Effect of Chicken Manure and Organic Wastes from Cassava Starch Manufacturing Plant on Cassava Grown on Dan Khun Thot Soil

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ABSTRACT: The experiment was carried out in a farmer field at Ban Sapphlu Noi, Huay Bong subdistrict, Dan Khun Thot district, Nakhon Ratchasima Province, Thailand on Dan Khun Thot soil (Typic Paleustult) between 2013 and 2014. The objectives were to investigate the effect of chicken manure, cassava starch waste, tails and stalk used as soil amendment on yield and plant components of cassava, Huay Bong 80 variety, and chemical property of soil after growing for one crop. Experimental design employed in this study was split plot in randomized complete block with three replications. Main plot consisted of no soil amendment application, (T1), the applications of cassava starch waste at the rate of 6.25 t/ha (T2), cassava tails and stalk at the rate of 6.25 t/ha (T3), chicken manure at the rate of 6.25 t/ha (T4), T2++chicken manure at the rate of 3.125 t/ha (T5), T3++chicken manure at ten rate of 3.125 t/ha (T6), T2+chicken manure at the rate of 6.25 t/ha (T7), and T3++chicken manure at the rate of 6.25 t/ha (T8). All soil organic amendments were incorporated into the soil before planting. Sub plot comprised two rates of complete chemical fertilizer (15-15-15), 312.5 and 625 kg/ha. Cassava was harvested at ten months of age. Soil organic amendment had more effect on fresh root yield and plant components of cassava than did rates of fertilizer (15-15-15) applied. The applications of cassava tails and stalk and chicken manure, and cassava starch waste and chicken manure all at the rate of 6.25 t/ha significantly promoted the greatest amounts of cassava fresh root yield, starch yield, above ground biomass, and starch content. The fresh root yields obtained were 33.94 and 33.61 t/ha, respectively. The combination between incorporating cassava tails and stalk and chicken manure both at the rate of 6.25 t/ha into the soil before planting and the application of chemical fertilizer at the rate of 625 kg/ha gave the highest cassava fresh root yield and starch yield but barely different from the use of the same soil organic amendment with half of the chemical fertilizer applied. The use of cassava tails and stalk and chicken manure, and the application of cassava starch waste and chicken manure all at the rate of 6.25 t/ha had no effect on soil pH, extractable potassium and CEC of soil after one crop but resulted in higher amounts of organic matter, total nitrogen, available phosphorus, available potassium, extractable calcium and extractable magnesium remained in the soil.
Keywords: cassava, soil amendment, cassava starch waste, tails and stalk, sandy soil

Introduction

Cassava (*Manihot esculenta* Crantz.) is one of the major economic crops in Thailand. There were 1.41 million ha of cassava growing areas all over the country in the year 2014/2015 (Thai Tapioca Starch Association, 2015). Major cassava growing areas in Thailand are located in the northeast where Nakhon Ratchasima province has the most extensive planting area, accounting for 0.268 million ha in 2014 with the average fresh root yield of 22.94 t/ha (Office of Agricultural Economics, 2015). Repeated cultivation in the area without soil improvement practices has steadily induced soils degradation in addition to poor fertility status of soils in the region. Animal manure or compost has become one of the most popular organic amendments. There have been researches on the use of this soil organic amendment instantly in order to improve soil

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fertility (Kapkiyai et al., 1999), increase soil organic matter content (Kaur et al 2008), enhance plant growth (Mhlontlo et al., 2007), and improve some soil properties (Maerere et al., 2001; Hao et al.,2003). The growth of chicken production farming in Thailand has increased, leading to having the enormous amount of chicken manure (Fan et al., 2000; Gay et al., 2003). Several reports showed that chicken manure used as soil amendment can improve soil properties due to its very high contents of organic carbon and containing macro and microelements needed for plant growth (Woomer and Swift 1991; Nicholson et al., 1996; Prasad, 1996; Chen et al., 2001) as also shown by numerous recent studies in the northeast, Thailand (Riyapun et al., 2010; Tanimman et al., 2012; Mutchima et al, 2012; Plengsuntia et al., 2012). In northeast Thailand, there are several cassava starch processing plants that generate large amount of wastes such as cassava peel, tails and stalk, and cassava starch waste. They are high in organic carbon content and composed of some plant nutrients (Chadha 1961, Barrios and Bressani, 1967, Devendra 1977, Hutagalung, 1977; Eneje and Nwosu, 2012). Nevertheless, there has been very few numbers of researches on using these wastes as soil amendments for growing cassava in the region. Thus, this study was carried out objectively to investigate the effect of chicken manure, cassava starch waste, and cassava tails and stalk on cassava, Huay Bong 80 variety, grown on Dan Khun Thot soil, and to examine the effect of these organic wastes on soil property after one crop.

Materials and Methods

The experiment was conducted on Dan Khun Thot soil in a farmer field at Ban Supplu Noi, Huay Bong subdistrict, Dan Khun Thot district, Nakhon Ratchasima province. The soil was classified as Typic Paleustult. The soil representing the experimental area has an undulating surface with 6% slope, having been developed from wash over residuum derived from sandstone and conglomerate with well-drained feature, rapid permeability and moderate runoff. It had loamy sand texture throughout the top 60 cm of soil profile. Properties of this soil prior to conducting the experiment are presented in **Table 1**.

Table 1 Properties of soil prior to conducting the experiment.

Depth	pH_w	Total N	OM	Avail. P	Avail. K	Extr.Ca	Extr.Mg	Extr.K	Extr.Na	CEC
(cm)	1:1	(----g/kg-----)		(-------mg/kg------)		(----------------------$cmol_c$/kg---------------------)				
0-30	5.47	0.19	4.45	0.52	13.61	0.41	0.17	0.03	0.48	0.8
30-60	4.60	0.09	1.35	0.27	10.99	0.25	0.13	0.03	0.29	4.3

The experiment was arranged in split plot in a randomized complete block design (RCBD) with 3 replications. Main plots consisted of 8 treatments as follows; T1 = control with no application of soil amendment, T2 = cassava starch wastes applied at the rate of 6.25 t/ha, T3 = tails and stalk applied at the rate of 6.25 t/ha, T4 = chicken manure applied at the rate of 6.25

t/ha, T5 = T2+chicken manure applied at the rates of 3.125 , T6 = T3+chicken manure applied at the rates of 3.125 t/ha, T7 = T2+chicken manure applied at the rate of 6.25 t/ha, and T8 = T3+checken manure applied at the rate of 6.25 t/ha. Sub plot comprised two rates, 312.5 and 625 kg/ha of 15-15-15 formula chemical fertilizer. Soil organic amendments with their properties being shown in **Table 2** were spread onto the ground with respect to treatments designed and then incorporated into the soil using 3-disc plough. The area was left for 2 weeks before being loosened using 7-disc plough and then ridge was built up across the slope. Fertilization was made at 2 months after planting. Cassava, Huay Bong 80 variety, was harvested at ten months of age and soil sample for examining chemical property of soil as affected by soil organic amendments applied was collected from each plot at the time of harvest. Analysis of variance (ANOVA) was performed by using SPSS Statistics 17.0 software package. Means among treatments were compared using Duncan's multiple range test (DMRT) with differences being tested at 0.01 and 0.05 levels of significance.

Table 2 Chemical properties of soil organic amendments used in the experiment.

Property	CM	CSW	TS	Property	CM	CSW	TS
pH (1:1 H_2O)	7.0	5.8	4.6	Total Ca (g/kg)	26.2	5.6	9.7
EC (dS m^{-1} 1:1 H_2O)	1.5	0.62	1.5	Total Mg (g/kg)	3.2	1.4	1.9
CEC ($cmol_c$/kg)	65.1	0.62	1.5	Total Na (g/kg)	11.4	2.9	0.5
OM (g/kg)	406	433	269	Total Mn (mg/kg)	500	28	290
Total N (g/kg)	46.9	3.5	3.9	Total Zn (mg/kg)	500	21	77
Total P (g/kg)	7.6	6.6	0.3	Total Fe (mg/kg)	300	71	51
Total K (g/kg)	17.6	2.8	6.2	Total Cu (mg/kg)	40	44	42

Remark: CM = chicken manure, CSW = cassava starch waste, TS = tails and stalk

Results and Discussion

Cassava fresh root yield

The application of soil organic amendments clearly affected fresh root yield. Yields obtained from cassava grown on the soil amended with cassava tails and stalk with chicken manure (T7), and cassava starch waste with chicken manure (T8), all at the rate of 6.25 t/ha were highly significantly greater than the others, giving the fresh root yields of 31.61 and 33.94 t/ha, respectively (**Table 3**). Sole application of chicken manure (T4), cassava starch waste (T2), and cassava tails and stalk (T3), all at the rate of 6.25 t/ha did not give any higher fresh root yield than the control (T1), 26.54 compared to 24.42 t/ha. However, slightly greater yield was achieved when the soil was incorporated with those organic wastes from cassava starch manufacturing plant and chicken manure at the rate of 3.125 t/ha (T5 and T6).

Different amounts of applied chemical fertilizer did not give any different yield, statistically. There was no interaction between soil organic amendment and rate of chemical fertilizer applied. Without statistical difference, the application of cassava tails and stalk and chicken manure, both at the rate of 6.25 t/ha and the addition of 6.25 kg/ha chemical fertilizer (HT8) gave the highest fresh root yield of 33.96 t/ha. However, the amount was very slightly higher than the same soil organic amendments applied but with half of chemical fertilizer added (LT8), offering the yield of 33.92 t/ha.

The result is in agreement with previous studies that showed the effectiveness of chicken manure in terms of increasing cassava yield when grown on poor soils (Riyapun et al., 2010; Tanimman et al., 2012; Mutchima et al., 2012; Plengsuntia et al., 2012) because chicken manure usually contains high amounts of plant nutrients with some additions of some nutrients from cassava tails and stalk and cassava starch waste, carbon in particular. These always serve well to the increase of plant yield. However, it has to be taken into consideration that applying both organic waste and chicken manure increases the cost of cassava production. Thus, a different gap of yield between sole application and combining application must be economically calculated and also cumulative effect if they are to be applied for some consecutive years.

Starch content and starch yield

The combinations between cassava starch waste and chicken manure (T7), and cassava tails and stalk and chicken manure (T8), all applied at the rate of 6.25 t/ha, highly significantly gave the highest starch content of 31.0 and 31.8%, respectively (**Table 3**). All other treatments had lower content of starch in cassava fresh root. Again, there was no different effect of different rate of chemical fertilizer applied in neither this context nor the interaction between soil organic amendment and chemical fertilizer added.

Due to a combination between fresh root yield obtained and starch content, the gap of starch yield among treatments was wider among treatments even though the trend was almost similar to that of fresh root yield. The incorporation of cassava tails and stalk and chicken manure (T8) both at the rate of 6.25 t/ha highly significantly gave the highest starch yield of 10.81 t/ha, which was almost 4 t/ha greater than that of the control without amending the soil before planting (**Table 3**). There was no statistical difference in the interaction between soil organic amendment and fertilizer added, nevertheless.

Above ground biomass and other plant components

Soil organic amendments also had clear effect on above ground biomass of cassava. The highest above ground biomass of 8.53 t/ha was found in the plot amended with cassava tails and stalk and chicken manure (T8) both at the rate of 6.25 t/ha (**Table 3**), while the lowest amount being in the control (T1), having only 5.44 t/ha of above ground biomass. The use of cassava starch waste and chicken manure both at the rate of 6.25 t/ha gave inferior amount of above ground biomass to T8, however. The application of chemical fertilizer at the rate of 625 kg/ha (H) highly significantly stimulated greater above ground biomass than did the lower amount (L). No interaction between soil organic amendment and fertilizer applied was found in this context.

Growing cassava, Huay Bong 80 variety, on this Dan Khun Thot soil with or without using soil organic amendment, survival rate was no difference (**Table 3**). The same result was obtained in the case of different rate of applied chemical fertilizer and the interaction between soil organic amendment and fertilizer applied. There was no statistical difference in number of stem per hectare despite the pot amended with cassava tails and stalk and chicken manure (T8) both at the rate of 6.25 t/ha giving the greatest number of 20,089 stems/ha (**Table 3**), which the amount was nearly 3,000 stems higher than that obtained from the control (T1). However, the application of 6.25 kg/ha chemical fertilizer highly significantly gave higher number of stem than did the addition of 312.5 kg/ha (19,841 compared to 16,989 stems/ha). There was also no statistical difference of stem weight as affected by soil organic amendments, different rates of applied chemical fertilizer, and the interaction between these two (**Table 3**). Soil organic amendments evidently had the impact on leaf and branch of cassava. The highest amount (2.48 t/ha) was found when incorporating cassava tails and stalk together and chicken manure (T8) both at the rate of 6.25 t/ha into the soil before planting. This amount was highly significantly two times greater than that of the control without using soil amendment (T1). Chemical fertilizer also played a part in this case with the application at the rate of 6.55 kg/ha (H) highly significantly promoting greater leaf and branch weight of 2.00 t/ha than that of 1.64 t/ha gained when applied chemical fertilizer only 312.5 kg/ha (L). In the case of stem base, the same response by cassava to soil organic amendments but not to different rates of applied chemical fertilizer appeared in stem weight. The application of cassava tails and stalk and chicken manure (T8) both at the rate of 6.25 t/ha still highly significantly gave the highest stem base weight of 3.08 t/ha (**Table 3**), while unsurprisingly the lowest amount (1.74 t/ha) being from the control (T1) with no soil amendment applied. Soil organic amendments barely had the effect on harvesting index, giving the range of values between 0.79-0.82. However, the higher rate of chemical fertilizer applied (H) that promoted better above ground biomass highly significantly gave lower harvesting index than that of the lower rate (L) but with a slight margin.

Chemical properties of soil after growing cassava for one crop

1. Soil pH

Soil organic amendments and rates of applied chemical fertilizer had no different effect on pH of soil between 0-30 cm after growing cassava for one crop. Soil pH among treatments involving soil organic amendment ranged between 5.30-5.4. Although some studies indicated that chicken manuring had the effect on reducing soil acidity level in Yasothon soil (Typic Paleustult) (Thanimmarn, 2011). This result was described by Odedina et al. (2011) that chicken manure contains base elements, which will serve to reduce soil acidity. The increase of soil pH as affected by chicken manure application was also reported by Anyaegbu (2009) and Bakayoko et al. (2009).

2. Organic matter

The applications of cassava tails and stalk and chicken manure (T8), and cassava starch waste and chicken manure (T7) all at the rate of

6.25 t/ha resulted in the soil highly significantly having the highest amounts of organic matter (5.81 and 5.46 g/kg, respectively) remained in the soil after one crop. The lowest content of organic matter was in the control plot (3.37 g/kg). Rates of applied chemical fertilizer also had slightly different effect on organic matter content. The increase of organic matter induced by chicken manure is due to the manure playing three roles; 1) organic matter sources, 2) protecting soil against erosion, and 3) increasing activities of earthworms, which subsequently reduces water runoff (Hole et al., 2005; Parfitt et al., 2005). However, the amounts of soil organic matter in all treatments varied from 3.37-5.87 g/kg, which were still very low to low. This is described by Wang et al. (2006) that under the climatic conditions where the temperature and moisture are high, the decomposition of organic matter is intense, especially in the case of this soil studied that contain mainly macropores of which leaching plays a role in terms of carrying organic matter away from the soil. The result agrees with Thanimmarn (2011) that chicken manuring had the effect on enhancing the level of soil organic matter in a coarse-textured soil. These results are similar to those studied by Wang et al. (2006) who observed that the manure increased the concentrations of organic matter significantly. Bakayoto et al. (2009) also reported that chicken manure treatment significantly increased soil organic matter content of a sandy soil under cassava cultivation from 4.6 to 11.0 g/kg.

3. Total nitrogen

The same story as organic matter content was found in the case of total nitrogen (**Table 4**) that the applications of cassava tails and stalk and chicken manure (T8), and cassava starch waste and chicken manure (T7) all at the rate of 6.25 t/ha highly significantly resulted in the highest amount of total nitrogen (0.34 and 0.32 g/kg, respectively) left in the soil after harvesting cassava. The lowest total nitrogen content was obtained from the control (0.14 g/kg). Rates of applied chemical fertilizer also had slightly different effect on organic matter content. That is due to the fact that the manure applied to soil provides the nutritive elements by mineralization, especially in the case of nitrogen (Wuest et al., 2006).

4. Available phosphorus

In the case of available phosphorus, result showed that the application of cassava tails and stalk and chicken manure both at the rate of 6.25 t/ha highly significantly supported the highest amount of available phosphorus (3.47 mg/kg), whereas the control had only 1.37 mg/kg of available P left in the soil after one crop (**Table 4**). However, the amounts measured from all treatments were still far too low to be sufficient for the next crop. In addition, rates of applied chemical fertilizer had no different effect on available P in the soil.

5. Available potassium

Effect of the application of soil organic amendments on mean values of available potassium after the harvest is also shown in **Table 4**. The result markedly showed that the additions of chicken manure and this manure together with cassava starch waste and with cassava tails and stalk made the soil to have the highest remaining available potassium after one crop. The greatest amount was 39.7 mg/kg. However, the concentrations of available potassium in all treatment were still very low. Bakayako et al. (2009) reported that the use of chicken manure makes it possible to improve available potassium in a sandy soil, due to their very high organic matter contents.

6. Extractable bases

The application of cassava tails and stalk seemingly related well with the amount of extractable calcium left in the soil (Table 4). Both T3 and T8 that this organic waste involved highly significantly showed the highest contents of extractable Ca (0.73 and 0.83 cmolc/kg, respectively). The higher amount of chemical fertilizer (H) given to the plant also statistically gave the higher amount of extractable Ca left in the soil than did the lower rate (L). It was the same for the case of extractable magnesium content. However, all plots amended with organic amendments highly significantly had higher amounts of extractable Mg (0.17-0.21 cmolc/kg) than did the control with no application of soil organic amendment incorporated (0.11 cmolc/kg). It was quite interesting that the addition of soil organic amendments significantly increased the amount of extractable sodium, when compared to the control, since this element was considered not essential for plants. Monitoring of the amount should be done regularly if there are consecutive applications.

7. Cation exchange capacity

There was no difference in cation exchange capacity of the soils no matter what and how much soil organic amendments were applied. This indicates that changes of CEC in this sandy soil is difficult and will take time to reach the level that is favourable for growing plant or to the level that soil can become more effective in terms of it retainability of plant nutrients. Thus, the application of this type of soil organic amendments will essentially be implemented in a longer term. However, this CEC result is not in an agreement with the study of Bakayako et al. (2009), which showed that the manure allowed significant increases in CEC soil content. In accordance with results and with those of Hao and Chang (2002), the manure increased sum of the exchangeable bases (Ca2+, Mg2+, K+ and Na+) and the cation exchange capacity (Ca2+, Mg2+, K+, Na+, H+, Al3+).

The analytical data of soil organic matter and CEC are indicative of good response of soil to soil amendment despite the levels of soil organic matter and CEC apparently being low. This is also attributed by exposures of soil surface to the highly erosive tropical rains allow the greatly needed topsoil with its organic matter and other plant nutrients to be wash away (Harris, 2002). These undesirable conditions occur in cassava cultivation during the period before the crop canopy adequately closed. Though, the soil erosion varies with location depending upon many factors including land slope, soil texture, etc (Howeler, 2002). In the case of this study, these explanations may not wholly be responsible for the low amount of organic matter and low CEC but may include the reason explained above.

Table 3 Cassava fresh root yield, starch content, starch yield and above ground biomass as affected by soil organic amendments and rates of chemical fertilizer.

Tr.	FTY	Starch content	Starch yield	AGB	Survival rate	Number of stem	Stem	LB	Stem base	HI
	(t/ha)	(%)	(--------t/ha--------)		(%)	(No./plant)	(-------------t/ha------------)			
Main plot: soil organic amendment										
T1	24.42cd	28.5b	6.96e	5.44e	100.0	17,361	2.49	1.22e	1.74f	0.82
T2	22.12d	29.5b	6.52e	6.05de	98.8	16,121	2.41	1.57d	2.07e	0.78
T3	24.28cd	29.3b	7.13de	6.77cd	100.0	18,725	2.88	1.75cd	2.14e	0.78
T4	26.54bc	29.8b	7.91cd	6.81cd	94.1	16,989	2.78	1.61d	2.42d	0.80
T5	27.35b	29.5b	8.07c	7.51bc	98.8	19,345	3.03	1.88c	2.60c	0.79
T6	27.41b	29.4b	8.08c	7.06c	97.6	18,849	2.72	1.80cd	2.54cd	0.80
T7	31.61a	31.0a	9.82b	8.41ab	98.8	19,841	3.34	2.23b	2.84b	0.79
T8	33.94a	31.8a	10.81a	8.53a	98.8	20,089	2.98	2.48a	3.08a	0.80
F-t	**	**	**	**	ns	ns	ns	**	**	ns
Sub plot: rate of fertilizer										
L	26.94	29.9	8.09	6.68b	98.2	16,989b	2.64	1.64b	2.40	0.80a
H	27.48	29.8	8.23	7.46a	98.5	19,841a	3.01	2.00a	2.46	0.79b
F-t	ns	ns	ns	**	ns	**	ns	**	ns	**
Interaction: soil organic amendment x rate of fertilizer										
LT1	22.20	28.8	6.40	5.48	100.0	17,361	2.53	1.17	1.79	0.80
LT2	24.23	29.5	7.15	5.93	100.0	15,377	2.48	1.31	2.13	0.80
LT3	25.58	29.7	7.60	7.07	100.0	19,345	3.22	1.56	2.28	0.78
LT4	26.80	30.5	8.15	6.55	88.1	14,881	2.73	1.41	2.41	0.80
LT5	26.98	29.9	8.06	6.62	100.0	17,361	2.66	1.46	2.50	0.80
LT6	24.88	28.7	7.14	6.08	100.0	16,369	2.13	1.61	2.33	0.80
LT7	30.95	30.4	9.44	8.01	97.6	17,361	3.08	2.08	2.85	0.79
LT8	33.92	31.9	10.82	7.71	100.0	17,857	2.33	2.48	2.90	0.81
HT1	26.63	28.2	7.52	5.41	100.0	17,361	2.46	1.26	1.69	0.83
HT2	20.02	29.4	5.89	6.18	97.6	16,865	2.33	1.84	2.01	0.76
HT3	22.98	29.0	6.67	6.47	100.0	18,105	2.53	1.94	2.01	0.78
HT4	26.28	29.1	7.67	7.07	100.0	19,097	2.83	1.81	2.43	0.79
HT5	27.73	29.1	8.08	8.41	97.6	21,329	3.40	2.31	2.70	0.77
HT6	29.95	30.1	9.02	8.04	95.2	21,329	3.30	1.99	2.75	0.79
HT7	32.26	31.6	10.21	8.80	100.0	22,321	3.60	2.38	2.83	0.78
HT8	33.96	31.8	10.80	9.35	97.6	22,321	3.62	2.48	3.25	0.78
F-t	**	ns	**	**	ns	ns	ns	*	**	ns
%CV	34.5	42.6	38.8	56.9	4.8	15.9	24.4	11.3	15.4	0

Remarks: ns = no significant difference, mean values within the same column followed by the common letter are not significantly different using DMRT, *, ** = statistical difference at 95 and 99% levels of confidence

T1 = control, T2 = cassava starch wastes (CSW) 6.25 t/ha, T3 = cassava tails and stalk (CTS) 6.25 t/ha, T4 =chicken manure (CM) 6.25 t/ha, T5 = CSW 6.25 t/ha + CM 3.125 t/ha, T6 = CTS 6.25 t/ha + CM 3.125 t/ha, T7 = CSW 6.25 t/ha + CM 6.25 t/ha, T8 = CTS 6.25 t/ha + CM 6.25 t/ha

L = 15-15-15 at the rate of 312.5 kg/ha, H = 15-15-15 at the rate of 625 kg/ha

Tr. = treatment, FTY = fresh root yield, AGB = above ground biomass, LB = leaf and branch, HI = harvesting index, F-t = F-test

Table 4 Chemical properties of soil after growing cassava for one crop.

Treatment	pH	OM	Total N	Avail. P	Avail. K	Extr. Ca	Extr. Mg	Extr. K	Extr. Na	CEC
	(1:1 H_2O)	(------g/kg-------)		(-------mg/kg------)		(------------------------$cmol_c$/kg-----------------------)				
Main plot: soil organic amendment										
T1	5.48	3.37c	0.14f	1.37e	17.0a	0.41d	0.11b	0.04	0.28c	1.41
T2	5.38	4.21b	0.16e	1.76d	17.0a	0.51cd	0.17a	0.04	0.39bc	1.17
T3	5.30	4.30b	0.20d	1.96cd	23.6ab	0.73a	0.21a	0.04	0.43abc	1.66
T4	5.31	4.24b	0.21d	2.05cd	31.4c	0.70ab	0.18a	0.03	0.46ab	1.45
T5	5.35	5.31a	0.25c	2.23c	36.7a	0.56bc	0.19a	0.04	0.41ab	1.20
T6	5.28	5.50a	0.29b	2.21c	37.4c	0.55bcd	0.20a	0.03	0.57a	1.62
T7	5.43	5.46a	0.32a	2.60b	38.1bc	0.70ab	0.20a	0.03	0.51ab	1.37
T8	5.40	5.87a	0.34a	3.47a	39.7ab	0.83a	0.20a	0.04	0.37bc	1.45
F-test	ns	**	**	**	*	**	**	ns	*	ns
Sub plot: rate of fertilizer										
L	5.35	4.38b	0.22b	2.15	41.0a	0.53	0.14b	0.03	0.40b	1.46a
H	5.37	5.19a	0.26a	2.26	19.2b	0.72	0.23a	0.04	0.45a	1.38b
F-test	ns	**	**	ns	*	**	**	ns	ns	ns
Interaction: soil organic amendment x rate of fertilizer										
LT1	5.50	2.25	0.14	0.96	21.3	0.45	0.09	0.04	0.33	1.66
LT2	5.36	2.76	0.15	1.89	17.6	0.56	0.17	0.04	0.45	1.18
LT3	5.43	2.90	0.17	1.74	25.6	0.68	0.20	0.04	0.38	1.75
LT4	5.23	3.40	0.18	2.02	45.1	0.53	0.14	0.03	0.44	1.25
LT5	5.36	5.43	0.22	2.26	56.1	0.54	0.12	0.03	0.33	1.33
LT6	5.30	6.00	0.26	2.37	53.4	0.46	0.11	0.02	0.46	1.50
LT7	5.46	5.58	0.29	2.54	52.0	0.52	0.13	0.03	0.45	1.41
LT8	5.36	6.73	0.34	3.44	57.1	0.50	0.12	0.03	0.38	1.58
HT1	5.46	4.50	0.14	1.78	12.7	0.36	0.14	0.05	0.22	1.16
HT2	5.40	5.67	0.18	1.63	16.3	0.46	0.17	0.04	0.32	1.16
HT3	5.16	5.71	0.22	2.18	21.6	0.78	0.22	0.03	0.48	1.58
HT4	5.40	5.09	0.24	2.09	17.7	0.87	0.22	0.03	0.48	1.66
HT5	5.33	5.20	0.28	2.20	17.2	0.59	0.27	0.05	0.49	1.08
HT6	5.26	5.01	0.32	2.04	21.4	0.65	0.29	0.03	0.68	1.75
HT7	5.40	5.33	0.35	2.66	24.2	0.88	0.28	0.03	0.56	1.33
HT8	5.43	5.01	0.34	3.50	22.4	1.16	0.28	0.05	0.37	1.33
F-test	ns	**	**	*	*	**	**	**	ns	ns
%CV	3.5	10.8	0	12.5	59.7	19.5	53.1	10.4	29.4	39.6

Remarks: ns = no significant difference, mean values within the same column followed by the common letter are not significantly different using DMRT, *, ** = statistical difference at 95 and 99% levels of confidence, respectively

T1 = control, T2 = cassava starch wastes (CSW) 6.25 t/ha, T3 = cassava tails and stalk (CTS) 6.25 t/ha, T4 =chicken manure (CM) 6.25 t/ha, T5 = CSW 6.25 t/ha + CM 3.125 t/ha, T6 = CTS 6.25 t/ha + CM 3.125 t/ha, T7 = CSW 6.25 t/ha + CM 6.25 t/ha, T8 = CTS 6.25 t/ha + CM 6.25 t/ha

L = 15-15-15 at the rate of 312.5 kg/ha, H = 15-15-15 at the rate of 625 kg/ha

Conclusion

Soil organic amendment had more effect on fresh root yield of cassava, Huay Bong 80 variety, than did rates of fertilizer (15-15-15) applied when grown on Dan Khun Thot soil. The applications of cassava tails and stalk and chicken manure, and cassava starch waste and chicken manure all at the rate of 6.25 t/ha promoted the greatest amounts of cassava fresh root yield, starch yield, above ground biomass, and starch content. The latter type of application also stimulated the highest amounts of stem base, and leaf and branch. The higher rate of applied chemical fertilizer (625 kg/ha) only brought on the higher above ground biomass than did the lower rate (312.5 kg/ha). The combination between incorporating cassava tails and stalk and chicken manure both at the rate of 6.25 t/ha into the soil before planting and the application of chemical fertilizer at the rate of 6.25 kg/ha gave the highest cassava fresh root yield and starch yield but barely different from the use of the same soil organic amendment with half of the chemical fertilizer applied. However, the higher rate of applied chemical fertilizer gave more number of stem than did the lower rate which will be beneficial for propagation purpose in the next crop. The use of cassava tails and stalk and chicken manure, and the application of cassava starch waste and chicken manure all at the rate of 6.25 t/ha had no effect on soil pH, extractable potassium and CEC but resulted in higher amounts of organic matter, total nitrogen, available phosphorus, available potassium, extractable calcium, extractable magnesium and some micronutrients in exchangeable form left in the soil after one application at the beginning of the experiment. However, cumulative effect needs to be observed if consecutive applications are to be undertaken on the same area.

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