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Minimal tillage in cassava cultivation on peat

(Pembajakan yang minimum dalam penanaman ubi kayu di tanah gambut)

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Key words: cassava, tillage, liming, peat cultivation, reduced costs

Abstrak

Pembajakan untuk penanaman ubi kayu dapat dikurangkan daripada dua pusingan kepada hanya satu pusingan pada musim penanaman yang pertama sebelum pengapuran dilakukan. Kapur yang ditaburkan tidak perlu dicampur ke dalam tanah sekiranya tanah telah dibajak sebelum itu. Pada musim penanaman yang kedua, pembajakan tidak diperlukan kerana rumpai dapat dikawal dengan cara kimia sebelum ubi kayu ditanam. Amalan pembajakan satu pusingan telah meningkatkan hasil ubi sebanyak 10 t/ha dalam tempoh dua musim penanaman, dibandingkan dengan amalan pembajakan biasa. Oleh sebab kos pengeluaran dapat dikurangkan manakala hasil pula meningkat, maka pendapatan bersih daripada dua musim penanaman ubi kayu bertambah sebanyak M$1 323.50/ha dengan amalan mengurangkan pembajakan.

Abstract

Tillage in cassava cultivation on peat may be reduced from two rounds of rototilling in the first season of cropping to a single round prior to liming. It was found that lime could be broadcast without subsequent incorporation provided the land had been tilled beforehand. In the second season of cropping, instead of clearing surface weeds by one round of rototilling, these were controlled chemically prior to planting. A significant yield increase of 10 t/ha over the normal tillage practice was recorded using this system over the two seasons of cropping. As a result of reduced costs and increased yield, an additional net income of M$1 323.50/ha over the two cropping seasons was achieved with reduced tillage in cassava cultivation.

Introduction

Cassava (*Manihot esculenta* Crantz) is a root crop which adapts readily to drained peat (Joseph et al. 1974; Chew 1977; Tan and Thiagarajan 1986; Tan and Chan 1989). Some liming is essential to raise the low pH of peat to a level which ensures optimal cassava growth and yield. A single application of lime has been found to have effects lasting 3–5 years before a fresh application is required (Chew 1977).

Peat is a friable organic soil which is particularly amenable to the harvesting operation in root crops as well as groundnut. The current practice is to till the land (one round of ploughing or one round of rototilling), apply lime and incorporate it into the soil with an additional round of rototilling. The cost of land preparation per hectare is around M$100 per round of tillage (ploughing or rototilling). Subsequent seasons of cropping are preceded by tillage

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Table 1. Tillage treatments over two seasons of cropping cassava on peat

Treatment	First season	Second season
T1	Normal tillage (one round of rototilling): lime incorporated by another round of rototilling	One round of rototilling
T2	Minimal tillage: lime broadcast followed by one round of rototilling to incorporate it	Zero tillage
T3	Minimal tillage: one round of rototilling followed by lime broadcast without incorporation	Zero tillage
T4	Zero tillage with lime broadcast	Zero tillage

before planting.

The question arises that without the need to apply lime and to incorporate it into the soil, is it in fact necessary to till the soil prior to planting? Tillage in general is carried out mainly to control and eliminate weeds, incorporate lime and improve soil structure or tilth. Surface weeds at planting can be easily taken care of by chemical means. Lime as mentioned earlier is applied only once in 3–5 years, implying that tillage to incorporate lime is not really necessary after the initial lime application. Unlike seed crops, cassava can be planted using 60 cm long mature stem cuttings planted vertically (Chan et al. 1983), hence it is less important to loosen the soil for planting.

The objectives of the study, therefore, were to examine the effects of reduced and zero tillage (in relation to lime application) on the growth and yield of cassava on peat, and to compare the economics of such practices.

Materials and methods

The study was conducted at the MARDI Integrated Peat Research Station in Pontian, Johor over two cropping seasons. Lime was applied only before the first season of cropping. Dolomitic lime was applied at 2 t/ha one month before planting. Soil samples were collected to a depth of 15 cm. From these, soil pH readings (1:10 soil/water determination) were recorded before and after liming (the latter just prior to planting), and also at the end of the first season's crop after cassava had been harvested.

Three degrees of tillage were tested over the two seasons, namely normal (or current) tillage practice (which entailed one round of rototilling at the start of each cropping season as well as an additional round after lime was applied in the first season), minimal tillage (which reduced rototilling to only one round in the first season), and zero tillage (with lime broadcast but not incorporated). The minimal tillage practice consisted of two separate treatments, depending on whether rototilling was performed before or after lime was broadcast. The four treatments are summarized in *Table 1*.

Rototilling was achieved using a pedestrian tractor-mounted implement which tills to an average depth of 20 cm. In treatments T2 and T4, the weeds were controlled chemically with paraquat (2 L/ha, equivalent to 0.56 kg a.i./ha) before the lime was applied.

In the second season, no lime was applied. Rototilling was carried out prior to planting only in T1. The other three treatments (T2, T3 and T4) received no tillage (*Table 1*), and weeds were controlled by spraying with paraquat prior to planting cassava.

The variety used in the study was Black Twig, and the cuttings used were mature stem portions of 60 cm length. Planting was vertical and spaced at 1.0 m x 1.0 m. Plot sizes measured 10 m x 10 m to allow for the sampling of the 64 central plants (8 x 8).

A randomized complete block design, replicated four times, was adopted. Treatments in the second season were

Table 2. Crop performance data under four levels of tillage in the first season of cropping

Tillage level*	Germination (%)	Plant height (cm)	Fresh root yield (t/ha)	Weight of "tops"** (t/ha)	Harvest index	Commercial root no. (per ha)	Total root no. (per ha)	Starch content (%)	Starch yield (t/ha)
T1	100.0a	343a	26.8a	61.2a	0.47a	55 600a	183 500a	23.5a	6.29ab
T2	100.0a	312a	26.2a	62.4a	0.46a	52 800a	197 100a	23.4a	6.14ab
T3	100.0a	324a	29.4a	66.9a	0.47a	57 100a	190 300a	24.3a	7.14a
T4	100.0a	332a	25.2a	65.4a	0.44a	51 500a	188 000a	23.5a	5.89b

Note:

* T1 : One round of rototilling, application of lime, followed by another round of rototilling
T2 : One round of rototilling, following application of lime
T3 : One round of rototilling, followed by lime broadcast
T4 : No tillage; lime broadcast

** "Tops" include cuttings, stems and leaves

Values in each column with the same letter are not significantly different from one another according to Duncan's New Multiple Range Test ($p = 0.05$)

located in the same treatment plots as the first season.

The crop was supplied with a compound fertilizer of formulation 12:6:22:3 ($N:P_2O_5:K_2O:MgO$) at 680 kg/ha supplemented with sulphate of ammonia and copper sulphate at 575 and 10 kg/ha respectively [since applied copper has a long residual effect on peat (Chew et al. 1978), lasting 3–5 years, it was applied only in the first season]. The fertilizers were banded by the side of the planted row and covered with soil at the time of planting.

Pre-emergence weed control was effected by spraying alachlor at 4 L/ha (equivalent to about 3.0 kg a.i./ha). Paraquat, a contact herbicide, at 2 L/ha (equivalent to 0.56 kg a.i./ha) was applied to control weeds in the mid-season and prior to harvesting.

The crop was harvested at 12 months after planting. Data were collected on germination, plant height at harvest, fresh root yield, weight of top growth including cuttings, harvest index [fresh root weight per total fresh plant weight], number of commercial-sized roots, total number of roots, starch content of roots [estimated by specific gravity measurements, after Noor Auni and Tan (1980)] and starch yield (starch content x fresh root yield).

Results and discussion

Effects of tillage on crop performance

There were no significant effects on all the characters studied in the first season except in starch yield (*Table 2*). Treatment T4 produced a significantly lower starch yield (by 21%) than Treatment T3. Although statistical analyses did not reveal significant differences in root yield and harvest index, the same two treatments showed respectively the lowest and highest values in these two characters. Since harvest index is an indicator of efficiency in partitioning dry matter or photosynthate, it would appear that the zero tillage treatment depressed cassava efficiency in starch production. More dry matter was directed to the aerial plant parts rather than the storage roots. Besides the possibility of a reduced root sink (as reflected by a smaller absolute commercial root number), the actual mechanism is unclear.

In the second season, no significant differences were detected in all the characters studied. In other words, even without tillage over two seasons, peat does not seem to have compacted to the extent of affecting crop growth and root development.

Combined analyses of the data collected for the two seasons were carried out on the means for germination, plant height, harvest index and starch content of the roots, and

Table 3. Mean performance data and cumulative yield data under four levels of tillage over two seasons of cropping

	Mean data				Cumulative data	
Tillage level*	Germination (%)	Plant height (cm)	Harvest index	Starch content (%)	Fresh root yield (t/ha)	Starch yield (t/ha)
T1	99.5b	356a	0.42a	23.9a	48.7b	11.6b
T2	99.4b	351a	0.40a	23.8a	49.1b	11.7b
T3	99.5b	352a	0.44a	24.0a	59.3a	14.3a
T4	100.0a	343a	0.40a	24.1a	49.0b	11.8b

Note:

*	1st season	2nd season
T1 =	One round of rototilling, application of lime, followed by another round of rototilling	One round of rototilling
T2 =	One round of rototilling, following application of lime	Zero tillage
T3 =	One round of rototilling, followed by lime broadcast	Zero tillage
T4 =	Zero tillage; lime broadcast	Zero tillage

Values in same column with same letter are not significantly different from one another according to Duncan's New Multiple Range Test ($p = 0.05$)

also on the cumulative fresh root and starch yields over the 2 years. For some unknown reason, mean germination was highest in Treatment T4 compared with the rest. The mean data for plant height, harvest index and starch content showed no differences among the four treatments *(Table 3)*. Cumulative root and starch yields from the Treatment T3 were significantly higher than those of the other treatments. Total root yield over the two seasons was higher in Treatment T3 by about 10 t/ha over the other tillage treatments.

It was surprising that the results of the study show there was no advantage in terms of cassava yield in incorporating lime into the soil by tillage after application (T1 or T2 vs. T3). pH readings tended to be generally quite high for peat. This could be due to residual effects of lime applied previously to the experimental area to raise pH close to 5.0 for a sweet potato crop. The values show that the increases in pH due to liming at 1 month after application were in the following order:
Treatment T3 (0.4) > Treatment T1 (0.3) > Treatment T2 (0.2) > Treatment T4 (0.1) *(Table 4)*. The LSD test on these values showed that Treatment T3 was as effective as Treatment T1 and T2 in raising pH and was significantly better than Treatment T4.

At the end of the first crop, the pH increases due to liming in the various treatments remained in the same order as before. This time pH in Treatment T3 was not significantly different from that of Treatment T1, but was significantly higher than in Treatment T2 *(Table 4)*. Since Treatment T3 and T2 differed only in the time of tillage (before and after liming, respectively), it would appear that it is more important to till the land prior to liming to facilitate the infusion of applied lime into the soil, possibly through rain action. This is borne out by examining plot data in these two treatments. For example, when pH before liming was 4.6, it was raised to 4.8 at 1 month after liming in Treatment 2. However, in Treatment T3, the same pH was raised to 5.0, implying a more efficient liming effect with the latter tillage treatment. The effect would appear to be in contrary to

Table 4. pH readings in individual plots before and after liming, their means and differences (at 1 month and at the end of the first season's crop)

Tillage level	Rep. 1			Rep. 2			Rep. 3			Rep. 4			Mean			Difference	
	B	A1	A2	B	A1	A2	B	A1	A2	B	A1	A2	B	A1	A2	A1 - B	A2 - B
T1	5.2	5.4	6.3	4.9	5.0	5.6	4.8	5.3	5.5	4.8	5.0	5.7	4.9	5.2	5.8	0.3ab	0.9ab
T2	4.7	5.0	5.5	4.7	4.7	5.4	5.2	5.4	5.8	4.6	4.8	4.9	4.8	5.0	5.4	0.2ab	0.6b
T3	4.2	4.8	5.4	4.6	5.0	6.0	4.6	5.0	5.5	4.9	5.0	5.9	4.6	5.0	5.7	0.4a	1.1a
T4	4.5	4.5	5.6	4.9	5.2	5.6	4.8	4.8	4.7	4.9	5.0	5.1	4.8	4.9	5.2	0.1b	0.4b

Note:
T1 = One round of rototilling, application of lime, followed by another round of rototilling
T2 = One round of rototilling, following application of lime
T3 = One round of rototilling, followed by lime broadcast
T4 = No tillage; lime broadcast

B = Before liming
A1 = After liming before first season's planting
A2 = After first season's crop harvest

In the last two columns, values with same letter are not significantly different from one another according to LSD. test ($p = 0.05$)

results on mineral soils where the raising of soil pH is dependent on the degree of incorporation into the soil (of course, drained peat has a completely different texture from mineral soils). Further research will be required to substantiate this current finding.

Data were collected on rates of harvesting for the various tillage treatments in the second season of cropping. No discernible increase in difficulty in extracting the roots from the soil was observed with reduced or zero tillage compared with normal tillage practice. This again implies little or no compaction had taken place because of less tillage.

Economic comparisons among tillage treatments

Comparative costings for each of the tillage levels were computed using partial budgets *(Table 5)*. It may be seen that the minimal tillage system with lime broadcast but not incorporated (T3) produced the highest extra income of M$1 323.50/ha over 2 years when compared with the normal tillage practice. In this system, the land was rototilled once in the first season of cropping to clear the ground surface of weeds before lime was broadcast. No mechanical land preparation was carried out in the second season of cropping. The savings came from reducing the need for rototilling in two seasons of cropping from three rounds to one. Additional expenditure came from spraying paraquat either prior to harvesting the first crop or just prior to planting the second. The higher root yield from this system amounted to an extra 10 t/ha (total over the two crops).

Carrying this further, it may be assumed that if the system is practised for three consecutive seasons (before lime application becomes necessary again), the partial budget reveals an extra revenue of M$1 397/ha *(Table 6)*. This assumes the costs of field preparation, paraquat and labour for spraying remain unchanged, and no addition to or loss in yield is encountered. A trial on monocropping cassava over five consecutive seasons has shown that root yields can be sustained given the correct fertilizer rates (Tan and Chan 1989). In other words, over three seasons of cropping, a farmer on peat can expect M$1 397 over and above the normal returns he gets from cassava cultivation, which is estimated at around M$1 800 for a yield of 30 t/ha at a root price of M$115/t and costs of production amounting to $1 655/ha (Anon. 1988).

An additional advantage of this minimal

Table 5. Partial budget for different tillage levels vs. normal tillage (for 1 ha production over two seasons)

A. Minimal tillage with lime incorporated (T2 vs. T1)			
Extra costs		**Costs saved**	
Paraquat (4 L)	M$ 23.00[1]	Tillage (x 2)	M$200.00[2]
Spraying (x 2)	M$ 30.00[3]		
Revenue foregone	M$ 0.00	Extra revenue	M$ 0.00
Total	M$ 53.00	Total	M$200.00
			M$147.00
B. Minimal tillage with lime broadcast (T3 vs. T1)			
Extra costs		**Costs saved**	
Paraquat (2 L)	M$ 11.50	Tillage (x 2)	M$200.00
Spraying	M$ 15.00		
Revenue foregone	M$ 0.00	Extra revenue	
		Increased yield 10 t	M$1 150.00[4]
Total	M$ 26.50	Total	M$1 350.00
			M$1 323.50
C. Zero tillage with lime broadcast (T4 vs. T1)			
Extra costs		**Costs saved**	
Paraquat (4 L)	M$ 23.00	Tillage (x 3)	M$300.00
Spraying (x 2)	M$ 30.00		
Revenue foregone	M$ 0.00	Extra revenue	M$ 0.00
Total	M$ 53.00	Total	M$300.00
			M$247.00

Note: [1] Price of paraquat: M$26/4.5 L
[2] Contract price for one round of rototilling: M$100/ha
[3] Wage rate for spraying herbicide: M$15/man-day
[4] Price of fresh roots: M$115/t

tillage system is that the second and third crop may be planted following the harvest of the previous one with minimal delay since there is no need to wait for mechanical land preparation. This saving in time also adds to the overall productivity of a given piece of land over time.

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References

Anon. (1988). *CM 982-7: Klon ubi kayu baru untuk tanah gambut* Serdang: MARDI

Chan, S. K., Khelikuzzaman, M. H., Tan, S. L., Geh, S. L. and Lo, N. P. (1983). *Cassava in Peninsular Malaysia: with particular reference to production techniques* (A special report) 97 p. Serdang: MARDI

Chew, W. Y. (1977). Assessment of cassava as an industrial crop on Malaysian peat. *MARDI Rep. No. 57* 12 p. Serdang: MARDI

Chew, W. Y., Ramli, K. and Joseph, K. T. (1978). Copper deficiency of cassava (*Manihot esculenta* Crantz) on Malaysian peat soil. *MARDI Res. Bull. 6(2):* 201–13

Joseph, K. T., Chew, W. Y. and Tay, T. H. (1974). Potential of peat for agriculture. *MARDI Rep. No. 16* 16 p. Serdang: MARDI

Table 6. Partial budget for minimal tillage with lime broadcast vs. normal tillage (T3 vs. T1) over three consecutive seasons of cropping 1 ha of cassava

Extra costs		**Costs saved**	
Paraquat (4 L)	M$ 23.00	Tillage (x 3)	M$ 300.00
Spraying (x 2)	M$ 30.00		
Revenue foregone	M$ 0.00	Extra revenue	M$ 0.00
		Increased yield 10 t	M$1 150.00
Total	M$ 53.00	Total	M$1 450.00
			M$1 397.00

Assumptions:

Cropping season	Minimal tillage with lime broadcast	Normal tillage
1st	1 round rototilling (before lime application)	2 rounds rototilling (before and after lime application)
2nd	Chemical control of weeds	1 round rototilling
3rd	Chemical control of weeds	1 round rototilling

Price of paraquat : M$26.00/4.5 L
Contract price for one round of rototilling : M$100/ha
Wage rate for spraying herbicide : M$15/man-day
Price of fresh roots : M$115/t

Noor Auni, H. and Tan, S. L. (1980). Perbandingan di antara cara-cara menentukan kandungan kanji di dalam ubi kayu (*Manihot esculenta* Crantz). *Teknol. Pert., MARDI 1:* 30–4

Tan, S. L. and Thiagarajan, S. (1986). Promising new cassava clones for mineral and peat soils. *Teknol. Pelbagai Tanaman, MARDI 2:* 21–9

Tan, S. L. and Chan, S. K. (1989). Nutrient requirements of cassava for continuous cropping on tropical peat. *Proc. Intern. Symp. on Peat/Peatland Characteristics and Uses* 16–19 May 1989, Bemidji, Minnesota, USA, (Spigarelli, S. A., ed.) p. 436–49. Bemidji: Bemidji State Univ., Center for Environmental Studies

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