ORIGINAL ARTICLE

Minimum tillage for cassava production in Khon Kaen Province, Thailand

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Abstract

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This research paper study on the comparison between no-tillage (NT) and conventional tillage (CT) incorporated with 3 levels of nitrogen fertilizer application rate (0, 50 and 100 kg N/ha) on the fresh root yield of cassava (var. Rayong 72). The field trial has been established since 2000 on the Satuk soil series (fine loamy, silicious, Oxic Paleustults) Khon Kaen, Thailand. Under no-tillage practices, the physical soil properties were improved compared to the conventional tillage system and the original soil properties at the start of the trial. The soil structure parameters such as total porosity, soil saturated hydraulic conductivity (K_{sat}) increased in NT plot, whilst soil bulk density (ρ_b) decreased compared to CT plot. Results indicated that the higher yield of fresh root of cassava was observed in the NT plot ($P<0.05$) of the first year of the experiment. By contrast, the higher yield of the fresh root of cassava was observed in the conventional tillage of the second year but the different yields were not statistically significantly different ($P>0.05$). For the nitrogen application, the yield increased as nitrogen supply increased but the increment was not significant statistically ($P>0.05$).

Key words : no-tillage, tillage, physical soil properties, cassava

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การปลูกมันสำปะหลังโดยลดการไถพรวนที่ จังหวัดขอนแก่น ประเทศไทย

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ศึกษาการปลูกมันสำปะหลังโดยลดการไถพรวน ได้ดำเนินการทดลองที่ศูนย์ศึกษาค้นคว้าและพัฒนาเกษตรกรรมภาคตะวันออกเฉียงเหนือ จังหวัดขอนแก่น ปี พ.ศ. 2543-2545 โดยวางแผนการทดลองแบบ Split plot จำนวน 4 ซ้ำ ประกอบด้วย ปัจจัยหลักคือระบบการเตรียมดิน (ไถพรวน และไม่ไถพรวน) ปัจจัยรองประกอบด้วย ปุ๋ยไนโตรเจน 3 อัตรา 0, 50 และ 100 กก. N/เฮกตาร์ จากผลการทดลองพบว่า แปลงที่ไม่มีการไถพรวนดินก่อนปลูกมันสำปะหลังทำให้สมบัติทางกายภาพของดินดีขึ้น เมื่อเปรียบเทียบกับก่อนการทดลองคือ ทำให้ความหนาแน่นรวมของดินลดลง ความพรุนรวมของดินสูงขึ้น และค่าสัมประสิทธิ์การนำน้ำของดินสูงขึ้นเมื่อเปรียบเทียบกับแปลงที่มีการไถพรวนดินปลูกมันสำปะหลัง ในด้านผลผลิตของปีแรกพบว่ามันสำปะหลังที่ปลูกในระบบการไม่ไถพรวนดินก่อนปลูกให้ผลผลิตหัวมันสด (59.38 ตัน/เฮกตาร์) ซึ่งสูงกว่าอย่างมีนัยสำคัญทางสถิติเมื่อเปรียบเทียบกันแปลงที่มีการไถพรวนดิน (47.13 ตัน/เฮกตาร์) สำหรับปีที่สองพบว่า ระบบการเตรียมดินปลูกมันสำปะหลังทั้งสองให้ผลผลิตไม่แตกต่างกันทางสถิติ ปุ๋ยไนโตรเจนมีผลทำให้ผลผลิตมันสำปะหลังมีแนวโน้มสูงขึ้น ทั้งในระบบปลูกแบบไถพรวนและไม่ไถพรวนดิน แต่ไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ

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In tropical areas, soil ecosystems are often constrained beyond their natural capacity. Consequently, the soils are reduced in productivity and sustainability. while, the traditional methods of farming in Thailand have resulted in soil deterioration without considering the soil improvement. Continuous cultivation at constant depth creates a zone of high compaction in the surface soil. The depth of this zone will depend on the farmer practices (Spoor, 2000). Thus, soil management will be responsible for important changes in soil quality parameters, particularly those related to soil structure and water movement. Most of cassava plantations in Thailand are grown in light textured soils where the soils are easily eroded. In most cases, cassava farmers prepare their land by plowing with a 3-disc plow followed by a 7-disc harrow and ridger. This causes a very loose soil which is free of weeds and easy to plant. It also causes the soil to be highly susceptible to erosion, while the direct exposure of the soil to sun and rain causes rapid decomposition of organic matter, leaving many soils almost devoid of organic matter and with very poor structure. A minimum tillage system is thought to be the appropriate technique for these soils. A broad range of the minimum tillage systems is used to conserve soil and water, and sustain agricultural productivity. No-till is one type of this system, in which the crop is sown directly into an untilled seedbed without any primary or secondary tillage. Previous crop residue is left on the surface and weeds are generally controlled by herbicides. This system is also called zero-tillage or no-tillage system (Lal, 1995). In a Brazilian Oxisol, Roth *et al*., (1988) reported that bulk density at 20-30 cm depth was significantly lower in no-tillage and minimum tillage systems compared with the conventional tillage system. Accordingly, the total porosity was significantly higher in minimum tillage and no-tillage compared with conventional tillage systems. Despite the large amount of information available on no-tillage practice, there is still lack information related to the use of sandy soil on cassava production.

The objective of this experiment is to develop no-tillage management for cassava production as well as to improve soil physical condition.

Materials and Methods

The field trial has been established since 2000 at Japan International Research Centre for Agriculture Science (JIRCAS), Khon Kaen, Thailand. The soil is Satuk series (fine, loamy silicieous, Oxic Paleustults). The experimental design was split plot in RCBD with 4 replications. Main plots comprised two tillage systems, no-tillage (NT) and conventional tillage (CT). There were three levels of nitrogen supply (0, 50 and 100 kgN/ha) in subplots. Every plot was supplied with 50 kg P_2O_5/ha and 50 kg K_2O/ha. Prior to planting cassava, herbicide was sprayed for weed control in the NT plot. Cassava (var. Rayong 72) was used as a plant index.

Two undisturbed soil samples were collected at each depth within the profile (0-10, 10-20, 20-30, 30-50 and 50-70 cm) for physical soil analysis before and after the first year harvesting. Soil bulk density was determined by the method described by Black (1965). Total porosity was calculated by using the equation $\varepsilon = 1-\rho_b/\rho_s$: where ρ_b is the measured bulk density and ρ_s is the density of soil particles taken as 2.65 Mg/m^3. It is generally accepted for soil particle size density as it represents an average figure that is sufficiently exact for the majority of mechanical analyses (Baver *et al.*, 1972). Changes in the water profile through the experimental period were measured by pressure plate. The other measurements eg,: soil saturated hydraulic conductivity were measured by the method of falling head (Klute, 1986). Soil texture was determined by pipette method (Gee and Bauder, 1986). For chemical soil analysis, a composited soil sample was collected at the start of the trial at 0-10, 10-20, 20-30, 30-50 and 50-70 cm for measuring the pH (1:1 soil:water), organic matter (Walkley and Black, 1934), available P_2O_5 (Bray II) and exchangeable K_2O (NH_4OAc). The obtained data were statistically analyzed using IRRI STAT version 92-1 of the Department of Agriculture.

Results and Discussions

At the start of trial in the 0-50 depth, the soil texture was loamy sand with the bulk density of 1.645 Mg/m^3. The other base measurements taken before the trial showed the mean values of soil pH, organic matter (OM.), avilable P_2O_5 and exchangeable K_2O as 4.97, 0.57%, 17.52 mg/kg soil, and 21.12 mg/kg soil, respectively (Table 1). Based on the soil physical and chemical analyses, the data indicated that the soil used in this trial had low fertility and poor physical properties. At the beginning of the trial, the value of soil porosity was higher and bulk density was lower than the values taken from the no-tillage (NT) and conventioal tillage (CT) plots at the soil surface (0-10 cm). That probably was because the root of cassava pushed the soil ped and caused the more soil compaction. Secondly, the high bulk density and low porosity occurred due to the soil being disturbed by cultivation practice. Moreover, under NT plot, there were certain improved structural parameters, with

Table 1. Soil properties at the start of trial average in the 50 cm depth.

pH	4.97
Organic matter (Walkley and Balck, 1934)	0.57%
Available P_2O_5 (Bray and Kurtz, 1945)	17.52 mg/kg
Exchangeable K_2O (Peech *et al.*, 1947)	21.12 mg/kg
Texture (Pipette method)	Loamy sand
Bulk density (Black, 1965)	1.645 Mg/m^3

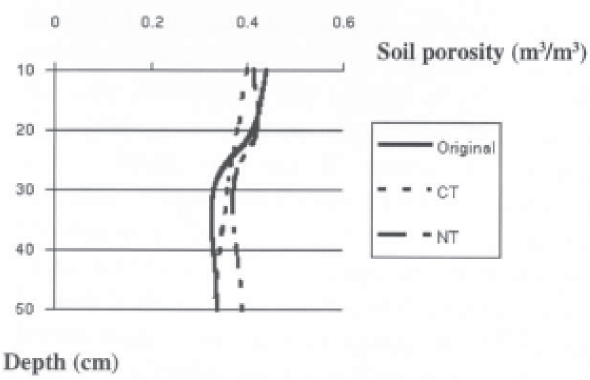

Figure 1. Effect of tillage systems on the soil porosity (m^3/m^3)

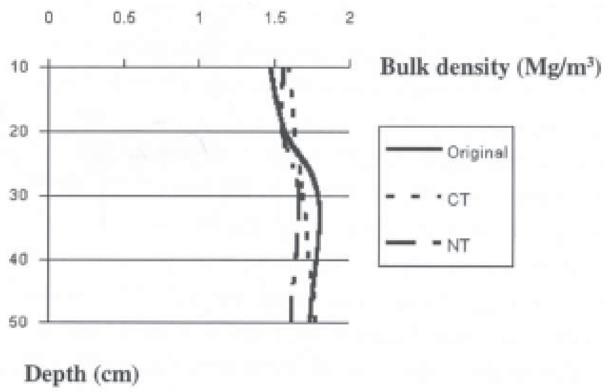

Figure 2. Effect of tillage systems on the soil bulk density (Mg/m^3)

an increase in air porosity (Figure 1) particularly at the depth below 20 cm compared to CT plot and at the start of the trial. There was also an improvement in soil bulk density, the values in NT plot at each depth were lower than those in CT plot (Figure 2). This could be attributed to, firstly, the *in situ* mulching of the plant biomass residues in NT plot - numerous studies have also indicated that crop residues decrease soil compactability (Gupta *et al*., 1987; Ohu *et al*., 1985) -and,secondly, the compaction was due to the cultivation practice, in CT plot. The other parameter which was improved was the saturated hydraulic conductivity. The results indicated that soil saturated hydraulic conductivity values under NT plot were higher than those obtained from CT plot at each depth interval (Table 2). Although, at this period the soil saturated hydraulic conductivity under NT plot was lower than the value from the beginning of the trial, in the long-term experiment, this value might be improved. Probably the porosity and the bulk density were improved and made it possible for soil particles to produce a greater value of soil saturated hydraulic conductivity. In addition, it could also be a result of the influence of *in situ* mulching on soil water content. Unger (1994) pointed out that a major advantage of maintaining crop residues on the surface soil is improved soil water conservation as a result of reduced surface runoff of water and improved soil structure. For the soil water retention, in general, the retained soil water at the beginning of the trial seemed to be lower than those of the CT and NT plots with the exception of the values from pF 0, in particular at 0-20 cm depth {Figures 3(A-C)}. In most cases, the retained water contents in the soil under NT and CT plots were not much

Table 2. Effect of tillage system on soil saturated hydraulic conductivity (K_{sat}, mm/hr) compared to the original (K_{sat}) at 0-10, 10-20, 20-30, and 30-50 cm depth.

Soil depth (cm)	Soil saturated hydraulic conductivity (K_{sat}, mm./hr)		
	Original (at start)	CT	NT
0-10	139.68	13.7	20.15
10-20	29.088	10.30	13.91
20-30	2.385	4.28	15.33
30-50	3.61	0.54	1.64

different from each other at each soil water potential and depth. That might be a result of the root penetration into subsoil of CT and NT plots leading to the water movement. In the result of both years, there were no interactions between the tillage system and the nitrogen application. For the first year (2000/2001), the fresh root yield of cassava grown under no-tillage system was significantly higher (59.38 ton/ha) than that of cassava grown under conventional tillage (47.13 ton/ha) (Table 3). Considering the soil properties after the first year harvest, they were improved as mentioned above. For the nitrogen application, it was found that the cassava fresh root tended to increase as nitrogen supply increased. The average yields were 48.94, 50.50 and 60.31 tons/ha at the nitrogen rates of 0, 50 and 100 kg N/ha, respectively (Table 3). In the second year (2001/2002), the result showed that the different tillage systems gave similar effect on the cassava fresh root yield. Under no-tillage plot, the plants produced the average yield of 52.44 tons/ha which was slightly lower than those grown

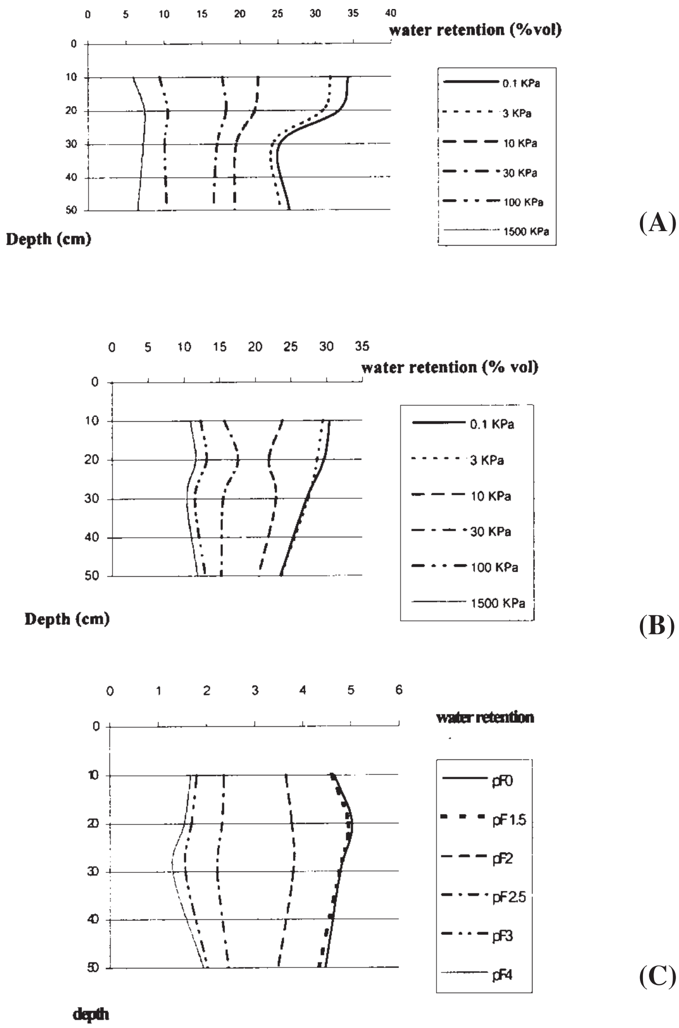

Figure 3. Effect of soil water potential (Kilo Pascal, KPa) at 0-10, 10-20, 20-30, 30-50, and 50-70 cm at (A) the beginning of the trial; (B) under conventional tillage; and (C) under no-tillage system

Table 3. Effect of tillage system and nitrogen on the first year fresh root yield (tons/ha) of cassava cv Rayong 72 grown on Satuk soil series.

Chemical Fertilizer Rate $N-P_2O_5-K_2O$ kg/ha	Tillage system		
	CT	NT	Average
0-50-50	42.75	55.13	48.94
50-50-50	44.94	56.06	50.50
100-50-50	53.69	67.00	60.31
Average	47.13	59.38	53.25
CV 21% F (a) *	F(b) ns	F(axb) ns	

Table 4. Effect of tillage system and nitrogen on the second year fresh root yield (tons/ha) of cassava cv Rayong 72 grown on Satuk soil series.

Chemical Fertilizer Rate $N-P_2O_5-K_2O$ kg/ha	Tillage system		
	CT	NT	Average
0-50-50	51.31	42.69	47.00
50-50-50	54.81	52.19	53.50
100-50-50	55.75	52.44	54.13
Average	54.00	49.13	51.56
CV 12.8%	F (a) ns	F(b) ns	F(axb) ns

under conventional tillage having average yield of 54.00 tons/ha (Table 4). For the nitrogen application, the results showed as the same pattern as in the first year (Table 4).

Conclusion

In growing cassava on fine loamy soil, no-tillage system improved physical soil conditions compared to conventional tillage. The porosity and soil saturated hydraulic conductivity increased under no-tillage plot whereas the soil bulk density was reduced. The cassava fresh root of the first year was significantly higher than that of CT plot. However, the results in the second year were different from the first year. Nitrogen applications in both years had no effect on the cassava fresh root yields.

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