Effect of Methods of Land Preparation on the Yields of Four Cassava Cultivars in Thailand

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Abstract

Cassava has been grown in Thailand for many years. Land is usually prepared by plowing with a 3-disk plow followed by a 7-disk harrow and ridging. This method of land preparation results in a very loose soil, which is free of weeds and easy to plant. However, it has also led to the formation of a compacted subsoil or hardpan. A trial on alternative methods of land preparation was conducted at three sites from 2001 to 2004 to determine the effect of land preparation on the yields of four cassava cultivars. The results indicate that on average for three years in a farmer's field near Rayong Field Crops Research Center, tillage treatments had a significant effect on the fresh root yield of the four cassava cultivars. Using a subsoiler followed by 3-disk plow produced the highest fresh root yield of 24.60 t/ha, while the no-tillage treatment produced the lowest yield of 19.26 t/ha. At the Thai Tapioca Development Institute site, there were significant differences among tillage treatments for fresh root yield of the four cassava cultivars. Using the subsoiler followed by a chisel plow produced the highest fresh root yield of 21.59 t/ha and the second highest net income; this was followed by the no-tillage treatment (which brought in the highest net income). At Khaw Hin Sorn Research Station of Kasetsart University, tillage treatments also had a significant effect on fresh root yields. Using a 3-disk plow followed by 7-disk harrow and ridging up-and-down the slope produced the highest fresh root yield of 32.21 t/ha, but using a 3-disk plow followed by a 7-disk harrow, with or without subsoiling, brought in the highest net incomes. Among the four cultivars, there was no significant difference in fresh root yield; however, they differed in starch content.

INTRODUCTION

In Thailand, most cassava farmers prepare their land by plowing with a 3-disk plow followed by a 7-disk harrow and ridging. This results in a very loose soil, which is free of weeds and easy to plant (Tongglum et al., 2000). It also leaves the soil highly susceptible to erosion, while direct exposure of the soil to the sun and the rain causes rapid decomposition of organic matter (OM), resulting in many soils being almost devoid of OM and with very poor structure. Moreover, frequent passes with a disk plow has caused the formation of a hardpan at about 20 cm depth which impedes drainage, resulting in high runoff and erosion, and in some years low yields due to waterlogging.

On the other hand, the hardpan may help to retain moisture during years of low rainfall and during the dry season, thus increasing yields and allowing the planting of cassava during the dry season. The use of tillage implements that loosen but do not turn over the soil may require less energy and be cheaper than the use of disk plows, but the crop will probably require chemical weed control. This leaves the soil better protected against erosion. The breaking of the compacted subsoil will probably improve drainage, which may increase yields, especially in very wet years. The objective of this study was to compare several methods of land preparation, from zero tillage to complete tillage (traditional practice in Thailand) in terms of management (planting, weed control, harvest), cassava root yield and starch content, as well as economic benefits.

MATERIALS AND METHODS

The experiments were conducted for three consecutive years from 2001/02 to 2003/04 at three sites: in a farmer's field near Rayong Field Crops Research Center (RFCRC); at Khaw Hin Sorn Research Station of Kasetsart University; and at Huay Bong Cassava Research and Development Center of the Thai Tapioca Development Institute (TTDI). The experimental design was a split-plot in randomized complete blocks with four replications at each site, except for three replications at Khaw Hin Sorn Research Station. Treatments comprised 10 tillage treatments in the main plots: 1. no tillage, initial weed control with glyphosate; 2. tillage by chisel plow, spaced at 50 cm apart, initial weed control with glyphosate; 3. tillage by subsoiler (ripper), spaced at 50 cm apart, initial weed control with glyphosate; 4. tillage by subsoiler followed by chisel plow, initial weed control with glyphosate; 5. tillage by cassava harvester, initial weed control with glyphosate; 6. tillage by one pass of a 3-disk plow; 7. tillage by subsoiler followed by one pass of a 3-disk plow; 8. tillage by one pass of a 3-disk plow, followed by one pass of a 7-disk harrow; 9. tillage by one pass of a 3-disk plow, followed by one of a 7-disk harrow and contour ridging; 10. tillage by one pass of a 3-disk plow, followed by one of a 7-disk harrow and up-and-down ridging. These treatments were tested over three years at Rayong, and only in the 1st year at TTDI and Khaw Hin Sorn. At these latter two sites, three other treatments replaced Treatments 6, 7 and 10 in the 2nd and 3rd years, namely: 11. tillage by subsoiler, followed by one pass of a 7-disk harrow, initial weed control with glyphosate; 12. tillage by subsoiler, followed by one pass of a 7-disk harrow; 13. tillage by subsoiler, followed by one pass each of a 3-disk plow and a 7-disk harrow. Subplot treatments were four cassava cultivars: V1 = 'KU 50'; V2 = 'Rayong 5'; V3 = 'Rayong 72' and V4 = 'Rayong 90'. Cassava was grown at a spacing of 100 cm x 80 cm. Chemical fertilizer of grade 15-7-21 or 15-15-15 was applied at the rate of 312.5 kg/ha at one month after planting. Cassava was harvested at 10-11 months.

Gross and net incomes were estimated for some land tillage treatments.

RESULTS AND DISCUSSION

There were no interactions between tillage treatments and cassava cultivars in terms of fresh root yield and starch content at all three sites of the experiment (Table 1). Means over the three years showed that at the farmer's field at Rayong, tillage treatments had a significant effect on the fresh root yields of the four cassava cultivars in the1st and 3rd years. Using a subsoiler followed by a 3-disk plow produced the highest fresh root yield of 24.60 t/ha, while the no-tillage treatment produced the lowest fresh root yield of 19.26 t/ha (Table 2). In a similar land preparation trial conducted at RFCRC in 1981, the use of a subsoiler followed by a 7-disk harrow produced the highest cassava yield (Tongglum et al., 2000).

At the TTDI site, tillage treatments also had significant effects on the fresh root yields of the four cassava cultivars in all three years. Using a subsoiler followed by a chisel plow produced the highest fresh root yield of 21.59 t/ha; this was followed by the no-tillage treatment, which resulted in a fresh root yield of 20.37 t/ha (Table 2).

At Khaw Hin Sorn Research Station, tillage treatments had a significant effect on fresh root yield only in the 2nd year. Using a 3-disk plow followed by a 7-disk harrow or followed by contour ridging produced the highest fresh root yields of 30.31 and 32.21 t/ha, respectively (Table 2). Means over three years and over three sites showed that the 3-disk plow followed by 7-disk harrow and contour ridging produced the highest fresh root yield of 24.16 t/ha. Using a subsoiler followed by a chisel plow produced a fresh root yield of 23.39 t/ha (Table 2). However, root starch content was not significantly affected by tillage treatments, but was significantly different among the four cassava cultivars (Table 1).

Using the third year's data on root yield and starch content from the TTDI and Khaw Hin Sorn sites, production cost, gross and net incomes were calculated for each the tillage treatments. Production cost at TTDI was highest (US$298.91) when tillage was by the subsoiler followed by chisel after initial weed control by glyphosate. This resulted in a net income of only US$84.59/ha. In contrast, the no-tillage treatment gave a highest net income of US$162.50/ha, compared with traditional practices using a 3-disk plow followed by a 7-disk harrow with or without contour ridging. These traditional practices at TTDI resulted in negative net incomes.

At Khaw Hin Sorn, tillage by a subsoiler followed by a 3-disk plow then a 7-disk harrow had the highest production cost of US$419.53/ha, but gave the highest net income of US$329.97/ha. For tillage by the cassava harvester, the production cost was US$380/ha which gave a net income of US$289.25/ha (Tables 3 and 4). At this site, the use of the cassava harvester after spraying with glyphosate, or tillage using a subsoiler followed by a 7-disk harrow alone, or by a 3-disk plow as well as a 7-disk harrow may be viable alternatives to the use of a 3-disk plow followed by a 7-disk harrow. Jongruaysup et al. (2002) reviewing the results of four land preparation trials conducted in Thailand from 1992 to 2002 concluded that the standard practice of using a 3-disk plow followed by a 7-disk harrow, with or without ridging, generally produced the highest cassava yields, but that no-tillage systems improved the soil's physical conditions such as porosity, bulk density and saturated hydraulic conductivity in a similar loamy sand soil in Khon Kaen, Thailand.

CONCLUSIONS

The standard practice of using a 3-disk plow followed by a 7-disk harrow and ridging, with or without prior subsoiling, produced the high cassava fresh root yields. Using the subsoiler followed by a chisel or by 3-disk plow and 7-disk harrow is a more costly method of land preparation, but it may result in a higher net income. There was no interaction between tillage treatments and cassava cultivars in terms of fresh root yield and starch content.

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Tables

Table 1. Effect of various methods of land preparation on the root yield and starch content of four cassava cultivars grown at three sites (Rayong, TTDI, Khaw Hin Sorn) in Thailand over three years (2001/02 to 2003/04)

Treatment	Root yield (t/ha)					Starch content				
	V_1[1]	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
1. No tillage; glyphosate	22.23	21.59	21.35	22.70	21.99	21.5	21.5	19.5	23.9	21.6
2. Chisel plow; glyphosate	20.95	21.59	20.79	21.20	21.13	22.7	22.0	19.4	24.2	22.1
3. Subsoiler; glyphosate	21.56	21.05	20.35	20.59	20.88	23.0	21.7	19.6	24.5	22.2
4. Subsoiler + chisel; glyphosate	22.23	24.72	24.18	22.44	23.39	23.7	22.2	20.1	25.5	22.9
5. Cassava harvester; glyphosate	21.48	23.14	23.16	22.29	22.52	22.7	21.6	19.4	24.4	22.0
6. 3-disk plow[2]	19.03	19.98	19.86	16.21	18.77	22.5	20.6	19.6	22.3	21.2
7. Subsoiler + 3-disk plow[2]	21.45	21.61	22.62	22.20	21.97	23.1	22.2	20.2	25.2	22.7
8. 3-disk plow + 7-disk harrow	22.88	21.88	22.76	21.46	22.25	22.6	21.4	19.5	24.1	21.5
9. 3-disk + 7-disk + contour ridging	25.27	23.69	23.56	24.14	24.16	22.5	22.0	19.2	25.0	22.2
10. 3-disk + 7-disk + up-down ridging[2]	19.66	21.38	21.48	22.41	21.23	23.0	20.7	19.6	24.6	22.0
11. Subsoiler + 7-disk; glyphosate[3]	25.93	22.78	28.07	23.15	24.98	22.4	23.4	20.9	24.7	22.8
12. Subsoiler + 7-disk harrow[3]	24.74	20.65	23.46	23.15	23.00	23.3	23.5	20.4	23.7	22.7
13. Subsoiler + 3-disk + 7-disk[3]	26.93	26.01	27.25	25.24	26.35	23.5	23.8	22.5	23.9	23.4
Mean	22.64	22.31	22.99	22.09	22.51	22.8	22.0	20.0	24.3	22.2

[1] V_1 = 'KU 50'; V_2 = 'Rayong 5'; V_3 = 'Rayong 72'; V_4 = 'Rayong 90'

[2] Only in the 1st year for the TTDI and Khaw Hin Sorn sites

[3] Only at the TTDI and Khaw Hin Sorn sites for the 2nd and 3rd years

Table 2. Summary of fresh root yields (t/ha) from a land preparation experiment conducted for three consecutive years in three sites in Thailand from 2001/02 to 2003/04

Treatment	Rayong				TTDI				Khaw Hin Sorn				Mean over 3 years and 3 sites	Mean over 2nd and 3rd years[3]
	1st year	2nd year	3rd year	Mean	1st year	2nd year	3rd year	Mean	1st year	2nd year	3rd year	Mean		
1. No tillage; glyphosate	11.46	23.95	22.39	**19.26**	19.91	26.07	15.14	**20.37**	21.45	32.71	24.90	**26.35**	21.99	24.70
2. Chisel plow; glyphosate	12.03	24.43	22.84	**19.93**	17.78	25.10	10.93	**17.94**	20.56	34.18	21.80	**25.51**	21.13	23.00
3. Subsoiler; glyphosate	13.70	24.91	22.62	**20.18**	16.31	24.32	10.10	**16.91**	19.20	33.01	24.48	**25.56**	20.88	22.98
4. Subsoiler + chisel; glyphosate	14.85	25.99	25.04	**21.96**	21.87	28.71	14.20	**21.59**	19.07	37.65	23.12	**26.61**	23.39	25.92
5.Cassava harvester; glyphosate	14.60	25.83	23.43	**21.28**	16.08	25.52	12.52	**18.04**	18.56	39.50	26.66	**28.24**	22.52	26.05
6. 3-disk plow[1]	13.66	22.60	23.82	**20.08**	18.00	-	-	-	18.81	-	-	-	-	-
7. Subsoiler + 3-disk plow[1]	17.57	28.54	27.68	**24.60**	16.59	-	-	-	24.71	-	-	-	-	-
8. 3-disk plow + 7-disk harrow	11.93	23.00	24.02	**19.65**	18.15	23.31	8.92	**16.79**	21.27	41.99	27.67	**30.31**	22.25	25.47
9. 3-disk + 7-disk + contour ridging	17.47	24.60	25.35	**22.47**	18.32	26.57	8.53	**17.81**	24.88	46.35	25.40	**32.21**	24.16	26.71
10. 3-disk + 7-disk + up-down ridging[1]	19.50	25.86	23.41	**22.92**	17.52	-	-	-	23.25	-	-	-	-	-
11. Subsoiler + 7-disk; glyphosate[2]	-	-	-	-	-	25.35	11.91	-	-	36.24	26.42	-	-	24.98
12. Subsoiler + 7-disk harrow[2]	-	-	-	-	-	24.90	10.04	-	-	28.65	28.39	-	-	23.00
13. Subsoiler + 3-disk + 7-disk[2]	-	-	-	-	-	26.40	10.88	-	-	38.95	29.16	-	-	26.35
Mean	16.68	24.96	24.06	**21.23**	18.05	25.63	11.32	-	21.18	36.92	25.80	-	-	
CV (%)	46.8	21.1	17.2		22.3	18.3	47.2		35.0	13.8	29.7			
Treatment	*	NS	*		*	*	*		NS	*	NS			
LSD (p=0.05)	4.98	4.55	3.00		2.92	3.42	3.88		6.36	4.37	4.97			

[1]Only in the 1st year for the TTDI and Khaw Hin Sorn sites; [2]Only at the TTDI and Khaw Hin Sorn sites for the 2nd and 3rd years
[3]Means over only the TTDI and Khaw Hin Sorn sites for the 2nd and 3rd year data

Table 3. Effect of various methods of land preparation on production costs of cassava planted at TTDI and Khaw Hin Sorn in Thailand

Treatment	Production costs (US$/ha)[2]									
	Land preparation		Planting cassava	Fertilizers + application	Weed control		Harvest + transport		Total	
	TTDI	KHS[1]			TTDI	KHS	TTDI	KHS	TTDI	KHS
No tillage; glyphosate	21.09	21.09	23.44	62.50	44.53	61.72	102.19	168.12	253.75	336.87
Chisel plow; glyphosate	44.53	39.84	23.44	62.50	44.53	61.72	73.75	147.19	248.75	334.69
Subsoiler; glyphosate	49.22	49.22	23.44	62.50	44.53	61.72	68.12	165.16	247.81	362.03
Subsoiler + chisel; glyphosate	72.66	67.97	23.44	62.50	44.53	61.72	95.78	156.09	298.91	371.72
Cassava harvester; glyphosate	52.34	52.34	23.44	62.50	44.53	61.72	84.53	180.00	267.34	380.00
3-disk plow + 7-disk harrow	51.56	46.87	23.44	62.50	44.53	61.72	60.16	186.72	242.19	381.25
3-disk + 7-disk + contour ridging	70.31	65.62	23.44	62.50	44.53	61.72	57.50	171.41	255.16	381.56
Subsoiler + 7-disk; glyphosate	72.66	72.66	23.44	62.50	44.53	61.72	80.47	178.28	283.59	398.59
Subsoiler + 7-disk harrow	51.56	46.87	23.44	62.50	44.53	61.72	67.81	191.56	249.84	386.09
Subsoiler + 3-disk + 7-disk	79.69	75.00	23.44	62.50	44.53	61.72	73.44	196.87	283.59	419.53

[1]Khaw Hin Sorn

[2]Inputs:	Cost (US$)	
	TTDI	Khaw Hin Sorn
Glyphosate (48%)	3.75/liter	3.75/liter
Herbicide application	9.37/ha	9.37/ha
Tillage by chisel plow	23.44/ha	18.75/ha
Tillage by subsoiler	28.12/ha	28.12/ha
Tillage by 3-disk plow	28.12/ha	28.12/ha
Tillage by cassava harvester	18.75/ha	31.02/ha
Tillage by 7-disk harrow	23.44/ha	18.75/ha

Inputs:	Cost (US$)	
	TTDI	Khaw Hin Sorn
Ridging	18.75/ha	18.75/ha
Fertilizers, 15-7-18	9.00/50 kg	9.00/50 kg
Fertilizer application	1.00/50 kg	1.00/50 kg
Hand weeding (once)	23.44/ha	40.62/ ha
Harvesting cassava	3.00/t	3.00/t
Transporting cassava	3.75/t	3.75/t

Table 4. Effect of various methods of land preparation on production costs, gross and net incomes from cassava planted at TTDI and Khaw Hin Sorn, Thailand in 2003/04 (3rd year data)

Treatment	Starch content (%)		Gross income[1] (US$/ha)		Production costs[2] (US$/ha)		Net income (US$/ha)	
	TTDI	KHS[3]	TTDI	KHS	TTDI	KHS	TTDI	KHS
No tillage; glyphosate	25.0	19.2	416.25	612.50	253.75	336.87	162.50	274.63
Chisel plow; glyphosate	24.1	20.1	295.75	546.00	248.75	334.69	47.00	211.31
Subsoiler; glyphosate	23.5	20.0	270.25	612.00	247.81	362.03	22.44	249.97
Subsoiler + chisel; glyphosate	24.0	20.3	383.50	581.50	298.91	371.72	84.59	209.78
Cassava harvester; glyphosate	23.2	20.2	333.00	669.25	267.34	380.00	65.66	289.25
3-disk plow + 7-disk harrow	23.5	20.8	238.50	702.75	242.19	381.25	-3.69	321.50
3-disk + 7-disk + contour ridging	22.7	20.8	224.75	645.25	255.16	381.56	-30.41	263.69
Subsoiler + 7-disk; glyphosate	24.7	20.7	325.75	669.75	283.59	398.59	42.16	271.60
Subsoiler + 7-disk harrow	24.2	19.8	272.00	707.00	249.84	386.09	22.60	320.91
Subsoiler + 3-disk + 7-disk	23.6	21.4	291.50	749.50	283.59	419.53	7.91	329.97
Mean	23.8	20.3	305.00	649.50	263.09	375.33	42.03	274.22

[1]Based on root yields shown in Table 2 and price of cassava being US$0.03/kg fresh roots at 30% starch. There is a US$0.005 reduction in price for every 1% lower starch content than 30%.

[2]Production costs: see Table 3.

[3]Khaw Hin Sorn

Note: US$1.00 = 40 baht