Cassava as drought insurance: Food security implications of cassava trials in Central Zambia

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Abstract

Wide, weather-induced fluctuations in maize production lead to recurrent food shortages in Zambia's maize consuming regions, while the cassava-growing regions of the north enjoy stable food production, even in drought years. Noting this striking correlation between drought vulnerability and the prevalence of maize as a staple food, a growing array of agencies in Zambia has begun introducing highly productive new cassava varieties, developed in the north, to more central and southerly regions in an effort to provide low-cost food security during drought years. Yet agro ecological conditions in these drought-prone regions differ significantly from the northern research stations where Zambian scientists developed the new cassava varieties. So it is not clear that the varieties or management practices that work well in the north will prove optimal in other regions. In order to assist farmers and agencies interested in expanding cassava as a food security crop in central Zambia, we have conducted cassava trials in central Zambia over the past three years. Concurrently, we have engaged in regular on-farm discussions with early adopting farmers. Results from these investigations suggest that, with some modification of management practices recommended in the north, many of the new cassava clones offer a feasible means of mitigating lean season hunger and providing low-cost, in-kind drought insurance for rural households in central Zambia.

1. Introduction

Zambia's two main staples, maize and cassava, both reached Zambia about 300 years ago from their native home in the Americas. Since their arrival, these two imported food crops have revolutionized Zambian agriculture. As a result, today maize supplies about 60% of national calorie consumption and serves as the principal food staple in central, southern and eastern Zambia. Cassava furnishes a further 15% of total calories and constitutes the mainstay

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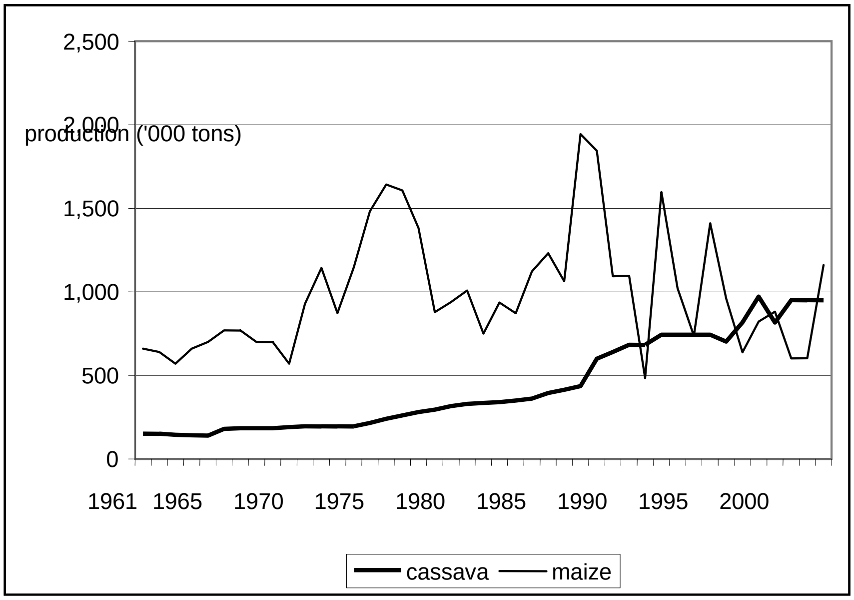
of diets in northern and western Zambia (FAO, 2002). Historically, heavy government subsidies for maize production - amounting to 17% of total government spending at its peak in the late 1980's - have artificially inflated maize production in Zambia (Howard and Mungoma, 1996). Following withdrawal of these substantial subsidies, maize production has trended gradually downward, while cassava production has grown rapidly (Figure 1).

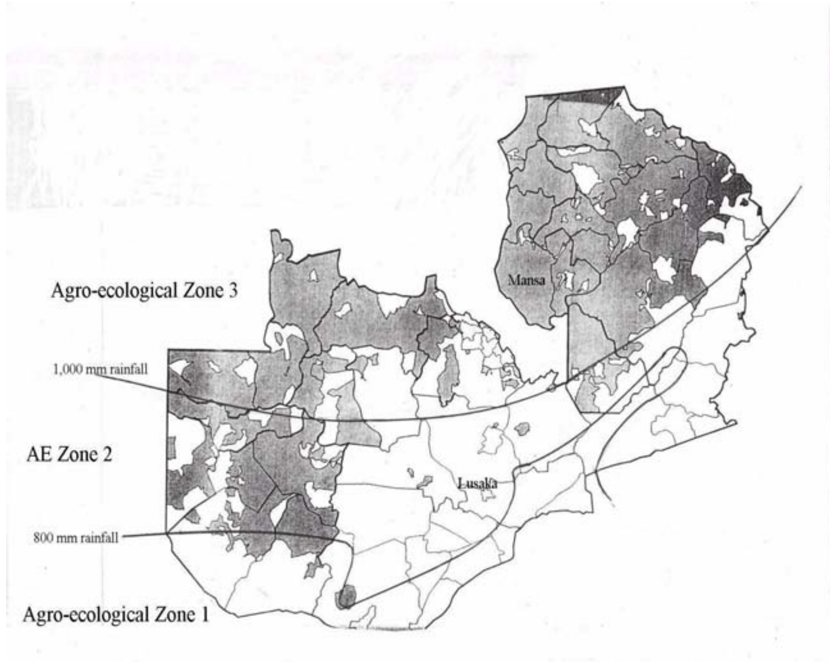


Source: FAOSTAT (2002)

Figure 1: Trends in staple food production in Zambia

Around its declining trend, maize production has varied widely from year to year over the past decade and a half (Figure 1). Its low drought tolerance, coupled with erratic rainfall, lead to recurrent food shortages in southern, central and eastern Zambia where households consume a primarily maize-based diet. Yet in northern Zambia, where more drought-tolerant cassava serves the principal food staple, food supply proves more stable and food aid appeals are rare (Figure 2).

Noting this striking correlation between drought vulnerability and the prevalence of maize as a staple food, Zambia's Programme Against Malnutrition (PAM) and a number of other agencies have been promoting cassava production in the country's erratic rainfall zones as a form of low-cost drought insurance. Although low temperatures in the plateau areas of the extreme south prevent production of a temperature-sensitive tropical crop such as cassava, the river valleys of the south and most areas of central and eastern Zambia house broad swaths of land suitable for cassava production.



* Shaded areas indicate cassava production of over150 bags per census supervisory area

Source: Republic of Zambia (1994)

Figure 2: Areas of heavy cassava production* in Zambia, 1990

Nationally, interest in cassava has accelerated in recent years, as Zambian scientists from the Root and Tuber Improvement Programme (RTIP) have released a stream of new, highly productive, early maturing cassava varieties. In research station trials in northern Zambia, these new varieties yield 30 to 40 tons per hectare using no purchased inputs (Table 1). Since cassava roots contain up to 70% water, this amounts to a dry-matter yield of 9 to 12 tons per hectare, far higher than the historic average smallholder maize yield of 1.5 tons (Ministry of Agriculture, Food and Fisheries, 1999). Not surprisingly, these highly productive recommended cassava varieties are spreading rapidly in northern Zambia, through farmer-to-farmer distribution of planting material (Ministry of Agriculture, Food and Fisheries 2000). Cassava production in eastern Zambia is also growing rapidly, though from a much smaller base (Table 2).

The research required to develop these new cassava varieties has taken place exclusively in northern Zambia, in Mansa and Solwezi, where cassava production and consumption remain concentrated (Figure 2). But drought and food shortages recur mainly in the maize-producing regions of central, southern and eastern Zambia where rainfall, temperature and soils differ significantly from those in the north. So it is not clear that the cassava varieties or agronomic practices that prove most suitable in the north will prove optimal in more southerly regions. Region-specific research is therefore necessary to identify varieties and practices most suitable for Zambia's more drought-prone regions. Given severe resource constraints, Zambia's RTIP has had to focus its scarce cassava research resources on the staple cassava-producing areas of the north.

Table 1: Cassava varieties released by the Root and Tuber Improvement Programme in Zambia

Variety	Type	Released	Yield (tons/ha)	Taste
1. Bangweulu	Cleaned local variety	1993	31	Bitter
2. Kapumba	Cleaned local variety	1993	22	Sweet
3. Nalumino	Cleaned local variety	2000	29	Sweet
4. Mweru	Bred by RTIP	2000	41	Sweet
5. Chila	Bred by RTIP	2000	35	Bitter
6. Tanganyika	Bred by RTIP	2000	36	Sweet
7. Kampolombo	Local variety	2000	39	Sweet
Traditional	Local variety		7	Bitter

* All yields refer to research station observations using no purchased inputs but following recommended agronomic practices. Yields were measured 16 months after planting.

Source: Chitundu and Soenarjo (1997) and Simwambana *et al* (2004)

Table 2: Growth in area under cassava production, by province

Province	**Cassava area ('000 ha) 1990**	**Annual growth rate % 1992-2000**
Northern	46	11.5
Luapula	49	9.6
Western	27	9.2
North western	38	3.2
Central	16	3.8
Eastern	1	16.1
Copperbelt	2	1.0
Southern	1	-
Total Zambia	179	11.5

Source: Base year from the agricultural census of 1990 (Central Statistics Office, 1992); annual growth rate from Post-Harvest Surveys 1992/3 through 1999/2000. See Haggblade and Zulu (2003) for full data series.

In order to assist farmers and agencies interested in expanding cassava as a food security crop in central Zambia, and to complement the RTIP work in northern Zambia, students and faculty at the American International School of Lusaka (AIS) have conducted cassava trials nearby Lusaka over the past three years. With design assistance from current and former RTIP scientists, the AIS students have conducted a series of cassava trials at the Zamseed Farm, 12 kilometers north of Lusaka. Reported here, this research aims to identify cassava varieties and management practices that will prove most feasible for small farmers in central Zambia in addressing their two recurring food security problems: drought-year food shortages and lean season hunger.

2. Methods

This research focuses on a series of key issues of interest to resource-poor farmers in central Zambia, who stand to benefit most from production of cassava as a hedge against recurrent failure of their maize crop. Given the tight cash constraints facing Zambian smallholder farmers, all trials have used hand-hoe labour as the sole input, with no application of fertilizer, pesticides or other inputs during the three-year trial period. Bangweulu, the most widely grown variety of cassava in Zambia, serves as a benchmark in all trials. Against this benchmark, the trials have focused on the following specific questions.

2.1 Variety trials

Key questions: Which cassava varieties yield most in the Lusaka region of central Zambia?

Given that 60% of small farmers in central Zambia till with a hand hoe (Haggblade and Tembo, 2004), the typical family can only farm 2 to 3 hectares using family labour. Under these conditions, increasing yield per unit of land and labour becomes a central criterion governing both crop and variety selection.

Research design: To asses yield differences, we have evaluated six different varieties of cassava: two recommended local varieties (Bangweulu and Kapumba), two of the newly developed varieties bred by RTIP scientists in Mansa (Mweru and Chila), one recommended local variety from Malawi (Manyopola), and one ordinary local Zambian variety (Muganga). The trials evaluated each of these six varieties in four randomly assigned plots. This resulted in 6x4=24 varietal test plots. For each, planting took place during the first week of December 2002, with harvesting 15 months later, in March 2004.

2.2 Weeding trials

Key questions: How many times do farmers need to weed their cassava? How much do they gain from each incremental weeding?

Peak-season labour constraints typically limit farm income among rainfed hand-hoe farmers. Given the rising prevalence of HIV/AIDS in rural areas, already serious labour constraints are becoming increasingly acute. In confronting these labour constraints, small farmers need to know how little labour they can devote to their cassava and still achieve an acceptable yield. Viewed another way, they need to know how much incremental output they will gain from each additional weeding.

Research design: To answer these questions, we tested Bangweulu and Mweru varieties of cassava under four different weeding regimes: no weeding (w_0), weeded once (w_1), weeded twice (w_2) and weed free (w_{free}). As in the variety trials, we replicated each treatment four times. Given two varieties, four treatments and four randomly assigned replications per treatment, we ended up with 2x4x4=32 individual trial weeding plots. As with the variety trials, we planted all plots on the same date in December 2002 and harvested them 15 months later, in March of 2004.

2.3 Timing trials

Key questions: How much flexibility do farmers have in determining when to plant and when to harvest their cassava? When can they plant their cassava to fit in best with other onfarm labour demands and at the same time ensure food security in the lean season?

Unlike most other crops, cassava offers farmers considerable flexibility since they can plant their cassava over many months and harvest throughout the year. In contrast, annual rainfed crops such as maize and cotton lose 1% to 2% of their potential yield for each day farmers plant them after the first planting rains (Ellwell, 1995; Howard, 1994). Consequently, a one-month delay in planting these crops can result in yield losses of up to 50% simply due to late planting. Cassava appears to be more forgiving. Farmers in northern Zambia plant their cassava over a period of several months. Given a two to three week shorter growing season in central Zambia, these trials aim to explore prospects for planting flexibility in this different agro-ecological environment.

In harvesting, cassava likewise offers great flexibility. While maize and cotton require harvesting at precise times to avoid pest and weather damage, farmers can harvest their cassava year-round. Cassava is, thus, the only food staple available for harvest at the beginning of the rainy season -- in December, January and February -- when vulnerable households typically face the most acute hunger. To explore options for mitigating lean season hunger, the timing trials evaluate yield increments achieved at different points during the lean season.

Research design: To address these issues, we tested the same two varieties of cassava as in the weeding trials (Bangweulu and Mweru) but planted them at three different dates and harvested at 12, 15 and 24 months after planting (MAP). A fourth harvest date, in March of 2005, provided an end-of-rainy-season assessment 25 to 27 months after planting, for each of the planting dates.

Planting took place at three different dates, during the first week of December 2002, then at one-month intervals, during the first week of January and of February 2003. Recognizing that households accustomed to maize cultivation will not readily abandon their longtime staple, and based on our field discussions with local adopting farmers, we anticipate that gradual testing on small plots, followed by incremental adoption, appears the most likely avenue for increasing household cassava production in central Zambia. Therefore, we did not plant in November, with the very first rains, expecting that adopting farmers would inevitably take care of their maize and cotton crops first and experiment with cassava only after they had planted their other, more highly time-sensitive crops.

Harvest dates were likewise staggered throughout the rainy season, the most critical hunger months for vulnerable households. In total, we harvested 96 timing trial plots: two varieties, planted on three different dates, harvested at four times and with four replications of each treatment (2x3x4x4 = 96).

2.4 Sampling design

In each of the trial blocks, we assigned treatments randomly. Each replication included eight cassava plants, plus a border row that remained unharvested.
For cuttings which failed to sprout or which fell victim to early season termite damage, we did not replant. Thus, although we planted eight plants in each trial plot, the number of plants remaining at harvest time varied according to the mortality rate within each plot.

2.5 Economic variables

To compute economic valuations of on-farm profitability from these agronomic findings, we have supplemented measurements from our on-station trials with data from a series of field visits with cassava farmers, traders and processors. We have verified pricing and labour input estimates from a variety of sources in order to ensure representative values for these economic parameters.

3. Results and analysis

3.1 Which varieties prove most productive in central Zambia?

Yields of the benchmark, Bangweulu, and three other varieties - Mweru, Chila and Muganga - all clustered around 20 tons per hectare, 15 months after planting (Table 3). In paired comparisons, none of these three produced yields statistically different from Bangweulu. Surprisingly, the local variety, Muganga, performed as well as the recommended varieties. Given its known susceptibility to cassava mosaic virus disease (CMD) in northern zones, we suspect this strong performance results from a lower prevalence of CMD in the less cassava-intensive Lusaka region. Over time, as cassava cultivation and exposure to disease increase in central Zambia, performance of the Muganga clones will likely diminish.

Table 3: Cassava yields by variety, 15 months after planting in Lusaka Province

	Variety 1 Bangweulu	Variety 2 Mweru	Variety 3 Chila	Variety 4 Kapumba	Variety 5 Manyopola	Variety 6 Muganga
Avarage yield tons/ha	21.3	19.6	18.2	6.4*	11*	20.5
St. dev.	5.8	4.2	1.8	5.2	4.2	2.6
Type	Recommended local variety	Newly bred by RTIP	Newly bred by RTIP	Recommended local variety	Recommended local variety from Malawi	Local variety
Taste	Bitter	Sweet	Bitter	Sweet	Sweet	Bitter

* Significantly lower than Bangweulu. T test significant at the 95% level

Source: American International School (AIS) cassava trial results

The two remaining varieties, however, yielded significantly less than the Bangweulu. Manyopola, despite its popularity in Malawi, yielded only 11 tons per hectare in these trials, roughly half that of Bangweulu. Kapumba fared worst of all, yielding only 6 tons per hectare. Though a recommended variety and strong performer in northern regions of the country, Kapumba appears to perform poorly in central Zambia.

Comparison of these results with those from the Mansa Research Station in Luapula (Figure 2) suggests significant differences in performance across regions. For both Bangweulu and Mweru, the two varieties for which we have yield data at a variety of harvesting dates, yields in the Lusaka trials stood at about two-thirds of those achieved in Luapula after a comparable period, 16 months after planting (Table 4). Cooler temperatures, lower rainfall and a shorter growing season apparently combine to produce slower cassava growth in central Zambia.

Table 4: Cassava performance in alternate agro-ecological conditions

Agroecological Zone		Agroecological characteristics					Cassava yield (kg/ha), 16 months after planting	
Zone#	Cassava test site	Annual rainfall (mm)	Growing season (days)	Mean winter temperature (July)		Soil	Bangweulu	Mweru
				Minimum	Maximum			
3	Mansa*	1200	140	9	25	Acidic	31	41
2	Lusaka**	1000	120	7	24	Alkaline	22	26
1	None	800	100	4	23	Acidic	-	-
	Lusaka/Mansa						72%	64%

* Root and Tuber Improvement Programme (RTIP) trial results from Mansa Research Station, 16 months after planting
** American International School (AIS) trial results from Zamseed Farm, Lusaka. Because AIS collected yield data at 12, 15 and 24 months after planting (MAP), this table uses linear interpolation to project likely yield at 16 months.

Source: Chipungu and Kunda (1994), Chitundu and Soenarjo (1997), Haggblade and Tembo (2004), Hong Kong Obs ervatory (2005), Veldkamp *et al* (1984), AIS cassava trials

3.2 How often do farmers need to weed their cassava?

Results from these trials suggest that farmers who fail to weed their cassava crop will likewise fail to harvest any output. Unweeded trial plots yielded zero output, because early season growth of broad-leaved weeds crowd out the cassava plants before they sprout and outcompete the cassava for moisture and light. Conversely, as expected, the weed-free plots performed best (Table 5).

The first weeding, and each successive one, increases average yield, although differences are not always statistically significant. Mweru, shorter and more compact than Bangweulu, appears particularly susceptible to lack of early season weeding. Both its plant survival rate and yield lag those of Bangweulu in the plots weeded only once or twice. However with weed-free plots, Mweru and Bangweulu perform similarly. In our trial plots, weed-free maintenance typically required three weedings.

Table 5: Cassava weeding trials, 15 months after planting in Lusaka Province

		Number of weedings			
		0	1	2	Weed free
V1	Bangweulu				
	Yield (tons/ha)	0.2	10.6*	12.5	15.6
	Standard deviation	0.3	8.7	3.5	7.4
	Plant survival rate	13%	69%	84%	94%
V2	Mweru				
	Yield (tons/ha)	0.0	2.5	8.8*	15.8*
	Standard deviation	0.0	2.3	2.9	3.8
	Plant survival rate	0%	50%	66%	84%

*Significantly greater than the prior column. T test significant at the 95% confidence level or better.

Source: American International School (AIS) cassava trials

Table 6: How many times should farmers weed their cassava?

	Bangweulu	Mweru
Cassava yeld (tons/ha)		
No weeding	0.2	0
1 weeding	10.6	2.5
2 weedings	12.5	8.8
3 weedings	15.6	15.8
Incremental gain from weeding (tons/ha)		
1st weeding	10.4	2.5
2nd weeding	1.9	6.3
3rd weeding	3.1	7
Total gain from weeding	15.4	15.8
Value per ton, fresh (Kwacha)	192,000	192,000
Value of incremental production (Kwacha)		
1st weeding	1,996,800	480,000
2nd weeding	364,800	1,209,600
3rd weeding	595,200	1,344,000
Total gain from weeding	2,956,800	3,033,600
Weeding costs		
Person-days per ha	25	25
Daily wage rate (K)	5,000	5,000
Kwacha/weeding	125,000	125,000
Benefit to cost ratio for each additional weeding		
1st weeding	16.0	3.8
2nd weeding	2.9	9.7
3rd weeding	4.8	10.8
Total gain from weeding	23.7	24.3
Incremental output from weeding labour (kg/person/day)		
1st weeding	416	100
2nd weeding	76	252
3rd weeding	124	280
Total gain from weeding	616	632

Source: Incremental gains computed from Table 5. Prices and labour inputs from field interviews.

Although output increases with each weeding, so too do labour requirements. Given labour constraints, the question farmers need to answer is how much it will cost them to weed compared to how much additional output they will gain. Our calculations suggest that each weeding produces substantially more benefits than costs, even if a farmer hires labour for weeding (Table 6). Payment in kind, common in northern Zambia, is also possible, particularly since weeding takes place during the lean season when poor households face their most acute food shortage. Incremental yield gains range from 76 to over 400 kg per person-day of weeding labour. With Mweru, incremental gains range from 100 kg to 280 kg per person day, and output increases with each successive weeding. These results suggest that cassava farmers could pay hired workers as much as 75 kg of fresh cassava per weeding and still gain substantially more in increased output. This is roughly double the normal in-kind wage rate paid for cassava weeding in northern Zambia. At these rates, even using hired labour, each additional weeding clearly pays.

3.3 When should farmers plant and harvest?

Early planting of cassava tends to improve yield, since the plants are able to establish roots more fully and better withstand the seven-month dry season. Early planting, at the beginning of December, proves most crucial for Mweru, while planting late, in February, produces yields less than one third those of the plots planted two months earlier (Table 7). Later harvesting likewise significantly improves yields, at least up to 24 months after planting. Beyond that, yield curves for both varieties level out (Table 7). Root quality may also deteriorate after this point if analyses of root contents undertaken in northern Zambia prove applicable in the more temperate zones of central Zambia.

To produce significant cassava output during the hungry season, from December through March, a small farmer needs to plant early. Planting in November, December, or at the latest in early January, will enable families to harvest 25- 35 ton cassava yields 24 months later.

Comparison with results from northern regions suggests that cassava bulking occurs more slowly in central Zambia, most likely because of cooler temperatures, less rainfall and a shorter growing season. While Bangweulu and Mweru reach maturity within about 16 months in northern Zambia, the yield curves from our trials indicate that the same varieties produce yield gains more slowly in central Zambia, achieving their maximum output at about 24 months after planting. Though slower to mature, yield potential remains roughly comparable. Our Bangweulu plots yielded 37 tons per hectare (at 24 months after planting), 120% of the 31ton yield potential achieved at maturity (16 months after planting) in the north. With Mweru, the

33 tons per hectare achieved in Lusaka province (at 24 months after planting) attained 80% of the 41 tons achieved in the north (at 16 months after planting). Though we have not conducted content analysis of the roots, it will be important in future research to evaluate dry matter, fibre, calorie, protein and cyanide content at various points in time.

Table 7: Cassava yield in Lusaka Province, by time of planting and harvest

Variety Month planted	Yield (tons/ha)**			
	Months after planting (MAP)			
	12 MAP	15 MAP	24 MAP	March 2005
V1. Bangweulu				
Dec 2002	7.6	18.6*	37.0*	37.7
	1.6	3.5	7.1	11.6
Jan 2002	7.1	19.9*	30.9*	30.5
	4.0	4.0	8.7	2.6
Feb 2003	5.1+	14.8*+	26.9*+	27.8
	1.3	2.6	3.4	12.9
V1. Mweru				
Dec 2002	10.4+	22.4*	32.8*	33.6
	2.9	3.5	6.2	11.6
Jan 2002	7.6	17.1*	26.1*	23.9
	2.0	3.1	5.6	11.0
Feb 2003	2.0	9.2*	13.9	14.4
	1.4	1.4	7.1	2.3

* Significantly greater than the prior harvest at the 95% confidence level
** Standard deviation listed underneath the mean
+ Indicates that this variety yields significantly more than the other at the corresponding planting and harvest date
Source: American International School (AIS) cassava trials

3.4 Cassava compared with maize

Even given its slower maturation in central Zambia, cassava strongly outperforms maize in terms of labour and land efficiency. Yield comparisons at maturity suggest an overwhelming advantage for cassava, which yields over 30 tons of fresh roots, or 9 tons of dry matter, compared to 1.5 tons for maize. Even dividing by 3, to account for a staggered harvest over a three-year cycle, this represents a 10 ton annual yield, equivalent in calorie terms to 3 tons of maize. Given zero recurrent cash costs in cassava production, greater flexibility in labour input, and higher yields, cassava proves more productive and more profitable than maize, as well as less vulnerable to drought (Table 8).

Table 8: Productivity and profitability of cassava and maize in Central Zambia

		Maize	
	Cassava	**HYV**	**Local**
Output			
Yield (tons/ha)	30	3	1.5
Seasons on plot	3	1	1
Price ($/ton)	40	150	150
Price (Kwacha/ton)	192,000	720,000	720,000
Value ('000,000 Kwacha)	5,760,000	2,160,000	1,080,000
Variable input costs ($/ha)			
($/ha)	$0	$107	$0
('000,000 Kwacha/ha)	0	511,560	0
Labour (person-days/ha)			
Land preparation	50	50	50
Planting	16	16	16
Weeding	75	50	50
Fertilizer application	0	18	0
Harvesting	30	20	16
Total	171	154	132
Gross margin (Kwacha/ha)	5,760,000	1,648,440	1,080,000
Financial returns			
Returns to labour (Kwacha/person/day)	33,684	10,704	8,182
Returns to land (Kwacha/ha/year)	1,920,000	1,648,440	1,080,000
Calorie returns			
Calories per kg fresh weight	1,098	3,071	3,071
Calories per person-day worked	192,712	59,831	34,901
Calories per ha/year	10,985	9,214	4,607

Note: Cassava is vegetatively propagated from stem cuttings, each of which when planted produces an offspring genetically identical to its parent. Therefore, to begin production of cassava using improved varieties farmers need to procure an initial supply of improved cuttings. The Root and Tuber Improvement Programme (RTIP) research station charges K75 per cutting or roughly $150 per hectare. Most farmers, however, receive small numbers of initial cuttings for free from neighbors or from NGOs and then expand from existing fields in successive years.

Source: AIS field trials, Haggblade and Tembo (2004), field interviews

3.5 Cassava as drought insurance

The most effective cassava-based food security system we have observed in field visits with Lusaka-area farmers suggests that a three-year sequencing of cassava plots offers farmers their most efficient hedge against maize crop failure. By planting one plot a year, three years in succession, a family can begin a cycle of perpetual harvests 24 months after planting. Using this cassava-based drought insurance system, a typical 5-person family would need to plant a series of three 0.04 hectare (20x20 meter) cassava plots to insure family calorie consumption against a 50% maize harvest failure (Table 9). In the event of a complete collapse in maize availability, ensuring satisfactory calorie consumption throughout the year from their fields would require harvest of one 0.07 hectare cassava plot. A set of three plots staggered over a three-year interval would, thus, require slightly less than one lima (.25 hectares) of total land under cassava. These calculations assume timely weeding and therefore good yields on all cassava plots. Under less diligent management, cassava area requirements would approximately double, still remaining well within the labour capacity of most small hand-hoe farming households. These calorie-sufficiency calculations also ignore protein and micronutrient balances which we signal as a worthy parallel exercise for nutritional scientists and which might be secured from sources such as cassava leaves, dried fish and wild fruits and vegetables.

Table 9: Cassava area required for ensuring food security

	Current situation		Drought year scenarios (maize consumption falls)		Lean season scenario
	Zambia average	Central Zambia estimate	by 50%	by 100%	
Calorie consumption (kcal/person/day)					
Maize	1,088	1,317	658	0	0
Cassava	254	25	684	1,342	1,342
Other foods	586	586	586	586	586
Total	1,928	1,928	1,928	1,928	1,928
Quantities consumed (kg/household**)	Annual		Annual		Lean season
Maize	647	782	391	0	0
Cassava	422	42	1,136	2,230	743
Required increase in cassava					
Consumption (kg/household)	-	-	1,094	2,187	743
Area harvested (ha), assuming 30 ton yields	-	-	0.04	0.07	0.02
Area harvested (ha), assuming 15 ton yields	-	-	0.07	0.15	0.05

* Assumes household maize is finished by December, and cassava must fill the 4-month maize calorie gap
** Household averages 5 people

Source: FAOSTAT food balance sheets and authors' estimates (2002)

3.6 Lean season hunger

Routine lean-season hunger prevention proves even more economical. Three staggered 0.02 hectare (200 square meters) cassava plots would permit a 5-person family, if need be, to supply all their starch requirements from cassava during the four-month lean season (Table 9). With cassava providing in-kind food insurance, the rainy season need no longer be a hungry season for poor Zambian farmers.

3.7 Policy implications

Agricultural diversification -- out of maize and into other food staples (cassava, sorghum, and sweet potato) as well as cash crops (cotton, tobacco, horticulture crops) -- remains stated national policy in Zambia (MACO, 2004;

Zulu *et al*, 2000). Results from these cassava trials suggest that expansion of cassava production outside of its traditional consuming zones indeed holds significant potential for increasing smallholder productivity and reducing hunger during the annual lean season as well as during drought years.

Realization of this diversification policy will a require commitment of public resources. In the short run, expansion of cassava production in central Zambia will require an expanded supply of clean planting material for the improved new varieties, necessitating an initial investment in nursery establishment and expanded seed certification systems. A focus on cassava market development - for food, livestock feed and industrial uses – will further facilitate diversification efforts. To this end, Zambia's Food Reserve Agency has conducted trial purchases of cassava during the past season, while Zambia's Agricultural Consultative Forum has recently launched a Cassava Task Force aiming to facilitate future cassava processing and market development. Given prevailing peak-season labour constraints among Zambia's predominantly hand hoe small farmers, and given the significant labour productivity advantage of cassava over maize, an expansion of cassava markets appears apt to elicit a significant supply response from farmers. Thus, where cassava markets emerge, household cassava production and food security are likely to follow.

In the long run, government funding for research and extension will need to reflect these new priorities. Zambia's current repertoire of improved cassava varieties represents the fruit of a 15 year research program that has now fallen largely dormant (Haggblade and Zulu, 2003). As pests and diseases continue to evolve, researchers will need to maintain an active cassava development program in order to maintain yields under evolving natural conditions (Nweke *et al*, 2002).

Further economic analysis can assist these efforts in several ways. More detailed timing trials, coupled with seasonal labour market studies and farmer interaction in different zones, will prove helpful in developing extension advice on the best ways of integrating cassava-based production into farmers' portfolios. Parallel investigations into the economics of cassava-based feed and food processing will serve to focus efforts on the most promising avenues for expanding cassava-based processing and commercialization.

4. Conclusions

As a result of erratic rainfall during the 2004/5 season, Zambia's maize crop will once again fail to supply domestic consumption needs (MACO, 2005b). While smallholder farmers in central Zambia will produce only one ton per hectare from their maize, our cassava plots yielded over 30 tons of fresh cassava roots (the calorie equivalent of 9 tons maize yields) under the same agro-ecological conditions (see MACO, 2005a). Under a staggered three-year planting cycle, harvesting the oldest plots 24 months after planting, a typical family of five would need to harvest only 0.07 hectares of cassava per year to fill the calorie gap arising from a complete failure of their maize crop. In all, a total of less than one lima (0.25 hectares) of land under cassava would completely insulate them from the calorie-compression induced by even the most volatile maize downturn.

These results suggest that current enthusiasm for expanding cassava production outside of northern Zambia is well founded. Cassava does, indeed, offer an affordable means of mitigating lean season hunger and providing low-cost, in-kind drought insurance for rural households in central Zambia. As a result, accelerated development of cassava markets and production offers a promising vehicle for improving food security of vulnerable households in central Zambia.

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References

Chitundu D & Soenarjo R (1997). *Cassava field production guide*. Mansa: Luapula Livelihood and Food Security Programme: Seed Multiplication Component.

Chipungu PM & Kunda DM (eds) (1994). *State of environment report in Zambia*. Lusaka: Environmental Council of Zambia.

Elwell H (1995). *An assessment of the performance of Minimum Tillage Technologies in Zimbabwe in terms of drought risk alleviation, yields and cost-effectiveness*. Harare: World Bank.

Food and Agriculture Organisation (FAO) (2002). *Zambia food balance sheet*. Rome: FAOSTAT.

Haggblade S & Tembo G (2004). *Conservation farming in Zambia*. EPTD Discussion Paper No 108. Washington, DC: International Food Policy Research Institute.

Haggblade S & Zulu B (2003). *The recent cassava surge in Zambia and Malawi.* Conference Paper No 9 presented to the InWent, IFPRI, NEPAD, CTA Conference on "Successes in African Agriculture", Pretoria, December 1-3, 2003.

Hong Kong Observatory (2005). *World climatological information*. www.hko.gov/wxinfo/climat/world/eng/africa.

Howard JA (1994). *The economic impact of improved maize varieties in Zambia*. PhD Thesis, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

Howard JA & Mungoma C (1996). *Zambia's stop and go revolution: The impact of policies and organizations on the development and spread of maize technology.* MSU International Development Working Paper No 61. East Lansing, Michigan: Michigan State University, Department of Agricultural Economics.

Ministry of Agriculture, Food and Fisheries (1999). *Zambia agricultural sector performance analysis, 1997-1998.* Lusaka: Institute of Economic and Social Research, University of Zambia.

Ministry of Agriculture, Food and Fisheries (2000). *Impact assessment of root and tuber research in Northern Zambia.* Soils and Crops Research Branch, Farming Systems and Social Sciences Division. Chilanga, Zambia: Mt Makulu Central Research Station.

Ministry of Agriculture and Cooperatives (MACO) (2004). *National Agricultural Policy 2004/2015*. Lusaka: MACO.

Ministry of Agriculture and Cooperatives (MACO) (2005a). *Statement by Honourable Mundia F Sikatana, MP, Minister of Agriculture and Cooperatives on the*

Crop Forecasting Survey for 2004/5 Agricultural Season and the Food Balance Status for the 2005/6 Marketing Season. Lusaka: MACO.

Ministry of Agriculture and Cooperatives (MACO) (2005b). 2004/5 Crop Forecast Survey. *The Zambian Farmer* (July).

Nweke F, Spencer DSC & Lynam J (2002). *The cassava transformation in Africa: Africa's best-kept secret*. East Lansing, Michigan: Michigan State University Press.

Republic of Zambia (1994). *National Census of Agriculture (1990/92) Census Report (Part 1)*. Lusaka: Central Statistics Office.

Simwambana MSC, Chiona M, Chalwe A & Mutuna S (2004). *Basic cultural practices of cassava (Manihot esculenta Crantz) crop production in Zambia*. Solwezi: Ministry of Agriculture and Cooperatives.

Veldkamp WJ, Muchinda M & Delmotte AP (1984). *Agro-climatic zones in Zambia*. Soils Bulletin No 9. Lusaka: Soil Survey Unit.

Zulu B, Nijhoff JJ, Jayne TS & Negassa A (2000). *Is the glass half-empty or half full? An analysis of agricultural production trends in Zambia*. Working Paper No 3. Lusaka: Food Security Research Project.