Agronomic Traits of Pineapple Plant and Fruit

Agronomic traits of the plants at 6 months and of the fruits at 9, 11 months after planting and a week before fruit harvesting are presented in Table 3 and Table 4. Plant heights, widths and weights were linearly increased ($p<0.05$) as a result of the increased levels of manure application (Table 3). Accordingly, fruit heights and perimeters were linearly increased ($p<0.05$) according to the increased rates of manure application (Table 4).

In general, chicken manure contains not only nitrogen but also other required plant nutrients, including macro and trace elements (Table 2).

Table 3 Botanical traits of pineapple received different levels of chicken manure at 6 month after planting

	Manure application rates (g N plant^{-1})				SEM$^{@}$	Contrast		
	0	3	6	9		linear	quadratic	cubic
Plant height (cm)	70.90	75.55	80.30	82.65	0.91	***	ns	ns
Plant width (cm)	93.55	110.55	121.00	125.33	1.47	***	***	ns
Plant fresh weight (kg plant^{-1})	1.70	2.08	2.40	2.58	0.07	***	ns	ns
Plant dry weight (g plant^{-1})	187.50	224.00	249.50	275.75	11.16	***	ns	ns

$^{@}$standard error of the mean (n= 4); ***= p value < 0.001, ns= non-significant.

Table 4 Fruit physical traits of pineapple received different levels of chicken manure

	Manure application rates (g N plant^{-1})				SEM$^{@}$	Contrast		
	0	3	6	9		linear	quadratic	cubic
At 9 months after planting								
Height (cm)	12.80	15.33	15.30	14.88	0.57	*	*	ns
Perimeter (cm)	29.38	31.75	31.18	31.53	0.68	ns	ns	ns
At 11 months after planting								
Height (cm)	15.58	17.10	19.50	20.30	0.32	***	ns	ns
Perimeter (cm)	35.55	38.03	40.98	41.75	0.73	***	ns	ns
A week before harvesting								
Height (cm)	16.93	18.23	20.60	21.05	0.47	***	ns	ns
Perimeter (cm)	37.48	39.43	42.30	43.00	0.65	***	ns	ns

$^{@}$standard error of the mean (n= 4); *= p value < 0.05, ***= p value < 0.001, ns= non-significant

Therefore, the manure can provide a variety of nutrients to plants, which subsequently results in an improvement in growth performance of the pineapple (Malezieux and Bartholomew, 2003). Moreover, Omotoso and Akinrinde (2013) reported that physical traits of the pineapple (such as numbers of leaves, leaf lengths and leaf areas) are increased as a result of the increased rates of nitrogen fertilizers. In addition, it has been reported that agronomic traits of the pineapple (for instance, plant heights, leaf and root lengths, leaf widths, numbers of leaves, and fresh weights of aboveground and belowground components) can be improved when the plants receiving either composts (Lui et al., 2013) or poultry manure (Daramola et al., 2013).

Fruit Yield and Chemical Composition

Fresh yield and chemical composition of the fruits from the plants receiving different rates of manure are presented in Table 5. Average fresh weight of pineapple fruits was linearly improved ($p<0.05$) as the rates of manure application increased. While total soluble solids and total sugars of the fruits were not significantly affected ($p>0.05$) by manure application, citric acid and vitamin C contents were linearly increased ($p<0.05$).

The application of chicken manure at the level of 9 g N plant^{-1} to the plants was 63% higher fresh fruit production, equivalent to 34,650 kg ha^{-1}. This is possibly due to the improved plant growth which can support increased fruit production. It has been reported that there was highly positive relationship between plant weight and fruit weight (Hepton, 2003). In addition, Daramola et al. (2013) reported that the pineapple plants received higher rates of poultry manure can have bigger fruit sizes and higher numbers of fruits. This is because chicken manure is a good source of plant nutrients. The manure contains not only macro elements but also trace elements (which may frequently be deficient in tropical soils) required by plants for their growth and development (Daramola et al. (2013).

In this experiment, total soluble solids and total sugars were not affected ($p>0.05$) by manure application. Malezieux and Bartholomew (2003) reported that nitrogen mineral application in the plots, which had enough potassium, did not affect the total solids of pineapple fruits. The application of nitrogen and potassium in low potassium soils can result in the improvement in the total soluble solids and total titratable acids (Spironello et al., 2004). Therefore, it can be assumed that potassium content (47.82 mg kg^{-1}, Table 1) of the soil used in this experiment had enough potassium for pineapple cultivation.

Table 5 Fruit weight and chemical composition of pineapple received different levels of manure

	Manure application rate (g N plant^{-1})				SEM$^{@}$	Contrast		
	0	3	6	9		Linear	quadratic	cubic
Fresh fruit weight (kg fruit^{-1})	1.23	1.45	1.80	2.00	0.10	***	ns	ns
Soluble solids (°brix)	10.50	11.75	12.25	12.25	0.64	ns	ns	ns
Citric acid (%)	0.37	0.50	0.60	0.69	0.02	***	ns	ns
Vitamin C (g ml^{-1})	0.88	1.10	1.14	1.51	0.07	***	ns	ns
Total sugars (mg g FW^{-1})	11.94	11.96	12.25	12.09	0.22	ns	ns	ns

$^{@}$standard error of the mean (n= 4); ***= p value < 0.001, ns= non-significant

Conclusion

Based on the results of this experiment, it can be concluded that the agronomic traits of pineapple plants and fruits, and fresh fruit production and the concentrations of citric acid and vitamin C of pineapple fruits were improved according to increased rates of chicken manure application. At the highest rates (9 g $Nplant^{-1}$), fruit production was 63% higher than the control. However, the optimal rate could not be determined in this experiment as the response of pineapple to the manure application remained linear over the ranges of manure applied. Moreover, the economic and environmental traits should be elaborated for improving the entire food chain of pineapple.

Acknowledgment

This study was funded by the Faculty of Animal Sciences and Agricultural Technology, Silpakorn University, Petchaburi IT campus. The author would like to thank Mr. Jeerasak Chobtang for his help with the statistical analysis. The contributions of Mr. Chatree Janlarpwattanakul and Mr. Titipong Laohaudomchok are acknowledged.

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