

COFFEE RESEARCH AND THE COFFEE FARMER IN THE SOUTHERN HIGHLANDS OF TANZANIA

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ABSTRACT

The Southern Highlands of Tanzania are gaining in importance in the production of coffee, mainly because of an expansion in the area planted. Yields have remained at about 250-300 kg ha⁻¹, mainly because of diseases, pests, weeds, nematodes, soil erosion and poor crop management. Unfavourable economic conditions also contribute to the low yields.

In experiments conducted in the Southern Highlands of Tanzania, the varieties K.7, KP.162, KP.423, P313, SL. 28 and N. 197, and the hybrid N.39 x VC.298, have shown outstanding yield performance over a 12 year period compared with the traditional variety, N.39. Significant yield increases have been obtained by the use of grass mulch, farmyard manure, nitrogen fertilizer (especially in combination with potassium and/or phosphate), copper sprays (which also control coffee leaf rust) and increased plant populations (from 1343 to 3585 trees ha⁻¹). Among the different pruning systems, the best yields have been obtained by allowing free growth. Fungicide trials have demonstrated that spraying should commence in October/November and end by April instead of from September to May spray period as at present. If Fluazinam and Anilazine 720 maintain their performance in trials to screen fungicides for the control of coffee berry disease, they will be proposed for recommendation next year (1993). The insecticides Beta-cyfluthrin and Lambda-cyhalothrin have shown outstanding control of leaf miners.

As well as summarising this research, this paper presents maps showing the suitability of land for coffee production in Mbeya and Iringa Regions. Coffee growing in areas classified as either unsuitable or marginally suitable should be avoided.

INTRODUCTION

The economic production of Arabica coffee is only possible in a limited range of environmental conditions (Robinson, 1964). Soils with a rooting depth of more than 120 cm are essential. They should be well-drained and have a pH of 5.2-6.2. Coffee needs a sub-tropical to temperate climate that is frost free and without high wind, with a minimum annual rainfall of 760 mm and 125 rain days in bi-modal rainfall areas, and 1140 mm per annum with 150 rain days in mono-modal rainfall areas (Robinson, 1964). A dry season lasting between 6 and 14 weeks is essential to break of dormancy and initiate the development of flower buds (Wrigley, 1988; Purseglove, 1984). Temperatures should remain as close to 20°C as possible throughout the year, although in practice coffee is grown in areas with temperatures as low as 10 and as high as 31°C (Wrigley, 1988).

In the Southern Highlands of Tanzania, coffee is grown as a cash crop in Mbozi, Rungwe, Mbeya and Ileje Districts of Mbeya Region, Mbinga and Songea Districts of Ruvuma Region, Mpanda District in Rukwa Region, and Njombe District of Iringa Region, almost entirely by smallholder farmers. According to the 1981/82 Coffee Tree Census, the number of growers in the Southern Highlands totalled 73,814 and the area under coffee was 47,100 ha of mature and 13,393 ha of immature trees (TCDP, 1983a). New planting is currently taking place in Makete and Ludewa Districts of Iringa Region and in Nkasi and Sumbawanga Districts of Rukwa Region.

Coffee is a very important export crop for Tanzania, accounting for 57% of the value of all exports in 1986 (MDB, 1987). In 1972/73, 15% of the coffee produced in the country came from the Southern Highlands; increasing to 21% in 1977/78, 34% in 1982/83, and 42% in 1986/87 (MDB,

1987). However the coffee yields from smallholder are low between 200 and 500 kg ha⁻¹ (TCDP, 1983a; Nsemwa, 1987) compared with yields of 1-2 t ha⁻¹ that have been obtained from Mbimba and Mitalula sub-stations in the Southern Highlands in recent years (Matumla, 1988).

The major constraints to arabica coffee production include diseases such as coffee berry disease (*Colletotrichum coffeanum* Noak), coffee leaf rust (*Hemileia vastatrix* Berkret Br.) and Fusarium Wilt (*Fusarium stilboides* Wr.) and root knot nematodes (*Meloidogyne* spp), copper toxicity resulting from soil contamination by copper sprays used to control diseases, insect pests (leaf miners and Antestia bugs), soil erosion, and poor management practices (Semuguruka, 1984). Adverse economic conditions make the use of improved management practices impractical, thus contributing to the poor yields obtained by farmers.

This paper reviews the research on coffee that has been carried out in the Southern Highlands to date, outlines current farmer practices and constraints and provides some suggestions for the development of the crop in future.

RESEARCH REVIEW

Variety selection

The yield of a number of coffee cultivars over the period 1961-74, recorded from three trials at Mitalula is shown in Table 1. Mulching significantly increased yields, but there was no significant interaction between cultivar and mulch (Swai, 1975). KP 162, KP 423, K 7, P313 and N 197 consistently out-yielded the other cultivars and were therefore proposed for recommendation to farmers (Swai, 1975).

The 10-year mean yields of a variety trial planted at Mbimba in 1960, and of a hybrid trial planted in 1965, are presented in Table 2. The coffee hybrid trial included a comparison of the effects of spraying with copper, which increased the overall mean yield from 374 to 646 kg⁻¹ ha. There was no significant interaction between hybrid/variety and spraying. The best yielding varieties were SL 28 and N. 197, and the best yielding hybrids were OP 517, OP 710 and OP 378.

A considerable amount of breeding and selection work has been carried out at Lyamungu in Northern Tanzania in recent years, with the aim of producing high yielding varieties that are resistant to coffee berry disease and coffee leaf rust. The results are presented in Table 3.

Table 1. Yield of clean coffee (de-husked and dried, kg ha⁻¹) over the period 1961-74 from three trials at Mitalula: Trial A, mean yield 1961-1972 of trees planted in 1959; Trial B, mean yield 1964-1974 of trees planted in 1961; and Trial C, mean yield 1961-1973 of trees inter-planted with bananas in 1959

	Trial A	Trial B	Trial C
KP 162	677	797	627
H 66	544	789	611
KP 227	441	-	491
KP 154	512	-	573
P 313	613	684	630
KP 532	475	-	560
N 197	467	809	568
N 218	489	-	666
KP 423	688	-	654
N 39	544	655	525
K 7	-	895	-
Kidachi	-	436	-
Kinairobi	-	768	-
LSD (P<0.05)	133	125	-

Table 2. Yields of clean coffee (kg ha⁻¹) from two trials at Mbimba: Trial D, mean yields of varieties 1968-1973; Trial E, mean yields of hybrids 1968-1973

	Trial D		Trial E
SL 6	731	OP 378	573
SL 14	1134	OP 392	549
SL 28	1305	OP 405	525
SL 34	1098	OP 502	512
I 5	931	OP 517	574
I 49	975	OP 539	521
N 5	917	OP 545	528
N 197	1167	OP 710	574
P 280	840	H 66	320
P 280/21	1019	KP 423	433
P 351	791	N197	553
N 39	939	N 39	433

Table 3. Yields of clean coffee (kg ha⁻¹) from promising Lyamungu coffee crosses

	1987	1988	Mean
Kaffa x KP 423	681	1085	883
(N. 39 x Kaffa) x Rume	787	830	809
Kaffa x Rume	724	936	830
(B.M. Jam x 5.6 Cioccie) x KP 423	1149	660	905
N. 39	404	404	404
Rume x Hb. de Timor	148	277	213
N. 39	148	277	213
(N. 39 x OP 729) x (Timor Hb. 1343) x 1 Ilubabor	1170	702	936
N. 39	-	362	362

Source: Nyange, 1989.

The low-yielding variety N. 39 is widely grown in the Southern Highlands by smallholders. The provision of superior material such as KP 162, KP 423, K 7, SL. 28 and N.197 to farmers is long overdue. There is also an urgent need to re-initiate variety screening and on-farm adaptation trials in the Southern Highlands. A particularly promising variety that could be included is N 39 x VC 298 (Rume Sudan), which was proposed for release in 1983 (RIL, 1983). It is high yielding (1,045 kg ha⁻¹ over 16 years), resistant to coffee berry disease, and has a good liquoring quality (RIL, 1983, 1986).

Fertilizer use

Organic fertilizers. Trials carried out from 1962 to 1970 at Mbimba with variety N 197 demonstrated consistent yield increases as a result of organic manure application (Kondeala, 1976). Mean yields were 1,121 kg ha⁻¹ clean coffee for the control, 1,507 kg ha⁻¹ for the treatment with farmyard manure (one *debe* = approximately 20 l of FYM applied annually to each tree), and 1,708 kg ha⁻¹ for the treatment with grass mulch (25 cm layer of mulch applied in lines approximately 1.5 m apart) treatments.

Inorganic fertilizers. The main results of various fertilizer trials carried out at Mbimba and Mitalula are summarized in Table 4 (Kondeala, 1976; Swai, 1974, 1975). All the trials indicated a considerable need for nitrogen fertilizer. There was little response to either phosphate or potassium in the absence of nitrogen, and only a limited response to liming on the orthic Ferralsol soils of Mbimba.

Table 4. Yields of clean coffee (kg ha⁻¹) from a number of fertilizer trials carried out at Mbimba and Mitalula

1. Mbimba, 1963-1973		2. Mitalula, 1962-1972	
78 kg N ha ⁻¹	509	Control	130
78 kg N ha ⁻¹ , 5 Cu sprays per year	1106	Five Cu sprays per year	538
156 kg N ha ⁻¹ , mulch, Mg, urea spray	797	Five Cu sprays per year, 300 g CAN ¹ per tree	955
156 kg N ha ⁻¹ , mulch, Mg, urea spray, 5 Cu sprays per year	1514	Five Cu sprays per year, 300 g CAN per tree, mulch	923
LSD (P< 0.05)	443	LSD (P<0.05)	72
3. Mbimba, 1964-70		4. Mitalula 1961-1972	
Control	685	Control	287
N	768	NPK	510
P	690	CaNP	516
K	669	CaNK	530
NP	936	CaPK	299
NK	842	CaNPK	599
PK	693	LSD (P<0.05)	131
NPK	985	N: 99 g CAN per tree; P: 113 g DSP per tree;	
LSD (P<0.05)	113	K: 85g potash per tree; Ca: 85 g lime per tree.	
5. Mbimba, 1964-1973		6. Mbimba, 1966-1972	
0 kg N ha ⁻¹	891	Control (no lime)	830
81 kg N ha ⁻¹	1318	6.8 kg lime per tree	924
161 kg N ha ⁻¹	1332	10.8 kg lime per tree	1031
322 kg N ha ⁻¹	1555	LSD (P<0.05)	118
LSD	NS		

¹CAN: calcium ammonium nitrate; NS, not significant.

Spacing and pruning

Pruning caused considerable yield reductions at Mbimba (Table 5). Similar effects were observed at Mitalula in another trial comparing four different pruning treatments: free growth, 4 multiple stem pruning (that is, four stems allowed to grow up after pruning), 4 capped multiple stem pruning (four stems checked, or capped at a height of about 1.5m), and 3 capped multiple stem pruning. Mean yields over the period 1968-1974 were 1091 kg ha⁻¹ for free growth (over a three year cycle) compared with 888 kg ha⁻¹ for 4 multiple stem pruning, 971 kg ha⁻¹ for 4 capped multiple stems and 888 kg ha⁻¹ for 3 capped multiple stems. Free growth cannot be strongly recommended, however, because of the difficulty of managing tall trees, but there is clearly a need for further investigation of different pruning systems.

Planting coffee in double and triple rows considerably increased yields at both Mbimba and Mitalula (Table 5). The results of Kessy (1989) on the effects of spacing on three different varieties, summarized in Table 6, confirm the beneficial effects of increasing plant population on coffee yield, and emphasize the need to re-evaluate the spacing of 2.7 x 2.7 m (9 x 9 ft) which is commonly used.

Table 5. Yields of clean coffee (kg ha⁻¹) for different pruning and spacing treatments at Mbimba and Mitalula, 1964-67

	Trees ha ⁻¹	Mbimba			Mitalula
		Not pruned	Pruned	Mean	Mean
Normal spacing (3 x 2.4 m)	1343	1318	9019	1110	1112
Single hedge (3 x 0.9 m)	3585	2588	2176	2382	2387
Double hedge (3 x 0.9 x 0.9 m)	5516	2622	2279	2450	2456
Double hedge (3 x 0.9 x 1.8 m)	2758	2172	1789	1980	1985
Triple hedge (3 x 0.9 m)	6721	2834	2320	2577	2583
Triple hedge (3 x 0.9 x 1.8 m)	3360	2227	1843	2035	2040

Table 6. Yields of clean coffee (kg ha⁻¹) averaged over three varieties grown at different spacings at Lyamungo

Spacing	Trees ha ⁻¹	1979-82 pruning cycle	1984-1987 pruning cycle
2.7 x 2.7 m	1330	195	1205
3.0 x 1.0 m	3300	1006	1739
2.0 x 1.0 m	5000	1401	1852
1.8 x 0.7 m	7190	1741	2010

Source: Kessy, 1989.

Plant protection

Data from a trial on the effects of spraying with diathion and copper hydroxide at Mbimba are summarized in Table 7. Similar results were obtained at Mitalula and Ndengo. The results indicate that there is little advantage in commencing spraying in September, since the best yields were obtained with the October-April spraying regime. The September, December, and March spraying regime which approximates to the usual farmer practice, gave yields similar to those of the other regimes. The treatment simulating farmer practice also gave similar results to other treatments for the percentage of berries with coffee berry disease, but gave very poor control of coffee leaf rust. All fungicide treatments reduced disease incidence and resulted in a considerable increase in yield. However, the percentage of leaves infected with coffee leaf rust in February was small (less than 4%) even in the control plots, indicating little need for spraying much before this time. Current recommendations are to commence spraying at least 21 days prior to the expected start of the rains (TCMB, 1991), implying the need to spray from September onwards. However, these results suggest that spraying for coffee berry disease and coffee leaf rust should commence in October/November and end by April.

During the 1987/88 season a fungicide screening trial was initiated for the control of both coffee berry disease and coffee leaf rust at Mbimba, using 14 different fungicides (Nsemwa, 1989). The highest yields in 1990/91 (800 kg ha⁻¹) were obtained with copper oxychloride and fluzinam, but DF-250, anilazine 720, and the currently recommended fungicides chlorothalonil and propiconazole + chlorothalonil also resulted in good yields (Nsemwa, 1992). If their performance continues to be good, fluzinam and anilazine 720 will be proposed for recommendation to farmers in 1993.

Table 7. Percentage berries with Coffee Berry Disease (CBD), and percentage leaves with Coffee Leaf Rust (CLR), during February, March and April, and yields of clean coffee (kg ha⁻¹), averaged over the period 1985/86-1989/90 at Mbimba

Spray period	Berries with CBD (%)			Leaves with CLR (%)			Yield
	Feb.	Mar.	Apr.	Feb.	Mar.	Apr.	
Sept.-May	11	13	13	0.4	2.1	1.8	457
Sept.-Apr.	11	12	12	0.3	1.9	1.7	674
Oct.-May	10	11	13	0.5	2.2	2.3	621
Oct.-Apr.	8	9	9	0.4	1.8	2.0	508
Nov.-May	11	14	14	0.5	1.8	2.5	507
Nov.-Apr.	10	11	12	0.7	2.4	2.7	536
No spray	24	27	28	1.8	7.4	9.7	112
Sept., Dec., Mar.	14	16	16	1.1	5.6	5.7	488

During the 1989/90 season, an insecticide screening trial for the control of Coffee Leaf Miner was carried out at Mbimba and Mitalula (Kabungo and Muhanna, 1991). Leaf damage increased considerably between July and December, and was significantly reduced by application of lambda-cyhalothrin and beta-cyfluthrin. Damage and leafminer infestation was worse in coffee planted under shade.

Land Suitability

Kamasho *et al.* (1981) surveyed Rukwa Region and reported that it was unsuitable for coffee because it has low and erratic rainfall, with an over-long dry season, and soils of low fertility and moisture-holding capacity. They also pointed out that coffee is currently being grown at altitudes too high for a successful commercial crop.

A land-suitability map for coffee for Rukwa Region is shown in Figure 1 and for Mbeya Region (TCDP, 1983) in Figure 2. The maps are based on the following criteria: highly suitable - over 1125 mm annual rainfall, with less than 75 days absolute drought; moderately suitable - over 1125 mm annual rainfall, with up to 90 days absolute drought; marginally suitable - over 1125 mm annual rainfall with up to 180 days absolute drought; and unsuitable - less than 1125 mm annual rainfall and/or more than 180 days drought. TCDP suggest, however, that in marginal areas, such as Mbozi, coffee can be grown successfully provided that the coffee husbandry practices are very good. A land suitability map for coffee for Iringa Region is shown in Figure 3 (Msaki, 1985).

Nsemwa (1991) showed that at the current coffee price of 230 TSh kg ha⁻¹, farmers need to produce about 474 kg ha⁻¹ to break even, which is difficult to achieve in areas classified either as wholly unsuitable or marginally suitable. This emphasizes the need to avoiding coffee production in such areas.

CURRENT FARMER PRACTICES AND CONSTRAINTS

Most farmers in the Southern Highlands are growing the variety N.39, distributed by the Tanzania Coffee Marketing Board or its predecessor, the Tanzania Coffee Authority. The popular plant spacing for both smallholders and large farms is approximately 2.7 x 2.7 m (9' x 9').

While most farmers hand weed their coffee quite well (Nsemwa, 1987) pruning is generally inadequate. With the exception of Mbozi District where most of the coffee is allowed to grow freely on single or multiple stems, most of the coffee in the Southern Highlands is maintained on a single stem-capped pruning system. In the case of stumped coffee, it is regenerated on a multiple stem capped pruning system. The farmers in Mbozi prefer free growth because it eliminates or minimizes

the labour required for pruning. Except for Rungwe, where most of the coffee is interplanted with bananas, most of the coffee in the Southern Highlands is grown as a monocrop. In Mbinga and Njombe the coffee is mostly grown under the shade of *Grevillea* sp. trees, whereas in other districts (especially in Mbozi) very little shade is provided.

Mulch is rarely used, and little fertilizer is applied. Farmers who keep animals usually apply farmyard manure, especially at planting. Most smallholder yields are in the range 250-500 kg ha⁻¹ (TDCP, 1983b; Nsemwa, 1987) on fields ranging from 0.65 ha (Mbinga) to 1.1 ha (Mbozi). Large estates generally achieve yields between 500 and 1000 kg ha⁻¹, with yields as high as 2000 kg ha⁻¹ occasionally being recorded (Matumla, 1988).

Constraints to coffee production can be divided into two categories, those concerning the crop and those concerning its marketing.

- The varieties currently in use are susceptible to coffee berry disease, coffee leaf rust, *Fusarium* diseases, insect pests including leaf miners, *Antestia* bugs, White Stem-borer, scales insects, mealybugs and nematodes. Pesticides are rarely available at the time and place needed.
- Soil fertility is often poor, frequently as a result of over-cropping, yet fertilizers are often unavailable and/or perceived as too expensive by resource-poor smallholders.
- Labour demands for weeding, pruning, spraying, fertilization and mulching frequently cannot be met by family labour as a result of both insufficient labour and demands for high priority food crops.
- Land scarcity in Rungwe has resulted in mixed cropping of coffee, which reduces coffee yield reductions.
- The price offered to farmers for coffee is low in relation to the price they have to pay for inputs. Coupled with the absence of credit facilities, and the extremely long delays in payment by the marketing Cooperatives, this has resulted in a very low level of input use, and correspondingly low yields.
- The absence of central processing plants obliges farmers to process their coffee themselves, which increases the demand for labour and equipment, and results in uneven quality.
- Farmers are obliged to sell their crop to primary cooperative societies which then forward the produce to the Coffee Marketing Board, which is responsible for marketing the crop. Overhead costs are deducted before the farmer is paid. Fluctuations in world market prices have often resulted in coffee being marketed at prices, well below those anticipated with farmers receiving only a small proportion of the final price. Changes in consumer preference, leading to an increased demand for a higher quality product, are extremely difficult to satisfy in a situation where inputs are costly and used in inadequate amounts.
- The road communication network in many parts of the Southern Highlands is poor, contributing to problems in input supply and produce collection.

SEQUENCE OF INNOVATIONS FOR INCREASED COFFEE PRODUCTION

A suggested sequence of innovations for introducing to smallholder farmers to increase their coffee production is shown in Table 8.

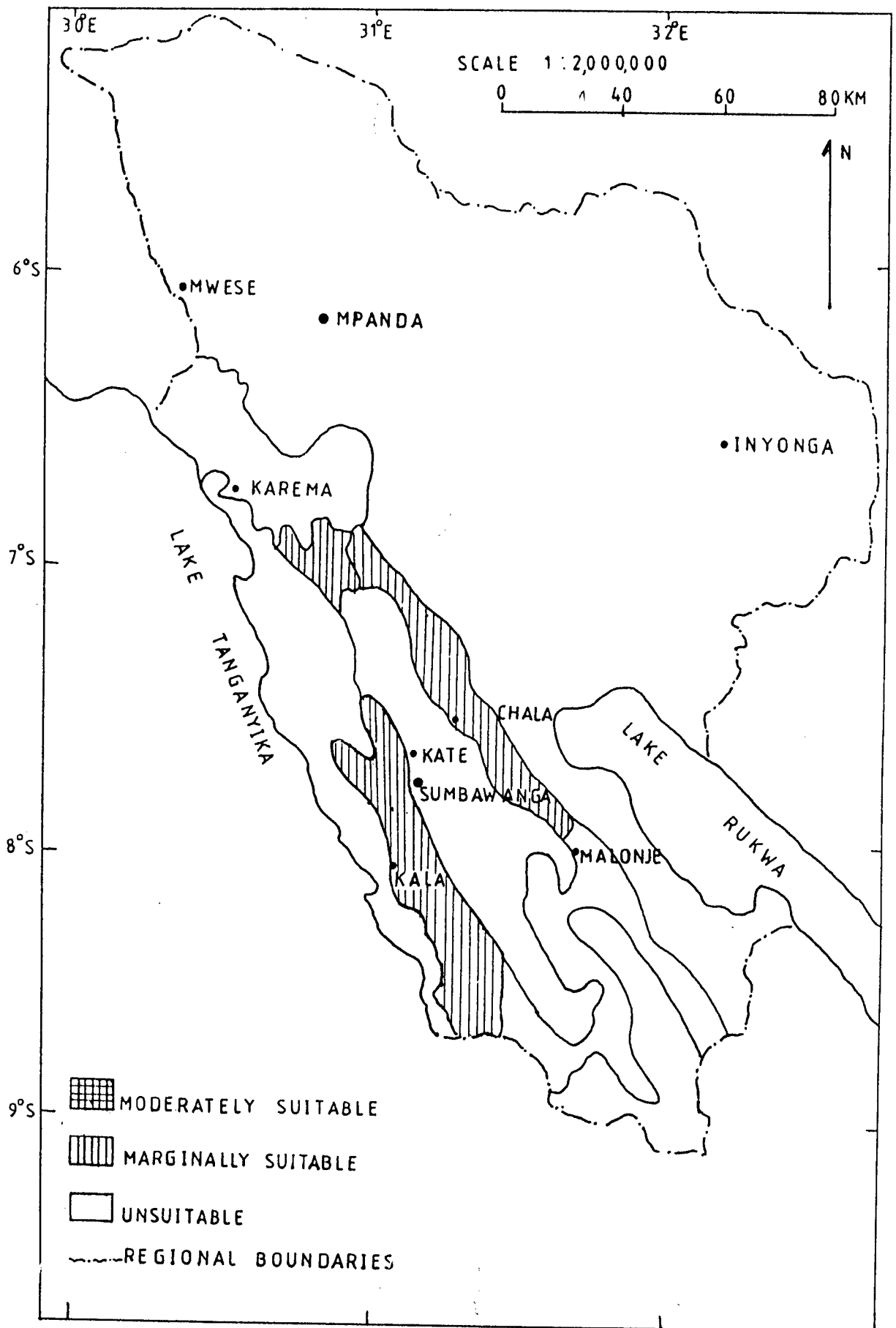


Figure 1. Land suitability map for coffee for Rukwa Region

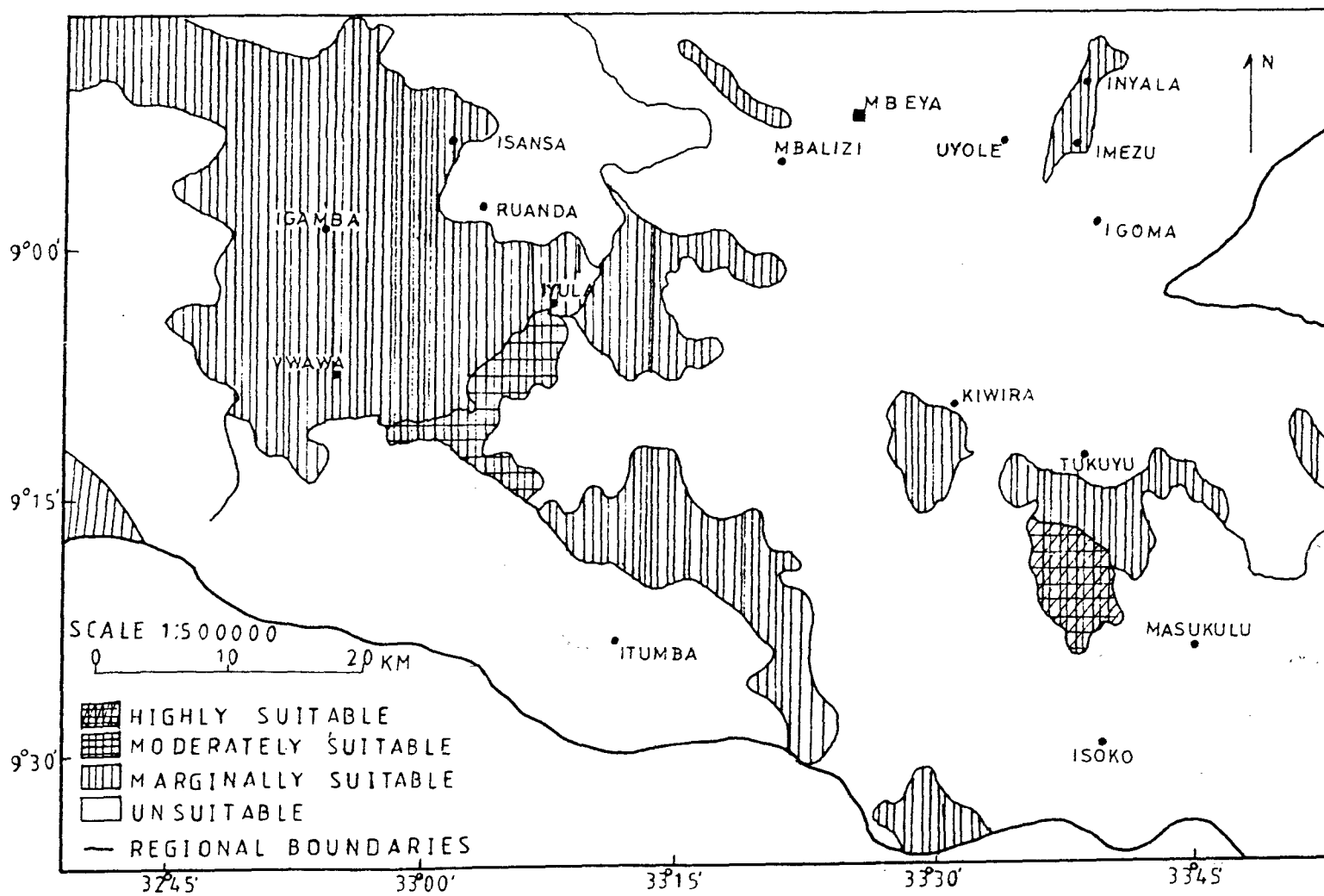


Figure 2. Land suitability map for coffee for Mbeya Region

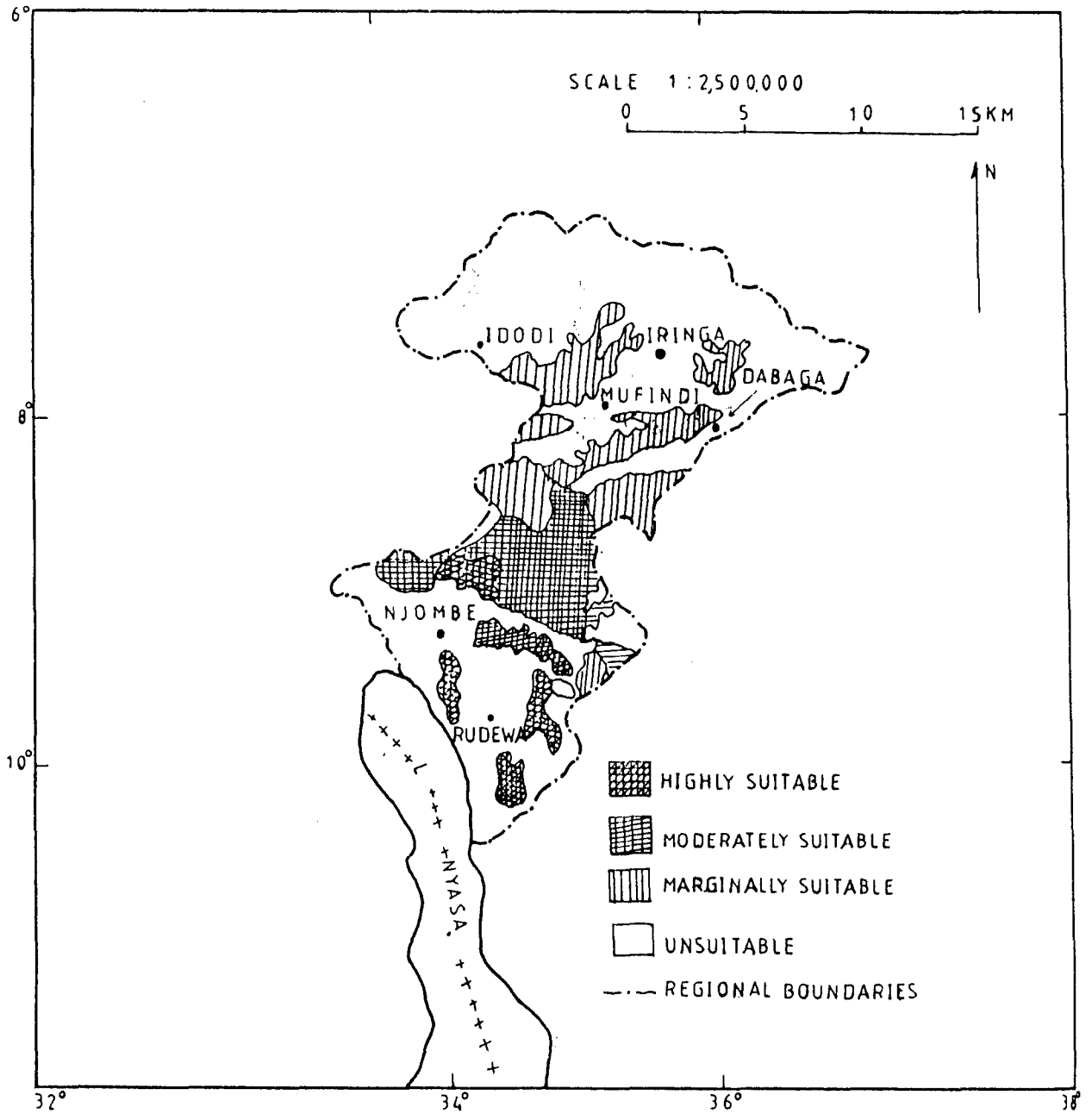


Figure 3. Land suitability map for coffee for Iringa Region

Table 8. A sequence of innovations for improving the production of smallholder coffee, and estimated yields

Management	Characteristics	Yield (kg ha ⁻¹)
'Zero' management level	Extremely low management (an unusual situation)	150
Weeding, Pruning, fertilizer use	At least two weedings per season and one pruning; 60 kg N ha ⁻¹	250
Disease control	Fungicidal spray at least three times to control CBD and CLR; 60 kg N ha ⁻¹	350
Pest control	Insecticidal sprays to control insect pests, including leaf miner, stemborers and antestia	500
Improved varieties	Resistant to CBD	750
Improved fertility	Three weedings + two prunings; 90 kg N ha ⁻¹	1000
Improved disease and pest control	Fungicidal sprays at least five times per season, and at least three insecticidal sprays per season; 120 kg N ha ⁻¹ .	1500
Additional improvements in fertility	180 kg ha ⁻¹ + 90 kg P ₂ O ₅ ha ⁻¹ .	2000

RECOMMENDATIONS FOR THE FUTURE

The following are lists of recommendations for the future, in the areas of research, government reforms and extension work.

Research

1. Cultivar development for high yield, resistance to CBD and CLR, and quality. Release of varieties already developed.
2. Location-specific fertilizer trials that include all the major nutrients, for both newly-planted coffee and established trees.
3. Development of agronomic recommendations for new varieties.
4. Development of acceptable and economic control methods for diseases, pests, weeds and nematodes, and pesticide screening that includes considerations of safety and environmental hazards. It is likely that damage by *Fusarium* is higher than presently acknowledged. The possibility of uprooting old *Fusarium*-infected trees and re-planting with new varieties should be considered, together with a shortened life cycle of 10 years, coupled with higher plant populations and consequent reductions in pruning requirements.
5. Intensification of on-farm experimentation in collaboration with extension agents.

Government reforms

1. In so far as it is possible, farmers should be offered prices adequate to compensate for the cost of inputs, and payments should be made promptly.
2. Government reform is required to reduce the bureaucracy involved in the purchase of inputs, including pesticides, and to assist suppliers to deliver on time.

3. A mechanism for extending credit to farmers, and recovering it, that takes into account the long period (two to three seasons) between the introduction of improved husbandry and the resulting increase in yield is needed.
4. The infrastructure, especially road communication needs further improvement.
5. Price fluctuations in the world market need not affect farmers if the Government or the Marketing Board of the Co-operative Unions could create a fund from the coffee proceeds from which they could pay the farmer stable prices. In 1990, for instance, whilst world market prices for coffee were between US\$ 1.1 and 2.8 (TCMB, 1991), the farmers were paid the equivalent of US\$ 0.6. Some of the difference could be used to create a price stabilization fund.
6. Release and multiplication of the hybrid variety N. 39 x VC. 298 could result in substantial improvements in the contribution of coffee to the national economy in a matter of three or four years. Hence there is a need for Government investment in this type of research.
7. Simplification of procedures to enable farmers to obtain the rights of occupancy would encourage permanent improvements to the land, such as the construction of fermentation tanks. It would also enable banks to lend money to farmers.

Extension

1. Improvements in research-extension linkages are essential to ensure that extension agents are well informed about research findings, and that research staff have a better understanding of farmer constraints and aspirations.
2. Kessy (1992) has suggested improvement to the organisation of the coffee training centres in the country, to enable farmer training, and the use of researchers in re-training extension personnel.
3. Extension workers should be provided with adequate transport and a sufficient salary to stimulate their work. The coffee industry, which will greatly benefit from such efforts, should be prepared to contribute to this.
4. Extension agents should be innovative and practical in advising farmers. For instance, ideas about how to reduce the costs of weeding, by under-sowing the coffee with beans, could be promoted.

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