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PROFITABILITY OF CASSAVA–MAIZE PRODUCTION UNDER DIFFERENT FALLOW SYSTEMS AND LAND-USE INTENSITIES IN THE DERIVED SAVANNA OF SOUTHWEST NIGERIA

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SUMMARY

Population pressure has diminished the role of the traditional bush fallow system in restoring the fertility of depleted soils following several years of cultivation in the derived savanna of southwest Nigeria. The search for alternative fallow systems led to the development of alley cropping using *Leucaena leucocephala* and cover cropping using *Pueraria phaseoloides*. These soil-conserving systems also embody the principles of sustainability by ensuring stable crop yields in spite of an increase in land-use intensity. Simulating smallholder farm conditions and based on a split-plot experiment with the three fallow systems as the main plots and four different land-use intensities (LUI) as the subplots, simple direct observation and record keeping were used to collect data on labour use in all farm operations including fuelwood cutting and stacking in alley cropping systems with fallow phases. Data collection covered a period of four years (1993–96), corresponding to one out of the three phases (or complete cycles) of the trial. Partial budget analysis was used to estimate profitability of cassava (*Manihot utilissima*)–maize (*Zea mays*) under each LUI. Results based on crop production indicate that each of the cassava-maize enterprises was profitable but the level of profit varied from 10 819 to 50 289 Naira ha^{-1}. Production under cover cropping has a net benefit advantage of 4–25% (over that under bush fallow) and 25–60% (over alley cropping). Profitability increased as the LUI decreased, depicting the overall importance of fallow periods on soil fertility restoration. Results based on crop production plus fuelwood operations indicate that production with cover cropping has a net benefit advantage over that of both bush fallow and alley cropping under both zero-fallow and one-year fallow LUIs. However, results from two- and three-year fallows indicate that fuelwood yield generated sufficient revenue to put alley cropping at a net benefit advantage of 29–42% over bush fallow and 26–37% over cover cropping. From these results, cover cropping is recommended, especially to farmers in areas where, although land shortage is a problem, fuelwood and the other sources of domestic energy are still cheap and easily accessible. However, in areas with abundant land and where farmers can still wait for fallow periods of at least two years, alley cropping is recommended since, in addition to soil fertility improvement, substantial revenue is obtained. However, considerations of yield variability, labour scarcity, as well as risk-aversion behaviour among farmers may alter their technology choice.

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INTRODUCTION

While searching for improved technologies, agricultural research scientists are always mindful of the need for innovations to meet the expectations and preferences of farmers and other end-users. Otherwise, adoption would be impaired. Although many factors such as wealth, education, farm size, risk, and uncertainty influence farmer adoption of new agricultural technologies, this paper focuses on the influence of profitability on farmer adoption of fallow management technologies.

Numerous studies have indicated that profitability drives the adoption of agricultural innovations (Griliches, 1957; Martinez, 1972; Bell, 1972; Ruttan, 1977; Current *et al.*, 1995). Potential profitability was noted as a key factor in farmers' decisions to adopt agroforestry technologies (Current *et al.*, 1995). The relative profitability of beef production and fertilizer use significantly affects the adoption of improved pastures in Uruguay (Jarvis, 1981). Farmers in Jordan do not adopt some agricultural technologies such as drill machines because the associated returns do not justify the costs (Emad, 1995). Farmers' decisions are often derived from their desire to maximize expected profit subject to resource constraints (Feder *et al.*, 1985). A higher probability of adoption of a seed variety in developing countries was found to be positively associated with higher profitability (Pitt and Sumodiningrat, 1991). Income (which has a strong association with profitability) has a positive influence on the adoption of soil conservation as well as erosion-control technologies (Baron, 1981; Lasley and Nolan, 1981; Norris and Batie, 1987). Lack of profit was observed as a constraint that could be a disincentive to farmer adoption of the cut-and-carry mulch farming system developed in southwest Nigeria (Kormawa *et al.*, 1999).

The above underscores the need to evaluate the profitability of cassava (*Manihot utilissima*)–maize (*Zea mays*) production under alley cropping using *Leucaena leucocephala* and cover cropping using *Pueraria phaseoloides* compared with the traditional bush fallow system. Cassava–maize is the most popular 'bi-specific' crop mixture in the tropics (Okigbo, 1978; Mureno and Hart, 1979). Alley cropping and cover cropping are improved fallow systems that embody the principles of soil conservation and sustainability by ensuring stable crop yields in spite of an increase in land-use intensity. This paper aims at evaluating the profitability of cassava–maize production under four different land-use intensities (LUI) (continuous cropping or zero-fallow, 1 year of cropping followed by 1, 2, and 3 years of uncropped fallow) in order to arrive at suitable fallow management recommendations for resource-poor farmers in southwest Nigeria. They are already facing different levels of land pressures and soil degradation problems, resulting in declining crop yields. Different levels of land pressure in various parts of southwest Nigeria informed the authors' choice of the four LUIs above. Data from a field experiment simulating the economic circumstances of smallholder farmers were used.

DESCRIPTION OF COVER CROPPING AND ALLEY CROPPING SYSTEMS

Cover cropping using Pueraria phaseoloides

This is an *in-situ* mulch system using *Pueraria phaseoloides* as a source of manure to increase soil fertility and the yield of arable crops. The system simulates the micro-environmental conditions of the natural bush regrowth so as to derive most of its beneficial effects on soil flora and soil fauna in a much shorter time. Mulch from *P. phaseoloides* provides constant soil cover, retards soil degradation, suppresses weeds, helps in soil water conservation, and leads to improvements in soil physicochemical properties and biological activities (Lal *et al.*, 1978; Wilson *et al.*, 1982; Akobundu, 1980; 1984; Mulongoy and Spencer, 1989). For farmers with limited access to farm inputs, planted fallow using herbaceous cover crops such as *P. phaseoloides* has been noted as one of the improved natural resources-conserving fallow systems, which increased crop yields (Mulongoy and Spencer, 1989). Mulching has also been found to lead to an increase in maize grain yields (IITA, 1972).

Alley cropping using Leucaena leucocephala

This is another type of planted fallow system, involving the cultivation of food crops between hedgerows of *Leucaena leucocephala*, a multipurpose leguminous tree. The system implies the use of green manure mulch and involves the production of arable crops in spaces (usually 4 m wide) between rows of woody legumes (Raintree and Turay, 1980). Alley cropping allows for a faster exploitation of the benefits found in the traditional shifting cultivation system (Spencer, 1990). *Leucaena* has a deep root system that helps in biological nitrogen fixation and nutrient cycling. Its nitrogen-rich leaves are periodically pruned and applied as mulch and manure on arable crops to increase yields. The trees also provide farmers with valuable bonuses of fuel wood and staking materials (Spencer, 1990). For farmers who keep livestock, the foliage can be used also as fodder and browse. When so used, the technology also has been referred to as 'alley farming' (Atta-Krah and Francis, 1987; Kang *et al.*, 1990).

THE STUDY AREA AND RESEARCH METHOD

The experiment site had been under secondary forest for over 23 years by the time of initial clearing in 1989. It is located at Ibadan (7° 30′ N and 3° 54′ E) in the derived savanna zone of southwest Nigeria. Average annual rainfall is 1252 mm with a bimodal distribution. November to February constitutes the major dry season (Akintola, 1986). Average annual temperature is about 26.6 °C. The soil of the experimental site consists mainly of an Alfisol, Egbeda-Iwo soil series (Oxic Paleustalf, USDA; Luvisol, FAO) in the upper section and an Entisol, Apomu series (Psammentic Ustorthent, USDA; Albic Arenosol, FAO) in the lower section (Mulongoy and Spencer, 1989). Population density is low to moderate, and road infrastructure is fairly good (Manyong *et al.*, 1996).

The experimental design was a split plot, with alley cropping, cover cropping and bush fallow as the main plot treatments. The subplots were the LUIs (zero fallow or 100% LUI, 1-year fallow or 50% LUI, 2-year fallow or 33% LUI, and 3-year fallow or 25% LUI). Adapting Ruthenberg (1980), the LUIs under which profitability was evaluated and compared among the fallow systems were derived using the formula:

$$\text{LUI} \; (Y_c/(Y_c+Y_f)) \times 100 \tag{1}$$

where LUI = land-use intensity; Y_c = number of years of cropping and Y_f = number of years of fallow.

Subplot size was 12 m × 20 m. Field layout was arranged in a randomized complete block design with four replications. Cassava and maize intercrop were the test crops. Fertilizer and herbicides were not applied since the soil fertility implications of the different fallow systems (captured mostly through crop yields) were also being evaluated. Each year, cropped plots representing all the different LUIs (replicated four times) under each of the fallow systems, were uniformly intercropped with cassava and maize. Cassava (var. TMS 30572) was planted at a spacing of 1 m × 1 m, giving a population of 10 000 plants ha^{-1}. Maize (var. TZSRW) was planted at a spacing of 1 m × 0.25 m, giving a population of 40 000 plants ha^{-1}. Maize was harvested at 3 months after planting and cassava at 12 months after planting. In alley cropping plots, *Leucaena* (var. K636 in replications 1 and 3, var. K28 in replications 2 and 4) was seeded in July 1989 at a rate of 3 kg ha^{-1} using 4-m inter-hedgerow spacing. Also, in July 1989, *Pueraria* was planted at a seeding rate of 15 kg ha^{-1}, using a spacing of 25 cm × 100 cm in all cover-cropping plots. Although the establishment of these planted fallows (*Leucaena* alleys and *Pueraria* cover crops) consumes labour, data presented in this paper exclude such overheads since these were not recorded when the planted fallows were established in 1989.

Simple direct observation and record keeping were used to collect labour-use data on all farm operations from the 48 plots (3 main plots × 4 subplots × 4 replicates) cultivated annually. Data were collected for four years (1993–96) and this corresponds to one out of the three phases of the trial. Each phase provides annual replicates of cropped plots from which data were collected under the different LUIs in each of the fallow systems. This allows cropping and collection of data every year in cropped plots representing different LUIs (replicated four times) under each of the three fallow systems. Following various agronomic practices that imitate the target farmers' economic circumstances, a stopwatch was used to record labour starting time, break time, as well as end time on all farm operations in cassava–maize production (clearing, burning, stumping, minimum tillage, planting, weeding, supplying, thinning, pruning, and harvesting). The number of persons performing each operation was recorded. Data were also collected on labour use for fuelwood operations (cutting and stacking) in alley cropping systems with fallow periods. Fuelwood supply is a major problem in populated areas such as southeast Nigeria where 80% of the villages noted that fuelwood is scarce or very scarce (Adesina *et al.*, 1997).

Average rural prices for maize grain and gari (a processed form of cassava) were estimated using data from the Central Bank of Nigeria (CBN, 1993–96). Gari is the most popular form into which cassava tubers are processed for longer shelf life. Average prices applied for fuelwood output were collected from Alabata and Ayepe villages in southwest Nigeria. Profitability analysis was based on average yields per hectare of cassava, maize and fuelwood. Cost of processing cassava tubers into gari was not determined.

ANALYTICAL APPROACH

Physical output and input data used for the analysis on enterprise profitability were based on an implicit production function, assumed to be of the form:

$$Y = f(X_i) \tag{2}$$

where Y = physical output (in kilograms or tonnes) and X_i = physical inputs of production (i = 1, 2, ..., n). This function indicates that the estimated profitability takes into account the outputs from each system and also the inputs that resulted in each output. Crop-based profitability was actually evaluated using a budget model given as:

$$NB_{ij} = (GBc + GBm)\ VC = TR - VC \tag{3}$$

where NB_{ij} = net benefit (Naira ha^{-1}) of fallow system i (i = 1 to 3) and land-use intensity j (j = 100%, …, 25%), GBc = gross benefit (price × harvested quantity) from cassava in form of gari (Naira ha^{-1}), GBm = gross benefit from maize (Naira ha^{-1}), VC = variable costs (Naira ha^{-1}) and TR = total revenue (Naira ha^{-1}).

For the analysis of crop+fuelwood-based profitability, the budget model used is given as:

$$NB_{ij} = (GBc + GBm + GBfw) - VC = TR - VC \tag{4}$$

where GBfw = gross benefit (price × harvested quantity) from fuelwood (Naira ha^{-1}) and NB_{ij}, GBc, GBm, VC, and TR are as described in equation (3).

Labour was the most important variable input considered in the study. As a result, only variable costs relating directly to the labour input were included in the analysis. These are the costs that would influence the profitability of cassava–maize production in the different fallow systems under various LUIs. Thus, the cost of maize seeds and cassava cuttings was not included since this did not vary across treatments. As a result, the variable cost is actually the cost of labour, valued at the average (1993–96) opportunity cost (Naira man-day^{-1}) of labour for different farm operations in the study area. This ranges from 78.75 Naira man-day^{-1} (for burning, destumping, planting, supplying, thinning, harvesting cassava and fuel wood) to 96.25 Naira man-day^{-1} (for tree felling).

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RESULTS AND DISCUSSION

Crop profitability

Results from the analysis of crop (cassava and maize) profitability are presented in Table 1 (for zero-fallow) and the crop columns of Table 2 (for 1-year fallow), Table 3 (for 2-year fallow), and Table 4 (for 3-year fallow).

Clearly, each of the 12 crop enterprises from the three different fallow systems was profitable in absolute terms. However, the level of profit varied from 10 819 Naira ha^{-1} in zero fallow under alley cropping to 50 289 Naira ha^{-1} in 3-year fallow under cover cropping. Under zero fallow (Table 1) net returns were generally low (ranging from 10 819 Naira ha^{-1} under alley cropping to 14 375 Naira ha^{-1} under cover cropping), compared with fallow periods. Under 1-year fallow (Table 2), net returns ranged from 15 660 Naira ha^{-1} under alley cropping to 39 520 Naira ha^{-1} under cover cropping. Under 2-year fallow (Table 3), they ranged from 23 069 Naira ha^{-1} (under alley cropping) to 45 447 Naira ha^{-1} (under cover cropping). For the 3-year fallow (Table 4), profitability of alley cropping was 26 034 Naira ha^{-1} while for cover cropping it was 50 289 Naira ha^{-1}. Under all LUIs, the profitability of cassava–maize production was higher under cover cropping than under alley cropping and the bush fallow systems. There were net benefit advantages of 10%, 25%, 4% and 7% in zero, 1-, 2- and 3-year fallows respectively under cover cropping compared with the bush fallow. Compared with alley cropping, production (crop) under cover cropping was accompanied by net benefit advantages of 25%, 60%, 49% and 48% in zero, 1-, 2- and 3-year fallows respectively. When the improved fallow systems are compared with the bush fallow system, only cover cropping was more profitable than the bush fallow system. The higher profitability is consistent for all the LUIs.

Table 1. Partial budget analysis of cassava and maize yields by different fallow systems under continuous cropping or zero-fallow.

Budget element	Bush fallow	Cover cropping	Alley cropping
1. Average cassava tuber yield (t ha^{-1})	6.3000	6.4350	4.9675
2. Average maize grain yield (kg ha^{-1})	800.50	1 048.25	1 143.75
3. Gross benefit from cassava in form of gari (Naira ha^{-1} at N14 938 t^{-1})	18 821	19 217	14 820
4. Gross benefit from maize grain (Naira ha^{-1} at N12 290 t^{-1})	9 831	12 893	14 079
5. Total gross benefit (Naira ha^{-1}) (3+4)	28 652	32 110	28 899
6. Average opportunity cost of labour[1] for cassava and maize production (Naira ha^{-1})	15 709	17 735	18 080
7. Variable cost (Naira ha^{-1}) (= 6)	15 709	17 735	18 080
8. Net benefit[2] (Naira ha^{-1}) (5–7)	12 943	14 375	10 819

[1] Based on unpublished data (on average seasonal on-going wages per operation) from Alabata and Ayepe villages, southwestern Nigeria.
[2] Based on constant prices and related to average yields.
Source: Computed from experimental data, 1993–96.

Table 2. Partial budget analysis of cassava, maize and fuelwood yields by different fallow systems under 1-year fallow.

Budget element	Bush fallow (Crop)	Cover cropping (Crop)	Alley cropping (Crop)	Alley cropping (Crop+ fuelwood)
1. Average cassava tuber yield (t ha^{-1})	9.9525	9.2675	6.5975	6.5975
2. Average maize grain yield (kg ha^{-1})	1 840.00	2 431.25	1 678.75	1 678.75
3. Average fuelwood yield (kg ha^{-1})	n.a.	n.a.	n.a.	12 224.0
4. Gross benefit from cassava in form of gari (Naira ha^{-1}at N14 938 t^{-1} gari)	29 739	27 713	19 711	19 711
5. Gross benefit from maize grain (Naira ha^{-1}at N12 290 t^{-1})	22 625	29 887	20 649	20 649
6. Gross benefit from fuelwood stacks (Naira ha^{-1}at N1.92 kg^{-1})	n.a.	n.a.	n.a.	23 465
7. Total gross benefit (Naira ha^{-1}) (4+5+6)	52 364	57 600	40 360	63 825
8. Average opportunity cost of labour[1] for cassava–maize production (Naira ha^{-1})	19 612	18 080	24 700	24 700
9. Average opportunity cost of fuelwood operations labour[1] (Naira ha^{-1})	n.a.	n.a.	n.a.	4 891
10. Total variable cost (Naira ha^{-1}) (8+9)	19 612	18 080	24 700	29 591
11. Net benefit[2] (Naira ha^{-1}) (7–10)	32 752	39 520	15 660	34 234

[1] Based on unpublished data (on average seasonal on-going wages per operation) from Alabata and Ayepe villages, southwestern Nigeria.
[2] Based on constant prices and related to average yields.
n.a. = Not applicable.
Source: Computed from experimental data, 1993–96.

The higher profitability of the cover cropping system over the bush fallow system and alley cropping with *Leucaena leucocephala* under short fallows is consistent with the findings of some earlier studies involving cover crops. An *ex ante* economic analysis of *Mucuna* intercropped with maize indicated that if seeds from *Mucuna* could be sold, then the system was highly profitable from the first year of introduction of the technology (Manyong *et al.*, 1998; Dogbe, 1998). Similarly, based on a policy analysis matrix (PAM) model, improved maize intercropped with *Mucuna* was found to have a high net social profitability (NSP) in northern Cameroon (Adesina and Coulibaly, 1998). The good performance of cover crops has been demonstrated to be due to their beneficial effects in controlling weeds (Aken'Ova and Atta-Krah, 1986; Anoka *et al.*, 1991; Akobundu *et al.*, 1999), improving soil fertility, increasing crop yields, and providing additional income

Table 3. Partial budget analysis of cassava, maize and fuelwood yields by different fallow systems under 2–year fallow.

Budget element	Bush fallow (Crop)	Cover cropping (Crop)	Alley cropping (Crop)	Alley cropping (Crop+ fuelwood)
1. Average cassava tuber yield ($t\ ha^{-1}$)	10.3175	10.3475	7.3800	7.3800
2. Average maize grain yield ($kg\ ha^{-1}$)	2 658.00	2 623.75	2 253.25	2 253.25
3. Average fuelwood yield ($kg\ ha^{-1}$)	n.a.	n.a.	n.a.	24 381.0
4. Gross benefit from cassava in form of gari (Naira ha^{-1} at N14 938 t^{-1} gari)	30 826	30 924	22 032	22 032
5. Gross benefit from maize grain (Naira ha^{-1} at N12 290 t^{-1})	32 653	32 258	27 713	27 713
6. Gross benefit from fuelwood stacks (Naira/ha at N1.92 kg^{-1})	n.a.	n.a.	n.a.	46 831
7. Total gross benefit (Naira ha^{-1}) (4+5+6)	63 479	63 182	49 745	96 576
8. Average opportunity cost of labour[1] for cassava–maize production (Naira ha^{-1})	19 661	17 735	26 676	26 676
9. Average opportunity cost of fuelwood operations labour[1] (Naira ha^{-1})	n.a.	n.a.	n.a.	8 398
10. Total variable cost (Naira ha^{-1}) (8+9)	19 661	17 735	26 676	35 074
11. Net benefit[2] (Naira ha^{-1}) (7–10)	43 818	45 447	23 069	61 502

[1] Based on unpublished data (on average seasonal on-going wages per operation) from Alabata and Ayepe villages, southwestern Nigeria.
[2] Based on constant prices and related to average yields.
n.a. = Not applicable.
Source: Computed from experimental data, 1993–1996.

through seed production (Mohamed-Saleem and von Kaufmann, 1995; Tarawali *et al.*, 1999). In each fallow system, the profitability of cassava–maize (crop) increased with a decrease in LUI. This depicts the overall importance of fallow on soil fertility restoration.

Crop+fuelwood profitability

In computing profit here, account was taken of the fuelwood output under alley cropping. This was in addition to the crop (cassava–maize) production considered in the analyses contained in Tables 1–4. Fuelwood was included because it is an important source of income for farmers in the study area. In an earlier study of alley cropping, Spencer (1990) noted that the shrubs or trees used in alley cropping also provided farmers with valuable bonuses of fuelwood and staking materials and even nutritious fodder for livestock. Fuelwood output was omitted from the analysis contained in Table 1 and the crop columns of Tables 2–4 because in

Table 4. Partial budget analysis of cassava, maize and fuelwood yields by different fallow systems under 3-year fallow.

Budget element	Bush fallow (Crop)	Cover cropping (Crop)	Alley cropping (Crop)	Alley cropping (Crop+ fuelwood)
1. Average cassava tuber yield (t ha^{-1})	11.0550	11.1350	8.0775	8.0775
2. Average maize grain yield (kg ha^{-1})	2 683.50	2 922.00	2 480.50	2 480.50
3. Average fuelwood yield (kg ha^{-1})	n.a.	n.a.	n.a.	33 644.7
4. Gross benefit from cassava in form of gari (Naira ha^{-1} at N14 938 t^{-1}gari)	33 049	33 246	24 157	24 157
5. Gross benefit from maize grain (Naira ha^{-1} at N12 290 t^{-1})	32 999	35 914	30 480	30 480
6. Gross benefit from fuelwood stacks (Naira ha^{-1} at N1.92 kg^{-1})	n.a.	n.a.	n.a.	64 615
7. Total gross benefit (Naira ha^{-1}) (4+5+6)	66 048	69 160	54 637	119 252
8. Average opportunity cost of labour[1] for cassava–maize production (Naira ha^{-1})	19 068	18 871	28 603	28 603
9. Average opportunity cost of fuelwood operations labour[1] (Naira ha^{-1})	n.a.	n.a.	n.a.	10 275
10. Total variable cost (Naira ha^{-1}) (8+9)	19 068	18 871	28 603	38 878
11. Net benefit[2] (Naira ha^{-1}) (7–10)	46 980	50 289	26 034	80 374

[1] Based on unpublished data (on average seasonal on-going wages per operation) from Alabata and Ayepe villages, southwestern Nigeria.
[2] Based on constant prices and related to average yields.
n.a. = Not applicable.
Source: Computed from experimental data, 1993–1996.

regions where fuelwood is readily available, most adopters of alley cropping would mostly be influenced by the outcome of the crop profitability analysis. However, a comparison of the fallow systems with the inclusion of fuelwood output (in alley cropping) was important because there are signs of an imminent increase in both the use of and the demand for fuelwood in some parts of Africa (FAO, 1978; 1981; World Bank, 1978). The scarcity is usually more serious around urban areas. There was no fuelwood within 70 km of Ouagadougou, Burkina Faso, and residents spent 20 to 30% of their income purchasing fuelwood (Eckholm, 1976).

Inclusion of fuelwood output in the crop+fuelwood columns of the alley cropping system improves the usefulness of the results obtained from comparison of profitability among the enterprises under study. Fuelwood results from the introduction of varying fallow periods (1-, 2- and 3-year) into the original configuration of alley cropping based on continuous cropping or zero-fallow. Generally, fuelwood yield increases with a decrease in LUI. While including fuelwood in the profitability analysis in the crop+fuelwood column of the alley cropping system with fallow periods, the authors assumed that smallholder farmers could afford both the extra man-days of labour usually needed for fuelwood harvest operations (cutting and stacking) and the additional costs, including the cost of waiting for a return from alleys in the form of fuelwood.

Results from crop+fuelwood analysis are presented in the crop+fuelwood columns of Tables 2–4. Under zero fallow (Table 1), there is no crop+fuelwood column under the alley cropping system. Data presented in Table 1 are, therefore, for crop (cassava–maize) only. This is expected because alley cropping does not possess any fuelwood under zero-fallow.

For the crop+fuelwood columns of Tables 2–4, the cost items also reflect the opportunity costs of labour for farm (crop aspect) and fuelwood (fuelwood aspect) operations commonly carried out by farmers in southwest Nigeria. The fuelwood advantage of alley cropping accompanied the inclusion of fallow periods. For instance, under 1-year fallow, a gross benefit of 23 465 Naira ha^{-1} was obtained from fuelwood. Compared with crop profitability analysis, the fuelwood effect greatly increased the net benefits obtained under alley cropping. Under 1-year fallow, the fuelwood advantage of alley cropping increased net benefit by about 119% over the level obtained in crop profitability analysis. However, results also indicate that even with the significant fuelwood advantage net benefits from crop+fuelwood under alley cropping (34 234 Naira ha^{-1}) were still lower than the net benefits obtained from crop (cassava–maize) under cover cropping (39 520 Naira ha^{-1}) (Table 2). This implies that a 1-year fallow was not sufficient for the fuelwood advantage under alley cropping to put the system at a net benefit advantage over cover cropping. The fuelwood advantage has, however, been able to put alley cropping at a net benefit advantage of about 5% over crop under bush fallow (with a net benefit of 32 752 Naira ha^{-1}). Under 1-year fallow, production (crop) under cover cropping has a net benefit advantage of 17% over that under bush fallow and 13% over production (crop+fuelwood) under alley cropping.

Under 2-year fallow, fuelwood yield under alley cropping increased by about 100% of its value under 1-year fallow. Similarly, under 3-year fallow, fuelwood yield under alley cropping increased by about 175% of its value compared with 1-year fallow. Results of analysis under 2-year fallow (Table 3) indicate that the increases in fuelwood yield have now generated sufficient revenue to put alley cropping at a net benefits advantage of 29% over bush fallow (crop) and 26% over cover cropping (crop). Under 3-year fallow (Table 4), the corresponding net benefit advantages of alley cropping (crop+fuelwood) were 42% (over bush fallow [crop]) and 37% (over cover cropping [crop]). Starting from 2-year fallow, the fuelwood-induced net benefit advantage of alley cropping increased with a decrease in LUI.

CONCLUSION AND IMPLICATIONS OF THE RESULTS

Although each of the compared enterprises is profitable, the level of profit differs significantly among the fallow systems, even under the same LUI. Crop profitability was highest among the cover cropping systems and lowest among the alley cropping systems under all LUIs. Cover cropping using *Pueraria phaseoloides* is recommended therefore to farmers in the derived savanna of southwest Nigeria, especially in areas where fuelwood is easily available, thereby depressing the market value. In all LUIs, there is a net benefit advantage in growing cassava–maize under the cover cropping system compared with alley cropping and the bush fallow systems.

In crop+fuelwood analysis, there is a net benefit advantage under cover cropping compared with alley cropping and the bush fallow systems under zero fallow and 1-year fallow. However, under 2-year and 3-year fallow, production under alley cropping has a net benefit advantage over both the other systems. Cover cropping is recommended to farmers in areas with insufficient land and where fuelwood or other sources of energy for domestic use are easily available. However, in areas with abundant land and where fallow periods of at least 2 years are still possible, the alley cropping system (which guarantees a higher profit than do cover cropping and the bush fallow systems) is recommended. In addition to improving soil fertility status, considerable revenue is obtained from alley cropping systems with at least 2-year fallow periods.

Since profitability of production is generally higher in the recommended options, the probability of their adoption by farmers is also higher. These environmentally friendly options are also much more likely to improve the welfare of farm families. However, it is crucial to emphasize that considerations of yield variability, labour scarcity, as well as risk-aversion behaviour among farmers may alter their technology choice.

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