Paper 16: The establishment and management of fodder banks

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Abstract

The herbaceous cover of Nigeria's subhumid zone consists mainly of annual grasses, and its fluctuating quality does not meet livestock feed requirements, particularly in the dry season. Supplementation with agro-industrial byproducts is ruled out because of their scarcity and increasing cost.

The fodder bank (FB) concept, whereby a forage legume is established and properly managed in a concentrated unit, can provide useful dry-season supplementation for the most responsive animals in an average herd. Since factors such as climate, soil, legume species and the access of pastoralists to resources - land, labour and capital - are not uniform throughout the zone, fodder bank development should be modified to suit a given situation. The general guidelines for establishing and managing fodder banks with minimum inputs can nevertheless be summarized as follows:

1. Fence a brook of about 4 ha.

2. Prepare the seedbed by confining the herd overnight in the area or by simply grazing down for 1 or 2 weeks following seed broadcast.

3. Broadcast scarified seeds.

4. Control fast-growing grasses through early-season grazing.

5. Allow forage to bulk up by deferring grazing until the dry season.

6. Graze the pregnant and lactating animals in the herd (up to a maximum of 5/ha) for 2.5 hours per day during the dry season.

7. Ensure sufficient seed drop and stubble for regeneration in the following season.

The profitability of fodder banks depends on the maintenance of high concentrations of legumes over several years. However, because of the nitrogen build-up in the soil they tend to be invaded by nitrophilous grasses. This nitrogen could instead be exploited by cereal crops, which in turn may provide farmers with an incentive to respond favourably to pastoralists' requests to use their land for fodder banks.

Research on fodder banks has so far been restricted to the three stylo cultivars: Stylosanthes guianensis cv Schofield, S. guianensis cv Cook and S. hamata cv Verano. The guianensis types are prone to anthracnose; there is therefore an urgent need to identify and multiply suitable resistant species.

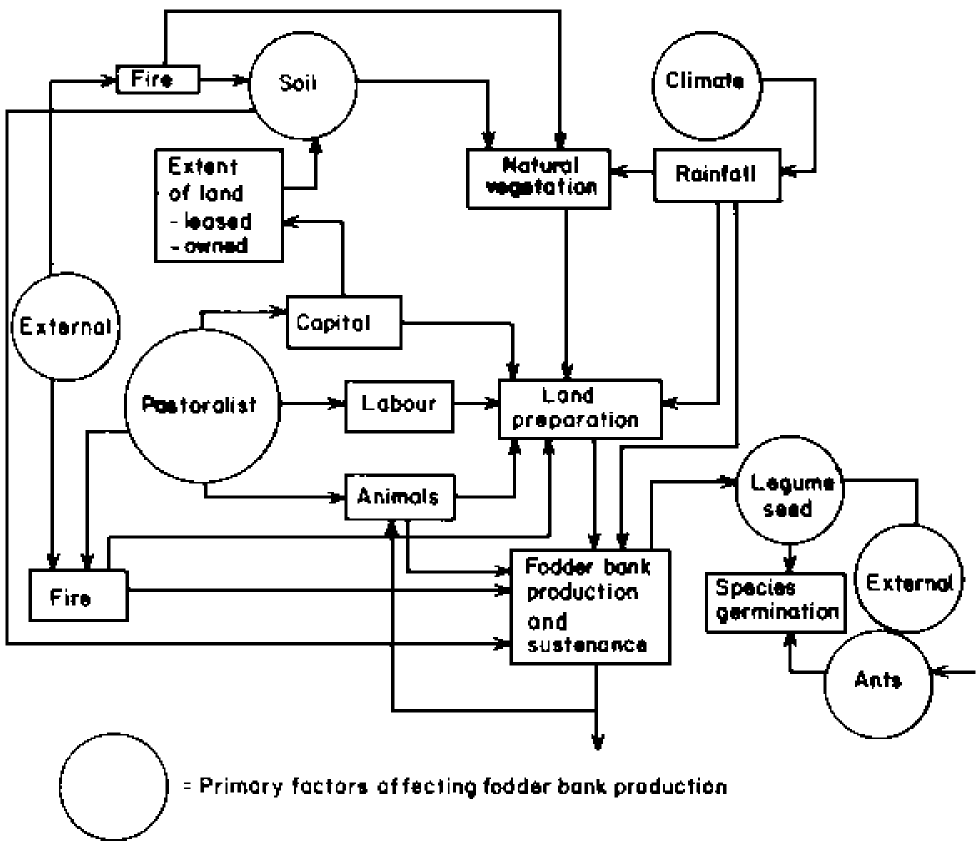
Introduction

The herbaceous cover of Nigeria's subhumid zone consists mainly of annual grasses with a very low percentage of native legumes (Paper 4). Seasonal changes in herbage quality are caused primarily by changes in plant development rather than by climatic conditions per se. The C_4 photosynthetic pathways in grasses allow a rapid accumulation of structural component, with the resultant dilution of nutrients, such as N and P in the tissue. Unlike grasses, legumes exhibit a less efficient C_3 photosynthetic pathway and are independent of soil N. which is secured through biological fixation in the root nodules. As a result, legumes are usually higher in protein and minerals. They have higher DM digestibility and voluntary intake by animals than associated grasses at similar stages of growth. Growing forage legumes is therefore one way of overcoming the protein deficiency of grasses. This is the objective of fodder banks, in which forage legumes are established and managed in concentrated units that can provide dry-season supplementation for ruminant livestock. The techniques for establishing and maintaining fodder banks have been adapted to the socio-economic environment and technical capability of the settled pastoralist.

Limitations to fodder bank development

The factors involved in fodder bank production in the subhumid zone of Nigeria have been identified and are shown in Figure 1.

Figure 1. Schematic representation of major factors affecting fodder bank production in the subhumid zone of Nigeria.



The principal factors that together influence the productivity of fodder banks are: land, labour, capital, soil, climate, seed (variety and quality), fire and ants. These and other factors are discussed below. Understanding how these factors operate under the varying conditions of different parts of the subhumid zone will help identify the problems and prospects of fodder bank development.

Soil

The poor soil structure and fertility typical of the subhumid zone, and the need for fallowing, have been discussed in Paper 4. These conditions provide a point of entry for fodder banks to improve soils for cropping.

Land, labour and capital

The availability of land for fodder banks depends on where a pastoralist chooses to settle; the most common choice is in the vicinity of crop farmers (Paper 4). Fallow land is attractive because it has less tree and shrub cover and requires less clearing, but there may be difficulties in obtaining it because of rising demand for cropland. Wherever there are arable farming communities in the subhumid zone they control land ownership and use. These communities will therefore play a significant, even if indirect, role in providing land for fodder banks to those pastoralists settled in their neighbourhood and must eventually benefit from fodder banks or else the intervention will have limited applicability.

Pastoralists settled on grazing reserves or in less heavily populated areas may have easier access to land, but the generally poorer soil and higher ligneous cover of these sites may require a different approach to fodder bank establishment and management.

Pastoralists' decisions on how much labour and capital (cash and livestock) to allocate to fodder banks will determine the area of land that can be used, the method of land preparation and other inputs affecting the productivity and continued existence of the banks. Many of the beneficiaries' responses cannot be predicted and are only observable once the pastoralists control their own fodder banks.

Climate

The climate of the subhumid zone has also been described in Paper 4. Forage legumes could help minimize moisture runoff and soil erosion and improve infiltration and water retention.

Seed (varieties and quality)

Although various forage legumes have been tested in Nigeria, little or no effort has gone into screening types suitable for the subhumid zone. The National Animal Production Research Institute (NAPRI) has released three stylo cultivars for general adoption: Stylosanthes guianensis cv Schofield, S. guianensis cv Cook and S. hamata cv Verano. Of these S. guianensis cv Schofield is highly susceptible to anthracnose, caused by the fungus Collectotrichum gleosporoides. When conditions are more humid S. guianensis cv Cook is also prone to anthracnose attack.

Pasture seed production is in its infancy in Nigeria. The few commercial producers do not adhere to proper quality standards, and there are no appropriate production, curative and storage facilities. Stylosanthes cultivars - Verano, Cook and Schofield are the only varieties with seed available in commercial quantities, and they are marketed at prohibitive cost: the price of a kilogramme of stylo seed ranges between 10.00 and 14.00 Naira (US$ 13 to 18). Table 1 shows the quality of a typical sample of commercial seed. Low seed quality increases the seed requirements, and hence the cost of establishing a unit area of fodder bank.

Table 1. Quality of commercially supplied stylo seed for fodder bank establishment.

Year	Stylo type	Composition by weight (%)				Germinability (%)
		Stylo	Sand	Weed	Trash	
1982	S. hamata cv Verano	36	42	18	4	60
	S. guianensis cv Cook	41	37	21	1	69
1984	S. hamata cv Verano	50	30	16	4	30
	S. hamata cv Verano	30	60	8	2	16
	S. guianensis cv Cook	60	20	12	8	80

Seed shortages and the absence of more appropriate legume varieties are the two most important impediments to fodder bank development. But until other species are identified and multiplied, work with S. guianensis cv Cook and S. hamata cv Verano will continue.

Fire

Fodder banks can only be useful for feed supplementation if forage is available throughout the dry season. Their regeneration depends on the amount of stubble (in the case of a perennial such as S. guianensis cv Cook) and of seeds in the soil. The annual burning of both crop- and rangeland by farmers and pastoralists is a serious problem for fodder bank management, since it not only destroys the herbage but may also affect legume regeneration.

Ants

Legume establishment in both the first and subsequent years is largely determined by the number of seeds germinating per unit area. About 1 kg/ha of seed out of 8 kg sown was recovered near ant holes when a broadcast of Stylosanthes guianensis cv Cook was followed by 2 weeks of drought. Although collection by harvester-ants has been found useful in concentrating good-quality seed so that it can be easily gathered, it can lead to a very serious loss of viable seed needed for establishment and regeneration.

Herbage production

Since grasses deteriorate rapidly in quality during the dry season, the quality of a fodder bank is a function of the proportion of legumes in the sward. Management practices on the fodder bank should aim at optimizing legume growth with respect to grass growth. To achieve this objective in the subhumid zone of Nigeria, the following factors must be considered.

Choice of site

A fodder bank should be situated near the dwelling of a settled pastoralist. The pastoralist must keep a close watch on the fodder bank to prevent its misuse by animals during the growing season, and to control animal grazing time and confinement during seedbed preparation.

The area of land required for a fodder bank depends on the number of animals that need to be fed. In ILCA's case study areas an average herd consists of about 50 animals, with 15 to 20 pregnant or lactating cows (Paper 6) that are likely to respond most profitably to supplementary feeding. Given the productive potential of a well managed fodder bank, 4 ha should be a reasonable size. Since a single piece of land suitable for a fodder back may not be available in one block, particularly in areas of intensive cropping, more fodder banks may be required but this increases the cost of fencing per unit area and raises other management problems.

Land preparation

Land preparation, from the time of site selection until sowing, must provide optimum conditions for germination, emergence and establishment.

Despite its high cost, fencing is indispensable. Pastoralists do not yet regard forage crops as private property in the way that they do food crops. Attempts to oversow or strip-sow stylo in natural pastures failed because of inadequate establishment under communal grazing. Fencing is thus obligatory, although the kind used (bush poles and barbed wire, or metal fences) remains at the discretion of the pastoralist.

Burning, grazing and trampling are cheap methods of reducing herbaceous cover. However, the timing of these operations is critical, and the choice of any one or a combination of them is site-specific, depending on vegetation, topography, etc. For instance, burning steep slopes leads to excessive soil erosion and wash-off of seeds.

Two methods of seedbed preparation, namely mechanical ploughing and dry-season confinement of animals on the site, were tested by ILCA. Both methods produced a satisfactory legume cover, but mechanical ploughing was considered irrelevant because of its high cost and the difficulty of securing such services in remote areas. It could upset the delicate patterns of land use, since the extent of cultivation is currently determined by labour availability (Paper 4). Dry-season confinement of animals was also unacceptable to pastoralists because of the need to deposit manure on crop fields. Even early in the dry season, confining animals to control grasses and weeds was unacceptable because of the fear of worm infection from recently manured areas.

However, confining animals during the wet season prayed to be effective, and the time required for trampling was short. Between 600 and 800 m^2 of land could be satisfactorily prepared in 1 night. At this rate it would take 2 months to prepare 4 ha, so a combination of techniques any or assistance from other herds may be necessary to prepare the seedbed in time. However, it has proven possible to establish a satisfactory fodder bank of S. guianensis cv Cook in an area having ferruginous soil by selectively cutting the shrubs, trampling the soil, and sowing the small, freshly trampled areas almost daily quite late into the wet season. The seed set in the first year should increase the cover in the second year.

Using land clearing machines to remove trees may not be wise. Land graded for fodder bank development in Kachia Grazing Reserve had the lower hard pan exposed, leading to erosion and extremely poor establishment of the legume. Machine clearing also led to impeded water infiltration and aeration. Such areas may have to be renovated using chisel or shatter ploughs to break the hard pans.

Establishment

Germination

Seeding rate depends on seed quality, and because the latter is generally poor 8 to 10 kg/ha was found necessary for satisfactory establishment. Commercially available seed has only 60% purity and 50% viability, whereas effective establishment requires at least 30 to 40 plants per m^2. The presence of other legume species in the seed may not be a disadvantage, but that of weeds is.

Stylo seeds have two dormancy mechanisms: embryo dormancy and seed coat impermeability (hardness of seed). These mechanisms gradually decrease when seeds are on the ground or are treated artificially by heat treatment or scarification. Such treatment allows a high germination per unit area within a short period early in the growing season. The pastoralists found scarification by brief immersion in boiling water easier than other methods. The length of time seed is in contact with boiling water is critical. Softening of seeds is achieved by taking 2 or 3 kg of seeds at a time in a cloth bag and immersing for 1 minute in boiling water. However, for testing germination with only small handfuls of seed, 20 to 30 seconds of hot water treatment will be adequate.

Scarified seeds need to be sown immediately because in storage they lose their viability. They germinate uniformly, leaving little reserve if the first flush of seedlings does not survive. At least one third of the seed should, therefore, be unscarified as an insurance against false starts. S. guianensis cv Cook and S. hamata cv Verano do not require seed inoculation because these two species nodulate freely with cowpea rhizobium, which is ubiquitous in Nigerian soils.

Stylo seeds can germinate under a wide range of soil surface conditions, but cultivated, trampled, grazed or burnt surfaces tend to have different temperatures and water potentials, which affect seed germination and seedling survival.

A cultivated surface, where the soil is loosened by ploughing, harrowing, etc. allows seeds to be covered with soil. Water imbibition by seed can therefore take place from all sides. Under these conditions, radicle emergence and root anchorage are easy. However, when seeds are broadcast on an uncultivated surface, water imbibition will take place only through the area of the seed in contact with the soil. Moreover, most of the water absorbed will be lost by evaporation through the part that is not in contact with the soil. This loss occurs especially in seed sown on burnt areas, or areas where weeds are trodden dawn by corralled animals or bared by intensive grazing. Maintaining low water tension and high humidity in the micro-environment is thus important when seeds are sown on uncultivated land. The consequence of high water tension and low humidity in dry spells varies according to the stage of germination. Seeds dehydrated before metabolic change begins may be reactivated when rehydrated. But dehydration after the initiation of the radicle may cause irreversible damage to the seed and hamper the emergence of seedlings.

The time taken to complete germination varies from species to species, depending on the nature of their seed coats. The length of time the soil is moist appears to be critical for both germination and establishment. In an experiment testing the effect of the frequency of wetting to the field capacity of a ferruginous soil on germination of S. hamata cv Verano, it was found that a break of 2 days in the watering regime was sufficient to reduce seed germination by 52% (Figure 2).

Once the radicle emerges, further survival depends on how successfully it is anchored in the soil. Survival is strongly determined by the type of land preparation. An experiment to determine the effect of different land preparation and sowing techniques on the establishment of S. guianensis cv Cook in fodder banks revealed that broadcasting seeds in mid-June, after the rains had properly set in, followed by 2 weeks of intensive grazing of the grass cover, gave a high seedling density at 6 weeks (Table 2). Dry spells following sowing encourage harvester-ants to work. A substantial amount of seeds were seen around ant-hills on pastoralists' fodder banks 1 week after broadcasting.

Figure 2. Effect of different moisture regimes on germination of Stylosanthes hamata cv Verano at Kurmin Biri, 1984.

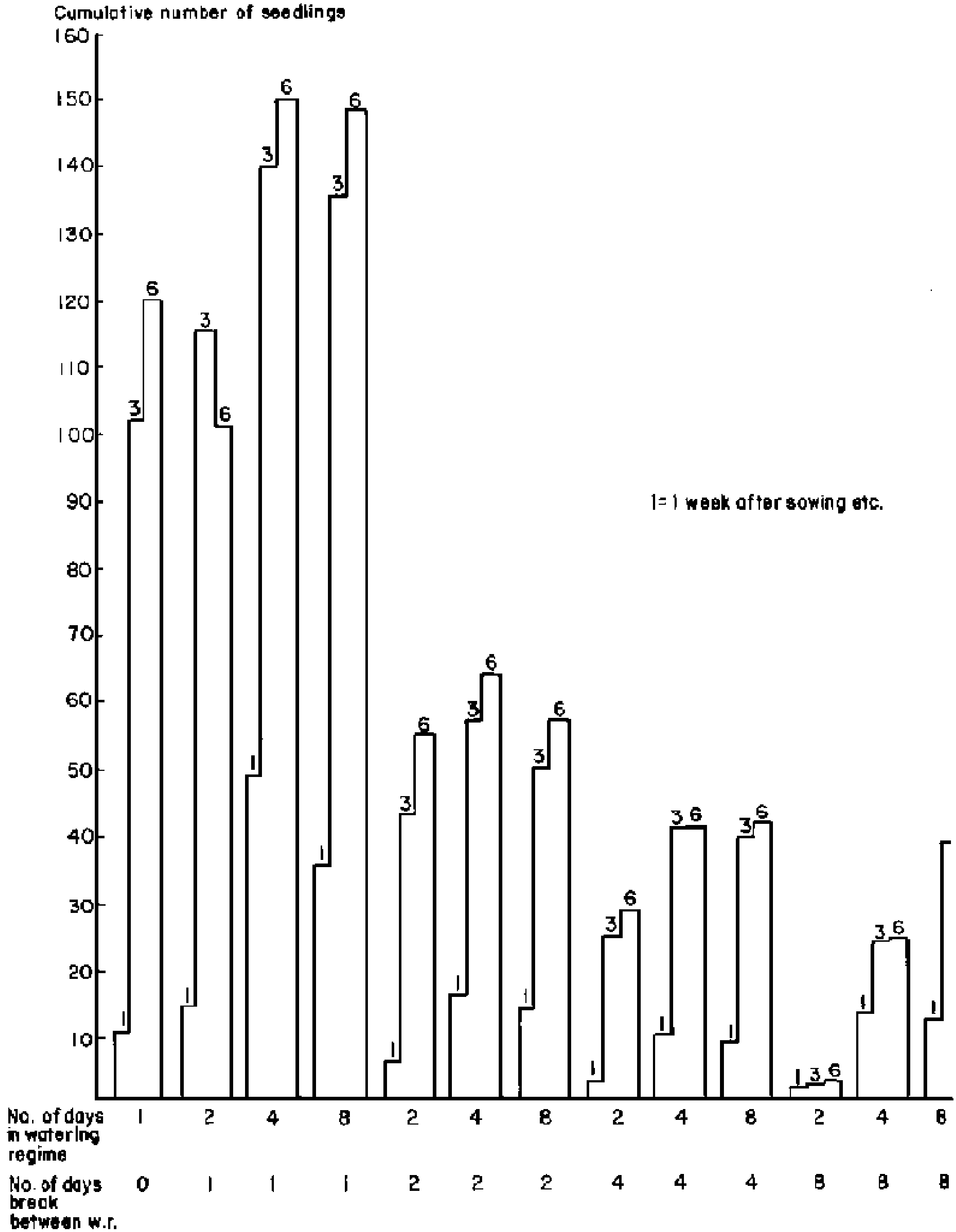


Table 2. Effect of different land preparation methods and seed treatment techniques on stand count/m^2 of S. guianensis cv. Cook 6 weeks after planting.

Land preparation method	Seed treatment techniques			
	Mixed with sand	Mixed with dung slurry	Insecticide dressing	Mean
1 week intensive kraaling	150	76	167	137

2 weeks grazing before sowing	69	99	67	78
2 weeks grazing after sowing	205	176	212	197
Burning in the dry season	45	195	133	108
Mean	117	137	133	-

The whole experimental area had been burnt during the previous dry season, so that its grass cover at the beginning of the growing season was all regrowth. Seeds mixed with a slurry of dung or insecticide generally gave improved establishment, compared to broadcasting seeds accompanied with sand.

Seedling establishment and early management

The appearance of the first trifoliate leaf marks the independence of seedlings from seed nutrients. It occurs about 12 days after sowing in S. guianensis cv Cook and S. hamata cv Verano. Seedlings with fast-growing root systems have a better chance of surviving the moisture stresses common in the subhumid zone at the beginning of the rainy season. However, even after that there are more hazards which will determine the quantity of the fodder finally available.

For instance, seeds of S. guianensis cv Cook with a viability of 80% and sown after scarification at the rate of 10 kg/ha (1 kg = 250 000 seeds) could potentially result in a population density of 200 plants/m^2. In practice, competition for space, moisture, light and nutrients, and the relative abilities of the various species in the micro-niche to utilize these are what determine legume survival, and the ultimate plant density is almost always lower than the potential number of 200. A legume such as S. hamata, which has faster root elongation, is more competitive than S. guianensis cv Cook.

Tropical grasses are generally endowed with a C_4 photosynthetic mechanism, making them physiologically and biochemically more efficient in high light intensities. When moisture is unlimited these grass species grow fast, rapidly occupying the available space and shading the legume growing underneath. Grasses at the early stages of growth are high in nutritive value and are selectively grazed by cattle either by choice or because they are so predominant. In tropical Australia, this selectivity facilitates legume growth in grass-legume mixtures when the mixed pasture is grazed early in the season. However, grazing behaviour studies on experimental fodder banks at the Kachia Grazing Reserve revealed that animals did not differentiate legumes from grass until 4 weeks after the start of the rainy season. This it suggests that the period for using grazing to control grass is quite critical. This practice is discussed in Paper 7.

The soils of the subhumid zone are generally low in organic matter, phosphorus and nitrogen. Legumes have higher P requirements than grasses. Under increasing levels of P, Stylosanthes spp. had better nodulation, increased N uptake and higher DM productivity (Figures 3 and 4). Soils in the subhumid zone may also be deficient in micro-nutrients, as evidenced by the performance of S. hamata cv Verano in an experiment that systematically omitted a particular element from the nutrients supplied to a plot. Elimination of Cu and S produced only 35% and 59% respectively of the potential DM, although the stylo was supplied with all other necessary nutrients (Figures 5 and 6).

In the subhumid zone of Nigeria, a dressing of 150 to 200 kg of single superphosphate should generally be provided at the time of sowing stylo. Depending on soil conditions, this rate may have to be varied and other nutrients added as more fodder banks extend to other parts within the zone.

Figure 3. Effect of phosphorus application on dry matter and crude protein productivity of stylo cultivars.

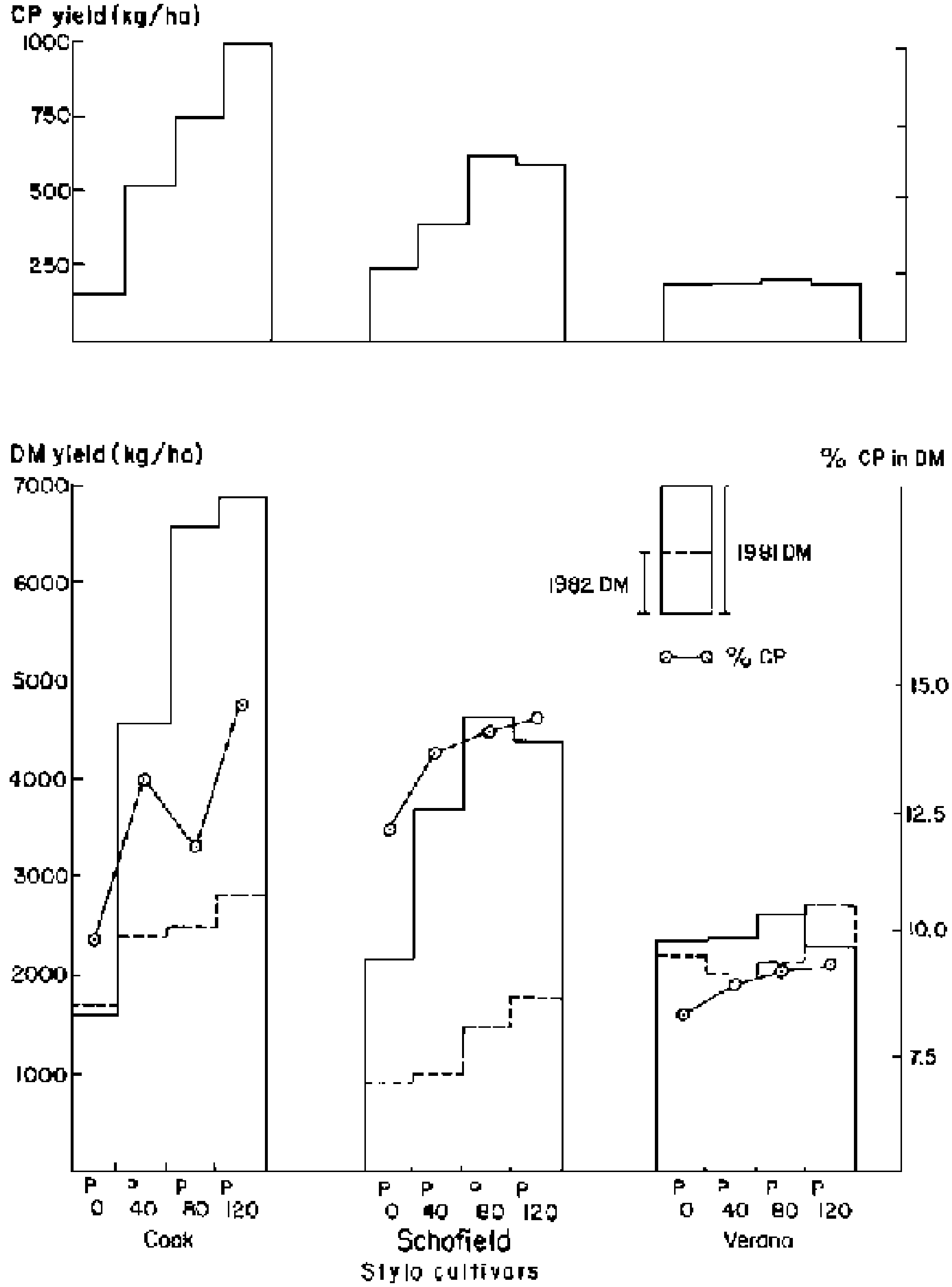


Figure 4. Effect of P application on modulation of stylo cultivars.

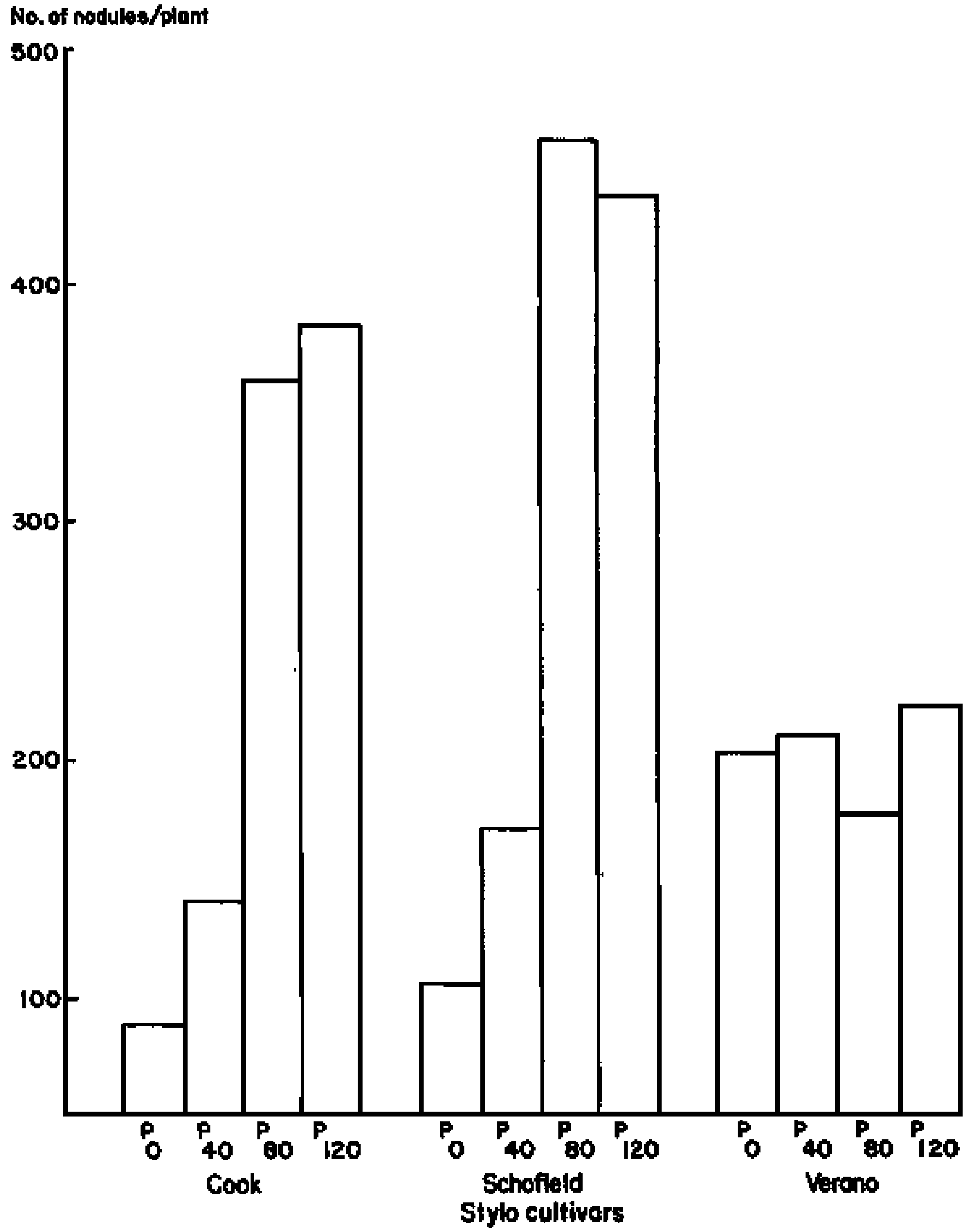


Figure 5. Dry matter productivity (kg/ha) of Stylosanthes hamata cv Verano on a soil with or without nutrients, Kurmin Biri, 1983.

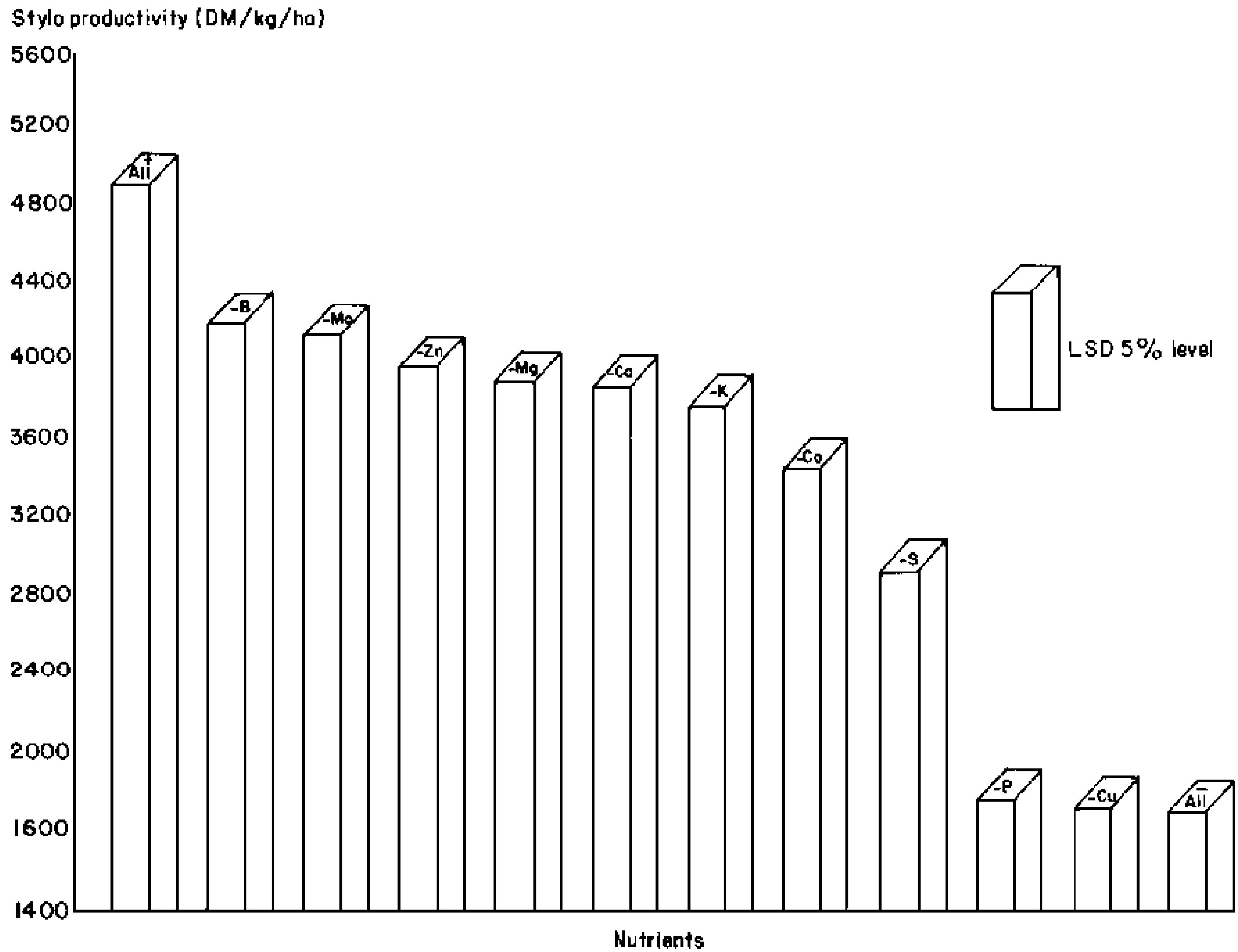
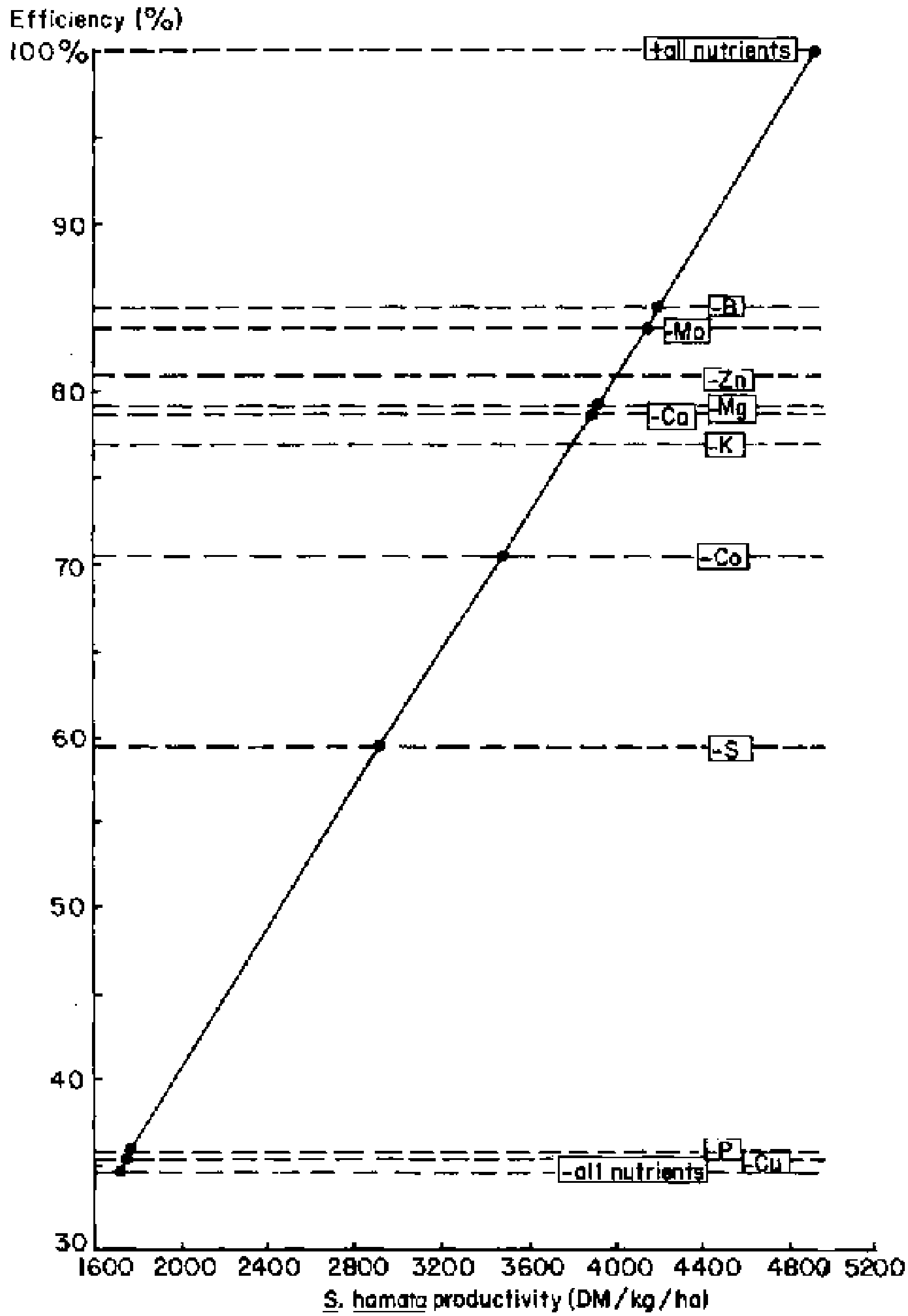


Figure 6. Efficiency of DM production of Stylosanthes hamata cv Verano in a soil with or without nutrients, Kurmin Biri, 1983.



Productivity

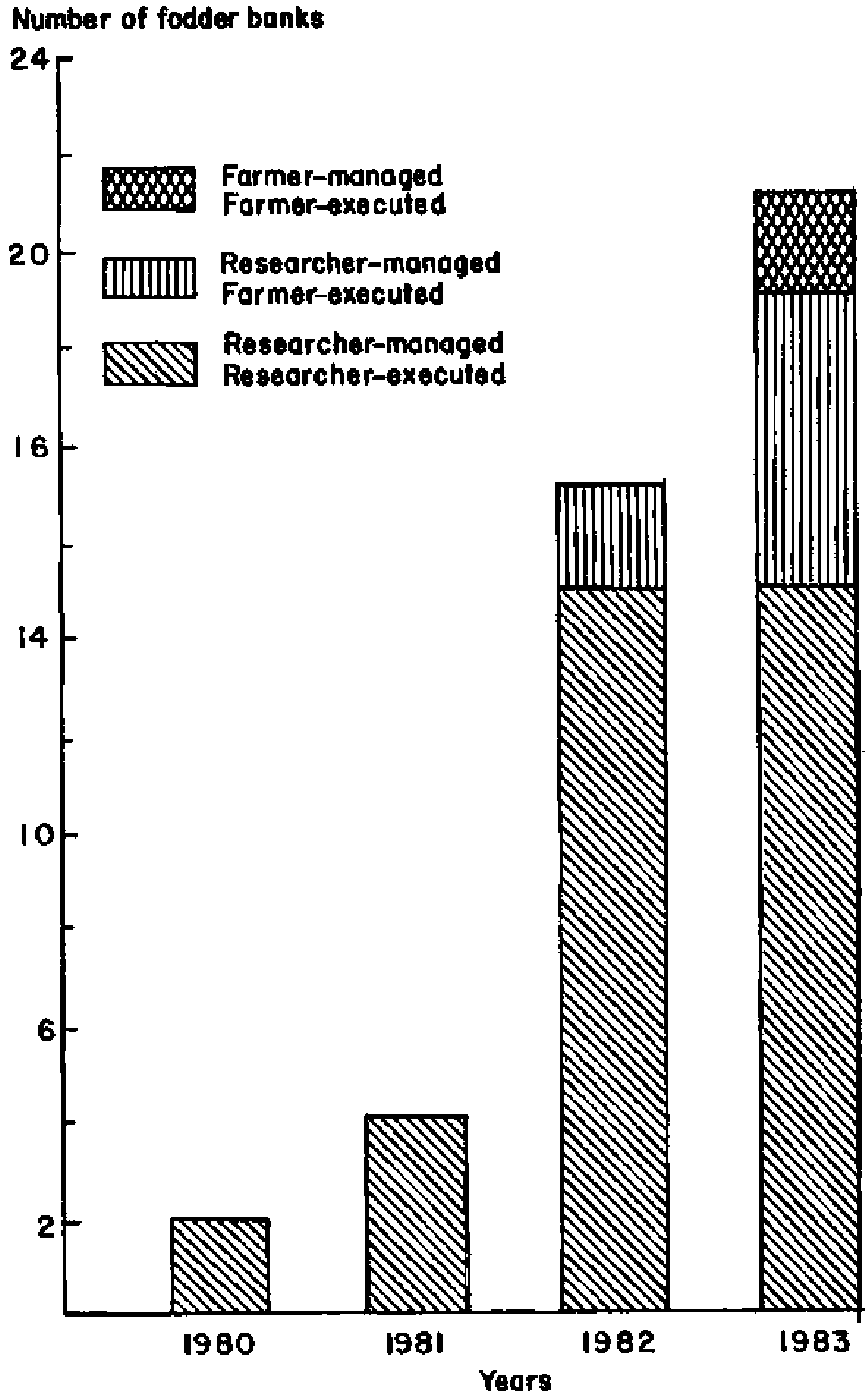
At the end of a normal growing season the two stylo cultivars used on fodder banks at the Kachia Grazing Reserve had an average of 12% CP. It was assumed that a daily ration of 2.5 kg of stylo DM would provide a protein supplement equivalent to 1 kg of cottonseed cake with 30% CP. A supplemented period of 6 months would therefore require 9000 kg of stylo for 20 animals. With utilization assumed at 50% of the available herbage, a fodder bank capable of producing about 20 000 kg of stylo DM would be required. Given an anticipated yield of 5000 kg of DM per ha, a fodder bank of 4 ha should suffice. In practice fodder bank size depends on land availability, size of herd, producer commitment and other factors. Even the recommended size of 4 ha may be changed as more information becomes available on botanical composition, seasonal changes in legume quality, grazing behaviour, and producer preferences with regard to the numbers and classes of stock to be grazed. The number of fodder banks at different stages of evaluation in 1983 in the various phases of systems research are shown in Figure 7. The first-year productivity of researcher-managed trials is given in Table 3.

Table 3. Stylo productivity and quality in researcher-managed and implemented fodder banks during 1981/82 dry season.

Location	Observation	Month			
		Oct 1981	**Dec 1981**	**Feb 1982**	**Apr 1982**
K'Biri	Total DM (kg/ha)	6824			
	Weight of stylo (%)	56.0			
	Weight of stylo (kg/ha)	3821			
	Stylo CP (%)	13.8	10.6	9.2	5.8
	Stylo CP (kg/ha)	527			78
K'Biri[a/]	Total DM (kg/ha)	4191			
	Weight of stylo (%)	68.0			
	Weight of stylo (kg/ha)	2850			
	Stylo CP (%)	13.0	10.4	9.8	7.9
	Stylo CP (kg/ha)	370			90
Abet[a/]	Total DM (kg/ha)	4900			
	Weight of stylo (%)	63.0			
	Weight of stylo (kg/ha)	3087			
	Stylo CP (%)	12.6	11.3	8.9	7.2
	Stylo CP (kg/ha)	389			88

[a/] Experiments on pastoralists' sites but under strict management of the researcher.

Figure 7. Number of fodder banks at various levels of evaluation by ILCA, 1983 .



The CP of the stylo in the fodder bank declined markedly during the dry season. Higher amounts of stylo will clearly be required to derive the same amount of protein supplementation as the season progresses, even if the animal rate of intake is assumed to remain unchanged.

Productivity and composition of stylo in the herbage were found to vary among fodder banks in the same soil top sequence, even in the first year. Herbage yield per unit area also varied within the same fodder banks as a function of the time of sowing stylo (Table 4). Such differences in herbage productivity with fodder banks may be more pronounced in years of unusual distribution of rainfall, such as 1983.

Table 4. Productivity and botanical composition at the end of the growing season within a farmer-

managed and -implemented fodder bank with areas planted at different times of the year.

Time of planting[a/]	Total weight of fodder (kg/ha)	Weight of stylo in fodder (kg/ha)	Weight of stylo in fodder (%)	Weight of grass in fodder (kg/ha)
June 1983	9111	6210	68	2910
July 1983	8310	4290	52	4020
Aug 1983	4380	2220	51	2160
Sept 1983	2460	1320	54	1140

[a/] Before each sowing the entire herd of cattle was confined in the area for 1 to 3 nights.

DM yields are normally measured by cutting, drying and weighing samples. Doing this for several 4-ha fodder banks, with their inter- and intra-variability, is very cumbersome. If measurements are to be taken repeatedly, a much faster and non-destructive technique is needed. The DM ranking method described by Haydock and Shaw (1975) was very useful in determining the yield and botanical composition of fodder banks. In this method a set of five fixed quadrats is first chosen to represent a yield scale, followed by rating on this scale. Other quadrats are laid out in a grid to cover the entire fodder bank. Laying quadrats on a grid helps monitor the productivity and condition of a fodder bank in successive years. The method is based on the belief that it is easier to estimate the yield of a sample that is at some point on a visual scale, than it is to estimate the actual weight. The estimates of six people involved in yield measurements using DM rating, correlated against the actual weights, are given in Table 5. Estimates of botanical composition can also be made, giving the species likely to take first, second and third places in the DM within a quadrat; these estimates are multiplied by weighing factors to produce dry weight percentages.

Table 5. Regression equations and coefficients of correlation between visual DM score (X) and DM yield (Y) for various enumerators.

Enumerator No.	Regression equation	r
1983		
1	Y = -19.1 + 34.9X	0.81
2	Y = 5.2 + 43.0X	0.88
3	Y = -4.5 + 40.6X	0.94
4	Y = -18.5 + 37.9X	0.84
1984		
2	Y = 10.6 + 31.9X	0.92
3	Y = 21.5 + 31.4X	0.88
5	Y = 19.7 + 37.1X	0.93
4	Y = 27.7 + 26.3X	0.92
6	Y = 8.3 + 30.6X	0.86
7	Y = 19.5 + 40.7X	0.83

Differences among fodder banks in herbage productivity within and between years must be anticipated because of differences in topography, patterns of land preparation, sowing time and technique, weed control methods and rainfall patterns. An effective fodder bank development programme thus requires a well researched set of alternative policies to fit different situations.

Regeneration

In order to be financially viable, fodder banks will have to remain productive for 5 years or more, and should be managed so that they will regenerate themselves.

In the case of perennial legumes, such as S. guianensis cv Cook regeneration can stem either from living shoots left after dry-season grazing or else from seed. Theoretically, S. guianensis cv Cook, repeatedly grazed to a height of about 10 to 15 cm, should regenerate for many years, but experience at the experimental fodder bank at Kurmin Biri has been somewhat different. Only about 0.7% of the established stylo went into the third year, while only 28.2% regenerated in the second. This loss occurred because termites attacked the old stylo stems. When fodder banks were managed by pastoralists, there were difficulties in controlling the stocking rate. On almost all such fodder banks, shoots of S. guianensis cv Cook did not last more than one season due to overgrazing. Furthermore, the accidental burning of fodder banks in bush fires kills all living stylo shoots from the previous season. Hence, the size of the seed reserve in the soil, even for this perennial legume, is very important.

The seed reserve depends on many factors. Under subhumid conditions, S. guianensis cv Cook flowers in

October/November and seed set takes place in January. Since the dry season normally begins in October/November, grazing an S. guianensis cv Cook fodder bank very early in the dry season reduces the seed returned to the soil.

S. hamata cv Verano flowers earlier, in July/ August and seed set generally takes place before the dry season begins. The quantity of seed set at the end of the growing season is very high (Table 6). In the subhumid zone S. hamata behaves like an annual and regenerates almost entirely from seed.

Table 6. Seed reserves of some fodder banks in ILCA case study areas (February 1983).

Fodder bank	Year of establishment	Stylo type	No. of seeds per m^2	Germination (%)	
				Unscarified	Scarified
Kurmin Biri[a/]	1981	Cook	860	25.7	62.6
Mairiga	1981	Cook	407	20.1	71.4
Mairiga	1981	Verano	1482	57.4	70.7
Yamusa	1982	Cook	204	14.5	68.6
Bairage	1982	Cook	82	17.5	66.8
Yakubu	1982	Cook	260	15.3	69.2
Damina	1980	Verano	2626	50.0	60.0

[a/] Experimental plot.

Burning of fodder banks changes the pattern of germination, probably because more seeds are softened. Higher germination has been recorded on burnt areas at the beginning of the rainy season (Table 7). This might be a disadvantage, especially in a year of erratic rainfall. However, regeneration, in particular of S. hamata cv Verano, was unaffected after the fodder bank had been burnt in the previous dry season.

Table 7. Effect of burning on the regeneration of stylo.

Area	Monthly new seedling counts/m^2				No. of plants at end of season
	June	July	Aug	Sept	
S. guianensis cv Cook					
Burnt	45	12	6	2	36
Unburnt	26	34	22	8	48
S. hamata cv Verano					
Burnt	280	196	72	16	259
Unburnt	264	74	126	81	268

Estimates of the seed reserve in the soil at the beginning and end of the dry season suggest a large discrepancy. Roughly 22% of the seed might have been gathered by harvester-ants from the area during that time. Grazing behaviour studies on heavily stocked fodder banks have recorded animals licking the ground, probably to pick up seeds. Seed losses of this kind could result in poor regeneration in subsequent years.

Integrated crop and livestock production with fodder banks

When allowed to grow for 2 or more years, a forage legume such as Stylosanthes increases soil N content. The amount of N returned to the soil by the legume depends on the same factors, varying from species to species, that favour legume growth (Table 8).

Table 8. Effect of phosphorus application on soil properties at the end of one season of growing different stylo cultivars.

Stylo cultivars	Treatments (P kg/ha)	Soil properties		
		pH	Organic C (%)	Total H (%)
Cook	0	5.1	0.87	0.061
	40	4.8	0.92	0.087
	80	5.2	0.93	0.100
	120	5.1	1.13	0.113
Schofield	0	5.1	0.76	0.069
	40	5.2	1.01	0.072
	80	5.2	1.11	0.075
	120	5.2	1.18	0.121

Verano	0	5.4	0.93	0.58
	40	5.2	0.90	0.48
	80	5.1	1.03	0.84
	120	5.2	1.18	0.122

Legumes also improve the physical properties of soil (Table 9) and hence resistance to erosion. With the increase in soil N, nitrophilous grasses tend to assert themselves. In one 4-year-old Verano fodder bank, although the proportion of legume in the total bulk declined the number and weight of stylo per unit area increased eased.

Table 9. Influence of vegetation on some soil physical properties (preliminary results).

Type of vegetation	Ultimate infiltration rate (mm/hour)	Mean soil bulk density (g. cm^{-3})
Hamata (After 3 years)	49	1.32
Uncropped areas with sub-climax vegetation	20	1.77
3-year cropped area	15	not determined

The possibility of soil improvement through the use of forage legumes adds another dimension to the fodder back concept in the subhumid zone. Crops such as maize, grown after 2 to 3 years of stylo, have indicated highly significant yield increases (Paper 17). Cereal cropping within a fodder bank in short rotations may prove a viable way of integrating crop and livestock production systems.

Future component research

The initial success of the researcher-managed trials suggests that fodder banks could play an important role in improving livestock productivity. However, numerous problems were encountered when fodder banks were developed without the close supervision of the researcher. Pastoralists failed to understand and/or carry cut recommended procedures at any point from the preparation of the land onwards. More research is needed to simplify, explain and increase the repeatability of the various technical aspects of fodder bank production. One of the main concerns is the need to look for ether legume species that are more suited for establishment based on surface sowing and sad sowing.

Reference

Haydock, K.P. and Shaw, N.H. 1975. The comparative yield method for estimating dry matter yield of pasture. Aust. J. Exp. Agric. Anim. Husb. 15: 663-70.