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Influence of adding various organic residues on some soil properties, growth and yield of Chilli Padi (*Capsicum flutescens* Linn.) grown under greenhouse conditions

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ABSTRACT: Most of the soils in northeast Thailand (NET) is sandy in texture. This type of soils contained low organic matter and nutrients, as well as low soil water holding capacity that results in poor crop productivity. Chili is the main vegetable crop cultivation in NET. Several kinds of Thai food included chili as an ingredient. The objective of this research was to investigate the influence of various organic residues applications on some soil properties, growth and yield of chili under greenhouse conditions. A completely randomized design with four replications was used for this study. The treatments consisted of three sources of organic residues; (T1) Coconut shell hair, (T2) M. *calabura* leaves, and (T3) S. *saman* leaves in comparison with (T4) without organic residues application (control). All various organic residues were incorporated into the soil at a rate of 50 g/pot in a plastic pot with size of 20 cm in diameter and 18 cm in height which filled 3 kg of dry soil. All treatments received chemical fertilizer at same amount. One chili seedling was transplanted into the soil of each pot. Results revealed that all various organic residues application increased soil pH and organic matter, while electrical conductivity (EC) tended to decrease in comparison with control after crop harvest. The application of coconut shell hair into the soil demonstrated the highest soil moisture content during the growing period. Adding all organic residues into the soil remained higher exchangeable K than that of control treatment. Irrespective of crop growth, the maximum root and shoot growth were observed in the M. *calabura* application treatment in this study. M. *calabura* or S. *Saman* residues integrated with chemical fertilizer application increased fresh fruit yield by 40 and 29% over control treatment, respectively.

Keywords: organic residues, soil properties, growth, yield, chili

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Introduction

Soil is a fundamental factor in plant life. In general, the soil that is suitable for plant growth is fertile soil. It contains essential nutrients for plant growth. At the same time, there must be appropriate physical and chemical properties for plants growth. (Land Development Department, YPP). Soil in the northeast, most of the soil is highly developed and have low agricultural potential, the soil rarely stores moisture and the soil is quite sandy low in organic matter and nutrients content (Vityakon, 2013). Soil improvement is, therefore, important to help soil become suitable for crop cultivation. Currently, chemical fertilizers are widely used and the use of chemical fertilizers for a long period of time causes the structure of the soil to deteriorate. Affecting the soil to become more tight, hard soil surface and air cannot pass through the soil. It also does not have the property to improve the soil to be airy, like the organic fertilizer. Many findings have reported related to the reduction in bulk density in response to the adding of organic residues (Singh et al., 2000; Mandal et al., 2003; Phogat et al., 2004). Increasing in water holding capacity in response to the integrated use of organic and chemical fertilizer (Sharma et al., 2001). The soil pH increased after the addition of organic residues (Bessho and Bell, 1992; Odlare et al., 2008). At present, there are many sources of organic residues to choose, some sources may not be suitable or expensive. The selection of organic residues for using must study fertility have enough nutrients to meet the needs of plants and can be easily found in locally (Thamsupha, 2012). Groundnut produced large amount of stover after harvest. It's incorporation into the soils can increase yields of maize (*Zea mays* L.) (Promsakha et al., 2005), cassava (*Manihot esculenta* Crantz.) (Toomsan et al., 1993) and rice (Toomsan et al., 1995). The use of non-legume crop residues, such as sugarcane leaf incorporation into the soil, have been found to increase millable yields and sugar content of the sugarcane crop (Hemwong et al., 2009).

The integrated use of organic and inorganic fertilizers has been reported to increase crop productivity. The application of Leucaena (*Leucaena leucocephala*) biomass in combination with chemical fertilizer has given higher maize yields when compared to the use of inorganic fertilizers or Leucaena biomass alone (Mugendi et al., 1999).

Chili (*Capsicum flutescens* Linn.) is an economic importance vegetable crop of Thailand and can be planted throughout the year (Techawongsathien, 2006). Chili is horticulture commodities with high economic value and it's contains protein, fats, carbohydrates, calcium, vitamin A, B1 and C (Hayati, et al., 2012). Setyowati et al. (2014) reported that Wedelia and Siam weed composts application are able to substitute nitrogen fertilizer and tends to give better yield of chili pepper as compared to application of nitrogen fertilizer alone. The objectives of this study were to investigate the influence of application various organic residues integrated use of mineral fertilizers on some soil properties, growth and yield of chili grown under greenhouse conditions.

Materials and methods

Greenhouse experiment was conducted in May 2018 to August 2018 at Department of Soil Sciences and Environment, Faculty of Agriculture, Khon Kaen University. A completely randomized design with four replications used in this study. The treatments consist of three sources of organic residues: Coconut shell hair (*Cocos nucifera* Linn.) application at rate of 50 g per pot (T1), *Muntingia calabura* application at rate of 50 g per pot (T2) and *Samanea saman* application at rate of 50 g per pot (T3) in comparison with without organic residues application (control, T4). Three kilograms of dry soil were filled in plastic pot with size of diameter of 20 cm and height 17 cm. Before planting, three sources of organic residues were incorporated into the soil of each pot. Coconut shell hair consisted of 0.46% total N, 0.004% total P and 1.43% total K. M. *calabura* leaves contained of 0.99% total N, 0.005% total P and 0.42% total K. While, S. *saman* leaves comprised of 1.5% total N, 0.005% total P and 0.8% total K. One chili seedling (45 days old) was transplanted into the soil of each pot. Crop received water by drip irrigation at rate of 200 ml per pot a day. Chemical fertilizer grade 15-15-15 (N - P_2O_5 - K_2O) was applied at rate of 1.03 g to the soil for all treatments by broadcasting every 14 days until harvest. Hand weeding was done twice during the growing season. Soil properties were determined such as % sand, %silt, %clay, bulk density, pH, electrical conductivity (EC), organic matter (OM), total N (%), available P (ppm) and exchangeable K (ppm) before planting and after harvest. The soil samples were classified as sandy loam. Soil moisture content (% by volume) was measured by soil moisture sensor after transplanting one month at 5 cm soil depth. The soil moisture content at field capacity (FC) and permanent wilting point (PWP) were determined in the present study. The leaf chlorophyll content was measured using an optical instrument called SPAD chlorophyll meter (SPAD – 502, Minalta Co., Ltd. meter, Japan) of the third, fourth and fifth fully expanded leaves from the top of branching at 1,2 and 3 months after transplanting. Crop growth such as plant height, root and shoot dry weight, number of fruit, as well as fresh fruit yield were recorded at harvesting time. Chili fruit was harvested approximately 90 days after transplanting.

Results and discussion

Soil property

In the present experiment, various organic residues application tended to increase soil pH after crop harvest. The soil pH increased when applied organic residues into the soil due to organic anions and amino acids in the organic residues attributed to decarboxylation processes (Yan et al., 1996; Odlare et al., 2008). In addition, OM and exchangeable K tended to increase as compared with no-crop residues application control treatments after crop harvest. While electrical conductivity (EC) decreased, depending on sources of organic matter residues application (**Table 1**). This agree with the previous research work. (Hemalatha et al., 2000; Algelava et al., 2013; Nopphan et al., 2017). Brown and Cotton (2011) reported that application of compost improve soil quality; higher total carbon, decreased bulk density, enhance microbial activity, total nitrogen, water holding capacity and water infiltration rate. In the present experiment, the highest exchangeable K remaining in the soil was observed after crop harvest in the S. *saman* leaves application treatment. This was probably due to the S. *saman* decomposed more rapidly than coconut shell hair, although, the potassium content in leaves was lower. Kunlanit and Nasompong (2017) reported that chemical fertilizer combined with S. *saman* residues application at rate of 500 and 1000 kg/rai was significantly increased exchangeable K (%) in soil over control after harvesting sweet corn. Sandy soils in texture are low ability of K^+ adsorption at soil colloid, resulting to more leaching to sub-soil was reported by Vityakon (2004).

Table 1 Soil physical and chemical properties prior to planting and after harvesting of various organic residues application, greenhouse experiment

Parameter	Prior planting	After harvesting			
		T1	T2	T3	T4
1. Bulk Density (g cm^3)[1]	-	1.54	1.36	1.45	1.46
2. pH[2]	6.63	7.03	6.98	7.01	6.56
3. EC 1:5 (μm/cm)[3]	268	755	717.5	747	778.5
4. Organic matter (%)[4]	1.90	2.33	2.58	2.58	1.90
5. Total Nitrogen (%)[5]	0.08	0.07	0.08	0.09	0.09
6. Available Phosphorus (ppm)[6]	9.55	9.80	8.40	9.45	12.28
7. Exchangeable Potassium (ppm)[7]	92.90	55.20	53.20	99.40	48.30

Remark: [1]= Core method (Casanova, 2016), [2] = (soil: water, 1: 5) by pH meter (Jones, 2001), [3]= (soil: water, 1: 5) by EC meter (Black, 1965), [4] = Walkley and Black (Walkley and Black, 1934), [5] = Micro-Kjeldahl method (Bremner, 1965), [6] = Bray II (Bray and Kurtz, 1945), [7] = NH_4OAc (Raymemt, 1992)

T1 = Coconut shell hair, T2 = M. *Calabura*, T3 = S. *Saman*, T4 = No-application (control)

Soil moisture content (SMC)

In the present experiment, SMC of all various organic residues application and control (no-crop residues) treatments located in the available ranges between FC (%by volume) and PWP (% by volume) entire the growing period (**Figure 1**). However, coconut shell hair demonstrated the highest SMC in comparison with the other treatments. This was probably due to the coconut shell hair incorporated into the soil increase water holding capacity at topsoil higher than those of the other organic residues. In some time, SMC above FC was observed at young crop growth stage (**Figure 1**). SMC above FC caused waterlogging damaged to the crop and resulting to poor crop growth. At later growing period, coconut shell hair application still maintained high SMC. This was probably due to low leaves transpiration rates and little water uptake from the soil, regarding to poor crop growth. On the other hand, M. *calabura* application illustrated the lowest of SMC entire the growing period in this study (**Figure 1**). This was attributed to better crop growth and resulting to high leaves transpiration rate, means high water uptake from the soil.

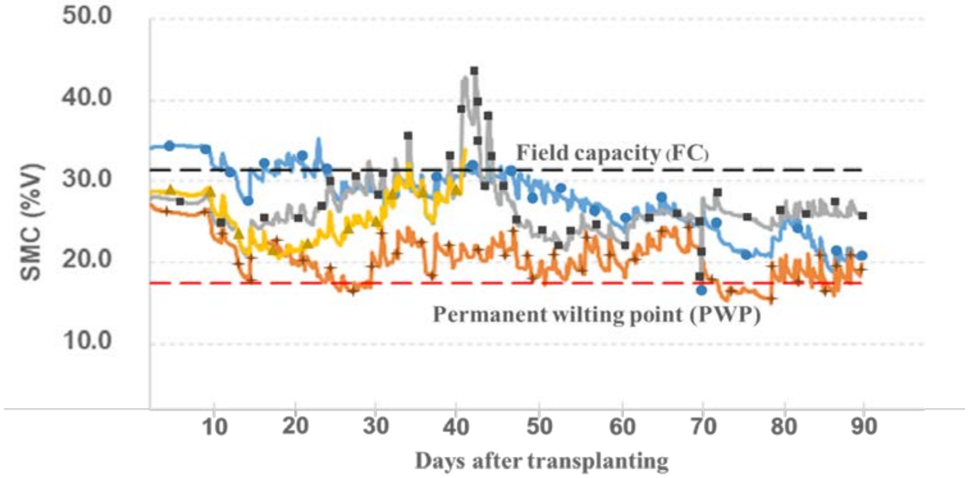

Figure 1 Soil moisture content (SMC) at 5 cm depth below soil surface during cropping period
Remark: T1 = Coconut shell hair (●), T2 = M. *Calabura* (✦), T3 = S. *Saman* (■), T4 = No-application (▲)

Leaf chlorophyll content index

SPAD chlorophyll meter reading values used for determining the chlorophyll content index. In the present experiment, application of various organic residues did not show a significant difference on the chlorophyll content index at 1, 2 and 3 months after transplanting (**Table 2**). However, application of M. *calabura* tended to give the highest chlorophyll content index in comparison with the other treatments. Many researchers confirmed a very close link between chlorophyll and nitrogen content in leaf (Evans, 1983; Amaliotis et al., 2004; Petz, 1985; Bojovic, 2009). This was probably due to M. *calabura* leaf contain high amount of nitrogen content released into the soil and consequently greater uptake by the plant in the present study.

Table 2 SPAD chlorophyll meter reading value in leaf of chili as affected by various organic matter application at 1, 2 and 3 months after planting (MAP), greenhouse experiment

Treatments	SPAD chlorophyll meter reading			Average
	1 MAP	2 MAP	3 MAP	
T1: Coconut shell hair	42.3	43.2	50.7	45.2
T2: M. *Calabura*	46.3	47.1	51.9	48.4
T3: S. *Saman*	34.2	45.2	52.4	43.9
T4: No-application	41.7	45.3	54.6	47.2
F-test	ns	ns	ns	ns
CV (%)	21.24	9.42	6.92	13.63

ns = not significant at P > 0.05 probability level

Crop growth and yield

Application of various organic residues were not significantly different (P ≤ 0.05) in plant height and leaf dry weight of chili at harvest, but significantly different (P ≤ 0.05) of various organic residues application were observed with respect to stem and root dry weight, fresh fruit yield and significantly different (P < 0.01) of number of fruit per plant (**Table 3)**. The maximum stem and root dry weight, number of fruits per plant and fresh fruit yield were obtained in the M. *calabura* application treatments. In this study, application of M. *calabura* or S. *saman* significantly increased fresh fruit yield over control. This was probably due to organic residues application provided available plant nutrients for crop growth. M. *calabura* or S. *saman* dry leaves incorporated into the soil to decompose and supply nutrients in the soil for crop growth. In the present experiment, S. *saman* supply N, P and K higher than the other organic residues sources (see crop residue analyzed before application). Setyowati et al. (2014) reported that Wedelia and Siam weedy compost provided nitrogen into the soil. OM improved soil moisture holding capacity and structure were reported by Murthy (1978). Bot and Benites (2005) reported that high OM increases crop productivity and, in turn, high productivity increases organic matter. Kunlanit and Nasompong (2017) stated that application of chemical fertilizer combined with S. *saman* residues increased sweet corn yield over chemical fertilizer application alone as recommendation based on the Department of Agricultural Extension' practice or based on soil testing. In addition, Leucaena biomass combined with chemical fertilizer has given high maize yields when compared to the use of chemical fertilizer or Leucaena biomass alone (Mugendi et al., 1999). Setyowati et al. (2014) found that application Wedelia and Siam weed composts at rate of 20 ton ha^{-1} increase fruit length, higher fresh fruit weight per plant and fruit diameter of chili pepper.

In the present experiment, it was observed that Coconut shell hair application produced lower fresh fruit yield than that of control. This was mainly due to the crop suffered from waterlogging during early growth stage (**Figure 1**), and resulting to poor crop growth (Table 3 and Figure 2). Bot and Benites (2005) stated that periods of water saturation lead to poor soil aeration. Most soil organisms need oxygen, and thus a reduction of oxygen in the soil leads to a reduction of the mineralization rate as these organisms become inactive or even die. Some of the transformation processes become anaerobic, which can lead to damage to plant roots caused by waste products or favorable conditions for disease-causing organisms.

Table 3 Growth and yield of chili as affected by various organic matter application at harvest, greenhouse experiment

Treatments	Plant height (cm.)	Leaf	Stem	Root	fruit number (no./plant)	Fresh fruit yield (gm/plant)
		⟵	dry weight (gm/plant)	⟶		
T1: Coconut shell hair	59.1	14.1	12.0b	5.4b	15.3c	25.2b
T2: M. *calabura*	73.0	19.2	22.1a	10.2a	40.3a	49.6a
T3: S. *saman*	65.0	17.8	19.1ab	9.1a	28.3b	35.5ab
T4: No-application	69.0	15.7	15.1ab	7.4ab	28.0b	33.3ab
F-test	ns	ns	*	*	**	*
CV (%)	19.41	23.36	35.95	25.52	20.12	31.85

Means followed by the same letter at the same column were not significantly different by LSD at P ≤ 0.05, ** significant at P < 0.01 probability level, * significant at P ≤ 0.05 probability level, ns = not significantly at P > 0.05 probability level

Figure 2 Comparison chili growth among treatments at 60 days after transplanting

Remark: T1 = Coconut shell hair, T2 = M. *Calabura*, T3 = S. *Saman*, T4 = No-application

Conclusions

In the present experiment, organic residues application increased soil pH, organic matter and water holding capacity, as well as remain exchangeable K in the soil higher than with no-application organic residues (control) after crop harvest. While, electrical conductivity (EC) tended to decrease. The application of M. *calabura* or S. *saman* combined with chemical fertilizer increased fresh fruit yield of chili by 40% and 29% over application chemical fertilizer alone treatments, respectively.

References

Angelova, V. R., V. I. Akova, N.S. Artinova, and K. I. Ivanov. 2013. The effect of organic amendments on soil chemical characteristics. Bulgarian Journal of Agricultural Science. 19: 958-971.

Anggraheni, Y. G. D., F. Nuro, and Y. B. Paradisa. 2019. Effect of organic fertilizer on growth and yield of chili pepper. Proceedings The 3rd SATREPS Conference. November 22, 2018, Indonesia.

Amaliotis, D., I. Therios, and M. Karatissiou. 2004. Effect of nitrogen fertilization on growth, leaf nutrient concentration and photosynthesis in three peach cultivars. ISHS, Acta Horticulture. 449: 36-42.

Bessho, T., and L.C. Bell. 1992. Soil solid and solution phase changes and mung bean response during amelioration of aluminum toxicity with organic matter. Plant and Soil. 140: 183-196.

Black, C.A. 1965. Method of Soil Analysis Part 2: Chemical and Microbiological Properties, American Society of Agronomy Inc.1572.

Bray II, R.H., and L.T. Kurtz. 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Science. 59: 39-45.

Bojovic, B., and A. Markovic. 2009. Correlation between nitrogen and chlorophyll content in wheat (*Triticum aestivum* L.). Kragujevac Journal Science. 31: 69-74.

Bot, A., and J. Benites. 2005. The importance of soil organic matter. Key to drought-resistant soil and sustained food and production. FAO Soil Bulletin: 1-95.

Bremner, J.M. 1965. Total nitrogen. In C.A. Black et al. (eds.) Methods of soil analysis, Part 2 Agronomy. 9: 1149-1278.

Brown, S., and M. cotton. 2011. Chemical in soil properties and carbon content following compost application: Results of on-farm sampling. Compost Science and Utilization 19 (2): 87-96.

Casanova, M., E. Tapia, O. Seguel, and O. Salazar. 2016. Direct measurement and prediction of bulk density on alluvial soils of central Chile. Chilean J Agric Res. 76: 105–113.

Land Development Department. YPP. Management of Saline Soil Problems: http://www.ldd.go.th/Web_Soil/salty.htm. Accessed Dec. 14, 2018.

Evans, J. R. 1983. Nitrogen and photosynthesis in the flag leaf of wheat (*Triticum aestivum* L.). Plant Physiology. 72: 297-302.

Hayati, E., T. Mahmud, and R. Fazil. 2012. Effect of organic fertilizer types and varieties on growth and yield of chili pepper (*Capsicum annum* L.). J Floratek.7:173–81.

Hemwong, S.B., B. Toomsan, G. Cadish, V. Limpinuntana, P. Vityakon, and A. Patanothai. 2009. Sugarcane residue management and green legume crop effects on N dynamic, N losses and growth of sugarcane. Nutrient Cycling in Agroecosystems. 83: 135-151.

Hemalatha, M., V. Thirumurugan, and R. Balasubramanian. 2000. Effect of organic sources of nitrogen on productivity, quality of rice (*Oryza sativa*) and soil fertility in single crop wetlands. Indian Journal Agronomy. 45: 564-567.

Jones, J., and J. Benton. 2001. Laboratory guide for conducting soil test and plant analysis. CRC Press. 27-35.

Kunlanit, B., and S. Nasompong. 2017. Fertilizer management on growth and yield of sweet corn. Khon Kaen Agriculture Journal. 45: 133-142.

Mandal, U.K., G. Singh, U.S. Victor, and K.L. Sharma. 2003. Green manuring: it's effect on soil properties and crop growth under rice-wheat cropping system. European J. Agron. 19: 225-239.

Mugendi, D.N., P.K.R. Nair, J.N. Mugme, M.K. Neil., and P. Woomer. 1999. Alley cropping of maize with calliandra and leucaena in the subhumid highlands of Kenya: Part 1: Soil fertility changes and maize yield. Agroforestry Systems. 46: 39-50.

Murthy, R.K. 1978. A manual on compost and other organic manures. Today and Tomorrow's Printers and Publishers. New Delhi, India. 13-119.

Nopphan, C., S. Thanachit, S. Anusontpornperm, and I. Kheoruenrpmne. 2017. Effects of deep placement organic soil conditioners on soil aggregate distribution, carbon sequestration, and yield of cassava in Yasothon soil. Khon Kaen Agriculture Journal. 45: 57-70.

Odlare, M., M. Pell, and K. Svensson. 2008. Changes in chemical and microbiological properties during 4 years of application. Waste Management 28: 1246-1253.

Petz, B. 1985. Osnovne statisticke metode za matematicare. Sveucilisna naknada liber, Zagreb: 173-222.

Phogat, S.B., I.S. Dahiya, R.S. Hooda, N.K. Sangwan, and Y.P.S. Solanki. 2004. Studies on residual effect of green manuring and farmyard manure for sustained productivity of rice-wheat cropping sequence and on soil health under shallow groundwater table conditions. Annals of Biology 20: 161-165.

Promsakha, S., B. Toomsan, G. Cadisch, E.M. Baggs, P. Vityakon, V. Limpinuntana, S. Jogloy, and A. Patanothai. 2005. Dry season groundnut stover management practices determine nitrogen cycling efficiency and subsequent maize yields. Plant and Soil. 272: 183-199.

Rayment, G.E., and F.R. Higginson. 1992. Australian Laboratory Handbook of Soil and Water. Chemical Methods. Intaka Prcss. 137.

Setyowati, N., Z. Muktamar, B. Suriyanti, and M. Simarmata. 2014. Growth and yield of chili pepper as affected by Weed Based organic compost and nitrogen fertilizer. International Journal on Advanced Science, Engineering and Information Technology. 4: 84-87.

Sharma, R., Y. Chioti, and U.C. Banerjee. 2001. Production, purification, characterization and applications of lipases. Biotech. Adv. 19: 627-662.

Singh, P.A., R.S. Trippathi, and B.N. Mittra. 2000. Effect of integrated use of organic and chemical sources of nitrogen in rice wheat cropping system. Oryza. 37; 205-208.

Techawangsathien, S. 2006. Chili: Production, management and breeding. Advance agriculture technology & supplies, Bangkok. Thailand. 168.

Thamasupha, P. 2012. Study of suitable materials for growth of marigolds. Research and Development Journal of Buriram Rajabhat University. Thailand. 7: 26-31.

Toomsan, B., V. Limpinuntana, J. Homchan, and S. Saranun. 1993. Nitrogen fixation of groundnut and it's residual nitrogen benefits to succeeding cassava. In: Proceedings of the 11th Thailand National Groundnut, Meeting, 17-21 May 1993. Published by Department of Agricultural Extension Ministry of Agriculture and Cooperatives. 465-475.

Toomsan, B., J.F. McDonagh, V. Limpinuntana, and K.E. Giller. 1995. Nitrogen fixation of groundnut and soybean and residual nitrogen benefits to rice in farmer's fields in Northeast Thailand. Plant and Soil. 175: 45-56.

Vityakon, P., V. Limpinuntana, W. Sriboonlue, S. Subhadhira, W. Trilokeat, and S. Prachunkanjana. 2004. Land-use patterns and associated land degradation in undulating terrain of Northeast Thailand. A research report to the National Research Council of Thailand, Khon Kaen University. 223.

Vityakon, P., A. Pudso, S. Budnan, P. Kamonmanit, B. Kulanit, and R. Saenghua. 2013. Enhancing fertility of sandy soils through the use of organic materials: Khon Kaen Agriculture Journal. 41: 1-12.

Walkley, A., and C.A. Black. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 37:29-38.