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A Comparison Among Various Robusta Coffee (*Coffea canephora* Pierre) Clonal Materials and their Seedling Progenies at Different Levels of Nitrogen

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Abstract

The propagation and distribution of robusta coffee *(Coffea canephora* Pierre), clonal selections in Uganda has been hampered by logistics. These clonal selections also exhibit a substantial degree of genotype-environmental interaction. Our objectives were to further elucidate the differences between these clones, the differences between individual clones and their corresponding seedling progenies and a farmer's elite entry and to define the nitrogen levels required for the optimal performance of the various clones and seedling progenies. A split-split plot, randomized complete block design with 4 replicates was used. Mean yield data for the years 1988 and 1989 are presented. There were significant differences in the response to nitrogen but a complete response curve was not established. Nevertheless, the data confirmed that it is highly profitable to apply nitrogen to robusta coffee. The differences between the yields of clonal cuttings and their corresponding seedling progenies were much higher for the *erecta* types of robusta coffee than for the *nganda* type. The *nganda* clones had a higher level of general combining ability than the *erecta* types. The correlations between the clonal parents and their corresponding seedling progenies were low for all entries but slightly higher for the *nganda* than for the *erecta* entries. Using clonal cuttings resulted in higher yields for the *erecta* entries compared to their corresponding seedling progenies. This was not necessarily so with the *nganda* material.

Key words: Robusta coffee, *erecta* type, *nganda* type, clones, seedlings, nitrogen.

Introduction

Up to the early 1970s the only recommended robusta coffee, *(Coffea canephora* Pierre), planting material in Uganda were seedling progenies obtained from polycross seed gardens at Kituza Coffee Research Sub-station (Leakey, 1970). The Kituza gardens were themselves established using open pollinated seed obtained from a polycross seed garden at Kawanda Research Station. The Kawanda mother garden had earlier been roughed of all inferior plants by Downie and Jameson (Jameson, 1955). The Kituza polycross seed gardens were, therefore, established using naturally crossed seed from the most elite robusta selections.

Two assumptions were made in distributing these planting materials: that the elite mother trees, when in panmixia would necessarily produce high yielding progenies of possibly reduced variability compared to random seedlings.

Alternatively that the successive mass selections exercised earlier, leaving a coffee population with a higher mean yield, could produce progeny populations with a higher mean yield than random seedlings.

Kerkham presented an analysis of correlations between yields of robusta coffee parents and their seedling progenies (Leakey, 1970). Five of the parents used in the analysis were of the *erecta* type while 10 were *nganda*. The correlations between the parents and their corresponding seedling progenies were very poor (r = 0.248 for *erecta* and r = 0.101 for *nganda*) (Leakey, 1970). The mean yields of the parents Kerkham used covered the period 1938 - 51 while those of the corresponding seedling progenies were obtained during the period 1943 - 1948. Consequently, the correlations Kerkham obtained were based on materials planted at different time periods and were of different ages. Thus the assumptions for running the correlations were not fully valid. The question is still valid as to whether a panmictic elite population of robusta coffee necessarily produces an elite population of progenies.

Since the early 1970s, eight elite robusta coffee selections have been available for distribution to Uganda coffee growers. These are raised from whole or split cuttings in the 11 robusta coffee clonal nurseries located in the various robusta coffee zones. The rate at which these clones have been adopted by the new planters or those replacing aged gardens has been disappointingly negligible. This has been mainly due to poor logistics resulting in insufficient clonal planting materials. It is, therefore, necessary to establish whether any of these clones has any appreciable level of general combining ability. If this be the case they would be distributed as seedlings, which are easier to handle, rather than cuttings.

Variable performances of these clonal selections in different farms also raised the question of nutrient requirements for optimal performance of these eight clones. The clones were originally selected under high fertility levels.

Materials and Methods

A group of three robusta coffee clones of the *erecta* type 1/2, 1/3 and 1/6 together with their seedling progenies and a group of five clones of the *nganda* type 236/26, 223/32, 257./53, 259./5 and 258/24(0) together with their corresponding seedling progenies as well as a seedling progeny obtained from the best 5% of open pollinated trees in a private farmer's garden were raised at the Kawanda Research Station clonal/seedling coffee nursery and transplanted into an approximately 3 hectare plot at Kituza Coffee Research Sub-station during May/June 1984. Both the clonal cuttings and the seedlings were of similar age when they were transplanted. The plot of land at Kituza had been under fallow for 8 years. The experimental design was a split-split plot randomized complete block with four replicates. The main plots consisted of 4 levels of elemental nitrogen 0, 52, 104, and 156, applied in two equal splits, one during the first rains and the other in the second rains.

The sub-plots were the clonal varieties and the farmer's elite seedlings. The sub-sub plots carried the planting materials, the clonal cuttings and their corresponding seedling progenies, each with a row of six trees. Two rows of the farmer's elite seedling material were also planted. Spacing was on the square at 2.5 m x 2.5 m spacing. Both the fertilizer levels in each replicate and the replicates themselves were separated by two guard rows. Two guard rows were also planted at the perimeters. The fields were kept weed free by alternating Round up or Gramoxone applications with hand weeding.

Results and Discussion

Response to nitrogen

The responses by different clonal and seedling entries to the various levels of nitrogen are shown in Table 1 and Figures 1 and 2. When the combined mean yield for the two years, 1988 and 1989, are considered, it is evident that the response to nitrogen was highly significant. Levels of 52, 104, and 156 elemental nitrogen gave responses of 104%, 167% and 262%, respectively compared to the 0 level.

Figure 1 indicates that the different varieties reponded more or less uniformly to any increase in the rate of nitrogen applied. This is evidenced by the parallel nature of the response curves for the different varieties. There was no interaction between the nitrogen and variety treatments.

Table 1: Response to nitrogen by the various clonal and seedling entries for 1988 and 1989.

Level of N	Mean
156	2511.0 a
104	1854.0 b
52	1416.0 b
0	693.5 c

Means not sharing a common superscript letter were significantly different at $P \leq 0.05$

The linear curves in Figure 2 illustrates that the varieties would respond to higher levels of nitrogen. It would obviously be necessary to increase the rate of nitrogen to a higher level to be able to establish the optimum response. Success in growing the Kawanda robusta coffee clonal selections or their seedling progenies depends on a high level of soil fertility especially for nitrogen. This is not surprising since the original selections were themselves made under high fertility levels.

Comparison of yields

The mean annual yield of the individual clonal and seedling entries averaged over 1988 and 1989 are shown in Table 2. The differences between them are highly significant. The data (in Table 2 and Figure 3) showed that the *erecta* coffee clones 1/3, 1/6 and 1/2 had the highest yields. It is notable that these three clones trace back to Maitland's No. 9 selection, (Maitland, 1926).

Generally, the clonal material yielded higher registering a mean yield of 1734 kg of clean coffee per hectare compared to a mean of 1503 kg of clean coffee per hectare for the corresponding seedling progenies (Table 2). However, Figure 3 revealled a bigger margin of difference between the *erecta* clones and their corresponding seedling progenies. The difference between the seedling progenies of the *nganda* type and their parental clones 236/26, 223/32, 257/53, and 259/56 are smaller. In the case of the *nganda* types 236/26, 223/32, 257/53, and 259/56, the mean yields of the seedling progenies are either slightly higher, equal to or slightly lower than those of the parental clones.

Table 2: Annual yield of individual coffee clones and seedlings averaged over 1988 and 1989.

Variety	Seedling	Rank	Clone	Rank
1/2	1298 f	17	1801 bc	3
1/3	1675 cd	6	2205 a	1
1/6	1612 cde	9	1917 ab	2
236/26	1311 f	17	1523 def	13
223/32	1678 cd	6	1657 cd	6
257/53	1371 cf	15	1368 ef	15
259/56	1540 cdef	11	1600 cde	9
258/24(0)	1536 cdef	11	1752 bcd	4
Farmer's elite	1504 def	13	1727 bcd	4
Mean	1503		1734	

Means not sharing common superscript letters were significantly different at $P \leq 0.05$.

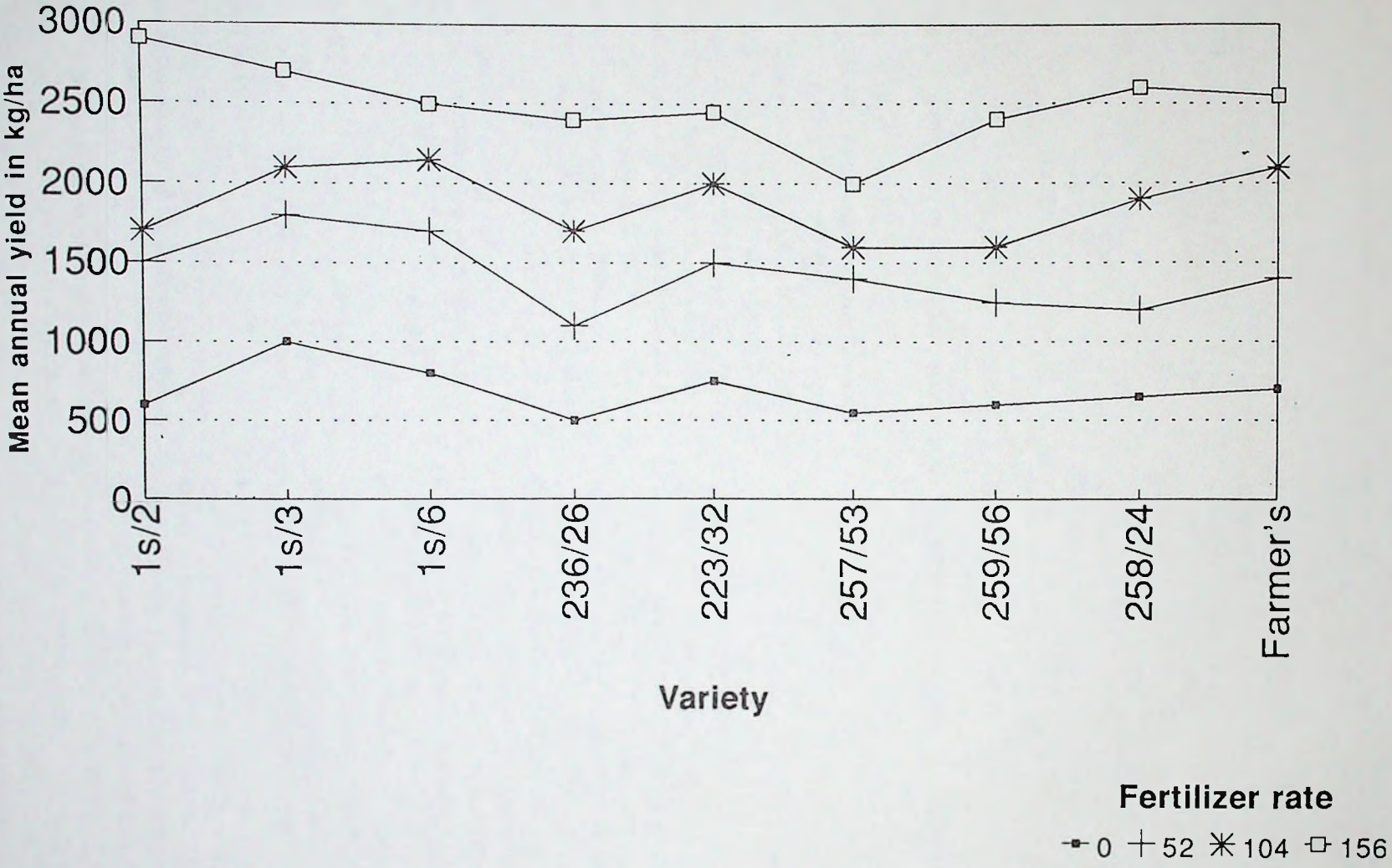


Figure 1. Variety response to fertilizer rate averaged over 1988 and 1989.

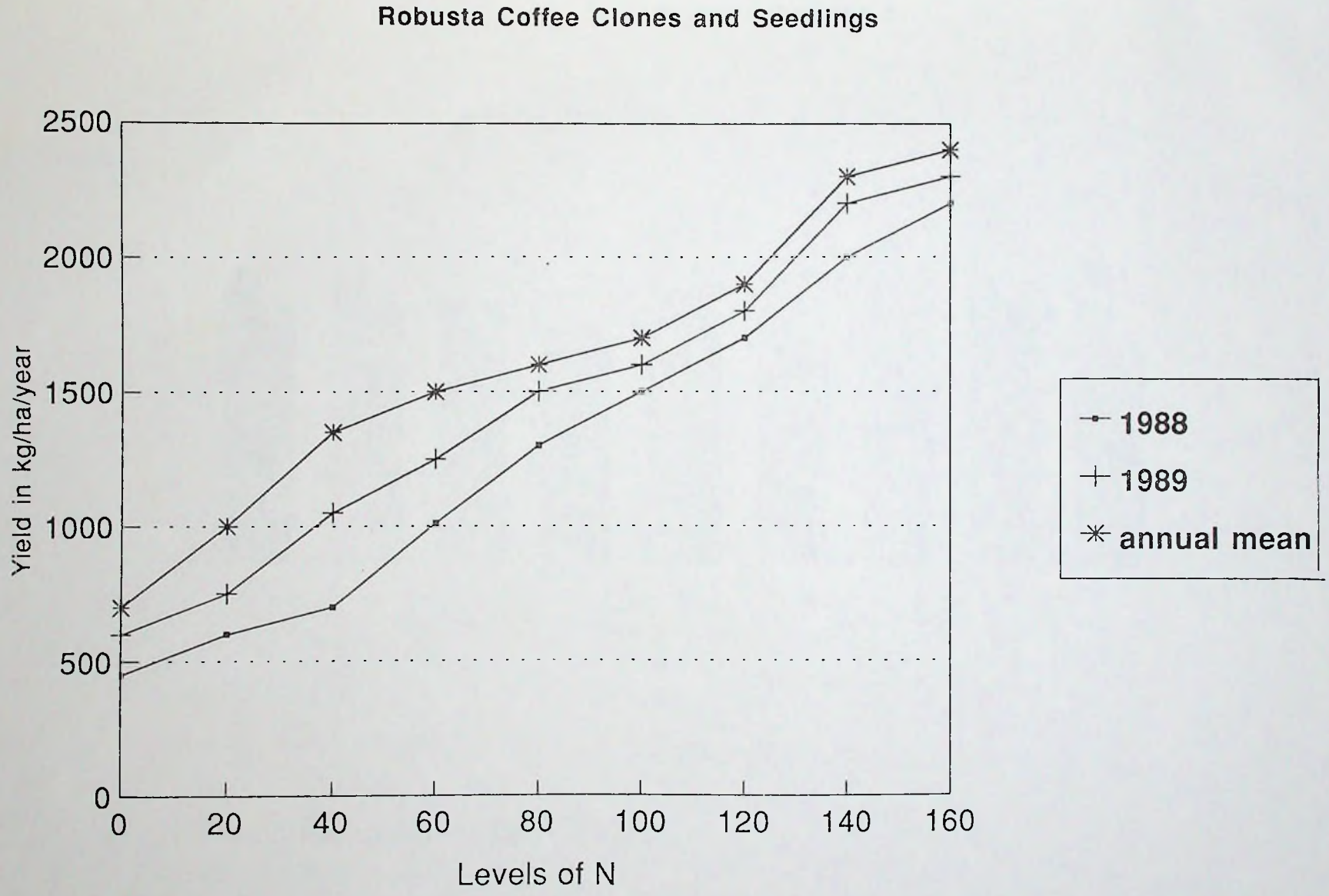


Figure 2: Effect of varying levels of nitrogen (N) on seedlings

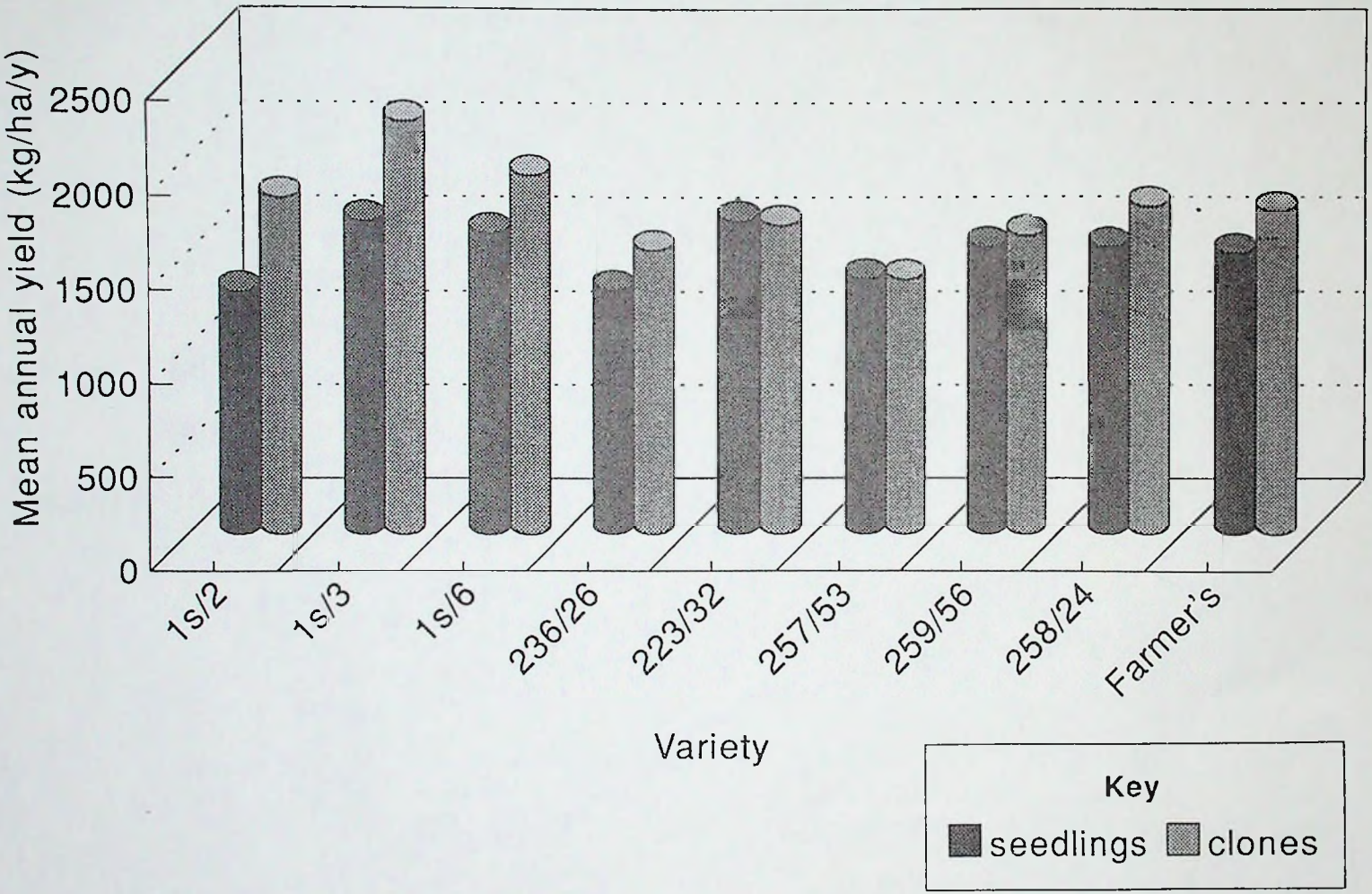


Figure 3: Mean annual yield for clones and seedlings averaged over 1988 and 1989.

Table 3: Correlation between seedlings and clones

Variety	df	Clone mean	Seedling mean	r
1/2	73	10.64	8.5	0.474
1/3	86	11.95	9.14	0.546
1/6	87	10.39	8.86	0.475
236/26	92	8.42	7.13	0.698
223/32	87	9.08	9.07	0.474
257/53	78	7.72	7.83	0.678
259/56	83	8.80	8.28	0.568
258/24(0)	89	9.63	8.25	0.659
Farmer's elite	89	9.32	8.03	0.582
Overall correlation coefficient:				0.582

Table 4: Profitability resulting from use of nitrogen in robusta coffee seedlings and clonal populations kept free of weeds.

Elemental Nitrogen Applied (gm/tree/year)	Equivalent Nitrogen /ha/year (kg)*1	Cost of Nitrogen*2	Total cost of Nitrogen	Increases in yield over zero level (kg)	Revenue accruing due to response to nitrogen*3	Actual profit*4	Percent profit
0							
52	57.8	540	31197.00	722.5	126,437.50	95,241	305%
104	115.5	540	62394.00	1160.5	203,087.50	140,694	225%
156	173.3	540	93591.00	1817.5	318,062.50	224,472	240%

Notes on Table 4:

* 1 Rate per tree x 1111 trees

* 2 Ug.Shs per kg - March 1991

* 3 Price per tone = Ug Shs 174,812 for grade B of clean coffee - March 1991)

* 4 Profit realised on the extra yields

Robusta coffee clones and seedlings

One can draw the inference that in the case of the *nganda* clones, generally, it may not matter whether one uses clonal cuttings or their seedling progenies if the major concern is on mean yields. It appears that the *nganda* clones have got a higher combining ability than the *erecta* clones. This, however, needs to be tested further in a structured top cross. The relationship between the clones and their corresponding seedling progenies is further revealed by Table 3. Although the correlations between the clones and their corresponding seedlings is generally low ($r = 0.474$ to 0.698), it is evident that the correlations involving the *nganda* combinations are higher than those of the *erecta* combinations. This is the first report of a direct comparison involving clones and their seedling progenies of equivalent ages.

Profitability of using nitrogen

Table 4 shows the profitability of the overall effect of nitrogen application on the coffee clones and the seedling progenies. In calculating the levels of profit, the following costs have not been taken into account:- cost of labour for applying the nitrogen, the cost of picking and drying the extra cherry or for removing the additional orthotropic shoots which may be the result of added vigour in tree growth due to nitrogen application. These will be considered elsewhere. Notwithstanding, the data clearly indicated that increases in the rate of nitrogen applied gave a linear increase in the level of profit even though the percent profit decreased as the nitrogen rates increased. These results concur with those reported by Butt *et al* (1970) who observed dramatic responses of a seedling population in an experiment at Kituza Coffee Research Sub-station during the 1960's and they re-enforce the recommendation to apply nitrogen to both seedling and clonal populations of robusta coffee. Failure to apply the nitrogen, definitely leads to forfeiture of the increases in yield, and the profit that accompanies it. It will however be necessary to establish the optimal rate of return due to nitrogen application.

There were significant differences in the response to nitrogen by the various *erecta* and *nganda* robusta coffee clonal entries as well as with the corresponding seedling progenies. A complete response curve required higher levels of elemental nitrogen than the 156, the maximum applied.

The differences between the clonal entries and their corresponding seedling progenies were higher for the *erecta* type than for the *nganda* type. Apparently the *nganda* type exhibit a higher level of general combining ability. Planting of the clonal cuttings of the *nganda* may not have any appreciable advantage in the yields realised.

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