EFFECT OF ORGANIC AND CHEMICAL FERTILIZER ON GROWTH AND YIELD OF PHYSIC NUT (*Jatropha curcas* L.) IN SLIGHTLY SALINE SOIL

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Abstract

The study was carried out at the Suphanburi Agricultural Research and Development Center, U-thong district, Suphanburi province during 2009-2011. The soils are classified as Kamphaeng Saen soil series. The objectives were to study appropriate management on slightly saline soil to increase the physic nut yield and to study the effect of soil amendments on changes to the soil's chemical properties. The experimental design was a randomized complete block design with 3 replications. The 10 treatments were: 1) control; 2) chemical fertilizer; 3) compost, 2 kg plant^{-1} year^{-1}; 4) compost, 4 kg plant^{-1} year^{-1}; 5) farmyard manure, 2 kg plant^{-1} year^{-1}; 6) farmyard manure, 4 kg plant^{-1} year^{-1}; 7) compost, 2 kg plant^{-1} year^{-1} + bio-extract; 8) compost, 4 kg plant^{-1} year^{-1} + bio-extract; 9) farmyard manure, 2 kg plant^{-1} year^{-1} + bio-extract; and 10) farmyard manure, 4 kg plant^{-1} year^{-1} + bio-extract. For treatments 2-10, chemical fertilizer (15-15-15) at a rate of 156.25 kg ha^{-1} was applied. The results showed that utilization of organic fertilizer plus chemical fertilizer resulted in increased growth of physic nut but this was not significantly different from the control treatment. Application of organic fertilizer had no effect on growth and yield of physic nut, however the use of organic fertilizer plus chemical fertilizer tended to give yields higher only than for chemical fertilizer and the control of 1906.25, 1421.69, and 1040.63 kg ha^{-1}, respectively, but these were not significantly different. After the experiment, the soil electrical conductivity (EC_e) changed slightly. No effect of the organic fertilizer and chemical fertilizer was found, however, variation in the EC_e was found. Soil organic matter tended to decrease while the available phosphorus tended to increase. Generally, the available potassium tended to increase except in the control treatment and the treatment with only chemical fertilizer.

Keywords: Physic nut, central plain saline soil, compost, farmyard manure, bio-extract

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Introduction

Salt-affected soils are soils containing high levels of soluble salts. Salinity adversely influences plant growth, leading to significant reductions in yield and degraded agricultural productivity. This is an important soil problem for crop production in Thailand. Salt-affected soils cover an area of 2.302 million ha in Thailand (Office of Soil Survey and Land Use Planning, 2006). About 1.841 million ha are located in northeastern Thailand, where as there are 0.425 and 0.063 million ha in coastal saline soils and other regions, respectively. In central Thailand, salt affected soil covers an area of 36096 ha which has been generally developed from old marine sediments (Hattori and Takaya, 1989). Rice and sugarcane cultivation are common, although yields are generally low. Farmers are changing from rice and sugarcane to higher income cash crops. Numerous studies have indicated that the selection of salt-tolerant varieties, mulching, and the application of organic amendments (green manure, compost, and farmyard manure) to improve soil fertility and the utilization of drip irrigation could increase crop yields. Successful production of asparagus and cantaloupe was reported by *Arunin et al*. (1995) and Hongnoi *et al*. (1999), broccoli cultivation was reported by Pongwichian *et al*. (2001), and sugarcane cultivation was reported by Pongwichian *et al*. (2007).

Physic nut or purging nut (*Jatropha curcas* L.) is a shrub that can grow well under drought conditions. Generally, it is distributed in the arid and semi-arid areas of South America and in tropical areas. It is considered an energy crop. Physic nut can adapt and grow in problem soils such as lateritic soil, sandy soil, and saline soil (Gao *et al*., 2008). Many studies in Thailand have shown that physic nut produces low yields. Soil improvement is needed to increasethe yield. However, little information on the effect of organic fertilizer on yields has been reported. Silpachai *et al*. (2009) reported that the application of VA-mycorrhizal fungus with organic fertilizer and phosphorus increased physic nut yields. Sukkarin (2008) found that the application of chemical fertilizer showed similar yields to treatment with an application of chemical fertilizer with organic fertilizer; however the yield was higher than the control plot.

The objectives of the current research were to study the appropriate management of slightly saline soil in the central plains of Thailand to increase physic nut yield and to study the effect of soil amendments on changesin the soil's chemical properties.

Materials and Methods

Experimental Design

The experimental design was a randomized complete block design with 3 replications. The 10 treatments were as follows.

1) Control

2) Chemical fertilizer, (15-15-15) at a rate of 156.25 kg ha^{-1}

3) Compost, 2 kg $plant^{-1}$ $year^{-1}$

4) Compost, 4 kg $plant^{-1}$ $year^{-1}$

5) Farmyard manure, 2 kg $plant^{-1}$ $year^{-1}$

6) Farmyard manure, 4 kg $plant^{-1}$ $year^{-1}$

7) Compost, 2 kg $plant^{-1}$ $year^{-1}$ + bio-extract, 3.125 l ha^{-1}

8) Compost, 4 kg $plant^{-1}$ $year^{-1}$ + bio-extract, 3.125 l ha^{-1}

9) Farmyard manure, 2 kg $plant^{-1}$ $year^{-1}$ + bio-extract, 3.125 l ha^{-1}

10) Farmyard manure, 4 kg $plant^{-1}$ $year^{-1}$ + bio-extract, 3.125 l ha^{-1}

Remarks:

1. Fortreatments 2-10, chemical fertilizer (15-15-15 of N-P_2O_5-K_2O) at a rate of 156.25 kg ha^{-1} was applied.

2. Compost showed N, P, and K contents of 2.4, 3.37, and 2.62%,while farmyard manure showed N, P, and K contents of 1.04, 1.08, and 1.31%, respectively.

3. Bio-extract is a biological extraction made from fresh vegetable waste and it was fermented and digested by effective microorganisms (Microbial Activator Super LDD 2).The bio-extract was diluted with water to 1:500 before spraying once per

month.

Cultivation Management

The experiment was conducted in an experimental field of the Suphanburi Agricultural Research and Development Center, U-thong district, Suphanburi province (Figure 1) during 2009-2011 where the soil was slightly saline. The soils were classified as Kamphaeng Saen soil series (fine-silty, mixed, active, isohyperthermic Typic Haplustalfs). Thirty experimental plots (6×8 m) were set up. The rate and type of soil amendments were applied according to the treatments.Plants were grown by transplanting cuttings at a spacing of 2×1 m (Figure 2). Conventional tillage was done in the experimental plots. Weeds were controlled and irrigation was applied as needed during the dry season. Ripened seeds were harvested and measured.

Figure 1. Experimental plot at Suphanburi Agricultural Research and Development Center

Figure 2. Land preparation and planting

Data Collection and Interpretation

1) Soil samples were taken at a depth of 0-30 cm for analysis of the soil's chemical properties. Soil pH was analyzed according to Peech (1965), soil electrical conductivity (EC_e) according to Rhoades (1982), soil organic matter (OM) according to Walkley and Black (1934), available phosphorus according to Bray and Kurtz (1945), extractable potassium according to Chapman (1965), and soluble sodium according to Rhoades (1982).

2) Plant growth, height, and the diameter of the physic nut crop were recorded from 8 plants per plot every month until 8 months after planting (Figure 3). Ripened seeds of the physic nut were harvested (Figure 4). The seeds were air dried and then weighed for determination of the yield. The total seed yield each year was determined and 100 seeds were weighed in addition.

Figure 3 Measurement of plant height and diameter

Figure 4. Harvest of ripened seeds

3) Data of soil samples, plant growth, total seed yield in each year, and 100-seed weight were interpreted by analysis of variance underthe randomized complete block design.

Results

Effect of Soil Amendments on Growth of Physic Nut

Plant height: The plant height was recorded once a month until 8 months after planting. The results showed that application of compost at 4 kg plant^{-1} year^{-1} with chemical fertilizer had the highest increased plant height of 96.75 cm at age 8 months (Figure 5), but it was not significantly different from the other treatments. The treatment of compost at 4 kg plant^{-1} year^{-1} with chemical fertilizer plus bio-extract resulted in the lowest growth rate of 77.71 cm. This result showed no evident effect of organic fertilizer and chemical fertilizer on plant growth.

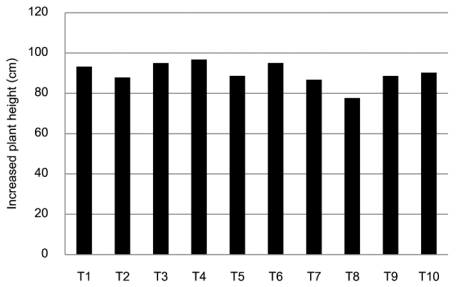

Figure 5. Effect of soil amendments on increased plant height of physic nut for 10 treatments during 8 months

Diameter: The plant diameter was measured at the same time as the plant height. The results showed that the application of compost at 2 kg plant^{-1} year^{-1} with chemical fertilizer plus bio-extract produced the highest change in the diameter of 1.01 cm (Figure 6), which was higher than the application of farmyard manure at 2 kg plant^{-1} year^{-1} with chemical fertilizer (0.95 cm), and of compost at 4 kg plant^{-1} year^{-1} with chemical fertilizer plus bio-extract (0.93 cm), but it was not significantly different. The application of compost at 2 kg plant^{-1} year^{-1} with chemical fertilizer produced the smallest diameter of 0.66 cm.

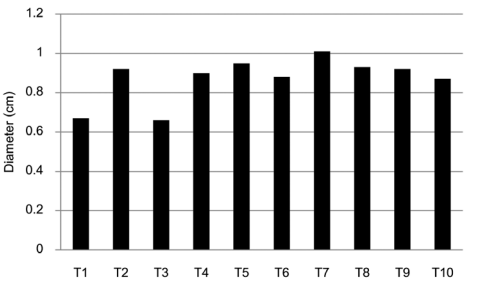

Figure 6. Effect of soil amendment on diameter of physic nut for 10 treatments during 8 months

Effect of Organic and Chemical Fertilizer on Yields and 100 Seed Weight of Physic Nut

Seed yield: In the first year (2010), the study on the effect of organic and chemical fertilizer on yields of physic nut showed that the application of compost at 4 kg plant^{-1} year^{-1} with chemical fertilizer resulted in the highest yield of 1266.2 kgha^{-1}, which was higher than the application of farmyard manure at 2 kg plant^{-1} year^{-1} with chemical fertilizer plus bio-extract (1182.5 kg ha^{-1}), and of farmyard manure at 4 kg plant^{-1} year^{-1} with chemical fertilizer (1174.31 kg ha^{-1}), but it was not significantly different. And the results showed that bio-extract application had no effect on seed yield. The control plot gave the lowest yield of 668.75 kg ha^{-1} (Table 1).

In the second year (2011), a similar trend to the first year was found; utilization of organic fertilizer plus chemical fertilizer gave a yield higher only than the chemical fertilizer and control,but not significantly higher. The application of compost at 2 kg

plant^{-1} year^{-1} with chemical fertilizer plus bio-extract produced the highest yield (1135.2 kg ha^{-1}), while the control plot had the lowest yield of 371.88 kg ha^{-1} (Table 1). However, in the second year of the experiment, bio-extract application also had no effect on seed yield.

Weight of 100 seeds: The seed weight was determined twice, in February and December 2010. At the first weighing, the application of compost at 2 kg plant^{-1} year^{-1} with chemical fertilizertended to give the highest 100-seed weight (63.36 g), while farmyard manure at 4 kg plant^{-1} year^{-1} with chemical fertilizer had the lowest 100-seed weight (40.10 g). In the second weighing, the application of chemical fertilizer tended to produce the highest 100-seed weight (60.34 g), while the control plot had the lowest 100-seed weight (20.04 g). The application of chemical fertilizer produced the highest average 100-seed weight of 60.18 g (Table 1).

Table 1. Effect of organic and chemical fertilizer on yields and average 100-seed weight of physic nut

Treatments	Yields (kg ha^{-1})		Average	100-seed weight (g)		Average
	Crop 2010	Crop 2011		Feb 2010	Dec 2010	
1) Control	668.75	371.88	520.32	40.89	20.04	30.47
2) Chemical fertilizer	685.88	735.82	710.85	60.03	60.34	60.19
3) Compost, 2 kg plant^{-1}	1094.94	707.38	901.16	63.36	48.93	56.15
4) Compost, 4 kg plant^{-1}	1266.19	718.56	992.38	44.91	52.44	48.68
5) FYM, 2 kg plant^{-1}	1064.81	645.50	855.16	60.48	49.33	54.91
6) FYM, 4 kg plant^{-1}	1174.31	1101.00	1137.66	40.10	56.84	48.47
7) Compost, 2 kg plant^{-1}+ bio-extract	1037.00	853.50	945.25	42.95	54.33	48.64
8) Compost, 4 kg plant^{-1}+ bio-extract	1008.06	577.94	793.00	49.25	54.03	51.64
9) FYM, 2 kg plant^{-1} + bio-extract	1182.50	1135.19	1158.85	60.74	57.89	59.32
10) FYM, 4 kg plant^{-1} + bio-extract	921.56	761.31	841.44	60.59	48.31	54.45
F-test	ns	ns		ns	ns	
CV (%)	24.20	73.36		41.89	26.43	

FYM = Farmyard manure; ns = Not significant at P < 0.05

Change in Soil Properties

The experiment was conducted in a field experimental plot of the Suphanburi Agricultural Research and Development Center, U-thong district, Suphanburi province. The soils were classified as Kamphaeng Saen soil series (fine-silty, mixed, active, isohyperthermic Typic Haplustalfs).The initial soil properties were determined. The soil pH varied from 6.83 to 7.27. The soil organic matter was in the range 1.57-1.89%, while the average available phosphorous (P) and potassium (K)were 76.48 and 68.97 mg kg^{-1}, respectively. This soil was slightly saline with an EC_e range of 1.33-2.90 d Sm^{-1}. The soluble Na varied from 9.06 to 26.16 m mol l^{-1}.

The effect of organic fertilizer and chemical fertilizer on changes in the soil properties is shown in Table 2. The application of organic fertilizer with chemical fertilizer resulted in a slight increase in the soil pH. The pH varied from 7.07 to 7.37. No effect of the different application rates of organic fertilizer was found. The EC_e changed slightly after the experiment. No effect of organic fertilizer and chemical fertilizer was found, however there was a soil sampling impact on the EC_e values as the EC_e varied from 0.97 to 2.90 dSm^{-1}. This result conformed withthe amount of soluble Na. Generally, the soluble Na decreased after the experiment, especially with the application of compost at 4 kg $plant^{-1}$ $year^{-1}$, where the soluble Na decreased from 20.69 to 11.86 m mol l^{-1}.

The OM tended to decrease when compared to initial soil levels. The OM varied from 1.3 to 1.63%. Utilization of compost at 4 kg $plant^{-1}$ $year^{-1}$ with chemical fertilizer resulted in the highest soil organic matter of 1.63%. Available P increased after the application of organic fertilizer and chemical fertilizer. The average available P was 181.20 mg kg^{-1}. Utilization of compost at 2 kg $plant^{-1}$ $year^{-1}$ with chemical fertilizer and bio-extract showed a highest available P level of 214 mg kg^{-1}. Generally, available K increased, except in the control treatment and the treatment with only chemical fertilizer. The application of compost at 4 kg $plant^{-1}$ $year^{-1}$ with chemical fertilizer and bio-extract produced the highest level of available K (189.67 mg kg^{-1}).

Discussion

This experiment was conducted in an experimental field of the Suphanburi Agricultural Research and Development Center, U-thong district,Suphanburi province where the soil was slightly saline. Salinity is an important soil problem for crop production in Thailand as it makes the land unsuitable for agriculture. However, some plants can survive under this condition. Physic nut is one of the species that can adapt to salinity (Gao *et al*., 2008). However, the salinity impacted on plant growth and yields. The physic nut showed low average yields of 1010.4 and 760.81 kg ha^{-1} in the first year and the second year of the experiment, respectively. The first year yield was higher because there was a longer harvesting period (12 months) than in the second year (9 months). These results were similar to those of Suriharn *et al*. (2011) who reported low yields of 1180 and 1559 kg ha^{-1} in the first year and the second year, respectively, while Kumar and Sharma (2008) reported that physic nut had an average annual seed yield range of 2000–3000 t ha^{-1} in semi-arid areas. Selection of cuttings was very important in the experiment. This resulted in plants that were better adapted to saline conditions. For the current experiment, cuttings were prepared from physic nut that had been cultivated in a saline area.

Many reports have shown that physic nut could adapt and grow under stress conditions with low nutrients; however all crops require nutrients. Thus, in this experiment, treatments 2-10 had applications of chemical fertilizer (15-15-15) at a rate of 156.25 kg ha^{-1}. In northeastern Thailand, Suriharn *et al*. (2011) recommended applying chemical fertilizer (15-15-15) at a rate not exceeding 312.5 kg ha^{-1}. The application of organic and chemical fertilizer in slightly saline soil resulted in increased growth of physic nut but

not at a level that was significantly different from the control treatment. This result differed from the research results of Sop *et al.* (2012) who reported that the plant growth and biomass development of physic nut were significantly enhanced by organic amendments compared to the control on completely barren and degraded soil.Silpachai *et al.* (2009) reported that the application of organic fertilizer at 4 kg plant^{-1} resulted in a higher growth rate than an application of 2 kg plant^{-1}.

For this experiment, the application of organic fertilizer had no effect on the growth and yield of physic nut. From the data of analysis, compost gave low N, P, and K content of 2.4, 3.37, and 2.62%,while farmyard

Table 2. Effect of organic and chemical fertilizer on soil properties at 0-30 cm depth

Treatments	pH		OM (%)		Available P-Bray2 (mg kg^{-1})	
	Before	After	Before	After	Before	After
T1	7.13	7.27	1.57	1.40	48.33	170
T2	7.23	7.23	1.68	1.6	46.76	185
T3	7.00	7.17	1.58	1.43	41.67	167
T4	7.07	7.10	1.79	1.57	105.00	203
T5	6.83	7.13	1.72	1.27	88.00	148
T6	6.93	7.23	1.79	1.63	101.67	198
T7	7.10	7.17	1.78	1.50	71.67	179
T8	7.27	7.37	1.60	1.30	89.00	157
T9	7.17	7.07	1.89	1.53	101.67	214
T10	7.03	7.23	1.62	1.47	71.00	191
F-test		ns		ns		ns
C.V. (%)		3.36		9.54		16.72
Treatment	**Extractable K (mg kg^{-1})**		**EC_e (dS m^{-1})**		**Soluble Na^+ (m mol l^{-1})**	
	Before	**After**	**Before**	**After**	**Before**	**After**
T1	63.33	60.67	2.56	1.56	20.52	9.67
T2	75.00	64.67	1.33	0.97	9.06	5.71
T3	78.00	98.67	1.84	1.98	11.42	12.15
T4	62.33	131.00	2.43	1.88	20.69	11.86
T5	64.33	159.33	1.83	2.90	12.01	15.52
T6	71.33	141.33	1.40	1.71	9.44	10.40
T7	70.33	118.67	1.38	1.46	9.41	9.08
T8	64.67	115.00	2.90	2.36	26.16	18.45
T9	70.67	160.00	2.06	2.29	18.32	15.38
T10	69.67	189.67	1.94	2.11	17.40	12.74
F-test		ns		ns		ns
C.V. (%)		59.50		40.10		47.61

ns = Not significant at $P < 0.05$

manure also gave low N, P, and K content of 1.04, 1.08, and 1.31%, respectively. These resulted in plant growth but plants may not get enough N to meet their requirements. However, application of organic fertilizer plus chemical fertilizer only tended to increase the seed yield compared to the chemical fertilizer and control,but not to a significant extent. Sukkarin (2008) reported a similar trend, where the application of organic fertilizer plus chemical fertilizer gave a similar yield to the treatment of only chemical fertilizer. Silpachai *et al*. (2009) reported that the application of VA-mycorrhizal fungus with organic fertilizer and phosphorus increased physic nut yields.The current study showed no such effect from organic fertilizer application. For this experiment, bio-extract application also had no effect on the seed yield. The Office of Soil Biotechnology (n.d.) reported that the functions of this material are to promote seed germination, root tissue development, and stem elongation, and to stimulate budding, flowering, and fruit growth.

The current experiment was conducted in slightly saline soil with low fertility. This area was unsuitable for agriculture. After the experiment, the EC_e was slightly changed indicating that there was no apparent effect from the organic fertilizer application. The OM tended to decrease when compared to the initial soil analysis. This means that the application of organic fertilizer did not result in increased OM levels. Under saline conditions, the OM decomposes easily. The residual effect of the application of organic fertilizer and chemical fertilizer resulted in an increase in the available P and available K. Organic amendment provided nutrients such as C, N, P, and K to the degraded soil.

Although growing physic nut under saline conditions will produce lower seed yields, physic nut is believed to have potential in the environmental reclamation of barren areas and degraded soil.

Conclusions

1. Application of organic fertilizer plus chemical fertilizer resulted in increased growth of physic nut but not at significantly different levels to the control treatment.

2. Application of organic fertilizer had no effect on the growth and yield of physic nut however, application of organic fertilizer plus chemical fertilizer resulted in a higher yield than for the application of chemical fertilizer and for the control, but not to a significant degree.

3. The EC_e changed slightly. The soil organic matter tended to decrease while the available phosphorus tended to increase. Available potassium tended to increase except in the cases of the chemical fertilizer treatment and the control treatment.

4. Thus it could be recommended that to increase the yield of physic nut, application of N from chemical fertilizer should be considered at a higher level, because P and K are usually contained at a sufficiently high level in the soil and from organic fertilizer.

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