Annex tables

Chapter 1: Cassava, a 21st century crop

Table 1.1 Harvested area of cassava (million ha)

	1980	1990	2000	2011
Sub-Saharan Africa	7.05	8.59	11.01	13.05
Asia	3.89	3.85	3.40	3.91
Latin America/Caribbean	2.65	2.75	2.54	2.67

Source: FAO. 2013. FAOSTAT statistical data base (http://faostat.fao.org)

Table 1.2 Cassava production (million tonnes)

	1980	1990	2000	2011
Sub-Saharan Africa	48.34	70.26	95.34	140.97
Asia	45.94	49.79	49.46	76.68
Latin America/Caribbean	29.70	32.21	31.30	34.36

Source: FAO. 2013. FAOSTAT statistical data base (http://faostat.fao.org)

Table 1.3 Average cassava yields (tonnes/ha)

	1980	1990	2000	2011
Sub-Saharan Africa	6.85	8.18	8.66	10.80
Asia	11.82	12.92	14.53	19.60
Latin America/Caribbean	11.23	11.72	12.34	12.88

Source: FAO. 2013. FAOSTAT statistical data base (http://faostat.fao.org)

Chapter 2: Farming systems

Table 2.1 Effect of method of land preparation on the yield of two cassava varieties in Mondomito, Cauca, Colombia in 1981/82

Tillage treatment	Cassava root yield (t/ha)	
	CMC 92	MCol 113
Without preparation	10.8	10.4
Hand preparation of planting holes	17.9	12.3
Preparation with oxen-drawn plough	16	11.6
Oxen-drawn plough followed by ridging	15	10
Preparation with tractor-mounted rototiller	15.7	14.1
Rototilling followed by ridging	16.8	10.9
1 m wide strips prepared with hoe, alternated with 1 m wide unprepared strips	12.2	9.7
1 m wide strips prepared with rototiller, alternated with 1 m wide unprepared strips	13.5	9.5
LSD 5%	4	1.8

Source: Howeler, R.H., Ezumah, H.C. & Midmore, D.J. 1993. Tillage systems for root and tuber crops in the tropics. *Soil Tillage Res.*, 27: 211-240.

Table 2.2 Effect of tillage system and nitrogen application rate in the first year on cassava root yield, Khon Kaen, Thailand, 2000/01 (tonnes/ha)

Fertilizer rate*	Tillage system	
	Conventional tillage	No tillage
0-50-50	42.7	55.13
50-50-50	44.94	56.06
100-50-50	53.69	67
Average	47.13	59.38

* N-P_2O_5-K_2O in kg/ha

Source: Adapted from Jongruaysup, S., Treloges, V. & Chuenrung, C. 2003. Minimum tillage for cassava production in Khon Kaen Province, Thailand. *Songklanakarin J. Sci. Technol.*, 25(2): 191-197.

Table 2.3 Average responses of cassava top biomass, yield and root dry matter content (8 years) on dry weight basis to surface plant mulch, fertilizer and tillage in sandy loam soils, northern Colombia

Treatment*	Fertilization			No fertilization		
	Root yield (t/ha)	Top biomass (t/ha)	Root dry matter (%)	Root yield (t/ha)	Top biomass (t/ha)	Root dry matter (%)
CT	5.51	3.18	30.2	2.19	1.43	30.1
CT+mulch	5.92	3.98	30.9	4.66	2.93	30.6
NT	4.42	2.77	29.5	1.93	1.43	29.2
NT+mulch	6.11	3.85	31	4.66	2.95	30.4
Mean	5.49	3.45	30.4	3.36	2.19	30.1

* CT = conventional tillage; NT = no tillage

Source: Adapted from Cadavid, L.F., El-Sharkawy, M.A., Acosta, A. & Sánchez, T. 1998. Long-term effects of mulch, fertilization and tillage on cassava grown in sandy soils in northern Colombia. *Field Crops Res.*, 57: 45-56.

Table 2.4 Effect of mulching on dry storage yield of late season cassava, Democratic Republic of the Congo (t/ha)

Cultivar	1981-82		1982-83		1983-84	
	Mulch*	No mulch	Mulch*	No mulch	Mulch*	No mulch
Mpelolongi	4.7	4	6.2	4.7	6.1	3.4
30085/28	5.3	4.4	6.7	5	6.8	4.7
2864	4.8	4.2	7.1	5.2	6.8	4.5
30122/2	3.7	3.6	4.5	3.9	4.7	3.1
30555/3	3.7	3.2	5.2	3.7	4.9	3.2
30010/10	3.4	3.7	4	3.1	4.4	2.8
Means	4.3	3.8	5.6	4.3	5.6	3.6

* Rice straw at 5 t/ha

Source: Adapted from Lutaladio, N., Wahua, T. & Hahn, S. 1992. Effects of mulch on soil properties and on the performance of late season cassava (*Manihot esculenta* Crantz) on an acid ultisol in southwestern Zaire. *Tropicultura*, 10(1): 20-26.

Table 2.5 Average results of three FPR intercropping trials conducted by farmers in Suoi Rao and Son Binh villages, Chau Duc district, Ba Ria-Vung Tau, Viet Nam in 2001/02

Treatment	Cassava yield (t/ha)	Starch content (%)	Inter-crop yield (t/ha)	Gross income	Production costs	Net income	Farmers' preference (%)
				(million dong/ha)			
C + groundnut intercrop	30.74	27.66	1.483	25.81	10.07	15.73	48
C + mungbean intercrop	29.81	26.66	0.57	20.38	8.64	11.74	42
C + soybean intercrop	34.54	27.5	0	19.00	8.62	10.38	6
C + maize intercrop	21.00	24.30	3.64	15.56	8.59	6.90	35
Cassava monoculture	31.88	27.93	-	17.53	7.12	10.42	29

Source: Adapted from Nguyen, H.H., Tran, T.D., Nguyen, T.S., Tran, C.K., Tuan, V.V. & Tong, Q.A. 2008. The FPR cassava project and its impact in South Viet Nam. *In* R.H. Howeler, ed. *Integrated cassava-based cropping systems in Asia. Working with farmers to enhance adoption of more sustainable production practices.* Proceedings of a Workshop on the Nippon Foundation Cassava Project in Thailand, Viet Nam and China, held in Thai Nguyen, Viet Nam. Oct. 27-31, 2003. pp. 140-156.

Table 2.6 Effect of various crop management treatments on soil loss due to erosion and the yield of cassava and intercropped groundnut, as well as the gross and net income in an FPR erosion control trial conducted by six farmers in Kieu Tung village of Thanh Ba district, Phu Tho province, Viet Nam in 1997 (3rd year)

Treatment*	Dry soil loss (t/ha)	Yield (t/ha)	
		Cassava	Groundnut
C monoculture with fertilizer, no hedgerows	106.1	19.17	-
C+G, no fertilizer, no hedgerows	103.9	13.08	0.7
C+G, with fertilizer, no hedgerows	64.8	19.23	0.97
C+G, with fertilizer, *Tephrosia* hedgerows	40.1	14.67	0.85
C+G, with fertilizer, pineapple hedgerows	32.2	19.39	0.97
C+G, with fertilizer, vetiver hedgerows	32	23.71	0.85
C monocult., with fertilizer, *Tephrosia* hedgerows	32.5	23.33	-

* C = cassava; G = groundnut; fertilizers = 60 kg N + 40 P_2O_5 + 120 K_2O/ha; all plots received 10 t/ha pig manure

Source: Adapted from Howeler, R.H. 2001. The use of farmer participatory research (FPR) in the Nippon Foundation Project: Improving the sustainability of cassava-based cropping systems in Asia. *In* R.H. Howeler & S.L. Tan, eds. *Cassava's potential in Asia in the 21st Century: Present situation and future research and development needs.* Proc. 6th Regional Workshop, held in Ho Chi Minh city, Viet Nam. Feb. 21-25, 2000. pp. 461-489.

Table 2.7 Economics of sequential cropping with cassava and vegetable cowpea, Tamil Nadu, India

Treatment*	Cassava root yield (t/ha)	Production cost ('000 Rs/ha)	Gross income ('000 Rs/ha)	Net returns ('000 Rs/ha)
No treatment	26.9	16.04	56.24	40.19
Half treatment	41.2	19.60	80.90	61.30
Full treatment	40.9	24.94	80.73	55.79

* Full treatment = 26 kg/ha P + 25 tonnes/ha farmyard manure

Source: Adapted from Tamil Nadu Agricultural University (TNAU). 2002. *Report to Quinquennial Review Team – Tuber crops (1997-98 to 2001-02)*. Coimbatore Centre, AICRP on tuber crops (other than potato). Dept. of Vegetable Crops, Horticultural College and Research Institute, TNAU Coimbatore. pp. 34-35.

Chapter 3: Varieties and planting material

Table 3.1 Major collections of cassava germplasm

Location	Number of accessions	Type of accession* (%)				
		WS	LR	BL	AC	OT
CIAT	5436	1	87	11	0	1
Brazil	2889	0	0	0	0	100
IITA	2756	0	28	47	0	25
India	1327	0	0	0	0	100
Nigeria	1174	0	0	0	0	100
Uganda	1136	0	4	89	7	0
Malawi	978	0	22	72	6	0
Indonesia	954	0	0	0	100	0
Thailand	609	0	0	100	0	0
Benin	600	0	100	0	0	0
Togo	435	0	100	0	0	0
Other	14148	6	26	3	14	51

* WS = wild species; LR = landraces/old cultivars; BL = research materials/breeding lines; AC = advanced cultivars; OT = others (type unknown or a mixture of two or more types)

Source: Adapted from FAO. 2010. *The second report on the state of the world's plant genetic resources for food and agriculture.* Rome.

Table 3.2 Effect of N, P and K fertilization of mother plants of cassava used for production of planting material on the root and stem yield of the subsequent crop

Fertilization of mother plants (kg/ha)*	Sprouting (%)	Fresh root and stem yields (t/ha)			
		Unfertilized		Fertilized**	
N P K		Roots	Stems	Roots	Stems
0 0 0	85	13.5	2.02	19.1	4.49
0 100 100	97	17.5	2.63	25.6	3.64
100 0 100	98	14.9	2.98	23.5	4.38
100 100 0	77	15.8	2.25	24.7	4.53
100 100 100	97	24.2	3.10	30.2	6.22

* Rates are in kg/ha of N, P and K

** Application at planting of 50 kg N, 43 kg P and 83 kg K/ha

Source: Adapted from Lopez, J. & El-Sharkawy, M.A. 1995. Increasing crop productivity in cassava by fertilizing production of planting material. *Field Crops Res.*, 44: 151-157.

Chapter 4: Water management

Table 4.1 Effect of delayed planting on root yield of late season cassava in southern Nigeria

Month of planting	Root yield (dry weight, t/ha)	Percent of June planting yield
June	10.81	100
July	9.72	90
August	6.91	64
September	6.70	62
October	4.48	41

Source: Adapted from International Institute of Tropical Agriculture (IITA). 1977. *Annual Report for 1977.* Ibadan, Nigeria.

Table 4.2 Effect of time of planting and age at harvest on yield (t/ha) in Thailand (1976-78)

	8 months	10 months	12 months	14 months	16 months	18 months	Average
May	20.27	26.98	36.49	42.46	49.52	57.06	38.76
Jun	22.15	27.73	36.51	47.31	51.93	53.36	39.83
Jul	19.82	29.07	35.07	40.74	44.05	48.51	36.21
Aug	14.46	22.96	29.14	38.62	39.57	43.68	31.41
Sep	12.25	17.64	28.65	32.48	34.59	36.26	26.98
Oct	8.16	16.69	22.17	23.95	29.52	32.61	22.18

Source: Adapted from Sinthuprama, S. 1980. Cassava planting systems in Asia. *In* E.J. Weber, J.C. Toro & M. Graham, eds. *Cassava cultural practices.* Proc. of a Workshop, held in Salvador, Bahia, Brazil. March 18-21, 1980. pp. 50-53.

Table 4.3 Effect of different planting dates, and the average rainfall received, on cassava growth and yield when cassava, cv. Rayong 90, was grown for three consecutive cycles at Rayong Field Crops Research Center in Thailand from 1994 to 1998

Month of planting*	Total rainfall** (mm)	Canopy cover*** (%)	Final plant stand (%)	Root yield (t/ha)	Starch content (%)	Starch yield (t/ha)
June	1402	77.3	97	23.32	21.27	4.96
August	1409	55.0	97	18.92	22.33	4.22
October	1267	55.0	91	24.56	25.73	6.32
December	1665	82.0	90	32.18	25.07	8.07
February	1633	89.2	88	27.92	30.35	8.47
April	1616	87.8	87	25.67	26.13	6.71

* Roots were harvested after 11 months

** Rainfall received during the 11-month growth cycle

*** Percent canopy cover averaged over all months of the growth cycle

Source: Adapted from Howeler, R.H. 2001. Cassava agronomy research in Asia: Has it benefited cassava farmers? *In* R.H. Howeler & S.L. Tan, eds. *Cassava's potential in Asia in the 21st Century: Present situation and future research and development needs.* Proc. 6th regional workshop, held in Ho Chi Minh city, Viet Nam. Feb 21-25, 2000. pp. 345-382.

Table 4.4 Effect of planting method, stake position, stake length, and planting depth on cassava yield, planted in both the rainy and dry season at Rayong Field Crops Research Center, Thailand

Treatment	Rainy season (May-August)			Early dry season (November)		
	No. plants survived ('000/ha)*	Root yield (t/ha)	Starch content (%)	No. plants survived ('000/ha)*	Root yield (t/ha)	Starch content (%)
Planting method **Ridge**	14.57	14.98	16.64	10.69	14.69	18.63
Planting method **No ridge**	14.43	13.47	16.66	12.09	14.96	18.65
Stake position **Vertical**	14.87	16.04	17.03	13.04	17.74	19.04
Stake position **Inclined**	14.89	15.46	17.14	11.99	16.40	18.68
Stake position **Horizontal**	13.74	11.08	15.85	9.31	10.32	18.17
Stake length **(20 cm)**	14.55	14.52	16.67	10.58	14.53	18.51
Stake length **(25 cm)**	14.41	13.54	16.69	13.02	15.41	18.87
Planting depth **(5-10 cm)**	14.43	13.90	16.61	9.74	13.14	18.21
Planting depth **(15 cm)**	14.56	14.43	16.73	12.71	16.17	18.97

Data are the average of three years, 1987-1989

* Out of a total of 15 625 stakes/ha planted

Source: Adapted from Tongglum, A., Vichukit, V., Jantawat, S., Sittibusaya, C., Tiraporn, C., Sinthuprama, S. & Howeler, R.H. 1992. Recent progress in cassava agronomy research in Thailand. *In* R.H. Howeler, ed. *Cassava breeding, agronomy and utilization research in Asia.* Proc. 3rd regional workshop, held in Malang, Indonesia. Oct. 22-27, 1990. pp. 199-223.

Table 4.5 Effect of supplemental flood irrigation on the average root yield, and starch and HCN contents of cassava planted at CTCRI, Trivandrum, India, 1982-1985

Level of irrigation*	Fresh root yield (t/ha)	Starch content (% on dry wt. basis)	HCN (ppm on fresh wt. basis)
IW/CPE = 0 (rainfed)	20.8	72.7	55
IW/CPE = 0.25	24.5	72.9	41
IW/CPE = 0.50	30.8	74.5	41
IW/CPE = 0.75	34.8	75.2	33
IW/CPE = 1.0	39.7	75	22
C.D. (0.05)	4.8		

* Irrigation during drought periods (more than 7 days without rains); IW = irrigation water in mm; CPE = cumulative pan evaporation in mm.

Source: Adapted from Nayar, T.V.R., Mohankumar, B. & Pillai, N.G. 1985. Productivity of cassava under rainfed and irrigated conditions. *J. Root Crops*, 11(1-2): 37-44.

Table 4.6 Effect of flood and drip irrigation on the fresh root yield of cassava grown for three consecutive years on sandy loam soils in Bhavanisagar, Tamil Nadu, India (t/ha)

Irrigation method/level*	1996/1907	1998	1999/2000
Flood irrigation, 5 cm at 0.60 IW/CPE	48.5	59.8	45.8
Drip irrigation at 100% of flood irrigation	57.6	67.3	51.2
Drip irrigation at 75% of flood irrigation	53.9	64.6	50.4
Drip irrigation at 50% of flood irrigation	51.6	62.2	46.2

* IW = irrigation water in mm; CPE = cumulative pan evaporation in mm.

Source: Adapted from Manickasundaram, P., Selvaraj, P.K., Krishnamoorthi, V.V. & Gnanamurthy, P. 2002. Drip irrigation and fertilization studies in tapioca. *Madras Agric. J.*, 89(7-9): 466-468.

Table 4.7 Effect of different amounts of supplemental drip irrigation on the tuber yield of cassava grown for two years at the Federal University of Technology in Akure, Nigeria

Level of drip irrigation (% of available soil water)	*Dry root yield (t/ha)**		*Total water supplied by irrigation as % of water used*	
	2006/07	*2007/08*	*2006/07*	*2007/08*
0	4.66	2.98	0	0
25	8.53	6.43	14.83	17.85
50	13.10	9.20	34.33	40.65
100	28.15	15.36	51.11	61.72

* For a 9-month growth cycle, during which period total rainfall was 872 and 795 mm in 2006/07 and 2007/08, respectively

Source: Adapted from Odubanjo, O.O., Olufayo, A.A. & Oguntunde, P.G. 2011. Water use, growth, and yield of drip irrigated cassava in a humid tropical environment. *Soil Water Res.*, 6(1): 10-20.

Chapter 5: Crop nutrition

Table 5.1 Nutrient distribution in 12-month-old cassava, cv. M Ven 77, grown without fertilization in Carimagua, Colombia (kg/ha)

	N	*P*	*K*	*Ca*	*Mg*	*S*	*B*	*Cu*	*Fe*	*Mn*	*Zn*
Roots	30.3	7.5	54.9	5.4	6.5	3.3	0.08	0.02	0.38	0.02	0.1
Plant tops	69.1	7.4	33.6	37.4	16.2	8.2	0.07	0.03	0.45	0.33	0.26
Fallen leaves	23.7	1.5	4	24.7	4	2.5	0.04	0.01	0	0.37	0.18

Source: Adapted from Howeler, R.H. 1985. Mineral nutrition and fertilization of cassava. *In* J.H. Cock & J.A. Reyes, eds. *Cassava: Research, production and utilization.* UNDP-CIAT Cassava Program. Cali, Colombia. pp. 249-320.

Table 5.2 Effect of four sources of nitrogen on the yield and quality attributes of cassava, cv. Sree Visakham, grown at the College of Agriculture, Trivandrum, India, 1989-1991

	Number of roots/plant	*Root yield (t/ha)*	*HCN content (ppm, fresh weight basis)*	*Total dry matter (t/ha)*
Urea	5.1	19.95	47.4	10.52
Neem-coated urea	5.8	22.59	46.8	12.13
Urea super-granule	5.9	25.65	48.4	13.97
Rubber cake-coated urea	4.9	17.76	48.2	10.4

Source: Vinod, G.S. & Nair, V.M. 1992. Effect of slow release nitrogenous fertilizers on the growth and yield of cassava. *J. Root Crops* (Special issue), 17: 123-125.

Table 5.3 Effect of planting intercrops, green manures and alley crops, with or without fertilizers, on cassava and intercrop yields, as well as the gross and net income obtained when cassava, KM 60, was grown for the 16th consecutive year at Hung Loc Agricultural Research Center in Dongnai, Viet Nam in 2007/08

	Root yield (t/ha)		Starch content (%)		Gross income (million d/ha)		Production costs (million d/ha)		Net income (million d/ha)	
Treatment*	with fertilizer	without fertilizer	with fertilizer	without fertilizer	with fertilizer	without fertilizer	with fertilizer	without fertilizer	with fertilizer	without fertilizer
C monoculture	17.44	4.81	23.28	21.28	20.41	5.63	6.01	3.80	14.40	1.83
C+pigeon pea GM	15.62	6.75	23.6	21.7	18.28	7.90	8.11	5.90	10.17	2.00
C+*Mucuna* GM	17.82	8.56	24.45	22.35	20.85	10.02	8.11	5.90	12.74	4.12
C+groundnut IC	20.41	8.62	25.35	24.08	24.82	10.09	8.11	5.90	16.72	4.19
C+cowpea IC	19.44	7.44	24.92	22.65	22.75	8.71	8.11	5.90	14.64	2.81
C+*Crotalaria* GM	18.75	8.5	24.95	21.72	21.94	9.95	8.11	5.90	13.83	4.05
C+*Leucaena* AC	20.68	13.39	25.52	24.4	24.20	15.67	7.71	5.50	16.49	10.17
C+*Gliricidia* AC	19.3	16.75	26.32	24.95	22.58	19.60	7.71	5.50	14.87	14.10
Average	18.68	9.35	24.8	22.89	21.98	10.94	7.75	5.54	14.23	5.40

Source: Nguyen Huu Hy, personal communication.

* C = cassava; GM = green manure; IC = intercrop; AC = alley crop

Table 5.4 Effect of application of various rates of chemical fertilizer and incorporation of the green manure species *Tithonia diversifolia* and *Chromolaena odorata* on cassava fresh root yields (t/ha) during two cropping cycles at two sites in the Bas-Congo region of DR Congo

Green manures	Fertilizer rate* (kg/ha)	First crop		Second crop	
		Kiduma	Mbuela	Kiduma	Mbuela
None	0	12.7	10.5	10.1	5.4
None	283	23.7	14.9	14.9	7.4
None	850	31.4	19.6	17.6	9
None	1,417	39.6	18.6	33.1	18
Tithonia	0	32.8	18.1	12.7	6.4
Tithonia	283	37.6	23.5	17.8	8.7
Tithonia	850	41.5	21.7	20.2	8.2
Chromolaena	0	19.9	18.2	12.2	7.3
Chromolaena	283	29.5	21.1	18.4	8.5
Chromolaena	850	35.2	23.4	18.6	9

Source: Adapted from Pypers, P., Sanginga, J.M., Kasereka, B., Walangululu, M. & Vanlauwe, B. 2011. Increased productivity through integrated soil fertility management in cassava-legume intercropping systems in the highlands of Sud-Kivu, DR Congo. *Field Crops Res.*, 120: 76-85.

* Fertilizer = 17-17-17 as N-P_2O_5-K_2O

Table 5.5 Effect of the application of farm-yard manure (FYM) and chemical fertilizers on cassava yield and economic benefit at Thai Nguyen University of Agriculture and Forestry in Thai Nguyen province of Viet Nam, in 2001 (2nd year)

Treatment	Cassava root yield (t/ha)	Harvest Index	Gross income	Fertilizer costs	Production costs	Net income
			('ooo dong/ha)			
No fertilizers, no FYM	3.25	0.39	1,625	0	2,800	-1,175
5 t FYM/ha	7.79	0.49	3,895	500	3,300	595
10 t FYM/ha	10.02	0.52	5,010	1,000	3,800	1,210
15 t FYM/ha	13.11	0.52	6,555	1,500	4,300	2,255
80 N+80 K_2O/ha, no FYM	15.47	0.5	7,735	680	3,580	4,155
80 N+80 K_2O/ha + 5 t FYM/ha	17.98	0.48	8,990	1,180	4,080	4,910
80 N+80 K_2O/ha + 10 t FYM/ha	18.7	0.49	9,350	1,680	4,580	4,770
80 N+80 K_2O/ha + 15 t FYM/ha	18.5	0.48	9,250	2,180	5,080	4,170

Source: Adapted from Nguyen The Dang, personal communication, 2002.

Table 5.6 Effect of various fertilizer combinations on the fresh root yields of cassava, cv. Faroka, and on the grain yield of intercropped maize, as well as gross and net income when grown in Jatikerto Station in Malang, East Java, Indonesia, in 2005/06 (2nd year)

Treatment N-P_2O_5-K_2O (kg/ha)	Organic (t/ha)	Cassava yield (t/ha)	Maize yield (t/ha)	Gross income	Fertilizer costs	Production costs	Net income	Farmers' preference
				(mil. Rp/ha)				
0-0-0	0	10.96	1.1	4.72	0	4.1	0.62	
135-0-0	0	35.6	1.93	13.52	0.45	7.01	6.51	2
135-50-0	0	36.8	2.07	14.05	0.69	7.37	6.68	3
135-50-100	0	37.47	2.1	14.3	1.27	8.02	6.28	4
0-0-0	10 manure	26.53	1.66	10.32	2	7.65	2.67	
0-0-0	10 compost	22.67	1.63	9.05	1	6.27	2.78	
135-0-0	5 manure	35.63	2.26	13.89	1.45	8.01	5.88	1
135-0-0	5 compost	39.33	1.97	14.75	0.95	7.88	6.87	5
135-50-0	5 compost	39.07	1.87	14.56	1.19	8.1	6.46	
135-0-0	5 sugar mud	33.73	1.67	12.63	0.95	7.32	5.31	

Source: Adapted from Utomo, W.H., Marjuki, W., Hartoyo, K., Suharjo Retnaningtyas, E., Santoso, D. & Wijaya, A. 2010. Enhancing the adoption of improved cassava production and utilization systems in Indonesia (The ACIAR Cassava Project in Indonesia). *In* R.H. Howeler, ed. *A new future for cassava in Asia: Its use as food, feed and fuel to benefit the poor.* Proc. 8th Regional Workshop, held in Vientiane, Lao PDR. Oct. 20-24, 2008. pp. 490-507.

Table 5.7 Average nutrient content of one tonne of various types of wet manure and compost as compared to 50 kg of 15-15-15 chemical fertilizers

	DM (%)	N (kg)	P (kg)	K (kg)
1 t cattle manure	32	5.9	2.6	5.4
1 t pig manure	40	8.2	5.5	5.5
1 t chicken manure	57	16.6	7.8	8.8
1 t sheep manure	35	10.5	2.2	9.4
1 t city garbage compost	71	6.9	3.3	6.1
50 kg 15-15-15 fertilizer	100	7.5	3.3	6.2

Source: Howeler, R.H. 2001. Cassava agronomy research in Asia: Has it benefited cassava farmers? *In* R.H. Howeler & S.L. Tan, eds. *Cassava's potential in Asia in the 21st Century: Present situation and future research and development needs.* Proc. 6th regional workshop, held in Ho Chi Minh city, Viet Nam. Feb. 21-25, 2000. pp. 345-382.

Table 5.8 Effect of various soil conservation practices on the average relative cassava yield and dry soil loss due to erosion as determined from soil erosion control experiments, FPR demonstration plots and FPR trials conducted in Viet Nam from 1993 to 2003

Soil conservation practice	Relative cassava yield (%)		Relative dry soil loss (%)	
	Cassava monoculture	Cassava + groundnut	Cassava monoculture	Cassava + groundnut
With fertilizers; no hedgerows (check)	100	-	100	-
With fertilizers; vetiver grass hedgerows	113	115	48	51
With fertilizers; *Tephrosia candida* hedgerows	110	105	49	64
With fertilizers; *Flemingia macrophylla* hedgerows	103	109	51	62
With fertilizers; *Paspalum atratum* hedgerows	112	-	50	-
With fertilizers; *Leucaena leucocephala* hedgerows	110	-	69	-
With fertilizers; *Gliricidia sepium* hedgerows	107	-	71	-
With fertilizers; pineapple hedgerows	100	103	48	44
With fertilizers; vetiver + *Tephrosia* hedgerows	-	102	-	62
With fertilizers; contour ridging; no hedgerows	106	-	70	-
With fertilizers; closer spacing, no hedgerows	122	-	103	-
With fertilizers; groundnut intercrop; no hedgerows	106	100	81	100
With fertilizers; maize intercrop; no hedgerows	69	-	21	-
No fertilizers; no hedgerows	32	92	137	202

Source: Adapted from Howeler, R.H. 2008. Results, achievements and impact of the Nippon Foundation Cassava Project. *In* R.H. Howeler, ed. *Integrated cassava-based cropping systems in Asia. Working with farmers to enhance adoption of more sustainable production practices*. Proc. of a Workshop on the Nippon Foundation Cassava Project in Thailand, Viet Nam and China, held in Thai Nguyen, Viet Nam, Oct. 27-31, 2003. pp. 161-209.

Chapter 6: Pests and diseases

Table 6.1 Effect of hand weeding at different times and frequencies on the fresh root yield of cassava, cv. CMC 39, at 280 days after planting at CIAT, Cali, Colombia

No. of hand weedings*	Frequency of hand weeding (days)					Fresh cassava root yield (t/ha)	Yield as % of maximum yield***
4 +	15	30	60	120	UH**	18.0	86
3 +		30	60	120	UH	16.0	76
2+			60	120	UH	11.0	52
1+				120	UH	7.0	33
4	15	30	60	120		19.5	92
3	15	30	60			12.9	61
2	15	30				13.3	63
1	15					5.8	28
2		30	60			16.3	77
2	15	45				15.4	73
0	Chemical weed check					21.1	100
0	Weedy check					1.4	7

Source: Doll, J.D. & Piedrahita, C.W. 1978. *Methods of weed control.* Cali, Colombia, CIAT.

* + = additional weedings

** UH = until harvest, as needed

*** Percentage of the yield of cassava weeded with herbicides

Chapter 7: Harvest, post-harvest and value addition

Table 7.1 Average effect of the number and timing of leaf cutting on the total dry leaf and protein yields, root yield and starch content of two cassava varieties, as well as gross and net income obtained in an experiment at TTDI Center in Huay Bong, Thailand

No. of leaf cuts*					Total dry leaf yield (t/ha)	Protein content (%)	Total leaf protein yield (t/ha)	Fresh root yield (t/ha)	Root starch content (%)	Gross income			Production costs	Net income
										Leaves	Roots	Total		
1	2	3	4	5						('000 B/ha)				
				x	0.71	24.46	0.17	39.89	19.58	4.15	45.43	49.58	24.3	25.28
x				x	1.5	25.16	0.38	39.91	20.15	9.02	46.01	55.04	30.68	24.35
x	x			x	1.99	25.21	0.5	27.02	21.1	11.92	31.59	43.51	32.53	10.99
x	x	x		x	2.56	25.13	0.64	28.6	19.75	15.34	32.53	47.88	36.78	11.09
x	x	x	x	x	2.57	25.28	0.65	24.46	18.19	15.56	27.2	42.76	40.07	2.7
Average					1.87	25.05	0.47	31.97	19.75	11.2	36.55	47.75	32.87	14.88

* Cuts no. 1, 2, 3, 4 and 5 correspond to leaf cuttings at 2.5, 5, 7, 9 and 11 MAP, respectively, with the last cut at time of root harvest

Source: Adapted from Howeler, R.H. 2012. Cassava leaf production for animal feeding. *In* R.H. Howeler, ed. *The cassava handbook – A reference manual based on the Asian regional cassava training course, held in Thailand.* Cali, Colombia, CIAT. pp. 626-648.

Chapter 8: The way forward

Table 8.1 Effect of various crop management treatments on soil loss due to erosion and the yield of cassava and intercropped groundnut, as well as the gross and net income in an FPR erosion control trial conducted by six farmers in Kieu Tung village of Thanh Ba district, Phu Tho province, Viet Nam in 1997 (3rd year)

Treatment*	Gross income	Production costs	Net income	Farmers' ranking
	(mil. dong/ha)			
C monoculture with fertilizer, no hedgerows	9.58	3.72	5.86	6
C+G, no fertilizer, no hedgerows	10.04	5.13	4.91	5
C+G, with fertilizer, no hedgerows	14.47	5.95	8.52	-
C+G, with fertilizer, *Tephrosia* hedgerows	11.58	5.95	5.63	3
C+G, with fertilizer, pineapple hedgerows	14.55	5.95	8.6	2
C+G, with fertilizer, vetiver hedgerows	16.1	5.95	10.15	1
C monocult. with fertilizer, *Tephrosia* hedgerows	11.66	4.54	7.12	4

* C = cassava; G = groundnuts; fertilizers = 60 kg N + 40 P_2O_5 + 120 K_2O/ha; all plots received 10 t/ha pig manure

Source: Adapted from Howeler, R.H. 2001. The use of farmer participatory research (FPR) in the Nippon Foundation Project: Improving the sustainability of cassava-based cropping systems in Asia. *In* R.H. Howeler & S.L. Tan, eds. *Cassava's potential in Asia in the 21st Century: Present situation and future research and development needs.* Proc. 6th Regional Workshop, held in Ho Chi Minh city, Viet Nam. Feb. 21-25, 2000. pp. 461-489.

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Abbreviations

CGIAR Consultative Group on International Agricultural Research
CIAT International Center for Tropical Agriculture
CBSD cassava brown streak disease
CMD cassava mosaic disease
CTCRI Central
FAO Food and Agriculture Organization of the United Nations
FFS farmer field school
FPR farmer participatory research
GDP gross domestic product
ha hectare
IFAD International Fund for Agricultural Development
IITA International Institute of Tropical Agriculture
IPM integrated pest management
ITPGRFA International Treaty on Plant Genetic Resources for Food and Agriculture
K potassium
K_2O potassium oxide
N nitrogen
NGOs non-governmental organizations
P phosphorus
P_2O_5 phosphorus pentoxide
t tonne
TUUSI Technology Uptake and Upscaling Support Initiative

This guide is the first on the practical application of FAO's "Save and Grow" model of agriculture to specific smallholder crops and farming systems. It comes as cassava production intensifies worldwide, and growers shift from traditional cultivation practices to monocropping, higher-yielding genotypes, and greater use of agrochemicals. Intensification carries great risks, including soil nutrient depletion and upsurges in pests and diseases. The guide shows how ecosystem-based "Save and Grow" approaches and practices can help tropical developing countries to avoid the risks of unsustainable intensification, while realizing cassava's potential for producing higher yields, alleviating hunger and rural poverty, and contributing to national economic development.

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