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2     **Impact pathway evaluation of an integrated**  
3     *Striga hermonthica* **control project in Northern**  
4     **Nigeria**

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13     **Abstract**

14     This paper evaluates a project that developed and introduced integrated *Striga* control  
15 (ISC) in Northern Nigeria. Adoption of ISC jumped from 44 participating farmers in four  
16 pilot areas to more than 500 farmers in 16 villages and hamlets in three seasons. On average,  
17 farmers adopted 3.25 different *Striga* control options from a basket of six “best bets”.  
18 Resource-poor and -medium farmers were more likely to adopt than resource-rich ones.  
19 Adopting farmers enjoyed livelihood improvements, largely through selling ISC soybean.  
20 Women in most adopting households benefited through selling food products based on soy-  
21 bean. Adoption of ISC can be attributed to four factors: (1) farmer-field-school-type training  
22 that explained how the technologies worked; (2) incorporation of at least one technology that  
23 gave quick benefits to sustain farmer interest in adopting and learning other components  
24 whose effects took longer to become evident; (3) allowance for farmer experimentation and  
25 adaptation to local conditions; and, (4) use of a monitoring and evaluation component that  
26 identified and incorporated farmer modifications to continually improve the “basket of  
27 options”. These principles are likely to be valid for research and extension approaches for

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28 similar integrated natural resource management (INRM). Impact pathway evaluation meth-  
29 odology used for the evaluation helped give the project a greater impact focus; helped design  
30 and reporting of the evaluation; and, by identifying early adoption pathways, has provided a  
31 firm basis for any future ex post impact assessment of ISC in Northern Nigeria.  
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33 *Keywords:* Impact assessment; Natural resource management (NRM); Integrated pest management (IPM)  
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## 35 1. Introduction

36 Monitoring and evaluation (M&E) is increasingly seen as crucial to the success  
37 of rural research and development projects because it supports the real time feed-  
38 back and learning required to successfully implement projects in complex and  
39 unpredictable environments (Bayerlee and Alex, 1998; Sayer and Campbell,  
40 2001; Probst, 2002; Douthwaite et al., 2005). Writing in this journal, Douthwaite  
41 et al. (2003) proposed the use of impact pathway evaluation (IPE) to carry out  
42 project to guide M&E and subsequent ex post impact assessment. In the M&E  
43 stage, a project develops an impact pathway for itself, which is an explicit theory  
44 or model of how the project will achieve impact. The project then uses the impact  
45 pathway to identify performance indicators. Monitoring of these indicators pro-  
46 vides information to guide project management and update the impact pathway  
47 itself. In the ex post impact assessment, which occurs some time after the project  
48 has finished, the evaluator seeks to establish plausible links between the project's  
49 impact pathway and subsequent developmental changes, such as poverty  
50 alleviation.

51 This paper presents data from the first implementation of impact pathway evalu-  
52 ation. The evaluation was of a project that carried out on-farm research, develop-  
53 ment and extension of integrated *Striga hermonthica* control (ISC) methods in  
54 Kaduna State in Northern Nigeria. The paper has three objectives: (1) to assess  
55 the actual and likely future impact of ISC on rural livelihoods, especially for women  
56 and the poor; (2) to identify the characteristics of an extension system suitable to  
57 scaling out ISC; and, (3) to evaluate the impact pathway evaluation (IPE) method  
58 itself.

### 59 1.1. Introduction to *S. hermonthica* and the project to control it

60 *S. hermonthica* (Del.) Benth., a root-parasitic flowering plant, is endemic in Africa  
61 and constitutes one of the most severe constraints to cereal production in sub-Sah-  
62 aran Africa (Dashiell et al., 2000). Research at the International Institute of Tropical  
63 Agriculture (IITA) and elsewhere has shown that *Striga* control requires an inte-  
64 grated approach that attacks *Striga* from several sides (Schulz et al., 2003) because  
65 the genetic plasticity of *Striga* means that the weed can adapt and overcome control  
66 measures employed singly (Dashiell et al., 2000). A key technology in integrated  
67 *Striga* control (ISC) is the use of a legume crop (e.g., soybean, cowpea, groundnut)

68 that induces a proportion of *Striga* seeds to germinate, which then die because they  
69 cannot parasitize legume roots. This is called ‘trap cropping’, and to be effective  
70 requires legumes that are screened to stimulate germination of local *Striga* ecotypes.  
71 Other ISC control measures are: legume rotation with *Striga*-resistant maize; seed-  
72 cleaning to remove *Striga* seeds; improved soil fertility; and, weeding of *Striga* before  
73 it sets seed (Schulz et al., 2003).

74 The Agronomy Unit at the International Institute of Tropical Agriculture (IITA),  
75 led by the second author, began working in 1999 in Northern Nigeria to develop  
76 locally adapted ISC, using participatory research approaches (Schulz et al., 2003).  
77 The work began with 19 participating farmers in three pilot areas, Rimau  
78 (10.42N, 7.77E), Mahuta (11.20N, 7.67E), and Kaya (11.25N, 7.27E). In 2000, 17  
79 additional farmers were included, and 8 farmers from a fourth pilot area, Ankwa  
80 (9.85N, 7.88E) joined the project, making a combined total of 44 participating farm-  
81 ers. The Agronomy Unit chose the pilot areas (see Fig. 1) on the basis of having  
82 severe *Striga* problems, and to allow convenient access for a technician based in  
83 Zaria (11.10N, 7.71E) and another based near Rimau (Schulz et al., 2003). The  
84 Agronomy Unit then used the problem census and solving approach (Schulz,  
85 2000), beginning with a community meeting to list and rank production constraints.

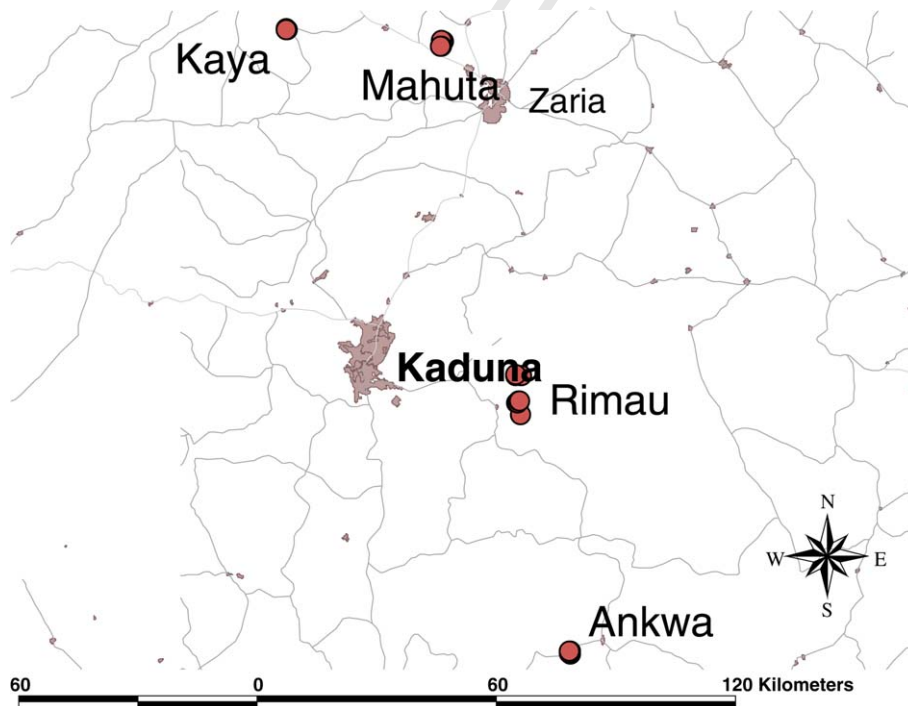


Fig. 1. Position of the pilot areas in Northern Nigeria.

86 If *Striga* was identified as major problem a second meeting was held a few days later  
87 to discuss control options, identify participants, and to design experiments with these  
88 participants to evaluate the control options.

89 The experimental design agreed with farmers is summarized here from Schulz  
90 et al. (2003). Each farmer agreed to establish one ISC plot and one control plot.  
91 The ISC plot consisted of a legume trap crop, either soybean (TGx 1448-2E or  
92 TGx-1864) or cowpea (IT-90K-284-2) in the first year followed by *Striga*-resistant  
93 maize (TZL Comp 1) in the second year. The treatment reduced *Striga* by depletion  
94 of the *Striga* seed bank through both suicidal germination and lack of a cereal host  
95 in Year 1, and then rotation with a maize variety that does not allow much *Striga* to  
96 germinate in Year 2. Average plant densities were 44,000 plants ha<sup>-1</sup> for the legume  
97 trap crop and 34,000 plants ha<sup>-1</sup> for *Striga*-resistant maize. The control plot con-  
98 sisted of farmers' traditional cropping practice (sole cereal crop or cereal-legume  
99 intercropping or fallow) in the first year, followed by local sole cropped maize in  
100 the second year.

101 The Agronomy Unit hypothesized that the adoption of these *Striga* control  
102 options would be enhanced if farmers had a basic understanding of *Striga* biology  
103 and of the *Striga* control technologies. Therefore, training sessions were organized  
104 over the two-year period, applying aspects of the farmer field school (FFS) approach  
105 (Kenmore et al., 1995).

106 In 2000 it became clear from feedback that farmers were expanding their use of at  
107 least some components of ISC from their experimental plots to their other fields, and  
108 that other farmers were also adopting them. At the same time, some apparent con-  
109 straints to adoption were emerging. As a result, IITA's Adoption and Impact Unit,  
110 led by the first author, became involved to monitor and evaluate adoption processes.

## 111 2. Methods

112 The project impact pathway (Fig. 2) shows how the project output "validation  
113 and adaptation of ISC options in farmers' fields" will ultimately lead to the project  
114 goal of improved livelihoods for the 100 million people in Africa that are affected by  
115 *Striga*. The shaded boxes are the outcomes that were monitored and evaluated. The  
116 unshaded boxes will be evaluated in the ex post impact assessment, if and when it is  
117 conducted.

118 We implemented three surveys to monitor and evaluate the outcomes shown in  
119 the shaded boxes. The way the outcomes relate to the surveys is shown in Table 1.

### 120 2.1. Survey 1

121 The first survey mapped the adoption of ISC within and beyond the four pilot  
122 areas. An enumerator interviewed key informants to identify who had adopted  
123 aspects of ISC. The key informants included the two AU technicians, village assis-  
124 tants employed by the AU, and participating farmers. The enumerator then visited  
125 each field mentioned, recorded its position with a hand-held global-positioning

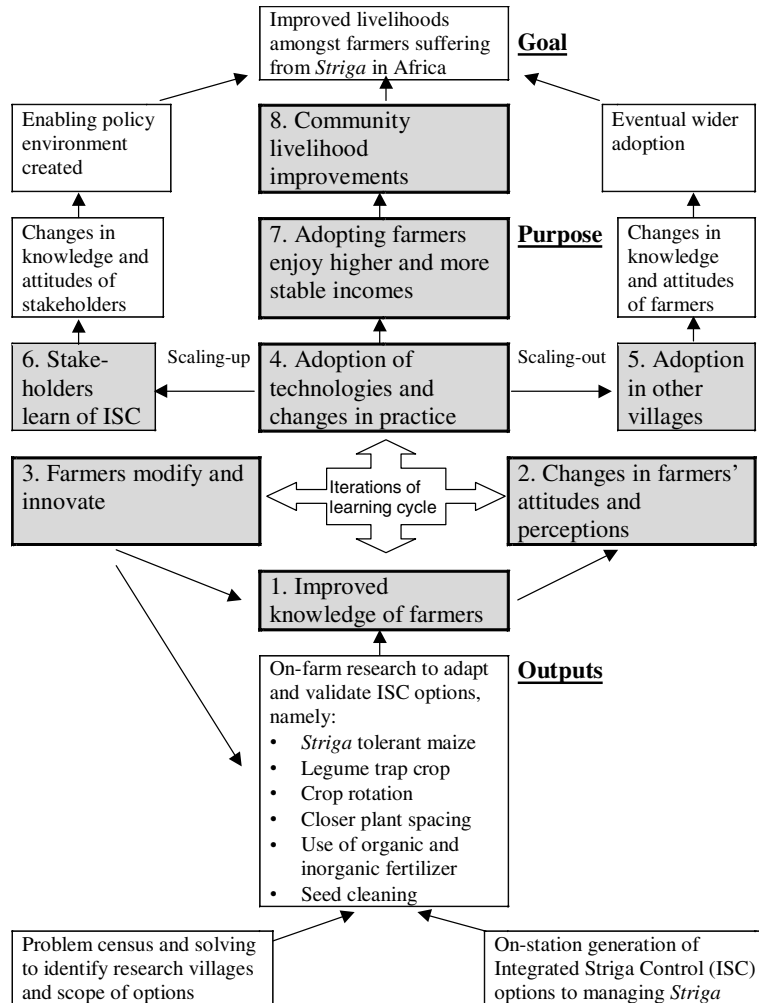


Fig. 2. Impact pathway for an Integrated *Striga* Control (ISC) Project in Northern Nigeria (from Douthwaite et al., 2003).

126 system (GPS), and recorded the ways the ISC options were being applied, making  
 127 particular note of any modifications from project “good practice” recommendations.  
 128 This survey took place from October 2001 to January 2002 and identified 336 fields  
 129 owned by 271 farmers in 16 hamlets and villages.

130 The survey identified three levels of adoption:

131

132 *Evaluation:*

133 Participating farmer with only an experimental plot;

Table 1  
Sources of evaluation information used to monitor the project outcomes

Outcome	Sources of evaluation information
1. Improved knowledge of farmers about ISC	Surveys 2 and 3
2. Changes in attitudes and perceptions towards ISC	Surveys 2 and 3
3. Farmers modify ISC technologies	Surveys 1, 2 and 3
4. Adoption of ISC and changes in practice	Surveys 1, 2 and 3
5. Adoption of ISC in other villages (scaling-out)	Surveys 1, 2 and 3
6. Other stakeholders hear of ISC (scaling-up)	Project documentation
7. Farmers adopting ISC enjoy higher and more stable incomes	Survey 3
8. Communities adopting ISC enjoy livelihood improvements	Survey 3

134

135 *Expansion:*

136 Participating farmer with experimental plot and one or more expansion plots  
137 (fields where he or she has expanded the use of one or more of the ISC  
138 technologies);

139

140 *Scaling-out:*

141 Non-participating farmers who have adopted one or more ISC technologies.

142

143 *2.2. Survey 2*

144 The second survey was a semi-structured interview of a sub-set of the 271 farmers  
145 identified in Survey 1. All the participating farmers were interviewed to avoid some  
146 feeling left out. Half the scaling-out farmers were interviewed giving a total sample  
147 size of 152. The purpose of the survey was to collect socioeconomic data to allow  
148 farmers' households to be ranked according to their resource use, as well as to ask  
149 questions to determine the achievement, or lack of it, of outcomes 2–5 shown in  
150 Fig. 2. The same enumerator carried out Survey 2 between February and June 2002.

151 The resource ranking method we used was an adaptation of one used by Okike  
152 et al. (2002) in the same area. Households were ranked based on ownership of land,  
153 livestock and assets as shown in Table 2.

154 A household was rated poor if their combined score was 0 or 1, medium 2–4, and  
155 rich 5–6.

Table 2  
Scoring system used to rate households according to resources owned

Household score		
0 points	1 point	2 points
• Less than 4 field parcels	• 4–9 field parcels;	• 10 or more field parcels
• Less than \$128-worth of livestock (the value of 3 goats and 10 chickens)	• \$128 to \$800 worth of livestock	• More than \$800 worth of livestock
• One or less assets (e.g., bicycle, radio, etc.).	• 2–4 assets	• 5 or more assets

### 156 2.3. Survey 3

157 Survey 3 constructed individual adopter case studies, using case study methodol-  
158 ogy (Yin, 1989), to assess the impact of ISC on farmers' incomes and livelihoods.  
159 The survey took place in February and March 2003 of 25 households purposely  
160 selected from the Survey 2 sample to be representative of the pilot areas. Survey 3  
161 also served to triangulate data from the other two surveys. Six households were  
162 selected from Kaya, Mahuta and Ankwa, and eight from Rimau. Ten poor house-  
163 holds, 12 medium and 3 rich were interviewed. Of these, 12 were expansion farmers  
164 and 13 were scaling-out farmers. All had two or more seasons' experience with ISC.

165 An enumerator facilitated the head of each household to construct and discuss a  
166 resource map (Guijt and Woodhill, 2002) to quantify the level of adoption of ISC  
167 technologies, and the benefits and costs of using them. Farmers drew their farms  
168 on a piece of paper and described what they had grown in each field in the four sea-  
169 sons from 1999 to 2002. Construction of the case studies was guided by the Sustain-  
170 able Livelihoods Framework (Scoones, 1998). Impacts on financial capital were  
171 assessed by asking farmers about the costs and benefits of adoption of ISC compared  
172 to traditional practice. Impacts on natural capital were assessed by asking about  
173 effects on soil fertility. Influence on social capital was addressed by asking farmers  
174 whether they had given ISC seed and/or information to other farmers, and the rela-  
175 tionships the farmers had with these people. Giving seed is a way of building social  
176 capital and reducing vulnerability (Christinck, 2002). The enumerator also explored  
177 what it meant to be a participating farmer in terms of prestige and relationships with  
178 other farmers and farmer groups. Human capital impacts were examined by asking  
179 one or more women in each household how adoption of ISC has affected family  
180 nutrition and use of family labour.

### 181 2.4. Baseline survey

182 The baseline data on adoption levels of different crops, varieties and management  
183 practices comes from a survey reported elsewhere (Douthwaite et al., unpublished  
184 data) and conducted as part of another project. The survey used the GPS transect  
185 walk method (Van der Meer et al., 2001) to measure the adoption of different crops,  
186 varieties and cropping patterns in 10 villages in the same area of Northern Nigeria.  
187 Kaya was part of the GPS transect walk survey.

### 188 2.5. Statistical analysis

189 Statistics allow the analysis of survey data to establish whether trends observed in  
190 the sample are likely to be true for the population from which the sample was drawn.  
191 In our case, the population was the farmers who had adopted ISC. Of these we sam-  
192 pled all the participating farmers and half of all of the scaling-out adopters identified  
193 in Survey 1. Given this large sample size in relation to the total population, findings  
194 from the sample can be assumed to apply to the population without the need for  
195 statistical tests. We use cross-tabulations together with the Pearson  $\chi^2$  to test for

196 significance between categorical variables, in particular whether adopters' access to  
 197 resources and the area in which they lived, affected their adoption behaviour. We  
 198 only use the word 'significant' to signify statistical significance following the stan-  
 199 dard convention (significant:  $*p \leq 0.05$ ; highly significant:  $**p \leq 0.01$ ).

200 Wealth ranking using an existing method, and with reference to other studies in  
 201 the area, allowed us to gauge the extent to which the sampled adopters are typical  
 202 of their wider community, at least with respect to access to resources. Adopters were  
 203 asked why other farmers might not adopt to identify differences between the adopt-  
 204 ers and non-adopters.

### 205 3. Results

206 We present the results according to the outcomes monitored (Fig. 2) after first  
 207 describing the socio-economic profile of the adopters.

#### 208 3.1. Adopter profile

209 The great majority (80%) of adopters were household heads and men (94%),  
 210 which reflects the Muslim culture of the pilot areas. Only 4% of adopters were rich  
 211 (Table 3), compared to 13% in the similar Okike et al. (2002) survey, suggesting that  
 212 ISC is more attractive to poor- and medium-resourced farmers. Education level was  
 213 relatively low with only 5% of the adopters having attended secondary or tertiary  
 214 education. Thirteen percent had received no education.

215 Cropping systems were cereal- and legume-based (Table 4). *S. hermonthica* para-  
 216 sitizes all the cereals grown in the area but its effects can be minimized by the use of  
 217 inorganic fertilizer. The amount of cereal a farmer grows depends on access to inor-  
 218 ganic fertilizer. One Kaya farmer, Sherihu Maaika, explained: "If I can get fertilizer  
 219 then I would prefer to plant cereals. If I can't afford fertilizer then I plant legumes."

220 Farmers generally preferred to grow more than one crop in their fields. In the  
 221 southern pilot areas—Ankwa and Rimau—farmers tended to mix several crops in  
 222 one field in no particular pattern. In Mahuta and Kaya further north farmers  
 223 commonly used the *gicci* and strip-cropping patterns. *Gicci* usually involved planting

Table 3  
 Resource ranking of farmers adopting ISC technologies in four pilot areas in Northern Nigeria

Pilot area	Resource ranking			Total number of farmers
	Poor	Medium	Rich	
Ankwa	3	14	0	17
Kaya	7	42	5	54
Mahuta	11	22	0	33
Rimau	19	28	1	48
Total	40	106	6	152

$N = 152$  respondents; data from Survey 2.

Table 4

Crops grown and types of fertilizer applied to them by farmers in four pilot areas in Northern Nigeria

Crop	Grown (%)	Type of fertilizer applied to crop (%)			
		Inorganic fertilizer	Farmyard manure	Ash	Kitchen waste
Sorghum	100	98	35	20	7
Maize	99	99	43	21	9
Soybean	95	25	3	0	1
Cowpea	88	2	0	0	0
Rice	55	98	1	0	0
Groundnut	39	3	0	0	0
Millet	34	73	8	0	0
Yam	32	47	20	10	2
Sweet potato	14	64	23	9	0
Cocoyam	14	52	48	26	9
Ginger	9	100	7	0	14
Hungry rice	3	25	0	0	0

N = 152 respondents; data from Survey 2.

224 single rows of sorghum, perpendicular to the ridges of legumes, at row spacings of 2–  
 225 5 m. Strip-cropping involves several rows of legume followed by several rows of cere-  
 226 als. Farmers' reasons for using both *gicci* and strip-cropping included: “otherwise  
 227 my land will be empty after harvesting soybean”, and “to guard against crop  
 228 failure”.

### 229 3.2. Improved knowledge of farmers about ISC (Outcome 1 of impact pathway)

230 An important source of information about ISC was training carried out by the  
 231 project which all participating farmers, and 42% of the scaling-out farmers, had  
 232 attended. Farmers who attended training sessions were asked what they had learnt.  
 233 Participating farmers, who had attended more training sessions than scaling-out  
 234 farmers, listed more topics, on average 3.3 compared to 2.6 answers. Farmers appre-  
 235 ciated the training, in particular question and answer sessions. As one farmer said: “I  
 236 asked questions and got other farmers' suggestions.” They also appreciated learning  
 237 that there are several ways to control *Striga*, that ISC helps them get higher yields,  
 238 and that this can be done at low cost.

239 Another way we evaluated farmer knowledge about ISC was asking them what  
 240 information they passed on to other farmers. Nearly half gave at least one instruc-  
 241 tion on management practice to another farmer. The most common message was  
 242 to plant the legume trap crop closely, and to use it on *Striga*-infested plots (Table 5).

243 Participating farmers were significantly more likely to give other farmers instruc-  
 244 tions on ISC than scaling-out farmers. Also, the number of messages they gave was  
 245 higher—2.7 compared to 2.0. Neither pilot area nor access to resources influenced  
 246 whether farmers gave instructions, or the number they gave.

247 To guide recommendations for a future ISC extension approach we asked farmers  
 248 about contact with other extension agencies and their preferences for receiving infor-  
 249 mation. Only 16% of farmers said with had had contact with village extension

Table 5

The instructions the adopters of aspects of integrated *Striga* control (ISC) gave to other farmers about ISC, in four areas in Northern Nigeria

Instructions	%
None	51
Close planting for legume trap crop	32
Plant on <i>Striga</i> infested plots	21
Rotate cereal with legume	16
Narrower ridge spacing	9
Plant on plots with poor soil fertility	6
What they see on my plot	6
Timing of weeding and/or fertilizer application	5
Weed <i>Striga</i>	2
Plant legume on both sides of the ridge	2
Other	10

*N* = 151 respondents; more than one answer allowed per respondent; data from questionnaire survey.

250 agents, most commonly with the Kaduna Agricultural Development Project  
 251 (KADP). The village extension agents were the least preferred information channel.  
 252 Farmers said they preferred to receive new information from research institutes, i.e.,  
 253 IITA/Institute for Agricultural Research (IAR), and other farmers, by word of  
 254 mouth supported by pictures and posters.

255 The great majority of farmers, 84%, listened to the radio. The preferred listening  
 256 time was 6–8 a.m. In contrast, less than one third (29%) of farmers said that they  
 257 read newspapers or magazines.

### 258 3.3. Changes in attitudes (*Outcome 2*)

259 This is one of the best measures of farmer attitudes to new germplasm is whether  
 260 they save and give seed (David et al., 1997). Nearly all farmers (95%) saved ISC seed:  
 261 85% saved soybean seed; 40% saved maize seed while only 7% saved cowpea seed.  
 262 The same trend was evident in gifts and sales of seed. Nearly two thirds (62%) gave  
 263 or sold ISC seed: 60% gave soybean, 16% gave maize, while no one gave cowpea. The  
 264 recipients of the seed were generally relatives, friends and neighbours, half of who  
 265 lived in other villages.

266 A second measure of farmer attitudes is whether they modify and adopt new tech-  
 267 nology (Douthwaite et al., 2001).

### 268 3.4. Farmers modify ISC technologies (*Outcome 3*)

269 In general, farmer modification involved partial adoption of “best practice” rec-  
 270 ommended by the project. The most common modifications were to the “sole-crop-  
 271 ping” and “close plant spacing” recommendations (Table 6). There was, however,  
 272 one farmer innovation that the project subsequently adopted as “good practice”.  
 273 A farmer in Mahuta planted ISC soybean on either *side* of his ridges, spaced tradi-  
 274 tionally at 70 cm, thus achieving the 35 cm row inter-row spacing recommended by

Table 6  
Modifications made to researcher-recommended usage of integrated *Striga* control (ISC) options

Modification	Pilot area (%)				Total (%)
	Ankwa	Kaya	Mahuta	Rimau	
None (mono crop)	59	10	35	73	35
Gicci	3	46	24	3	26
Strip-cropping	0	34	1	0	15
Inter-cropping	38	2	6	21	11
Relay-cropping	0	2	9	3	13
Planting on both sides of ridge	0	0	1	0	0
No. of fields surveyed	32	126	72	66	296

*N* = 296 fields; data from Survey 2.

275 the project. The project recommendation had been to plant one row per ridge and  
 276 use a 35 cm spacing between ridges, something that farmers found very difficult to  
 277 achieve with the animal-drawn ploughs and hand-hoes used in Mahuta and Kaya,  
 278 and Rimau and Ankwa, respectively.

### 279 3.5. Adoption of technologies and changes in practice (Outcome 4)

280 A conservative adoption estimate is that the project was able to scale-out ISC  
 281 from 44 participating farmers to an additional 458 farmers in three seasons. This  
 282 is calculated as follows. Survey 1 identified 271 adopters. Survey 2 found that nearly  
 283 two thirds of adopters (62%) gave or sold ISC seed directly to an average of 2.75  
 284 other farmers. Assuming that only 50% of farmers who received this seed went on  
 285 to adopt gives an additional 231 “second generation” adopters and a total of 502  
 286 adopters, of which 44 were participating farmers. This estimate does not include  
 287 the third generation adopters who adopted via the second generation adopters.

288 The great majority (84%) of participating farmers expanded the use of at least one  
 289 ISC technology from their experimental plot to their farm, and all the scaling-out  
 290 farmers had adopted ISC techniques because this was the basis for selecting them.  
 291 Both participating and scaling-out farmers had adopted an average of 3.25 ISC  
 292 options out of a total of 6. Resource poor farmers had adopted on half of their farms  
 293 compared to one third on the farms of resource medium and rich farmers. However,  
 294 farmers’ resource ranking made no difference to what farmers chose to adopt, or the  
 295 number of technologies they adopted.

296 Households of scaling-out farmers who adopted ISC were usually clustered  
 297 around the homes of participating farmers (Fig. 3). However, in some cases, adop-  
 298 tion of ISC jumped when farmers gave seed and know-how to friends and relatives  
 299 living in other villages.

300 The most popular technology was ISC soybean (Table 7). The soybean variety  
 301 TGx 1864 was introduced into Ankwa while TGx 1448-2E was introduced into  
 302 the three more northern pilot areas. The resource use mapping showed that on aver-  
 303 age farmers in Mahuta, Rimau and Ankwa grew soybean on 16% of their land and

304 ISC varieties of soybean made up 75% of that area. A survey of crops grown in farm-  
 305 ers' fields in the same area (Douthwaite et al., unpublished data) found that farmers  
 306 grew legumes (soybean, cowpea, groundnut) on only 12.5% of their land of which  
 307 1% was soybean. Hence the project led to a 25% increase in legume production  
 308 and an 11-fold increase in area of soybean. In Kaya, where ISC soybean had been  
 309 grown for a number of years prior to the project, the project increased soybean area  
 310 by 50%, from 14% to 21%.

311 There was a big difference between the measured and reported amount of adop-  
 312 tion of *Striga* resistant maize. The case study findings [Survey 3] support the lower  
 313 mapping estimate [Survey 1]. Overall all three surveys found that ISC soybean is  
 314 highly popular, TZL Comp 1 maize less so, and ISC cowpea (IT-90K-284-2) was  
 315 almost universally unpopular.

316 The adoption of close legume spacing was assessed by measuring plant spacing in  
 317 the field during the mapping survey. Soybean plant spacing was measured in 151  
 318 farmers' fields of which 27% had adopted the recommended plant spacing of  
 319 20 cm or less instead of the normal legume plant spacing of 30–45 cm. The low adop-  
 320 tion rate was because farmers found close planting too labour intensive or they  
 321 thought that their low soil fertility would not support such close spacing.

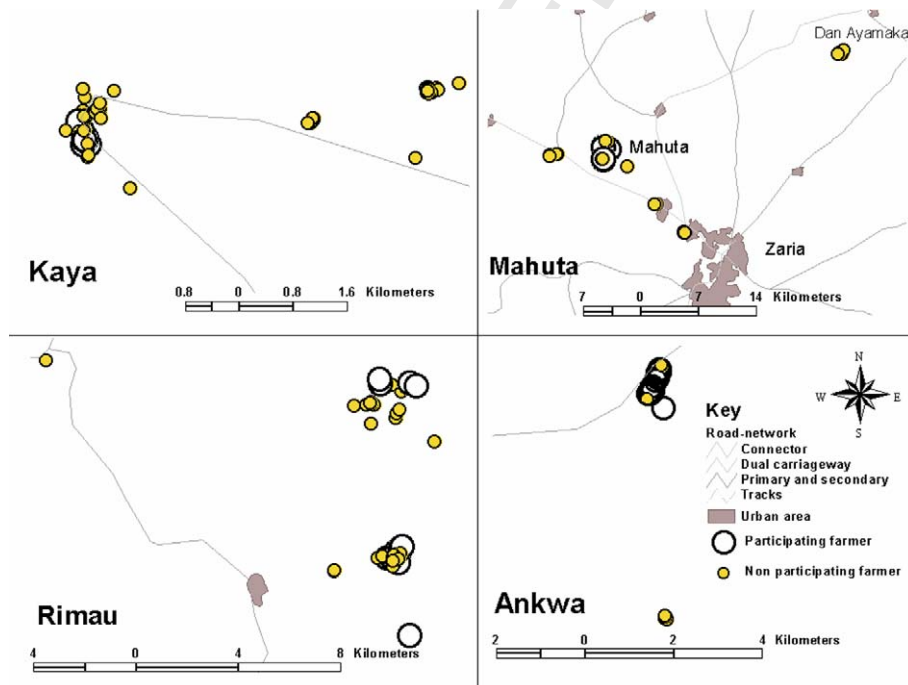


Fig. 3. Maps showing the position of the households of farmers who adopted ISC in four pilot areas in Northern Nigeria (from Ellis-Jones et al., 2004).

Table 7  
Adoption of ISC technologies reported by adopters in four pilot areas in Northern Nigeria

Technology	Ankwa (%)	Kaya (%)	Mahuta (%)	Rimau (%)	Average (%)
ISC soybean	77	93	71	100	89
Weeding of <i>Striga</i>	53	82	90	88	82
Rotation of legume and cereal	41	84	94	83	81
ISC maize	6	41	55	48	42
Sole crop of legume	24	11	26	23	19
ISC cowpea	6	2	19	4	7
Sole crop of cereal	6	4	3	6	4
Average number of technologies adopted	2.12	3.20	3.58	3.50	3.25
<i>N</i>	17	54	31	48	152

*N* = 152 respondents; data from Survey 2.

322 Weeding of *Striga* is the main local control method, but only 4% of farmers in the  
323 sample said that they adopted weeding prior to 1999 when the project began. Hence,  
324 95% of farmers who adopted did so after 1998, largely as a result of project training,  
325 which taught them that weeding reduces the number of *Striga* seeds in the  
326 soil.

327 Significant differences in adoption rates reflecting socio-economic, agro-  
328 ecological and cultural preferences (Table 7) that existed between the pilot areas. ISC  
329 soybean was more popular in Kaya and Rimau than in Ankwa and Mahuta. Adop-  
330 tion was constrained in Ankwa by distance to market (20 km along a bad road) while  
331 farmers in Mahuta had a cultural preference to grow cowpea. Rotation was much  
332 less popular in Ankwa which had a lower population density and more land avail-  
333 able for fallow than the other three pilot areas.

334 One quarter of farmers had learned about ISC technologies from sources other  
335 the project. In Kaya farmers had been introduced to ISC soybean (TGx 1448-2E)  
336 and the concept of cereal–legume rotation by other projects. Some farmers said they  
337 had adopted rotation and weeding as early as 1980. Nearly three quarters (70%) of  
338 farmers named weeding of *Striga* as one of their local control methods.

339 The resource mapping revealed that much of the adoption of rotation registered  
340 in Survey 2 was only partial compared to the ideal of changing from cereal to legume  
341 every year. For example some farmers adopted rotation in one field while continu-  
342 ously mono-cropping cereals in other fields. In other cases farmers grew a legume  
343 break crop after three years of cereals.

### 344 3.6. Adoption of ISC in other villages (Outcome 5)

345 ISC was clearly spreading from the four pilot areas (Fig. 3). Survey 1 found that  
346 ISC technology had spread to an additional 12 hamlets and villages. One third of the  
347 recipients of ISC seed lived outside the village of the giver, up to 200 km away.  
348 Farmers in the two southern areas of Rimau and Ankwa were highly-significantly  
349 less likely to give or sell seed outside of their village.

### 350 3.7. Other stakeholders hear of ISC (Outcome 6)

351 The work reported in this paper was pivotal in the success of an IITA project pro-  
352 posal to the British Government (DFID) for a 3-year project, “Realising Sustainable  
353 Weed Management to Reduce Poverty and Drudgery Amongst Small Scale Farmers in  
354 the West African Savannah”, which ran from April 2001 to March 2004. This DFID-  
355 funded project worked on two weeds, one of which is *S. hermonthica*, and built on the  
356 work reported in this paper. It worked in Kaduna State, where all four pilot areas are  
357 situated, to train 28 extension workers in elements of the Participatory Extension  
358 Approach (PEA) (Hagmann, 1999) which incorporated the elements of the approach  
359 used in this project, including farmer-field-school-type training and the use of partic-  
360 ipation of lead farmers with a responsibility to share their knowledge and new varieties  
361 more widely. By March 2004 the Kaduna State agricultural research and extension sys-  
362 tem, comprised of the Institute for Agricultural Research, Kaduna Agricultural Devel-  
363 opment Project (KADP) and the Local Government Area (LGA) extension network,  
364 had adopted the main ISC soybean (TGx 1448 – 2E) and maize varieties (ACR 97 TZL  
365 Comp1) used in this project. The KADP has adopted the DFID project’s participatory  
366 extension approach, although implementation is limited by lack of funds. The partic-  
367 ipatory extension approach was also adopted by a Canadian-funded project that is cur-  
368 rently working in Borno State, Nigeria. This project led to adoption of ISC by an  
369 additional 240 farmers by 2004 (Franke et al., in press).

### 370 3.8. Farmers enjoy higher and more stable incomes (Outcome 7)

371 It was too early to measure community-level benefits of ISC (Outcome 8 in  
372 Fig. 2). Instead Survey 3 focussed on identifying and understanding the effects of  
373 ISC on adopters’ livelihoods.

#### 374 3.8.1. Impact of ISC on financial capital

375 The largest impact of ISC came from the adoption of ISC soybean because it was  
376 adopted by more farmers than any other ISC component technology, and on a larger  
377 area. More than one third of farmers sold ISC grain at market, nearly all of which  
378 was soybean. Farmers sold on average 700 kg for \$0.37 (FAO, 2005) per kg, giving  
379 an average gross income from soybean of \$259. Most of these farmers came from  
380 Kaya which is more commercially orientated than the other pilot areas. Farmers  
381 in Kaya sold an average of 1150 kg of soybean compared to 250 kg in Mahuta  
382 and just 100 kg in Rimau and Ankwa.

383 Balarabe Musa, a rich expansion farmer in Kaya, gives an example of the impact  
384 soybean has had on his household:

385 “Since I started planting [ISC] soybean my production has increased from  
386 600 kg per year to 4000 kg per year. The extra income from selling soybean  
387 has allowed me to buy 2 oxen and 2 ox-ploughs as well as corrugated sheets  
388 to re-roof my house. The money is also helping him to keep my six children  
389 in primary school.”

390 Peter Bawa, an expansion farmer in Ankwa, explained that soybean is harder to  
391 process into food than cowpea or maize, and only a small amount is consumed in the  
392 household. Therefore, the main benefits of growing soybean only occur when farm-  
393 ers sell surplus in the market. Hence, it may be difficult for resource-poor farmers,  
394 used to growing food largely for home consumption, to fully benefit from growing  
395 soybean.

396 Women, particularly in Kaya, mentioned a number of improvements that they  
397 had noticed since their husbands started growing more soybean. These included  
398 tin roofing to replace the straw or mud roofs on their houses, new clothes for them-  
399 selves and their children and that school fees could be paid more easily. The wife of  
400 Lawal Shaibu, a resource poor farmer in Kaya said:

402 “There have been spectacular changes since the household started to grow  
403 improved soybean. For example, we were able to buy new clothes for the last  
404 Ramadan festival for the whole family and we can now buy fertilizer easily.”

405 The women in half of the households in Kaya, and all but one of the households  
406 in Ankwa, were selling products made from ISC soybean in the market. Soya cheese  
407 (tofu or *awara*) was the most common. The women said this income allowed them to  
408 buy things for themselves, like clothes and soap, and made them less dependent on  
409 allowances from their husbands.

410 *3.8.1.1. Labour requirement for ISC.* ISC requires farmers to plant at two and three  
411 times the traditional maize and soybean plant densities, respectively. ISC also  
412 requires farmers to weed more rigorously and place fertilizer in a hole and cover it  
413 rather than placing it on the ground. Two thirds of Survey 3 farmers said that the  
414 additional labour requirement was a constraint to adoption. Many thought that  
415 the close plant spacing of ISC was just not practical on large plots and two suggested  
416 that larger trial plots would be more realistic. Joshua Gaya, a participating farmer  
417 from Ankwa expressed the opinion of many:

419 “Some farmers may see some aspects of ISC as too tedious and time consum-  
420 ing. A poor farmer with little or no money to hire labour, limited household  
421 labour, i.e., just one wife and few children, may not find it possible to adopt  
422 ISC crop management practices.”

423 Farmers estimated that it required 56% and 83% more labour to grow ISC soy-  
424 bean and maize respectively, using ISC recommended practice (Tables 8 and 9).  
425 The largest and least popular increase in labour requirement was the more than dou-  
426 bling of the time required for planting at a time when labour is in short supply. There  
427 were some complaints about the weeding of *Striga* being tedious but the general con-  
428 sensus was that the approach was worth the effort. Nearly one in 10 adopters volun-  
429 teered the opinion that weeding was the best method of controlling *Striga*. There  
430 were no complaints about the additional labour required for harvesting and  
431 threshing.

432 Farmers estimate of average labour cost was \$2.25 per day. The additional labour  
433 costs of producing ISC soybean and maize compared to traditional practice is there-

Table 8

Average costs of land preparation, crop care and harvest activities for ISC and traditional practice in growing soybean in four pilot areas in Northern Nigeria

	N	Person days per ha		Percentage increase (%)
		Traditional	ISC	
Planting	19	22	47	114
Weeding	18	36	55	53
Fertilising	0	0	0	0
Weeding <i>Striga</i>	0	0	0	0
Harvesting	16	23	32	39
Threshing	14	29	38	31
Total		110	172	56

N = 19 respondents; data from Survey 3.

Table 9

Average costs of land preparation, crop care and harvest activities for ISC and traditional practice for growing maize for four pilot areas in Northern Nigeria

	N	Person days per ha		Percentage increase (%)
		Traditional	ISC	
Planting	9	13	30	131
Weeding	10	25	49	96
Fertilising	6	7	14	100
Weeding <i>Striga</i>	8	9	18	100
Harvesting	10	19	30	58
Threshing	9	23	35	52
Total		96	176	83

N = 10 respondents; data from Survey 3.

434 fore \$139 per hectare and \$180 per hectare, respectively. Given the 2002 farm-gate  
 435 prices of soybean and maize (FAOSTAT data, 2005) a farmer needed to harvest  
 436 an additional 376 kg of soybean and 563 kg of maize to pay for the additional  
 437 labour. These represent a 50% increase above average soybean and maize yields  
 438 (FAOSTAT data, 2005).

### 439 3.8.2. Impact of ISC on natural capital

440 Legumes fix nitrogen, therefore an increase in the total amount of legumes grown  
 441 will have a positive effect on soil fertility. All the participating farmers said that ISC  
 442 soybean had improved soil fertility. Dahiru Sani, a farmer from Kaya, summed up  
 443 the sentiments of many: "ISC soybean is a wonderful crop. Soil fertility is better,  
 444 yields are higher and it controls *Striga*."

### 445 3.8.3. Impact of ISC on human capital

446 In terms of family health, the largest impact of ISC came from increased con-  
 447 sumption of soybean. Soybean has the highest protein content amongst grain

448 legumes and contains more protein than meat (FAO, 1982). Women in the case-  
449 study households were making a variety of foods from soybean for sale and  
450 household consumption, including adding powdered soybean to maize porridge  
451 that is fed to babies, children and adults. Most of the women interviewed knew  
452 that eating soybean was good for their families' health and said they would buy  
453 soybean if their husbands did not grow it. They generally ate more soybean if  
454 their husbands had produced a surplus. Three households mentioned that sales  
455 of soybean had made it easier to pay school fees and send their children to  
456 school.

#### 457 3.8.4. *Impact of ISC on social capital*

458 As seen already, participating and non participating farmers valued the seed  
459 and training they received from the project, and passed both on to neighbours  
460 and friends. Giving seed and information are ways of maintaining or improving  
461 social capital. Women tended to share seed and information with other women,  
462 and men with men. In Survey 3, participating farmers said that they felt a  
463 responsibility to share what they had learnt with other farmers. This quote from  
464 Sherihu Maaika, a participating farmer from Kaya, is typical of the sentiments  
465 expressed.

466 “Being a participating farmer enabled me to work closely with ISC project staff  
467 and learn a few things. The knowledge is now always available to my commu-  
468 nity and me. I now have the possibility to lead other farmers in experimenting  
469 with ISC in the absence of expert researchers. I think I can set up trials that are  
470 not too complicated and if I find it too difficult to do by myself I can ask help  
471 from other participating farmers in our village.”  
472

## 473 4. Discussion

### 474 4.1. *Impact assessment of ISC*

475 After three seasons of farmer trials it was too early to assess impact at a commu-  
476 nity level. Nevertheless the project clearly had an impact on individual livelihoods  
477 within and beyond the pilot areas in which it worked. ISC technologies were adopted  
478 more by poor- and medium-resourced farmers than the rich. Women also adopted  
479 where cultural norms permitted. Adoption jumped from 44 participating farmers  
480 in four pilot areas to more than 500 farmers in 16 villages and hamlets in three sea-  
481 sons. On average, farmers adopted 3.25 different *Striga* control options from a bas-  
482 ket of six “best bets”.

483 Most benefit came through the adoption of ISC soybean. In the Mahuta, Rimau  
484 and Ankwa areas adopting farmers were growing soybean on 14% of their farms  
485 compared to an average of just 1% surrounding areas. In Kaya, where improved soy-  
486 bean has been promoted for longer and by other projects, ISC adopters were grow-  
487 ing legumes on 21% of their farms compared to a village average of 14%.

488 The main impact of ISC soybean adoption was on financial capital through farm-  
489 ers earning extra cash by selling the crop in the market. There was more evidence of  
490 this impact in Kaya where farmers grew more soybean. Impacts included improve-  
491 ments to housing, ability to buy more fertilizer; easing the burden of sending children  
492 to school; reduction in *Striga* and the labour needed to weed it; better family nutri-  
493 tion; new clothes for the Muslim festival of Ramadan and more luxuries. Women in  
494 most adopting households were selling food products based on soybean, and the  
495 additional production helped these micro-enterprises. Other ISC components, such  
496 as ISC maize, and cereal–legume rotation, contributed to impact, but were less  
497 important. The main constraint to adoption of ISC was increased labour require-  
498 ment for planting soybean and maize at two or three times the traditional plant den-  
499 sities. Three quarters of farmers chose not to adopt close plant spacing, thus making  
500 control of *Striga* less effective.

501 Benefits to human capital of ISC came through the consumption of soybean.  
502 Most of the case study households were consuming soybean in small amounts before  
503 adoption of ISC soybean but consumption generally increased with adoption of ISC  
504 soybean. Nearly all the households understood the benefits of eating soybean and  
505 several attributed the good health of their children to this.

506 Adopters benefited socially by being able to give neighbours, relatives and friends  
507 seed and information they had received from the project. These gifts are certain to  
508 increase the impact of ISC, both within and beyond the pilot areas, as adoption  
509 increases.

510 Adoption levels in Kaya show that farmers in the other three pilot areas could  
511 well increase their soybean production by an additional 50% or so, sell more soybean  
512 in the market and the household earn more money as a result. However the stability  
513 of this livelihood strategy depends on the stability of the soybean market price. Pro-  
514 motion of foods made from soybean, and the micro-agroenterprises based on pro-  
515 ducing these foods stuffs for sale, would increase the positive impacts of  
516 communities growing more soybean on the well-being of women and children.

517 The impacts discussed in this section cannot be wholly attributed to this project.  
518 There were other sources of innovation. For example, ISC soybean had been intro-  
519 duced into Kaya before the ISC project began, and the idea of crop rotation and  
520 weeding of *Striga* has been promoted in the area for tens of years. Nevertheless,  
521 the results showed that additional understanding of the importance of, and reasons  
522 for, weeding and rotation from project farmer-field-schools led to adoption, irrespec-  
523 tive of the original source of the ideas.

#### 524 4.2. Requirements of an effective extension method for ISC

525 The survey results show that farmers adopted and adapted ISC in different ways  
526 in the four pilot areas. For example, farmers in Ankwa and Rimau adopted less soy-  
527 bean because they had less access to market. The more isolated nature of these two  
528 pilot areas meant farmers were less likely to give or sell seed outside of their village.  
529 Farmers in Ankwa also adopted less rotation because their land use intensity was  
530 much lower than the other three pilot areas. This finding confirms the idea that

531 Integrated Natural Resource Management (INRM) technologies, such as ISC,  
532 require an extension approach that allows farmers to ‘unpack’ the package of tech-  
533 nologies recommended to them by researchers and/or extension, learn about and  
534 evaluate the different parts, and then adapt them into something that more closely  
535 fits their own systems (Sayer and Campbell, 2001). The importance of regular  
536 FFS-type training sessions in increasing farmers’ levels of knowledge of ISC and  
537 the farmer-to-farmer flow of information confirm findings elsewhere (e.g. Pound  
538 et al., 2003) on the need for, and value of, FFS-type training in the scaling-out of  
539 complex and knowledge intensive technologies like ISC.

540 The existing extension system in Northern Nigeria was given a very low rating by  
541 farmers in the pilot areas. This is partly because the extension system is chronically  
542 under-funded and partly because it is modelled on the World Bank Training and  
543 Visit (T&V) system (UNCCD, 2002), which is designed to provide blanket recom-  
544 mendations and does not support local adaptation.

545 The scaling-up of ISC will require additional funding to the existing extension sys-  
546 tem. It will also require the adoption of a participatory extension approach, rather  
547 than one based on the T&V paradigm. A number of participating farmers felt they  
548 had a responsibility to their communities and were considering setting up their own  
549 trials, although none had. Further research is required to identify what would be  
550 required to identify and support a network of “lead farmers” working with existing  
551 extension workers and motivated to help their communities. This network could be  
552 the backbone of a relatively cheap but effective participatory extension system in  
553 Northern Nigeria. The survey results suggest that this network should include both  
554 male and female extension-worker farmers, because men and women have different  
555 criteria for selecting technologies, and information sharing between men and women  
556 can be poor. There need not be an extension-worker farmer in each village because  
557 technologies to spread from village to village, although this spread is more difficult in  
558 areas with lower population densities and more isolated villages. Any basket of  
559 options should contain one or more component technologies that offer quick and  
560 substantial benefit to engage farmers and retain their interest and participation.  
561 Finally, use should be made of the radio to communicate information, particularly  
562 in the early morning because this is when many farmers listen.

#### 563 4.3. *Assessment of the impact pathway evaluation (IPE) method*

564 We found the IPE very useful because it forced the evaluating group and the pro-  
565 ject implementation group to jointly unpack the project’s process of achieving  
566 impact into its component parts, i.e., the intermediate outcomes shown in the impact  
567 pathway (Fig. 2). Having identified these intermediate outcomes, and the logic link-  
568 ing them together, it was then much easier to select appropriate survey methods. The  
569 impact pathway also helped us structure reporting the results in this paper.

570 The use of three different surveys helped bolster the internal validity of the results  
571 through triangulation. For example, it showed that Survey 2 gave higher adoption lev-  
572 els than the other two as a result of the natural tendency for interviewees to exaggerate  
573 adoption levels when the interviewer is perceived to be linked to the implementing

574 project. Analyzing the results from the three surveys revealed a problem in definition  
575 of adoption, in particular what constitutes adoption of rotation. Also, the resource  
576 mapping and in-depth interviews helped reveal that not all the adoption measured  
577 in Survey 1 and Survey 2 could be attributed to this project. Asking farmers to con-  
578 struct their resource maps some years before they claim to have adopted a technology  
579 is good way of seeing what changes have actually occurred since they adopted.

580 In carrying out the evaluation we confirmed the finding from elsewhere (Dou-  
581 thwaite et al., 2001) that identifying and seeking explanation for adoption and mod-  
582 ification is a good entry point to understand changes in perceptions and general  
583 knowledge levels. The focus also helped to identify farmer innovation and provided  
584 information for the project to adapt its recommended “good practice”. For example,  
585 the findings about farmer rejection of single hill planting in ISC maize led to the pro-  
586 ject changing its recommendation. M&E helped project scientists and technicians  
587 understand better labour shortage as a constraint to ISC.

588 Surveys to assess the adoption of new agricultural technologies are usually expen-  
589 sive, and carried out several seasons after the end of the project (David et al., 1997).  
590 The cost of data gathering for the impact pathway evaluation reported in this paper  
591 was \$10,000 – the cost of employing a full-time research assistant, plus travel expenses.  
592 Analyzing and writing up the data cost another \$10,000 in scientist time. It is hard to  
593 gauge whether this is expensive or cheap because published adoption surveys are gen-  
594 erally not costed. Nevertheless, the study did contribute findings that changed the  
595 course of the project, as already discussed. Such findings are difficult to value, but  
596 can make the difference between success and failure for NRM projects operating in  
597 complex environments (Sayer and Campbell, 2001; Douthwaite et al., 2005).

598 Impact pathway evaluation is a two-stage process. This paper presents the find-  
599 ings from the monitoring and evaluation phase that will be of value to any subse-  
600 quent ex post assessment of work to control *Striga* in Northern Nigeria. This  
601 second phase will benefit from knowing where, when and how adoption of ISC  
602 started. Continuing the adoption and impact story from where this one stops will  
603 make the final impact study easier to implement, and far more plausible.

## 604 5. Conclusions

605 This study found that it is possible to achieve demonstrable impact with relatively  
606 complex natural resource management technology packages in a relatively short per-  
607 iod of time. This success was based on: (1) farmer-field-school-type training that  
608 explained how the technologies worked; (2) incorporation of at least one technology  
609 that gave quick benefits to sustain farmer interest in adopting and learning other  
610 components whose effects took longer to become evident; (3) allowance for farmer  
611 experimentation and adaptation to local conditions; and, (4) incorporation of a  
612 monitoring and evaluation component that identified and incorporated farmer mod-  
613 ifications to continually improve the “basket of options”. These principles are likely  
614 to be valid for research and extension approaches for similar integrated natural  
615 resource management (INRM).

616 Training was most successful in changing farmers' perceptions and practices when  
617 it complimented what farmers already knew but were not practicing. For example,  
618 providing farmers with knowledge about the number of seeds produced by a single  
619 *Striga* plant, and the length of time the seeds can remain viable in the soil, led to a  
620 high rate of adoption of the little-used local practice of weeding *Striga*.

621 The methodology used in this paper – impact pathway evaluation – proved useful.  
622 It forced the evaluation group and the project implementation group to identify the  
623 steps between achieving the project outputs and eventual impact, and the logic link-  
624 ing them together. This impact pathway helped the evaluation group to select appro-  
625 priate survey methods, and it helped structure this paper. The results of the  
626 evaluation directly resulted in the project adopting farmer modifications in its recom-  
627 mendations of good ISC practice. It has also helped establish a starting point for any  
628 subsequent ex post assessment of ISC impact by signposting early adoption and  
629 impact pathways. Finally, the use of three distinct types of survey triangulated  
630 results and safeguarded the internal validity of the findings. Comparing and con-  
631 trasting been adoptions levels measured in the three surveys showed that farmers  
632 are likely to over-estimate adoption in questionnaire-based surveys and that the con-  
633 struction of land-use maps is a more reliable measure.

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