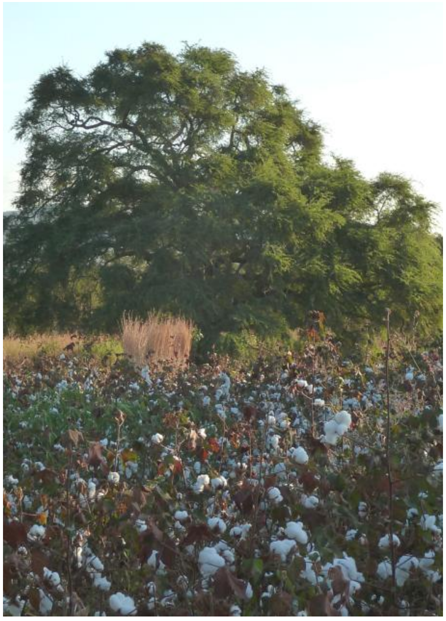
Encouraging the Adoption of Agroforestry: A Case Study in Eastern Province, Zambia

IN-DEPTH RESEARCH RESULTS

SUMMARY

Many agricultural technologies yield long-run benefits but come with short-run costs. Examples include tree crops, agroforestry and conservation farming practices, many of which also provide benefits to the environment. Because of the long-run nature of the benefits and the fact that some of the benefits accrue to people other than the adopting farmer, adoption rates by smallholder farmers can be low. Traditional efforts to increase adoption include training, information provision, subsidised inputs and cash incentives, but little clear evidence exists that breaks down the impacts and cost effectiveness of these approaches.

The study focuses on the adoption of *Faidherbia albida*, also known as musangu, an agroforestry species native to Eastern Province that offers both long run private benefits to the adopting farmer, as well as global carbon sequestration benefits. Musangu fixes nitrogen in its roots and leaves and loses its leaves during the planting season. This biological trait ensures that crops receive fertiliser and sunlight when they need it most. Indeed, existing field trial evidence on the impacts of musangu on maize yields suggests that mature trees, when intercropped with maize, can double yields in settings where no additional fertiliser is used[1]. However, for the first 5-10 years of tree growth, these fertiliser benefits are minimal.



KEY RESULTS

After one year of implementation, both input subsidies and short run incentives are positively associated with tree survival. Specifically, a one USD increase in the subsidy for seedlings increases tree survival by 11.3 percent, while a one dollar increase in the financial incentive increases tree survival by 2.3 percent. The larger effect of the input costs is due to lower participation in the programme at higher input costs. Incentives increase survival directly by increasing effort among participating farmers. At the end of the one-year study, 700 farmers were growing an additional 19,400 musangu trees in Eastern Province.

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In partnership with the *Trees on Farms* Programme, implemented by
Dunavant Zambia Ltd
Shared Value Africa

In collaboration with
Ministry of Agriculture and Livestock
Forestry Department, Ministry of Lands, Natural Resources and Environmental protection

With funding from
International Growth Centre
Climate and Development Knowledge Network
Musika Development Initiatives

While musangu grows extensively in Southern Province, both through natural propagation and active cultivation, it has been slow to take hold in much of the rest of Zambia. For example, in the study population, only around 10 percent of households had any musangu planted on their land prior to the intervention.

The combination of long run private benefits and environmental advantages led the research team to develop a set of interventions designed to explore the relative effectiveness of different approaches to encouraging adoption. To investigate barriers to the adoption of musangu, the programme systematically varied several features:

1) the seedling cost-sharing arrangement between farmers and the implementer

2) the cash incentives offered for successful adoption outcomes.

The study investigates two possible explanations for low adoption rates: upfront liquidity constraints or the lack of short-run benefits from adoption.

Box 1. REDD +

The adoption of agroforestry, including musangu, is a key REDD+ (Reduced Emissions from Deforestation and Degradation Plus) strategy. Zambia is one of 12 countries in a UN pilot programme for including developing country land use in international efforts to mitigate climate change. A recent study in Zambia ranked agroforestry first among possible land use strategies for REDD+ [2].

EVALUATION

The study was implemented over the course of a year, from November 2011 to November 2012. Over 1,200 farmers in Chipata district, Eastern Province were given the chance to participate in the study, all of whom worked with Dunavant Zambia Ltd as outgrower farmers during the 2011-12 agricultural season.

Figure 1. Map of Study Area. Map on right shows participating farmers.

Sample characteristics

The farming households in the study have an average landholding size of 7 acres but few have formal land title. Almost all of their land is under cultivation, producing primarily cotton, maize and groundnuts. In the baseline survey for the study, implemented in November 2011, farmers reported challenges of uncertain environmental conditions, shocks such as crop prices and illness, and, on average, are short of food for one month of the year.

Around 12 percent of the study population are from female-headed households and of the farmers trained by the programme, one-third are women. On average, study participants have five years of education and 72 percent of the trained individuals are heads of household. Further details of the study population are summarised in the first column of Table 1 (Page 6), which reports the means and standard deviations for the study sample.

Implementation

In November 2011, study households received training on tree planting and care through the *Trees on Farms* Programme, a partnership between Dunavant Zambia Ltd. and Shared Value Africa. After the training, farmers were given the opportunity to join the programme, which involved planting 50 musangu seedlings on their farm.

Several aspects of the programme were varied, in order to explore the following questions:

- What are the barriers to and determinants of adoption?
- What is the impact and cost-effectiveness of providing input subsidies? Do free inputs lead to wastage?
- What is the impact and cost-effectiveness of offering short-run cash incentives? Are farmers attracted by the cash incentives less likely to follow through on the programme?
- What types of farmers are most interested in agroforestry adoption, and which are most successful?

Input costs were varied at the farmer group level, based on random assignment (see Box 2) that balanced groups based on group size, shed and training dates. The input costs ranged from full subsidy to market value for 50 seedlings (ZMR 12). At the start of the programme, individual farmers were randomly offered financial incentives, either before or after choosing to participate. These incentives ranged from zero to ZMR 150 to be received after one year, dependent on at least 70% tree survival. Varying incentives at the individual level required a transparent and fair approach to randomisation. The programme offered farmers scratch cards, similar to talktime cards, with the reward written in the scratch-off window. Farmers perceived the approach as fair and did not argue with the enumerators about their draws. Figure 2 summarises the design of the experiment.

	Variation in input cost (A)			
	A = 0	A = 4000	A = 8000	A = 12000
Reward after take up Reward before take up	Continuous variation in the reward for keeping at least 35 trees alive			
1/5th receive ongoing monitoring				

Figure 2. Experimental Design

Box 2. Randomised controlled trials

One of the fundamental challenges of quantitative research is isolating the causal relationship between different factors. In particular, evaluating the impact of a programme or policy is made difficult by the fact that:

a) different types of individuals choose to join the programme than opt out, and

b) other factors are changing over time.

Random assignment of a programme to some individuals, households, villages, etc. can facilitate the construction of a clean comparison group. Any differences in outcomes between the programme and the comparison group can be interpreted as a causal effect of the programme.

Randomisation can be implemented in a number of ways, ranging from a simple lottery to a sophisticated computer-generated algorithm that balances assignment to the treatment and the comparison group. This study used both: a simple lottery to assign cash incentives and a computer generated algorithm to assign group-level input costs.

Data collection

Data were collected throughout the year at different stages with the following objectives:

i) a *baseline survey* at the point where farmers chose whether or not to participate in the programme, to learn about the farmers and their choices,

ii) *effort monitoring* visits throughout the year for one fifth of farmers, to track farming and tree-planting activities,

iii) a *planting survey*, to study tree-planting outcomes,

iv) an *endline survey*, to revisit farmers one year after the choice to participate, and

v) a *tree monitoring survey* to accurately record tree survival in the farmers' fields.

RESULTS

Overall, farmers showed high demand for the programme, with an average of 83% of the farmers across all variations in programme design choosing to take part, and these farmers made significant progress in terms of tree survival; after the first year, a total of 19,400 were being cared for by 700 of the 1090 participating farmers. A quarter of all participating farmers received the cash incentive by reaching at least 70% tree survival after one year. Among farmers with any surviving trees, the average number of surviving trees is 28.

Box 3. Cost implications

A one USD increase in the input subsidy

- increased take-up by 13 percent
- had no effect on tree-planting or tree survival, conditional on joining the programme
- increased tree-planting by 11.7 percent, overall, when looking at the combined effect of treatments on take-up and behaviour conditional on take-up
- increased tree survival by 11.3 percent, overall, when looking at the combined effect of treatments on take-up and behaviour conditional on take-up (marginally significant)

A one USD increase in the incentive for keeping 70% of the seedlings alive for one year

- increased take-up by 0.4 percent
- increased tree-planting by 1.3 percent, conditional on joining the programme
- increased tree survival by 2 percent, conditional on joining the programme
- increased tree-planting by 1.9 percent, overall, when looking at the combined effect of treatments on take-up and behaviour conditional on take-up
- increased tree survival by 2.3 percent, overall, when looking at the combined effect of treatments on take-up and behaviour conditional on take-up

Higher input costs lead to lower participation but do not affect tree planting and survival

Input costs do have an effect on participation rates, with higher input costs associated with lower take-up but the price the farmer pays for the seedlings does not have a significant impact on tree planting and survival outcomes.

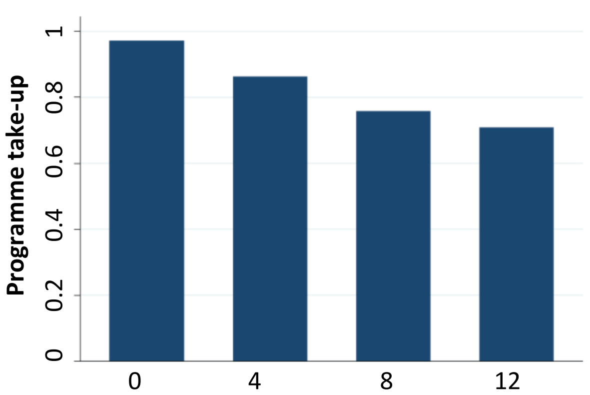

Figure 3. Take-up by input cost treatment (in ZMR)

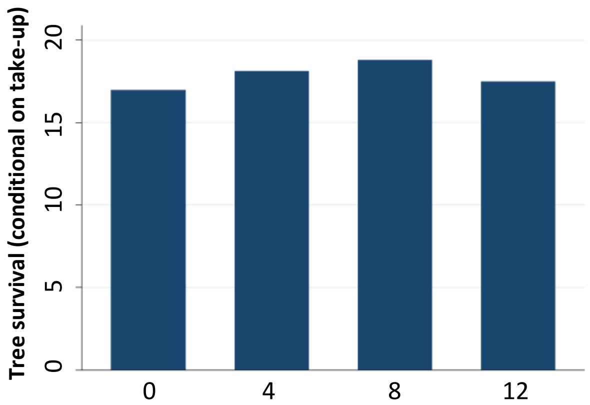

Figure 4. Tree survival by input cost treatment (in ZMR)

Overall, when inputs are charged at the market value, survival falls by 4 trees compared to free provision. As shown in the bar graphs of take-up and survival, this result is driven entirely by farmers who choose not to take up at higher input costs. Once they decide to join, farmers who paid more for the seedlings are no more likely to care for them than farmers who received the seedlings for free.

Higher cash incentives lead to increased adoption and tree survival

Incentives are shown to have an effect on participation rates when farmers are required to pay a higher price for inputs, with an increase of ZMR 100 in the cash incentive associated with a 7% increase in take-up. However, as shown in Figure 5, when inputs are more heavily subsidised or free, incentives do not affect take-up. This shows the take-up response only for farmers who knew about the cash incentives when they decided whether to join the programme.

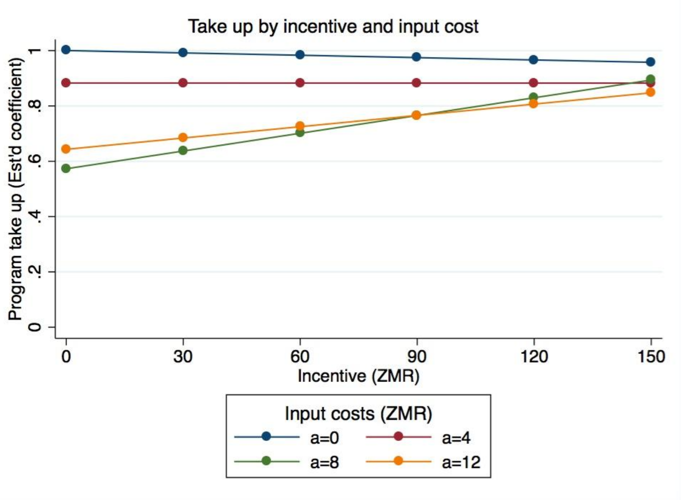

Figure 5. Take-up by incentive and input cost

When farmers are offered the opportunity to earn a higher short-run incentive, tree planting and tree survival outcomes are higher; a one USD increase in the incentive leads to a 2 percent increase in tree survival after one year. Figure 6 shows only farmers who learned about the incentives after choosing to join, so the results can be interpreted as the direct causal effect of incentives on effort and tree survival outcome. The effect of incentives on tree survival for farmers who learned about rewards after joining is very similar, suggesting that incentives do not attract farmers with little intention of following through with the programme.

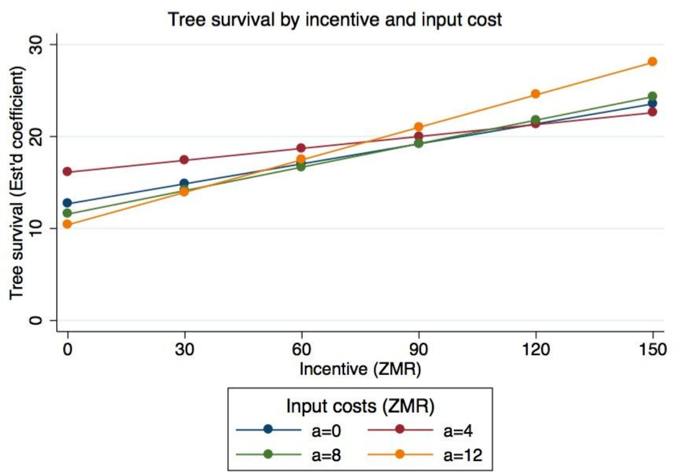

Figure 6. Tree survival by incentive and input cost

Recall that farmers had to keep 70 percent of their trees alive for one year to receive the incentive pay. Evidence on the effectiveness of the financial incentives can be seen from a simple histogram of the number of surviving trees. In Figure 7, the dashed line represents the reward threshold. A substantial portion of farmers kept exactly 35 trees alive, allowing them to qualify for the payment.

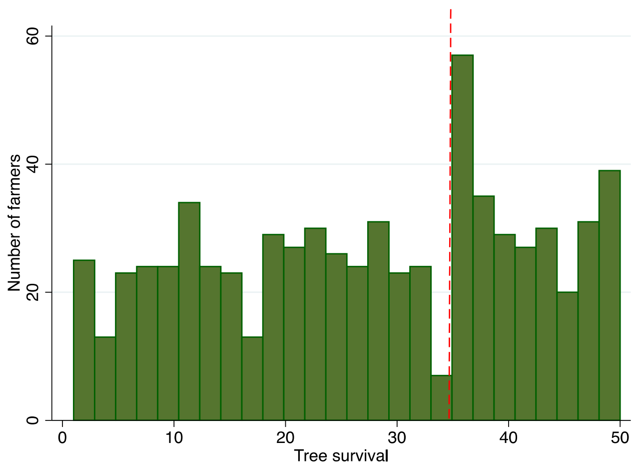

Figure 7. Tree survival by number of farmers

Overall, there is strong evidence that higher incentives lead to increased adoption of agroforestry, and that the potential perverse effects of subsidies and incentives are minimal. Follow-up research is required to investigate what happens after the payments stop.

Farmer group dynamics affect outcomes but incentives still matter

Differences in take-up and tree survival can be observed at the group level, suggesting that factors such as environmental conditions, nursery success, YGL capacity and peer effects all affect programme outcomes. However, because the incentives were assigned at the individual level, it is feasible to add group level controls (fixed effects) to the regression analysis and investigate the effect of the incentives *within* farmer group. The results are very similar to those shown above, suggesting that incentives matter above and beyond the group factors that contribute to the success or failure of the programme. The follow-up survey explored some possible explanation for large differences across groups. For example, a farmer who reports having seen his YGL more than 10 times during the year has around four more surviving trees than a farmer who has seen his YGL less frequently.

Farmers respond positively to higher incentives within their farmer group

Varying incentives at the individual level offers benefits in terms of analysis but it also raises the question of whether farmers are sensitive to the rewards that others in their group receive. A straightforward analysis suggests that they are, but that the results are largely positive. Higher incentives for others in the group have a positive effect on a farmers' own tree survival outcomes, controlling for the farmer's own incentive level. The interaction of own incentive and average group incentive is negative but small in magnitude and not statistically significant. Thus, it appears that encouraging farmers using incentives has a positive spillover effect through encouragement and cooperation, rather than a negative effect through jealousy or competition.

Certain types of farmers may be more likely to participate and achieve better outcomes

Controlling for household characteristics, we observe that larger households, female headed households, farmers who have more experience with Dunavant, and farmers who self-report a greater willingness to take risks are all more likely to join the programme. While the female headed household result is somewhat surprising, it is consistent with other evidence of higher take-up among female headed households for related conservation farming activities.

Tree survival appears to be influenced by respondent age, education, past experience planting musangu trees, and an indicator for having planted musangu trees the previous year, all of which have a positive influence. Of these characteristics, only education and the fertiliser indicator are also significant predictors of earning a reward.

Interestingly, indicators of wealth, including land size, appear to have little influence on programme outcomes. Additional investigation of these survey measures may provide valuable for investigating adoption patterns and correlations more generally.

Table 1 shows the basic findings from the correlation between programme outcomes and each of the covariates listed (no controls). The plus indicates that the characteristic has a positive impact on farmers choosing to participate (Column 2) and earning the cash incentive (Column 3). The mean and standard deviation of each characteristic is shown in Column 1.

Variables (statistically significant)	Mean (Column 1)	Take up (Column 2)	Earn reward (Column 3)
Household size	5.355 [2.197]	+	+
Respondent education	5.367 [3.299]	+	not significant
Non-agricultural assets	9.245 [5.553]	+	not significant
Total landholdings (hectares)	2.904 [2.358]	+	not significant
Number of fields	2.858 [1.115]	+	not significant
Grew cotton last year	0.793 [0.406]	+	not significant
Fertiliser purchased last year	0.634 [0.482]	not significant	+

Table 1. Impact of household characteristics on farmers participating and earning the incentive

POLICY IMPLICATIONS

Subsidising the price of inputs increases adoption without leading to wastage of inputs. We see no evidence that farmers who paid a higher price to be part of the programme did better once they joined. This finding contradicts some anecdotal evidence that suggests that farmers have to pay for inputs to value them.

Short-run incentives are effective for generating sustained adoption, and may be cost effective if the fixed costs associated with adding additional farmers to a tree planting programme are high. In other words, the implementing organisation can achieve a given tree survival target by contracting with more farmers, not offering incentives and having lower per-farmer tree survival outcomes or contracting with fewer farmers, offering incentives and having higher per-farmer tree survival outcomes.

Financial incentives do not appear to attract the wrong "type" of farmer. At high levels of rewards, farmers were equally effective at caring for trees whether they knew about the rewards when they decided to join or not.

We find no evidence that poorer or more marginalised households are unable to benefit from the programme. On the contrary, female-headed households are more likely to participate and do just as well as male-headed households when they do.

NEXT STEPS FOR THE RESEARCH

Analysis of the data is ongoing and an academic paper summarising the findings will be produced during 2013. The project raised a number of open questions for further research.

What happens once the incentive payments stop?

Conditional on funding, the research team will visit the study farmers in late 2013 to collect data on sustained tree survival and to record additional household-level outcomes associated with the programme.

How can we design effective monitoring programmes?

We find suggestive evidence that regular monitoring has a positive effect on tree survival outcomes, however, monitoring is costly and we are not able to determine which aspects of the monitoring are most influential. Future research could help investigate this issue.

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References: 1 – Sileshi, G., Akinnifesi, F. K., Ajayi, O. C., Place, F. (2008) Meta-analysis of maize yield response to woody and herbaceous legumes in sub-Saharan Africa. Plant and Soil 307: 1–19. **2 -** Kokwe, M. (2012) Forest management practices with potential for REDD+ in Zambia. UN-REDD Programme Report.

This document is an output from a project funded by the UK Department for International Development ("DFID") for the benefit of developing countries. However, the views expressed and information contained in it are not necessarily those of or endorsed by DFID, which can accept no responsibility for such views or information or for any reliance placed on them.

3 *"The Climate and Development Knowledge Network is a project funded by the UK Department for International Development (DFID). It is managed by an alliance of organisations led by PricewaterhouseCoopers LLP (PwC), and including Fundación Futuro Latinoamericano, INTRAC, LEAD International, the Overseas Development Institute, and SouthSouthNorth".*