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FACTORS AFFECTING THE ADOPTION OF LEGUMINOUS COVER CROPS IN NIGERIA AND A COMPARISON WITH THE ADOPTION OF NEW CROP VARIETIES

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SUMMARY

This paper presents the results of:

(a) On-farm trials (eight) over a two-year period designed to test the effectiveness of leguminous cover crops in terms of increasing maize yields in Igalaland, Nigeria.
(b) A survey designed to monitor the extent of, and reasons behind, adoption of the leguminous cover crop technology in subsequent years by farmers involved, to varying degrees, in the trial programme.

Particular emphasis was placed on comparing adoption of leguminous cover crops with that of new crop varieties released by a non-governmental organization in the same area since the mid 1980s. While the leguminous cover crop technology boosted maize grain yields by 127 to 136 % above an untreated control yield of between 141 and 171 kg ha^{-1}, the adoption rate (number of farmers adopting) was only 18 %. By way of contrast, new crop varieties had a highly variable benefit in terms of yield advantage over local varieties, with the best average increase of around 20 %. Adoption rates for new crop varieties, assessed as both the number of farmers growing the varieties and the number of plots planted to the varieties, were 40 % on average. The paper discusses some key factors influencing adoption of the leguminous cover crop technology, including seed availability. Implications of these results for a local non-governmental organization, the Diocesan Development Services, concerned with promoting the leguminous cover crop technology are also discussed.

INTRODUCTION

The use of leguminous cover crops (LCCs) to help maintain and improve soil quality has been researched and promoted for many years, and a substantial body of technical and economic knowledge has been established. Numerous trials have clearly shown yield advantages, benefits within livestock-based systems (Adeoye and Onifade, 1999; Muhr *et al*., 1999) as well as benefits to soil quality and erosion control (Dugue, 1998). The appeal of LCCs is not difficult to understand, given the contexts of declining fallow periods as population pressure increases (Adeoye and Onifade, 1999; Oyewole *et al*., 1999; Tarawali *et al*., 1999) and problems with the cost and availability of commercial fertilizer (Muhr *et al*., 1999). The result is the common labelling of LCC approaches as ‘sustainable’.

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Among the advantages associated with the use of LCCs are their contributions in terms of soil maintenance (Tian *et al*., 2000) and weed control (Osei-Bonsu and Buckles, 1993). Studies have shown substantial yield benefits to cereal crops such as maize and rice if planted after a LCC has been grown and incorporated (Asibuo and Osei-Bonsu, 1999; Mandimba, 1999; Tian *et al*., 1999; Ibewiro *et al*., 2000; Odhiambo and Bomke, 2001). The inclusion of a soil-maintenance LCC implies, however, that the farmer is willing to grow something that might not directly provide a benefit (food or cash). This has been raised as an issue with regard to adoption (Vanlauwe *et al*., 1999). Attempts to control noxious weeds, for example *Imperata cylindrica* (speargrass), with LCCs such as Mucuna, have provided encouraging results (Akobundu *et al*., 2000). This may mean, however, that such highly competitive LCCs cannot be so readily intercropped (Coultas *et al*., 1996), forcing their use within a relay instead. Nevertheless, where Mucuna has been introduced in parts of West Africa, farmers have quickly become aware of its potential for speargrass suppression, and this has been an important driving force in its adoption in Ghana at least (Anthofer, 1999).

While there are many studies of the agronomic and economic benefits of LCC systems, analyses of patterns of adoption by subsistence farmers in Africa have received far less attention than is desirable. There are studies that suggest that uptake is variable; some with examples of relatively high adoption rates. In general, though, adoption has been poor (Adeoye and Onifade, 1999). Indeed, periods of LCC adoption can be followed by abandonment, as shown by Honlonkou *et al*. (1999) with regard to Mucuna in southern Benin. It has been suggested that important factors for adoption are probably the apparency of benefits that accrue to farmers (Vanlauwe *et al*., 1999) and how easily LCCs can be slotted into current practice (Manyong *et al*., 1999; Pound *et al*., 1999). 'Sustainable' agricultural practices such as agroforestry and the use of LCCs often have greater temporal and spatial complexity compared with other agro-technologies (Cardoso *et al*., 2001; Franzel *et al*., 2001). With some LCCs, for example Mucuna and *Stylosanthes* spp., there have been problems with patchy establishment in parts of West Africa (Oyewole *et al*., 1999; Tarawali *et al*., 1999). This may be due, in part, to problems with availability of necessary strains of *Rhizobium* or lack of plant nutrients such as phosphorus (Tian and Kang, 1998). Careful selection of LCCs for the particular environment in which they are to be released is clearly important (Obiagwu, 1997a;b).

The aim of the research reported here was to examine the factors that influence the uptake of LCC technology in Igalaland, Kogi State, Nigeria, and to make comparisons between the adoption of this technology and that of new crop varieties (NCVs). A Catholic-based non-governmental organization (NGO), the Diocesan Development Services (DDS), has been working in the area since 1970. It has experienced much success in the area with employing on-farm research to introduce NCVs, particularly of maize (*Zea mays*), cowpea (*Vigna unguiculata*), cassava (*Manihot esculenta*), groundnut (*Arachis hypogaea*) and rice (*Oryza sativa*) (McNamara and Morse, 1997). Part of this process has involved the use of adoption surveys to measure uptake. Since the mid 1990s, DDS began to include other agro-technologies in its on-farm research programme, and in 1997 the focus shifted significantly to the use of LCCs. These trials have continued to the present, with measurements collected on biomass, grain yields and labour. In 2001, DDS decided to implement a survey to see how adoption patterns of this technology differed from that of the NCVs included in the earlier on-farm research programmes.

MATERIALS AND METHODS

Research area

Igalaland (part of Kogi State) is situated in the 'middle belt' of Nigeria, a region dominated by Guinea-savanna vegetation. A large part of Igalaland rests on a plateau, and its vegetation resembles that found in the southern states of Nigeria (rainforest, with oil palm, *Elaeis guineensis*, as the predominant species). Rainfall is variable, but averages around 1400–1600 mm per annum, falling mostly between the months of April and September. This is the growing season, and has a typical West African bimodal distribution: an early season (April to mid-July) and a late season (mid-July to September), divided by a few days of no rain.

There are two broad soil regions in Igalaland: (i) the Riverine (alluvial) region, along the banks of the rivers Niger and Benue, and (ii) the Plateau (upland) region, inland from the rivers.

The soils of the upland region, where the trials described here were located, are generally well drained, deep, of variable texture and have predominantly yellowish-red and red colours. They are of the Pedalfer-Latosol group. Due to the high temperature and the relatively high rainfall of this region, however, the soils are strongly weathered and leached. Hence they have a relatively low natural fertility and this explains the almost universal practice of shifting cultivation as a mechanism for renewing soil nutrients.

The local people (Igala) are predominantly arable farmers, keeping livestock such as goats, sheep, chickens and ducks as a secondary activity. Cropping systems are complex, with marked differences between the major soil types and between areas of high and low population density. The systems generally are based on bush fallow, with fallow periods ranging from zero to ten years or more. A wide variety of crops, annual and perennial, are cultivated in the area with maize being one of the most popular. However, in some areas the soil fertility is so low that maize production is not possible without significant inputs of nutrients, and farmers often revert to millet, cassava and legumes such as cowpea. The popularity of maize is such that Igala farmers are willing to embrace ideas for improving soil fertility.

DDS on-farm research programme

The DDS on-farm research programme began in 1983, and for the first four years the trials took the form of conventional designs (mostly randomised blocks) established on farmers' land. From 1987 the on-farm programme was changed to involve more farmers. The design was randomised blocks with each farm acting as a replicate. Until the early 1990s, treatments largely took the form of NCVs combined with methods of reducing fertilizer and/or pesticide costs. In the interest of simplicity, the on-farm

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Table 1. Varietal responses in terms of yield for new crop varieties (NCVs) relative to local varieties (LVs) from the DDS on-farm research programme. Percentage increase in yield, statistical significance of the increase, number of sites (n) and degrees of freedom (treatment, error).

Crop	Year	Difference in mean yield of NCV(s) over mean yield of LV (%)	n	*d.f.* Treatment	*d.f.* Error
Maize	1986	4 ns	17	2	79
	1987	12*	21	1	60
	1988	−12 ns	17	1	47
	1990	8 ns	24	1	69
	1992	4 ns	10	1	45
	1992	−12 ns	13	1	60
	1993	−2 ns	5	1	20
	1993	3 ns	16	1	75
	1993	−5 ns	15	1	70
	1994	21 ns	8	1	35
	1994	22 ns	16	1	75
	1994	9 ns	17	1	80
	1994	5 ns	8	1	35
	1995	19 ns	4	1	15
	1995	9 ns	16	1	75
	1996	68***	11	1	50
	1996	−9 ns	11	1	50
	1996	12 ns	11	1	50
	1997	36***	24	1	161
Mean difference		10 (3 out of 19 significant)			
Groundnut	1987	35***	23	1	65
	1988	34***	14	1	39
	1989	13 ns	24	1	68
	1990	17***	21	1	60
	1995	−25 ns	4	1	15
	1996	41***	11	1	50
Mean difference		19 (4 out of 6 significant)			
Cowpea	1987	29*	21	1	60
	1988	33*	21	3	59
	1988	24***	17	1	48
	1989	10*	21	1	60
	1989	15*	18	1	119
	1990	−4 ns	17	2	48
	1997	16***	27	1	52
	1998	14*	25	1	48
	1999	8*	35	1	68
Mean difference		16 (8 out of 9 significant)			
Cassava	1989	12*	46	1	134
	1992	−20 ns	5	1	20
	1993	2 ns	7	1	30
	1994	−11 ns	17	1	80
	1994	−11 ns	8	1	35
	1995	−43***	16	1	75
	1996	−11 ns	11	1	49
Mean difference		−12 (2 out of 7 significant)			

Table 1. (*cont.*)

Crop	Year	Difference in mean yield of NCV(s) over mean yield of LV (%)	n	*d.f.* Treatment	*d.f.* Error
Upland rice	1988	−23*	8	1	21
	1989	−17*	20	1	57
	1992	27*	10	1	45
	1993	26 ns	16	1	75
	1994	9 ns	8	1	35
	1995	77*	6	1	15
	1996	37*	7	1	18
Mean difference		19 (5 out of 7 significant)			
Lowland rice	1988	−17 ns	7	1	18
	1989	−33***	15	1	42
	1990	6 ns	10	1	27
Mean difference		−15 (1 out of 3 significant)			

ns = not significant at 0.05
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

trials conducted prior to 1991 did not include intercropping as a treatment *per se*, but NCV-based trials since 1992 incorporated intercropping. A summary of the on-farm results related to the yield benefits of some NCVs over local varieties (LVs) in the DDS programme is shown in Table 1. Yield advantages for the NCVs were highly variable both between and within crops, but for maize, upland rice, cowpea and groundnut the average gains over LVs were between 10 and 19 %. Surveys, one in 1991 (covering varieties released since 1986) and one in 1994, were implemented to determine the level of adoption (and reasons for or against) of NCVs. A summary of the results, along with the average increase in yield of NCVs over LVs, is presented as Table 2. Adoption rates were variable and not necessarily correlated with yield advantage, suggesting that NCV adoption was driven by many concerns (e.g. taste, early maturity, pest- and disease resistance). In both surveys, average NCV adoption over all crops was approximately 40 % (using the two indicators of adoption in Table 2). The two main factors facilitating adoption were the ability of farmers to multiply rapidly the NCVs, and the ease with which the NCVs were slotted into existing cropping systems.

Although most of the on-farm research focused on the introduction of NCVs, there were also various attempts to look at other technologies. Some of the early trials tested the use of commercial fertilizer and insecticide and, although these inputs were popular with farmers, they continue to be relatively expensive and availability can be irregular. Later in the 1990s, the on-farm programme looked at other sustainable alternatives, including the use of botanical pesticide (tobacco), liquid manure and LCCs. The last was born out of cooperation with the International Institute of Tropical Agriculture (IITA) and designed to test the effectiveness of the LCC approach. As far as DDS is aware, the LCC species it introduced were unknown in Igalaland prior to its on-farm programme.

Table 2. Summary of the results of the DDS-sponsored 1991 and 1994 new crop variety (NCV) adoption surveys.

Crop	Average yield increase for NCVs over local varieties reported from DDS on-farm trials (%) (1987 to 1999)	Respondents growing at least one DDS-released NCV (%) (1991 survey)	Plots planted to a DDS-released NCV (%) (1994 survey)
Maize	10	62	41
Lowland rice	−15	15	26
Upland rice	19	29	57
Cowpea	16	36	43
Groundnut	19	–	26
Cassava	−12	62	27
Average	6	41	44
Number of respondents		572	458

For the most part, the on-farm trials were carried out by farmers who were members of the DDS savings and loans scheme, namely, the Farmer Council (FC) Project, and no payment was involved. DDS employs a number of Extension Farmers (EFs) and Trainee Farmers (TFs) to help implement a range of development activities. The number of EFs and their geographical distribution within Igalaland has varied over the years, but has typically been around ten or less. EFs receive a regular income from DDS and are involved in various development projects. The TFs are a much larger group, numbering some 70 individuals by the end of 2001. Although they are not employed by DDS on a regular basis, some may be paid on an *ad hoc* basis for specific jobs, for example, carrying out an on-farm trial and helping other farmers to do the same. All TFs would have attended a one-year training programme organized and run by DDS on its farm at Iyegu village. In general, TFs do not have the level of training of EFs and they tend to be younger.

Because of the expected complexity of the LCC approach within the DDS on-farm trials, at least relative to previous efforts with NCVs, the trials were almost entirely implemented by EFs and TFs. This was in marked contrast to the other on-farm trials with NCVs in the 1980s and 1990s where farmers implemented the bulk of the plots, albeit with help from EFs and TFs.

LCC trials

The trial design for the LCC on-farm research was based on randomised blocks, with different locations (16 farms) representing the blocks. In the plateau (upland) region, sites were selected that were known to provide low yields of maize due to poor soil (i.e. the strategy was very much one of using LCCs for 'soil improvement'). At each site, four treatments were applied with only one within-site replicate:

i. control (nothing applied);
ii. LCC established in the late season of 1997;
iii. fertilizer (N : P : K = 15 : 15 : 15 compound) applied soon after maize germination; and
iv. cowpea established in the late season of 1997.

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Only eight of the 16 trials had complete data that could be analysed. For these sites, the LCCs planted were as follows: *Chamaecrista rotundifolia* (two sites), *Stylosanthes* spp. (three sites), *Centrosema pascuorum* (two sites) and *Mucuna pruriens* var. utilis (one site). In the late season of 1997, the sites were cleared and divided into four plots of 10 × 10 m, with a 1 m gap. The LCC and cowpea were planted in the late season of 1997. The small-seeded LCCs were planted on flat land using drills at a row spacing of 0.5 m (equivalent to a seed rate of 10 to 15 kg ha^{-1}). Mucuna was planted at a within-row spacing of 0.20 m. Cowpea was planted on 1-m spaced ridges with 0.20 m between stands. The plants were cut either in late 1997 or early 1998 and allowed to dry on the surface of the plot. After drying, the biomass (dry weight) produced by the LCC and cowpea was recorded, and the material was incorporated. In the early season of 1998, a maize crop (variety DMR-ESR-Y) was grown on the plots. The time of planting and density were left to the discretion of each farmer, but the latter was typically in the region of 40 000 plants ha^{-1} (1-m rows with two plants every 0.5 m within rows).

For the fertilizer treatment, N : P : K (=15 : 15 : 15) compound was applied at the rate of 10 g per stand (approximately 400 kg ha^{-1}; 60 kg ha^{-1} of N, P and K) some 10 to 14 days after planting. Crop biomass (sun dried) and grain yield were recorded, and maize stover was incorporated into the soil of the relevant plot. No further planting of LCC or cowpea took place in the late season of 1998 although natural re-generation of small-seeded LCCs (*C. rotundifoli*, *Stylosanthes* spp. and *C. pascuorum)* would have occurred (not for Mucuna and cowpea). In early 1999, the plots were again prepared (ridged) and maize (again DMR-ESR-Y) was planted. Fertilizer was applied to the plot requiring that treatment at the same rate as in 1998. Maize grain and stover yields were recorded after harvest and analysed using ANOVA.

LCC-adoption survey

The LCC-adoption survey was designed and implemented in July 2001. A total of 66 respondents were included in the main survey (following an earlier pilot), and these were selected on the basis of being closely involved with the LCC trials. They had directly implemented a trial (as an EF or TF), been closely involved with it in some way, perhaps by helping out with labour, observed the trial on a regular basis (e.g. while walking to their own farm), or seen LCCs in another setting (e.g. on the Iyegu farm or one of the other on-farm plots established by DDS that included an LCC). The 66 respondents could be seen, therefore, as a 'close contact' group. It was assumed by DDS senior staff involved in the on-farm programme that adoption of the LCC technology would be influenced by a range of factors that could be placed into eight categories:

i. *Exposure*. It was assumed that those who had more direct experience of the LCC trials (i.e. those who had actually worked on them) would be more likely to adopt than those who had only observed the plots.
ii. *Age*. Younger farmers were assumed to be more likely to adopt than older farmers.

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iii. *Involvement with DDS*. It was assumed that those more likely to adopt would be those who had a 'fuller' involvement with DDS. This was defined in terms of their being involved in the FC structures as a chairperson or secretary.
iv. *Occupation*. It was assumed that adopters were more likely to be farmers with significant off-farm income as a sign of entrepreneurship.
v. *Education*. It was assumed that more educated farmers would more readily adopt.
vi. *Experience*. It was assumed that adopters would be more widely travelled and hence experienced than non-adopters. It was also thought that adopters might have lived for a time outside of their village of birth.
vii. *Tree crops*. It was assumed that adopters would also be interested in tree crops (fruit trees and leguminous trees) supplied by DDS as they take a more long-term perspective.
viii. *Savings and credit*. It was assumed that adopters would tend to have more savings and less loan from DDS (i.e. be more self-reliant) than non-adopters

The questionnaire was designed to tackle these assumptions by asking a number of questions related to each. Four indicators of LCC adoption were employed throughout the survey: (i) adoption of LCC (yes or no); (ii) the number of LCC plots established by the respondent; (iii) the total area (m^2) of all the LCC plots established by the respondent; (iv) proportion of the total crop area that had been planted to LCC (e.g. if a farmer had 5000 m^2 of maize and 2500 m^2 of this was on land that had been occupied by a LCC then this indicator was equal to 50 %)

Numbers (iii) and (iv) in this list were determined by field measurement carried out in parallel with the survey.

Analysis of results

The maize grain and stover yields were analysed using ANOVA. Although four different LCCs were planted in the eight trials, they were treated the same (i.e. as a 'LCC group') in the analysis.

Adoption survey results were analysed using stepwise (backward) linear regression, with $p < 0.1$ significance as the cut-off for each iteration. Categorical answers (e.g. yes/no) were coded before analysis, and separate analyses were applied to all four LCC adoption indicators. The results of the analysis were fed back to groups of respondents to help provide an explanation.

RESULTS

The results of an analysis of variance applied to the maize yield and biomass data from 1998 and 1999 are shown in Table 3.

Although grain yields were low (<1 t ha^{-1}; with control plot yields of only 171 and 141 kg ha^{-1}), a reflection of the initial site selection policy to target poor land, they were significantly higher in both 1998 and 1999 for maize grown after LCC and with fertilizer than either the control or cowpea plots (Table 3). The LCC plots gave a yield increase of between 127 and 136 % over the control (1998 and 1999 plantings

Table 3. Grain and biomass yields of maize with three treatments designed to address soil fertility (LCC = legume cover crop).

(a) Grain yields (kg of dried and threshed seed ha^{-1}).

Treatment	Grain yield (1998)	Increase over control (%)	Grain yield (1999)	Increase over control (%)
Control	171	–	141	–
LCC (late 1997)	388	127	333	136
Cowpea (late 1997)	206	20	171	21
Fertilizer (1998 and 1999)	430	151	471	234
s.e.	59		55	

(b) Stover yields (t dry weight ha^{-1}).

Treatment	Stover yield (1998)	Increase over control (%)	Stover yield (1999)	Increase over control (%)
Control	1.51	–	2.73	–
LCC (late 1997)	2.71	80	4.53	66
Cowpea (late 1997)	1.87	24	2.95	8
Fertilizer (1998 and 1999)	2.25	49	3.77	38
s.e.	0.39		0.53	

(c) Harvest index (grain yield/grain + stover yield).

Treatment	Harvest index (1998)	Harvest index (1999)
Control	0.10	0.05
LCC (late 1997)	0.13	0.07
Cowpea (late 1997)	0.10	0.05
Fertilizer (1998 and 1999)	0.16	0.11

respectively), while fertilizer application increased yields by 151 and 234 % for 1998 and 1999 respectively. A similar trend could also be seen with the maize stover results, although these were higher for all plots in 1999 relative to 1998. There were 'blind' stalks (i.e. stalks without a grain yield) in all plots, hence the harvest indices based on average plot grain and stover yields were low (less than 0.2). Nonetheless, the grain and stover yield increases accruing from the use of LCCs were apparent to those involved in the trials and, indeed, were noted by almost all those questioned in the adoption survey.

Most (92 %) of the people making up the LCC adoption survey sample were males, aged between 20 and 59 years (74 %), and the bulk of respondents (82 %) reported their main occupation as farming, although 60 % had significant off-farm income. Most respondents had no experience of being a chairperson or secretary within the FC structures, although 80 % had taken some form of village responsibility. Only eight respondents had direct experience of implementing a LCC trial, but 70 % had seen a LCC trial and 31 % had seen various other DDS-sponsored trials with LCCs. Approximately 15 % had seen LCCs on the DDS farm, Iyegu, and a small minority, 9 %, had seen them planted by other farmers but not part of a trial.

The results of the step-wise regression of adoption factors performed on the sample of 66 respondents who had been exposed to the LCC technology in one form or another are shown in Table 4. The explanatory variables assumed when designing the survey are presented in the eight categories, and only statistically significant ($p < 0.05$) regression coefficients are presented (with a few exceptions where $p < 0.1$). The regression analysis of adoption indicators generated four highly statistically significant models having adjusted r^2 between 53 and 71 %. There is a spread of significant coefficients in Table 4 for all four indicators of adoption, and each of the eight explanatory categories had significant coefficients. However, following discussions with the respondents, perhaps the key factors in the adoption of LCC were direct involvement with the on-farm trials (usually as an EF or TF) and level of involvement with DDS. While the factors at play are complex and interact, two important elements were related to availability, for farming, of seed and time.

With regard to exposure to the technology, for example, it is interesting to note that adoption of LCC (yes/no) was positively related to whether or not the respondents had been involved with a trial plot. Those who had been most involved (EFs) were more likely to have at least one LCC plot. This was not an issue of apparency of benefits *per se*, however. After all, there was a negative relationship with two other indicators of adoption based on the area of LCC established (b = −0.44 and −0.65). Hence, those more closely involved with LCC trials were less likely to have larger areas of LCC on their own farms. Even if not directly involved in the trials, almost all farmers interviewed, were aware of the potential yield benefits of using LCCs, some because they had seen it while others because they had been told. Instead, those most likely to adopt on a greater scale (i.e. larger LCC area) would be those with the greatest exposure to DDS as a TF, but at the same time not heavily involved in other DDS activities. Note the negative regression coefficients related to number of years since TF training (b = −0.975, −1.114 and −0.433). Those most likely to adopt would be those who received training since the mid 1990s when LCCs were part of the curriculum and seeds would have been provided after graduation. Hence the TF group had the advantage of having good access to LCC planting material from DDS, indeed better than the access of FC members. Off-farm activities for this group were significant (hence the positive coefficient of 0.22) although typically closely allied to agriculture, for example, processing or trading of agricultural produce. The TFs also make use of their savings account with DDS (i.e. by withdrawing money saved before 2001) and taking loans (albeit at lower levels than many of the FC members), and accessing fruit and leguminous trees provided by DDS, and these characteristics largely account for the significant coefficients for the two categories at the foot of Table 4.

Only 12 out of the 66 respondents (18 %), however, practised the LCC technique on their own farms and, of these, the majority (nine respondents) had only one LCC plot. The adopters described the advantages of the LCC approach as being primarily the improvement of soil fertility, provision of fodder for animals and weed control, and

Table 4. Standardized regression coefficients significant at $P < 0.05$ (unless stated otherwise) for four indicators of adoption of leguminous cover crops (LCC) by a sample of farmers in Igalaland, Nigeria.

			LCC adoption indicator			
Category	Variable	Type of data and codes	Adoption of LCC (yes or no)	Number of LCC plots on farm	Area of LCC on farm (m^2)	Proportion of total crop area planted to LCC (%)
Exposure to the LCC technology	Directly involved with LCC trial	N (1)/Y (2)	0.53		−0.44	−0.65
	Seen LCC trial	N (1)/Y (2)				
	Seen LCC plots at DDS Iyegu farm	N (1)/Y (2)	−0.21			
	Seen LCC plots on other farmers' farms	N (1)/Y (2)				
Age of respondent	Age category of respondent (1 to 7)	category (1 = youngest)		0.26		
Level of involvement with DDS and responsibility taking within DDS FC structure and the village	Zonal responsibilities	N (1)/Y (2)				0.48
	Years of experience of zonal responsibilities	number of years				−0.40
	FC responsibilities	N (1)/Y (2)				
	Years of experience of FC responsibilities	number of years			−0.3.0	
	Trainee farmer (TF)	N (1)/Y (2)		1.26	1.56	1.11
	Number of years since TF training	number of years		−0.99	−1.11	−0.43
	Extension farmer (EF)	N (1)/Y (2)	0.40	0.62	0.68	
	Number of years experience as EF	number of years				
	Village responsibilities	N (1)/Y (2)				
	Number of village responsibilities held	number				
	Years of experience with village responsibilities	number of years		−0.25	−0.26	
Occupation	Main occupation	farming (1)				−0.26
	Presence of significant levels of off-farm income	N (1)/Y (2)				0.22
	Significant occupations	number				
Education	Primary level education	N (1)/Y (2)		0.2 ($P = 0.055$)		
	Secondary level education	N (1)/Y (2)				
	Tertiary level education	N (1)/Y (2)				0.42
	Other forms of education	N (1)/Y (2)			0.13 ($p = 0.08$)	
Travel outside of the village	Residence outside village in last year	number of places				0.21
	Travel outside village in last year	number of places				
Adoption of tree and leguminous crops obtained from DDS	Species of tree crop planted on own farm	number				
	Stands of tree crop planted on own farm	number			0.232	
	Species of leguminous tree planted on own farm	number				
	Stands of leguminous tree planted on own farm	number	0.46	0.32	0.29	
	July 2001account balance with DDS	Naira				
Savings and loan activity with DDS	Having new saving with DDS in 2001	N (1)/Y (2)				−0.30
	Volume of savings with DDS in 2001	Naira				
	Withdrawals in 2001	N (1)/Y (2)				
	Volume of withdrawals in 2001	Naira	0.15 ($P = 0.09$)	0.14		0.19 ($P = 0.07$)
	Taken loan from DDS in 2001	N (1)/Y (2)			0.195	0.29
	Size of loan taken from DDS in 2001	Naira				−0.36
	Intercept		0.74	−6.10	−22913.66	−140.99
	Adjusted r^2		0.53	0.71	0.69	0.63
	s.e. of the estimate		0.27	0.48	1846.45	12.08
	d.f.		4, 61	8, 57	10, 55	14, 51

Table 5. Crops planted on leguminous cover crop (LCC) plots established by adopters of the technology.

Crop planted on LCC plots	Area (m^2)	Proportion of total area (%)
Cowpea (*Vigna unguiculata*)	44 248	39
Maize (*Zea mays*)	24 470	22
Egusi melon (*Citrullus vulgaris*)	18 503	17
Millet (*Pennisetum* spp.)	9925	9
Groundnut (*Arachis hypogaea*)	8775	8
Benniseed (*Sesamum indicum*)	5700	5
Okra (*Hibiscus sabdaniffa*)	375	0
Yam (*Dioscorea* spp.)	30	0
Total	112 026	100

Note: these are the crops planted in 2001 (early and late seasons), and in some cases refers to an intercrop.

the two most significant disadvantages as the inability to intercrop LCCs (especially with Mucuna) and problems with harvesting. Seed availability was mentioned by 71 % of respondents (adopters and non-adopters) as a major constraint in the adoption of LCC. All respondents said they would plant more LCC if seed could be made available.

The crops and areas planted on LCC plots established by adopters of the technology are shown in Table 5, while Table 6 presents the areas of LCC in use by the adopters. In both cases the data refer to 2001, and in Table 5 the data include areas of intercrop and aggregated areas for both early and late growing seasons. Hence the total crop area on LCC plots (Table 5) is greater than the total area of LCC in use (Table 6).

Of those that did adopt the LCC method, the three favoured crops for planting on the LCC plots were cowpea, maize and melon (Table 5). The popularity of cowpea and melon after LCC is perhaps related to the high economic value of these crops in Igalaland. By far the most popular LCC employed by the adopters was Mucuna (Table 6).

Table 6. Areas of leguminous cover crop (LCC) in use by the adopters in 2001.

LCC planted	Area (m^2)	Total area (%)
Mucuna pruriens var. utilis	32 050	61
Centrosema poscuorum and *C. brasilianum*	7145	14
Lablab purpureus	4500	9
Canavalia spp.	3763	7
Aeschynormene histrix	3600	7
Stylosanthes guianensis and *S. hamata*	1190	2
Total	52 248	100

Note: includes areas planted and self-regenerated from previous seasons. The LCC is the one originally planted onto that land.

DISCUSSION

The maize grain yield results with LCC were highly encouraging and mirror the sort of increases mentioned by other workers, although an increase in yield of 130 % is possibly on the high side (Asibuo and Osei-Bonsu, 1999; Tian *et al.*, 1999; Ibewiro *et al.*, 2000). Commonly cited yield increases for maize following LCCs tend to be much less than 100 %, and usually in the order of 20 to 60 % (e.g. Oyewole *et al.*, 1999) although higher values comparable to those of the DDS programme have been recorded (Asibuo and Osei-Bonsu, 1999). No doubt the decision to target poor land for the trials was responsible for these marked increases, and the low absolute yields obtained.

The results clearly suggest that direct involvement by farmers in a trial or plot of LCC is highly important. On the surface, this would seem to support the views of Vanlauwe *et al.* (1999) regarding the apparent benefits to farmers, and those of Manyong *et al.* (1999) and Pound *et al.* (1999) regarding the ease in which the technology can be slotted into existing systems. However, it is not as straightforward as this. The main adopters (in terms of LCC area) are the TF group with good knowledge of the technology and having good access to seed and time with which to farm. They are also not expected, by either DDS or the FC members, to provide seed to others. The EFs have some of these advantages, but do not have so much time for farming given their DDS activities. Hence while they will have a LCC plot, it is not likely to be extensive. Also, they are called upon to supply seeds to others. Other farmers, although members of the DDS FC programme and having some knowledge of the benefits of LCCs, do not have such good access to planting material and this acts as the limiting factor to adoption irrespective of how much time they have for farming.

The level of uptake of the LCC technology is certainly much lower than that generally reported in the 1991 and 1994 NCV-adoption surveys where an average of 40 % of respondents grew at least one DDS-released NCV. A similar proportion of plots farmed by respondents were planted to a NCV. Given that the two technologies are qualitatively different, one perhaps shouldn't be surprised that adoption rates would also be different. Nonetheless, the low LCC adoption rate is especially marked when one remembers that the survey specifically targeted those known to have had a close association with the trial plots and hence are more likely to be adopters. It should also be born in mind that the yield benefits of using LCCs were far greater than the use of NCVs. Increases in grain yield over the control were on average 130 % with LCC, whereas yield increases from planting a NCV were generally much more modest (20 % at most when taken over all crops). There are, however, two points to note here. First, yield is not the sole determinant of adoption, and NCVs that never exhibited a statistically significant yield advantage over local types are now widely grown in Igalaland (McNamara and Morse, 1997). Second, the high percentage increase in yield for the LCCs was partly a reflection of a purposeful site selection policy that targeted poor land. Even so, the yield benefit of the LCC technology was readily apparent, yet adoption was poor.

The issue of seed availability is clearly of great importance as a factor in adoption, and many of the results in Table 4 can be explained in those terms. Indeed, according to the respondents, this is the prime reason for the difference in uptake between the LCC and NCV technologies. Problems with LCC seed availability have been mentioned by others who looked at adoption of this technology in West Africa (Anthofer, 1999). While farmers are willing to save their own LCC seed there are two issues that are particularly relevant:

i. LCC seed size is generally very small. Mucuna is an exception, and it is interesting to note that most of the land area adopters allotted to a LCC was planted to this crop. Small seed size is related to factors such as ease of loss of seed from shattering and difficult harvesting. Indeed, the latter was often referred to as being 'tedious', rather than labour-intensive. In addition, small-seeded LCCs are generally more difficult to establish than are larger seeded forms, although none of the farmers specifically mentioned this point.
ii. Dormancy. Much less of an issue than (i), but is nonetheless an important consideration.

Mucuna has a large seed, which is easily handled and hence multiplied by the farmers, but is seen to be very competitive with crops although this attribute may be helpful in terms of weed control. The other LCCs, while having less of a perceived problem in terms of competition, all have small seeds, which make harvesting very difficult and tedious. This ultimately results in a poor availability of seed, and something of a reliance on DDS to provide. By way of contrast, multiplication of NCV planting material was a much simpler and more rapid proposition for small-scale farmers, and all DDS had to do was provide the initial start-up material.

With regard to other factors that may play a role in adoption, a minority (26 %) complained of a perceived high labour requirement for the LCC approach and problems with the suitability of their soil (6 %) for LCCs. Anthofer (1999) arrived at a figure of 20 % of farmers perceiving the labour requirement of Mucuna fallow as 'high' in his Ghanian-based study (34 % and 46 % saw it as 'low' and 'moderate' respectively; sample size = 75). No respondent mentioned a commonly expressed disadvantage of the LCC approach from the perspective of researchers, namely, the need to grow something that does not immediately result in an economic or food benefit (Vanlauwe *et al.*, 1999). Interestingly, prior to the survey DDS staff were of the opinion that this issue of 'investment' was likely to be the biggest problem with the LCC technology rather than availability of seed. The response has often been to look at legumes such as cowpea that could provide an economic/food return as well as biomass, or even the intercropping of LCCs with crops such as maize (Adeoye and Onifade, 1999; Fischler and Wortmann, 1999; Oyewole *et al.*, 1999; Aguiar *et al.*, 2001). The trials and survey have highlighted some problems with both of these options. In these trials, cowpea did not perform well as a LCC in terms of increasing maize yield, and in the survey the views of those that had adopted the technique was that LCCs (especially Mucuna) could compete with crops and reduce yield. It should be noted, however, that no cowpea grain yield data were recorded in these trials so it is not possible to evaluate this treatment relative to the others in economic terms.

CONCLUSION

The LCC approach has potential in Igalaland, but there are complications that arise for DDS in terms of its testing and promotion as part of its on-farm research programme. With the LCC trials, direct involvement from farmers was related more to availability of seed than it was to awareness of benefits *per se*. Almost all respondents, even those with a more superficial contact with the trials or other LCC plots, were aware of the potential benefits and willing to try the technology and much of this was because of farmer-to-farmer communication. Rapid spread of LCC use independent of research activity may well occur, but much depends on seed availability. For DDS the need to address seed availability may mean a slower and more intensive promotion than with the previous on-farm research programme that concentrated more on NCVs. It is interesting to note that despite their extensive contact with Igala farmers DDS staff did not think that LCC seed availability would be such an important issue given their previous experience with NCVs. Instead, they expected to encounter problems with labour and the growing of a crop that would not provide a marketable product. Clearly non-governmental organizations, even if they have good linkages with their local groups, do need to constantly guard against transplanting learning outcomes from one technology to another.

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