Pilot Project Report

Pilot Study of a Rigorous Impact Evaluation (IE)

On Farmer Experimentation of Innovative Agricultural Practices

within the Sustainable Village Project (SVP) of Molumbo, Mozambique

Principal Investigators: Catia Batista (Universidade Nova de Lisboa)
Gharad Bryan (London School of Economics)
Dean Karlan (Northwestern University)

Field Coordination: Timoteo Eduardo Simone

November 2017

International Growth Center

1. Introduction

This report describes insights and results from the pilot study for an Impact Evaluation (IE) study of farmer experimentation on the adoption of innovative agricultural practices. The preliminary results presented lay the foundation for a full-scale Randomised Control Trial (RCT). The evaluation was implemented within the Molumbo Sustainable Village Project (MSVP), a development initiative aimed at reducing poverty through multi-sector interventions in the Molumbo District of Zambézia Province, Mozambique.

In rural Molumbo, lack of food security is the main driver of poverty. To alleviate this concern, one of the goals of the MSVP is to increase the reach of more productive agricultural practices. Some of the programmes currently in place consist of demonstration plots managed by extension agents or established on the fields of prominent farmers. These strategies alone, however, have seldom resulted in high adoption rates. The literature points to behavioral biases preventing farmers from adopting otherwise profitable technologies. In applying the practices in their own plots difficulties often arise, due to, among others, deficient learning experiences and different land conditions. These doubts can quickly become insuperable in the absence of guidance.

The IE study aims at providing scientific evidence on the effect of farmer direct experimentation with new practices on farmers' ultimate adoption. The cost-effectiveness of different experimentation programmes will also be considered. To measure the effects of different experimentation initiatives, farmers will be randomly assigned to treatment or control groups. Two control groups will be in place. The first will not involve any intervention, while the second, representing a typical information dissemination attempt, will establish a community plot managed by an extension worker. Treatment groups will experience different levels of experimentation and supervision. The simplest intervention, present in all treatment groups, will consist of incentives and guidance to set up plots in their fields. The remaining treatments test the (potential) incremental effect of follow-up visits and discussion groups.

The pilot study serves two fundamental purposes: it provides preliminary evidence on the effects of farmer experimentation, and it supports the choice of agricultural practices (out of several available) to be applied in the full-scale RCT. The suitability of different technologies is assessed through their relative agronomic performance, studied in a demo plot, but also through the farmers' own assessment. To obtain the latter, the pilot was built to allow farmers to fully experiment with the several techniques under consideration. This paramount need, as well as the low availability of non-irrigated agricultural land during the dry season (April/May to October), when the pilot took place, meant a pilot RCT could not be implemented. Rather, participants were selected from farmers willing to participate who had suitable land, and qualitative data were collected from surveys.

Farmers received training on several technologies and were incentivised to apply them in demo plots on their own land. Preliminary evidence of the effect of direct experimentation can be perceived through differences in intent-to-adopt between those who implemented the demos and those who did not.

2. Pilot Activities

The pilot study started in May 2016. Two separate endeavours were pursued: establishing Farmer Demo Plots, to allow farmers to directly experiment with new practices, and developing the agronomic experiment, to compare the technologies in a controlled extension plot.

2.1. Farmer Demo Plots

a) Farmer training:

Trainings were organized to teach farmers how to set up demo plots in their own fields. One training session was organised per community in Molumbo Sede, Namanja, Muhela II, and two training sessions were organised in Malico. The communities are located in the *Posto Administrativo* of Molumbo Sede, within 20 km from one another.

The pilot took place during the dry season, when below-average rains hinder crop growth. To be eligible to participate, farmers were thus required to have arable land with enough moisture to grow crops in the second season. The only additional criteria for selection was willingness to participate. In total, 41 farmers were trained. The distribution of trainees by community of origin was 15, 6, 6, 5, 2 and 7, from Malico, Molumbo sede, Muhela I, Muhela II, Nehia, and Namanja, respectively.

The trainings were given with assistance from an extension worker from the Molumbo District Agriculture Department (SDAE- *Serviços Distritais de Agricultura e Actividades Económicas*), and organised in a field belonging to one of the participants. On average, training sessions were 1-hour long.

During the trainings, farmers received specific instructions on how to set up demonstration plots. Detailed explanations were provided about the technologies and practices to be applied in the demos. It was explained that the demos would allow farmers to explore technologies in detail, to later put them to use profitably in their own farms. After the training, each farmer had to put forward a date by when his demos would be finalised. Each participating farmer received two 1kg bags of two improved seed varieties, two of the agricultural technologies to be tested in the demos.

Figure 1 – Training Sessions

(a)

(b)

(c)

Farmers being trained on how to set up demos in (a) Muhela II, (b)Molumbo Sede and (c) Malico communities.

b) Farmer demonstration plots:

Farmers were instructed to set up 5 plots of 15m*20m each, to accommodate 4 different technologies and a control. The first two plots tested improved seed varieties. A hybrid seed variety (PAN 3M), was planted on the first plot (treatment 1, T1) and one of two open pollinated varieties (ZM 523 or ZM 521) in the second (T2). Each farmer received a package of the hybrid seed and a package of either of the OPV varieties. All improved varieties were to be grown using the recommended spacing (30*70 cm) and seeds per hole (2 seeds) to achieve optimal plant population. The farmers were taught how to use ropes to maintain crop spacing and rope was provided to communities. In the third plot, the control (T3), a local seed variety was planted using conventional practices. The fourth plot tested a conservation agriculture practice, covering the soil with dry organic matter, as the fourth treatment (T4). For treatment 5 (T5), in the final plot, pit planting was chosen. Pits of 1m*0.5m were set up, containing 6 seeds each. For both practices, a local variety was used and no inputs provided.

Farmers who did not have enough arable land for 5 plots of 15m*20m were instructed to set up smaller equally-sized plots. It was also made clear that to allow for comparable results the same agronomic practices (for instance, amount of irrigation water) had to be in place in all plots.

After the training sessions, 19 out of 41 trained farmers had implemented the demo plots to various extents in their fields. Anecdotal evidence indicates some farmers did not proceed with the demos because of time constraints. Specifically, several farmers were hired as workers in the harvest and selling of tobacco by a local tobacco company. Most farmers did however keep the input seeds for the main agricultural season. Figure 2 shows a farmer's field after preparing the demo plots. This farmer innovated the design of the demo, replicating the treatments once. In total, the farmer had 10 plots instead of 5.

Figure 2 – Farmer demo plots

Farmer field prepared for demo plot. The farmer replicated each treatment, there were two blocks of 5 plots (10 plots in total).

2.2. Agronomic experiment - Testing the performance of practices and technologies

An agronomic experiment was set up to rigorously test and compare the performance of the different practices and technologies under consideration for the RCT. The trial also provides information on the operation of extension agents´

community demo plots. The trial followed a *Complete Randomized Block Design*, using 4 blocks/replicates with 6 treatments each, for a total of 24 plots. Each plot had 6m of length and 5m of width. Each block is separated by an alley of one meter. The five treatments made available to farmers were tested (the OPV seed used was ZM 523); the additional sixth treatment, T6, combined soil cover with intercropping with a leguminous crop. Figure 3 shows the agronomic experiment in the planting stage.

Figure 3 – Extension Demo Plot

Land preparation and planting of agronomic trials in Molumbo Sede.

3. Data Collection

Agronomic data was exclusively collected from the demo extension plot set up.

There were two main moments of farmer follow-up data collection. The first follow-up survey took place in August, roughly midway into the pilot, and the final follow-up was conducted in October, near the end of the second season. All 41 trained farmers were meant to be surveyed, to fully illustrate how experimentation impacted intent-to-adopt and the farmers' assessment of technologies. However, most farmers who did not implement the demos were unwilling to participate in the surveys. Our analysis is limited by this constraint.

Some farmers only partially implemented the demos. Those who applied only one or two of the four innovative techniques are grouped with farmers who did not implement the techniques at all and constitute the hereby designated *Low Experimentation* group.

Only 19 of the 41 trained farmers executed the demos completely or almost completely – these are part of our *High Experimentation* group. Despite this fact, other individuals free-willingly started demos on their own plots after learning about the opportunity. These farmers received information from trained individuals and not directly from our team.

The information collected from farmers served four purposes: farmer characterisation; technology assessment (to help choose the most suited technology for the RCT); experimentation assessment (to demonstrate the potential of farmer direct experimentation for increasing adoption); and organisation assessment (to evaluate and tailor logistics to farmer needs).

4. Extension Demo Plot Results

4.1. Yield per plot

Several agronomic measures were collected from the extension demo. Arguably the most important measure of technology effectiveness is the effect on yield per plot. Gains in productivity of land directly increase farmer income if not offset by substantial added costs.

Average yield in kg/plot is presented below in Table 1:

Table 1 – Yield per plot

	Average kg/plot
T1	1
T2	1.1
CONTROL (T3)	**0.4**
T4	0.5
T5	0.95
T6	0.2

The treatments that show potential are the two improved seed varieties (T1 and T2) and pit planting (T5).

Using restricted maximum likelihood estimation is typically advised for small-sample inference. The effect of pit planting is estimated more conservatively at 0.52 kg per plot through REML and rendered marginally significant (p-value=0.125), while both improved seed varieties appear still significant at the 10% level.

It is however worth noting that block effects are weak – we do not reject the absence of random effects (p-value=0.2467), and the estimated variance is less than one standard deviation away from zero. RMLE and MLE methods are necessarily less efficient than OLS if block differences are negligible. OLS analysis disregarding blocks still renders the effect of 0.55 kg of pit planting marginally significant (p-value=0.119), and the effects of both seed varieties significant at the 10% level.

Heteroskedasticity between treatments is a possibility commonly disregarded in Randomised Complete Block Designs. White standard errors can account for non-homogeneous variances across treatments, though in a small sample, efficiency gains are not ensured. The yield for the hybrid seed varies substantially more than for pit planting, thus, applying the white standard error correction renders only the effects of OPV seed and pit planting significant, at the 5% and the 1% level respectively.

Table 2 – Regression Results on Yield per plot

	REML Kenward-Roger			**POLS White Std. Errors**			**Random Effects/POLS**		
	Coef.	SE	p	Coef.	SE	P (t)	Coef.	SE	P (t)
T1	0.600	0.242	**0.056**	0.60	0.340	0.121	0.60	0.277	**0.067**
T2	0.700	0.242	**0.034**	0.70	0.249	**0.026**	0.70	0.277	**0.039**
T4	0.171	0.383	0.672	0.10	0.111	0.399	0.10	0.392	0.806
T5	0.518	0.285	0.125	0.55	0.121	**0.003**	0.55	0.310	0.625
T6	-0.334	0.383	0.419	-0.20	0.111	0.115	-0.20	0.392	0.119
Control	0.400	0.195	0.085	0.40	0.111	0.009	0.40	0.196	0.08
VAR(Block)	0.0265	0.0518							
VAR (Ind)	0.0876	0.0546							
Chi-square	0.47								
P-value	0.2467								

The estimates for pit planting signify a gain of between 129% and 137.5% on land productivity, values similar yet slightly larger than those found by other researchers (BenYishay & Mobarak (2014) and Haggblade & Tembo (2003) report 50-113% gains). The technology is particularly suited for arid regions as it conserves moisture, and as such, its use in a dry-season-only-pilot likely inflates its estimated effect. When rainfall is abundant, pit planting has been shown to lose its edge (Mmbaga & Lyamchai (2001)). Thus, it is possible that, during the main agricultural season, percent yield gains from pit planting will be smaller and closer to those previously reported.

Average yield is substantially below the technologies' potential, which can be attributed to the dry-season. The average yield of the OPV seed was of 0.367 tons/hectare, when its full potential is 6 tons per hectare; the hybrid seed, with a potential of 4 to 6 tons per hectare, did not go beyond 0.33. Since both seeds are engineered to endure drought, the gains in average yield might be overstated. It is likely gains during the main season will not be as substantial. According to Capstone seeds, who commercializes ZM 521 and ZM 523, the former yields 30 – 50% more than traditional varieties under drought and low soil fertility. (White Open Pollinated Maize/ Website Capstone Seeds)

4.2. Other agronomic measures

For the remaining agronomic measures, valid data was collected for 22 of the 24 plots. Measures at the plant level and leaf level are treated as replications of the same block-treatment, which minimises small sample concerns.

All plants, across all technologies, were severely attacked by pests - mainly, by worms. All plots except one saw their plants to some extent damaged by pests.

Only the plants under the mulching technique were substantially less targeted – the likelihood of each leaf being damaged was 18% lower than with conventional practices. These results were consistent across block as fixed-effects and as mixed effects models, both using Linear Probability Models (LPM) and Probit models.

Table 3 – Regression Results on Probability of Pest Damage to Leaves

	LPM		Fixed-Effects Probit			Mixed-Effects Probit		
	Margin	SE (White)	Coeff.	Margin	SE	Coeff.	Marginal	SE
T1	-0.0221	0.0683	-0.0596	-0.0231	0.181	-0.0465	-0.0181	0.18
T2	-0.0689	0.0641	-0.18	-0.0702	0.169	-0.167	-0.0652	0.168
T4	-0.190**	0.0757	-0.494**	-0.1898	0.2	-0.465**	-0.1796	0.199
T5	-0.00136	0.0698	-0.0109	-0.0042	0.18	0.00494	0.0019	0.179
T6	0.0334	0.0572	0.0825	0.0317	0.151	0.0915	0.0353	0.151
BLOCK 1	-0.0323	0.0464	-0.0807	-0.0317	0.116	-	-	-
BLOCK 2	0.185***	0.0428	0.484***	0.1849	0.115	-	-	-
BLOCK 3	0.0474	0.0442	0.123	0.0482	0.113	-	-	-
Control B4	0.502***	0.0578	0.00867	0.503	0.151	0.128	-	0.168
Observations	979					Chi-square	14.63	
						P-value	0.0001	

Some treatments seemed to result in larger leaves. Of note, the OPV seed, the pit planting and the intercropped mulch technique led to (statistically significant) increases of approximately 0.7 cm, 1.5 cm and 1 cm on average leaf width (see Annex, Table 8.1). Expanded leaf area increases light absorption and thus photosynthetic activity, possibly conducing to future higher yield. Per results in the literature, such connection between leaf area and yield is often found empirically, though some exceptions exist (Lambert et al (2014)). However, the measurements taken were only of leaf width, not leaf size nor number of leaves. It is not clear whether these technologies had the largest leaf areas. As such, it is not surprising results do not match highest-yield techniques. No truly useful comparison among technologies can be derived from leaf-width analysis.

Other morphological aspects of plants, possibly indicative of future high yield, such as plant height or number of leaves, varied little across treatments and blocks. Regardless of the model, results were far from significant (results not shown). Similar to yield, these variables were, for all techniques, substantially below typical main-season values. Plant height was on average only 68.6cm in the OPV variety, when its usual range is 180-185 cm. No plant across all plots was taller than 112 cm. Treatments did not have noticeable effects on the number of plants per plot.

5. Survey Results

5.1. Characterisation of Participants

Most participating farmers were middle-aged men. Farmers were experienced: no participant had been working with farming for less than 4 years, and on average, farming experience was 19 years. All except for 3 farmers had some degree of education, though most had less than 6 years of schooling, and many had been schooled only up to the 4th grade.

Average agricultural income per agricultural season was of approximately 32,000 MZN. Some farmers had sources of income other than agriculture. Most were traders, 2 of them tobacco traders. In October, five experimenting farmers had an alternative source of income. Though some individuals who did not proceed with the experimentation attributed their decision to extra activities, for several, it was possible to successfully combine the two.

There were no differences between low and high experimentation farmers in most aspects. Some of the factors possibly most influential for technology utilization, such as farming experience, education, agricultural income or age, to name a few, were comparable in the two groups. (see Tables 8.2 through 8.5 in Annex).

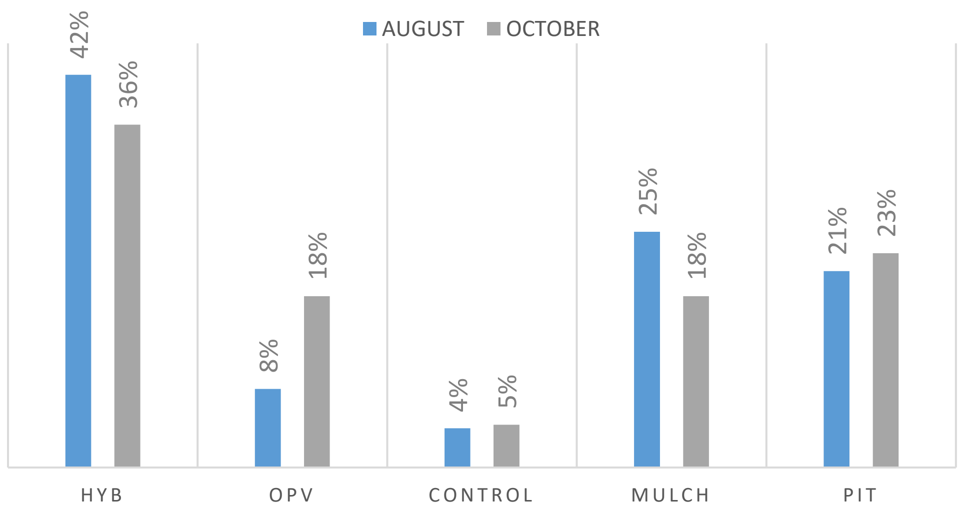
In August, high-experimentation farmers were more likely to be working in a machamba of their own than in family land. This difference could potentially explain the decision to participate in the demos itself: more autonomous individuals were more-willing to implement the demos. A concern in our data analysis could arise: less family responsibility could be associated with risk-taking behaviour. If high-experimentation farmers were substantially more independent, they could be more willing to adopt new technologies even if not entirely persuaded of their usefulness. Nonetheless, not only are the two-groups comparable in household size, but ownership differences dissipate in the October survey. It is easier to explain the discrepancy through difficulties in question interpretation. Since 5 farmers answered the question with both “Family” and “My own machamba” (considered family in the analysis), it is clear doubts came up.

The similar composition of both groups of farmers will allow us to attribute differences in intent-to-adopt and assessment of technologies to experimentation itself.

5.2. Technology Assessment

The farmers globally considered the treatments preferable to conventional practices – in August, 23 out of 24 farmers chose a treatment as the best performing technology, and, at follow-up, 21 out of 22 held this view. The hybrid seed variety (T1) was the most popular (favoured by 42% in August and by 36% in October). No clear differences amongst the remaining technologies surfaced (see Figure 5). The OPV seed, the best performing in the demo extension, was assessed less positively by farmers.

Figure 5 – Best Performing Technology (Farmer Assessment)

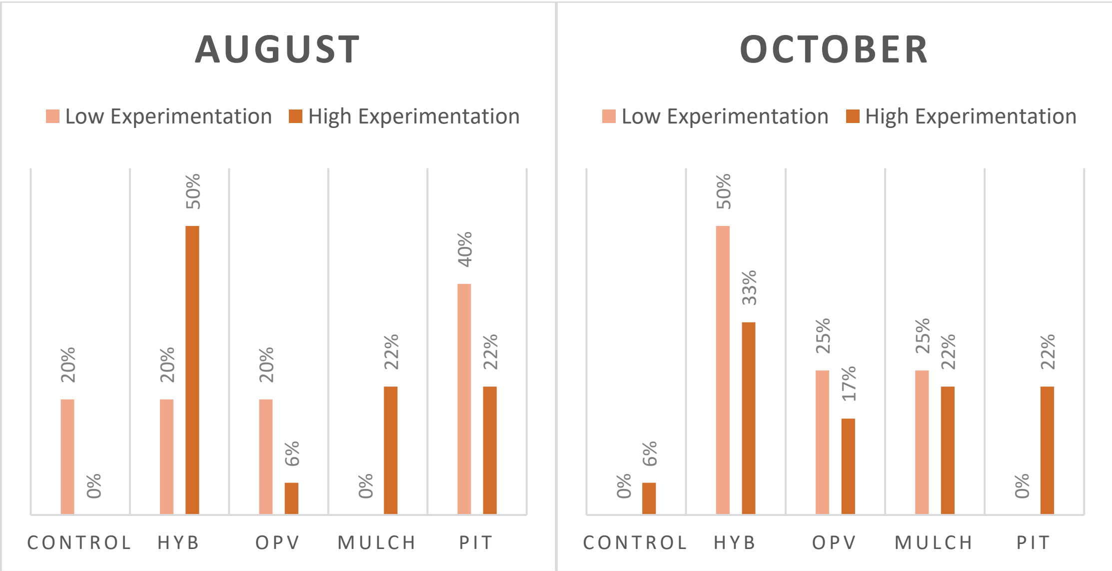


Farmer's Answers to " Which of the techniques if you had to choose ONE you would say is the one that is doing the best in terms of performance?"

Importantly, experimentation seemed to affect technology assessment. In the baseline survey, opinions are quite different between the group who implemented the demos and the trained-only group. In October, these differences dissipate, most likely reflecting the spread of information. Fisher's exact tests confirm this analysis: experimentation significantly affects opinions in August, but not in October.

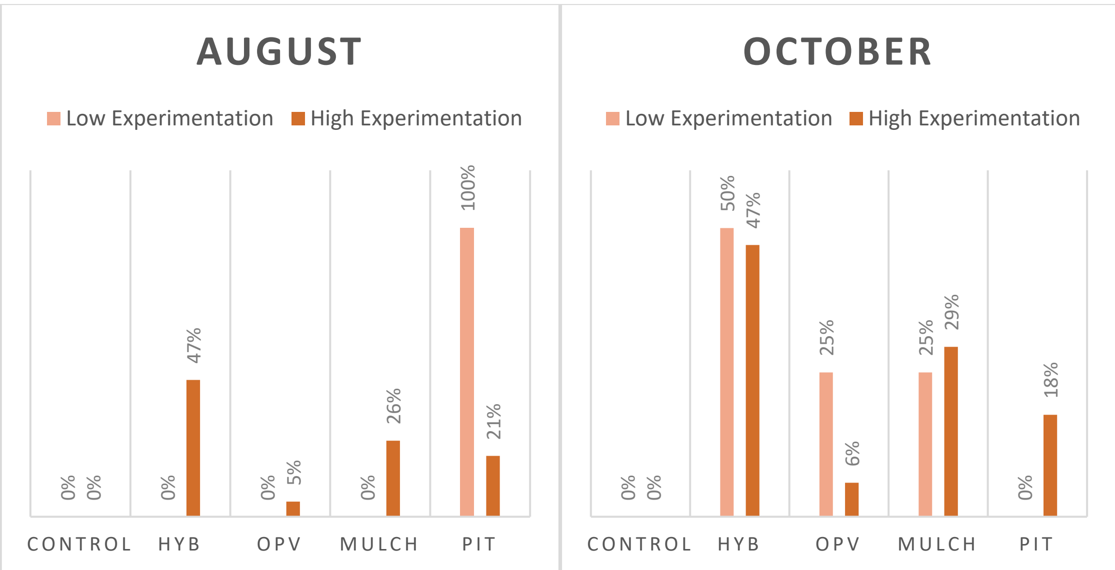
The hybrid seeds were considered the best-performing since the baseline survey for those who directly experimented with the practices. Farmers who only attended the training sessions favoured pit planting in August, but, in October, shared the experimenters' preference for the hybrid seeds. Mulch and pit planting were considered the second best by the same number of experimenting farmers in August and October (see Figure 6).

Figure 6 – Best Performing Technology per Experimentation Level (Farmer Assessment)



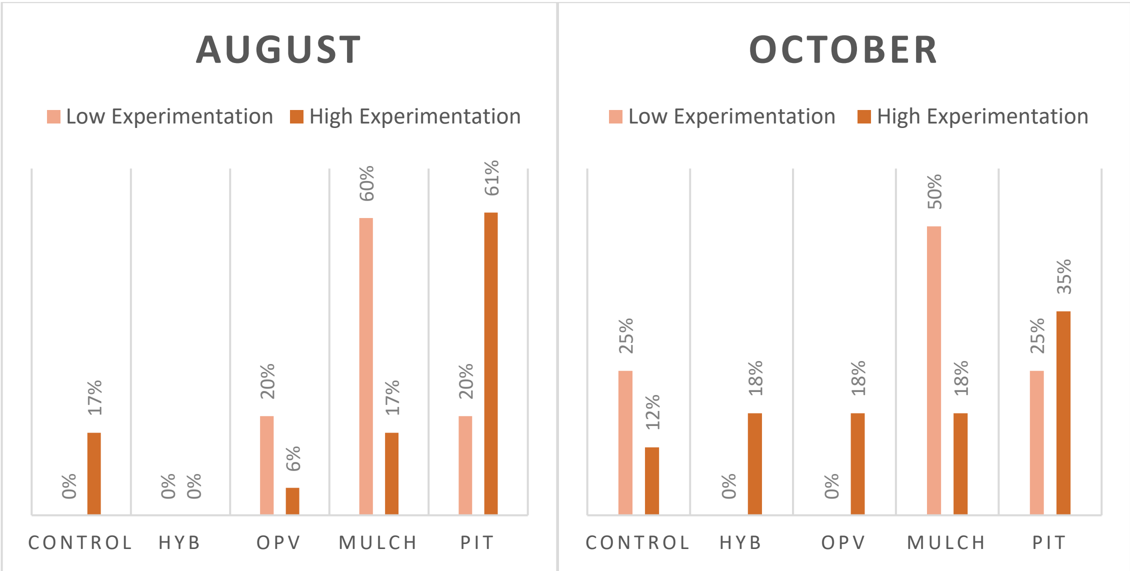
At baseline, those who had not experimented with the technology also believed pit planting should be the technology chosen for presentation to other communities, while those who implemented the demos, again, mainly favoured the hybrid seeds. In October, both groups shared a preference for the latter. Mulch and then pit planting followed, as represented by Figure 7.

Figure 7– Best Choice for future programmes per Experimentation Level (Farmer Assessment)



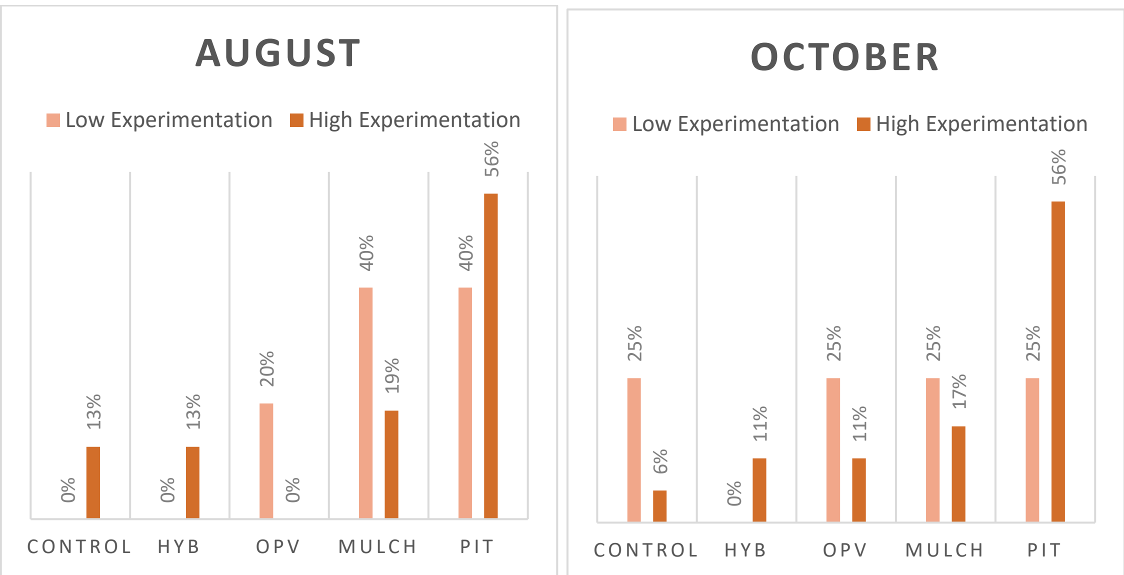
Farmers were asked to assess the difficulties in implementing each technology by themselves. Though one can be inclined to consider mulching and pit planting the hardest, outside the scope of the programme, using improved seeds can also be problematic - the closest sellers are roughly 100km away and the area road network is severely underdeveloped. Moreover, a falsified seed market thriving in Malawi further hinders access.

Figure 8 – Hardest technology to apply per Experimentation Level (Farmer Assessment)



Low-experimentation farmers seem to drastically overestimate the difficulties in mulching. Interestingly though, pit planting is considered the hardest to implement by experimenting farmers in both moments in time, in October the burden is considered lighter. Conversely, difficulties in obtaining improved seeds apparently only weigh in on the answers in October (Figure 8).

Figure 9 – Most Expensive technology per Experimentation Level (Farmer Assessment)



Mulching and particularly pit planting were considered the most expensive techniques, as presented in Figure 9. In this cost assessment, time considerations are most likely present.

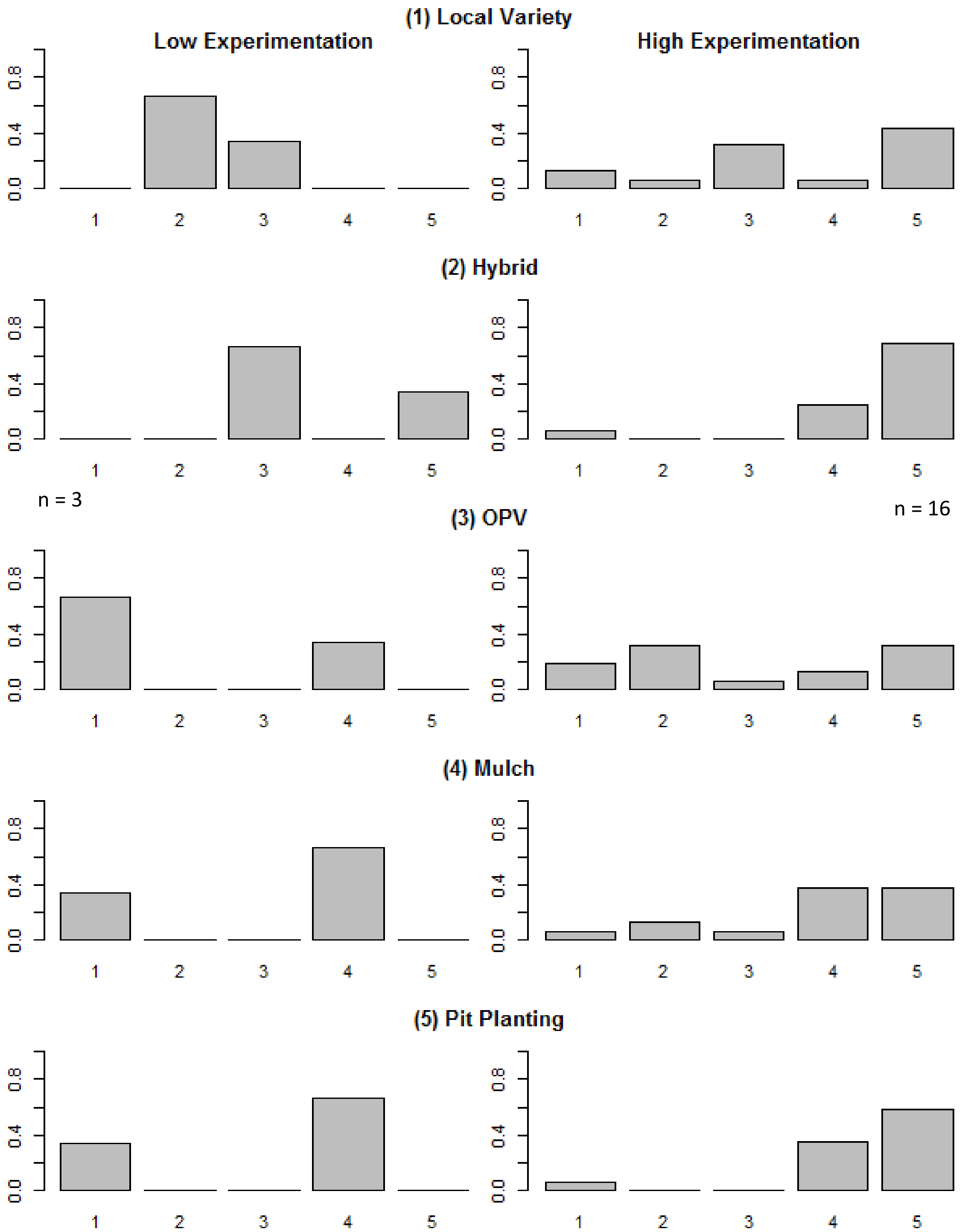
Answers to other questions provide additional clues on farmer assessment. Though in August, four experimenting-farmers thought pit planting was the worst choice for future initiatives, in October, only one farmer still held this view. (see Figure 8.3 in Annex). Hybrid seeds were considered the easiest to implement (Annex, figure 8.4). Finally, the seeds (and particularly the unimproved seeds) were considered the cheapest techniques (Figure 8.5 in Annex). It is possible, nevertheless, that analyses are slightly biased - the modified seeds were provided to farmers, eliminating both cost and time constraints, while no incentive was in place for pit planting or mulching.

Farmers were asked to grade all 5 technologies from 1 to 5, considering all the criteria discriminated above (performance, cost and implementation difficulty). In many cases, low experimentation farmers did not reply to these questions. Conclusions are limited by the low response but even so, some effects of experimentation transpire in the classifications given, particularly in the classification of the hybrid seed and of pit planting – experimenting farmers are substantially more positive about both technologies.

In October, the highest grades are given to the hybrid seeds, the best-scoring in most criteria. Interestingly, the second best-graded technology by experimenting farmers is pit planting. Though farmers recognise implementation difficulties in the technique, these do not lead to a low overall score. (see Figure 10). Views expressed in August can be found in Annex, Figure 8.6. Noteworthy differences are that pit planting was less popular at this earlier stage, while mulching seemed to be the second-favourite.

Through Mann-Whitney U-tests, it is possible to assess the significance of differences in scores between experimenting and non-experimenting farmers. In August, mulching is seen differently by low and high experimentation groups (p-value= 0.053), and so is pit planting (p-value=0.1). In October, none of the differences are rendered significant.

Figure 10 – Classification of Technologies (1-5) in October (Farmer Assessment)

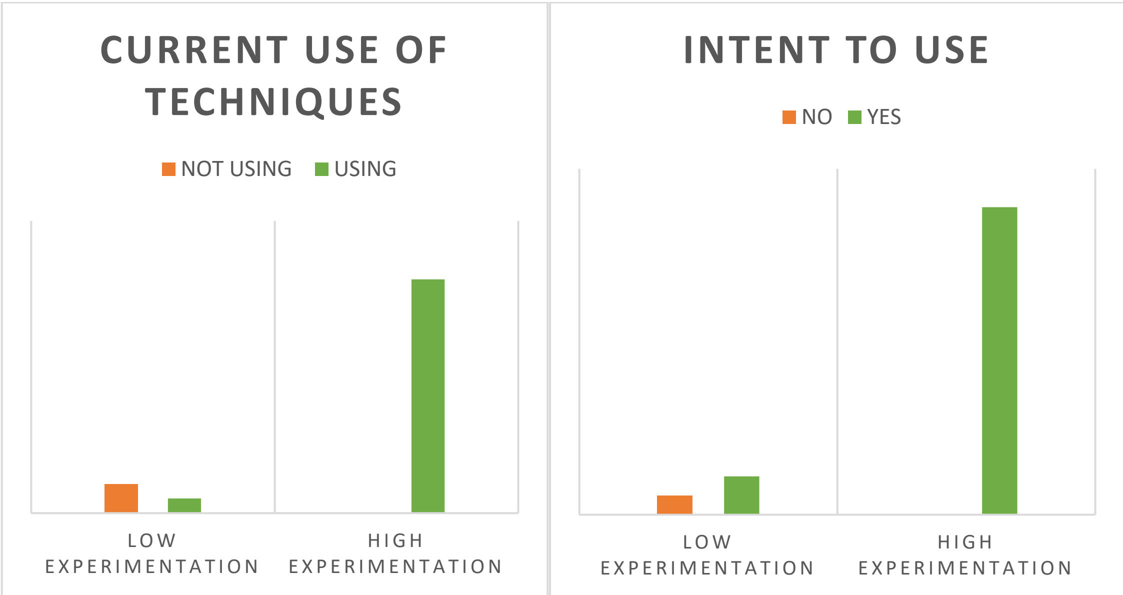


5.3. Experimentation Assessment

Farmers were overwhelmingly positive about the experiment. All farmers, in both surveys, were unequivocal about wanting to participate again. The great majority had never been involved in a training session before NOVAFRICA. An opinion repeatedly expressed was that our team ought to show the techniques to other farmers and other communities.

The experimentation seemed to be very effective in promoting technology utilization. In October, all farmers who had implemented the demos were also using the techniques elsewhere in their machambas; two of the three surveyed individuals who only attended the training were not. All farmers who proceeded with experimentation, also intended to keep using them in the future. From the three trained-only individuals, one did not intend to apply any of the techniques learnt in his field.

Figure 11– Technology use and Intent to use per Experimentation Level



Strikingly, some individuals implemented demos on their land free-willingly, based only on information provided by trained farmers. These situations illustrate knowledge about the practices spread from experimentation and promoted a desire to adopt, even amongst those not directly involved.

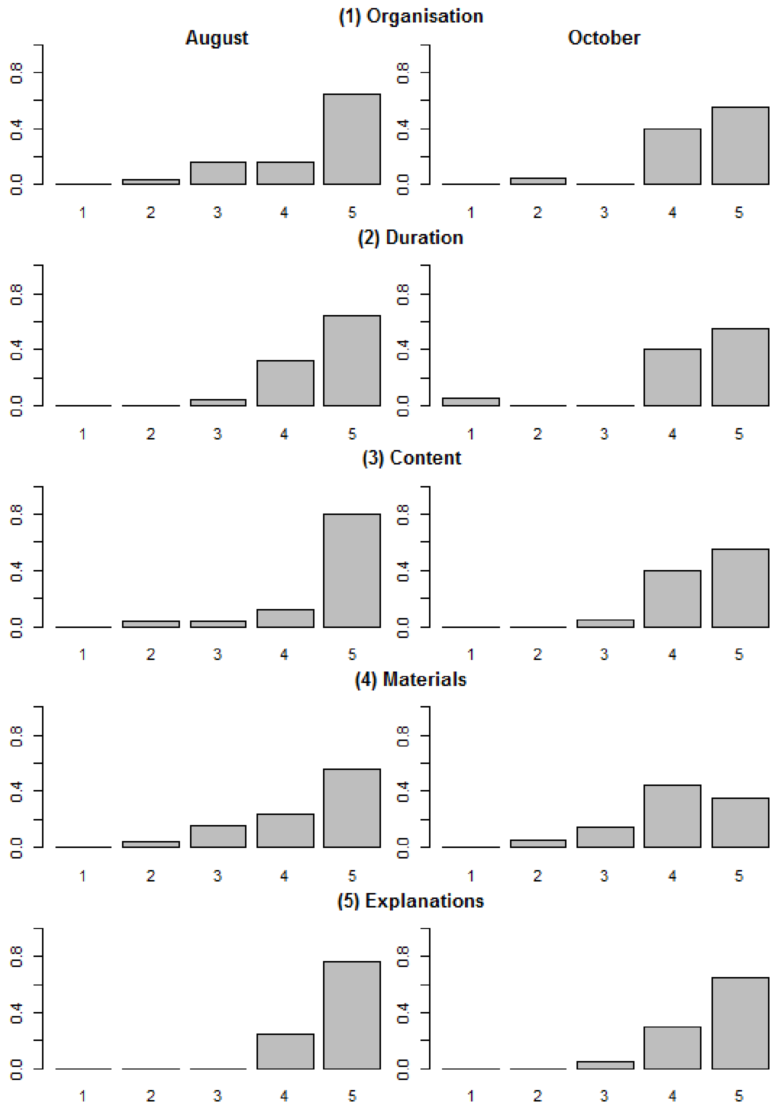
More supervision and guidance, fundamental elements of the interventions planned for the full-scale RCT, was asked for by numerous farmers. Besides general comments such as "more support", specific requests included "more visits from the extension agent", "supervision while setting up the demos", or "answering requests for information". An opinion from one of the farmers summarises both the potential of the technologies and of the experimentation techniques planned for the full-scale RCT: "The techniques are good but we sometimes feel abandoned when additional help is not provided". Moreover, when asked specifically what we should change about the programme, the most mentioned suggestion was "more visits to my demo plots". The great majority of participants were interested in continuing to receive help from an extension worker.

It is also worth noting farmers requested guides with detailed explanations about technique implementation, so they could share the information with other interested farmers and perfect their own technique.

5.4. Organization Assessment

Farmers were inquired about the quality of the training obtained, regarding duration, organisation, content, quality of explanations and quality of materials.

Fig. 12 – Classification (1-5) of the Training on 5 criteria (Farmer Assessment)



Views about the training were globally very positive. Most farmers evaluated the training with the maximum score (5) on all criteria, except for materials, which, in October, were given the grade 4 most often. The explanations and content were the aspects viewed most favourably.

All farmers surveyed in October saw the extension worker and the project coordinator as helpful during the training sessions. Participants were also very pleased with the performance of the project coordinator during the overall programme. On the contrary, the performance of the extension worker was seen as lacking. (see full data in Annex, Fig. 8.7). Several farmers considered the extension worker uninterested due to infrequent visits. Indeed, not all farmers were visited by the extension agent after the training. In October, only 14 of those interviewed stated visits had occurred.

6. Conclusion

The pilot served successfully its two main goals: providing preliminary evidence on the efficacy of experimentation, and supporting the choice of one technique for the full-scale RCT.

Direct experimentation was successful in promoting technology utuilization and intent to adopt. All farmers who implemented the demos were, at the end of the pilot, using the techniques learnt in their own machambas outside of their demo plots. Only one of the three non-experimenting farmers was doing so. One non-experimenting farmer (out of three) did not intend to use the practices in future agricultural campaigns either. Intent to adopt the new technologies in the next agricultural season has been full among experimenters; yet, future follow-up surveys would be necessary to confirm techniques remained in use. Often initial adoption is high, but drops in subsequent seasons. Recent requests for detailed technology manuals corroborate intent to use and warrant (cautious) optimism.

Information spread fast in the community: some farmers who had not been trained took it upon themselves to experiment with the techniques during the 6 months of the programme. Farmers were, at the end, unanimous about the technologies being superior to conventional practices.

Based on comments from participants, planned interventions for the RCT seem, likewise, promising. Farmer requests were perfectly in accordance with suggested interventions: more support, specifically, additional supervision, follow-up visits and discussion throughout the experiment. How cost-effective they will be can only be stipulated through the full-scale RCT, yet this pilot has established there is local interest in these specific initiatives.

The choice of technology must be based both on data from the agronomic experiment and from farmer surveys. The extension demo showed the OPV seeds, the hybrid seeds and the pit planting to be the only substantially yield-improving techniques. Their estimated effect on yield per plot was 0.7 kg, 0.6 kg and 0.52-0.55 kg respectively. Farmer assessment of performance, nevertheless, differed considerably. The hybrid seeds were the clear favourites, with pit planting and mulching second, while the OPV seeds were not favoured by participants. This was not a question of judgement but an actual discrepancy in performance: in the farmers' demo plots, for more than half of farmers, the OPV seeds did not grow. The seeds used by the extension agent and farmers were of the same origin. However, the severe drought impacted the machambas disproportionally, since many of them lacked the necessary water supply.

Even if the situation is mostly dry-season specific, it is possible that local farmers have at least partly internalised OPV seeds as worse-performing. Moreover, the

OPV seeds were not able to endure drought as well as the hybrid seeds or pit planting. Water supply concerns might persist in high-ground land even during the main season. Considering the gain in yield is not insurmountable, the choice of OPV seeds might be ill-advised. The hybrid seeds also mature earlier, which farmers in similar studies in nearby Malawi have welcomed (Lilongwe, 2009). Hybrid seeds are deemed the best choice and the easiest technology to implement by most farmers.

Cost-effectiveness and implementation difficulty must also be considered. The price of both improved seeds is comparable, with one kg costing between 125 and 150 MZN. This added cost could easily be overridden through the added output. Yet, access to improved seeds remains a problem in Molumbo. The varieties tested can only be bought in the nearby cities of Gurué and Milange. In contrast, local seeds can be recycled from season to season. An added concern is the growing market of falsified seeds from Malawi. While in the programme, improved seeds appeared cheap and easy to implement to farmers, the question remains whether the incentive to obtain the seeds will be strong enough after experimentation. Moreover, dependency on only a few suppliers and on a generally underdeveloped market can threaten future food security. (Suri, 2011) has shown these factors to be determinant in the decision to ultimately adopt hybrid seeds: even with high gross returns, many farmers still derive a net loss from using the seeds due to market constraints. Sustained use will thus hinge largely on factors beyond the effect of interventions. Only if reasonable access to seed is insured will the interventions contribute to income gains.

Pit planting is alongside the hybrid seeds a possibly viable choice. The technique carries costs due to its labour intensity and possibly added need for weeding. Even so, as agricultural seasons go by, the process becomes substantially less time-consuming - not only from farmer experience but specifically because excavations are conducted in the same location. Land preparation time has been shown to fall by 50% in 5 years (Haggblade & Tembo (2003)). Contrary to expectations pit planting has been suggested to be less time-consuming than ridging, the standard practice in Molumbo. BenYishay & Mobarak (2014) show a reduction in time dedicated to land preparation, and overall cost reduction when considering land preparation, planting, fertilizer application, weeding, and harvesting. Focus groups in Beaman et al (2015) signal lower weeding needs from pit planting as well. Despite implementation difficulties, most farmers still classified pit planting very positively, only second to the hybrid seeds. Experimentation already played a role: high experimentation farmers were more positive about the practice. Considering time requirements will decrease in subsequent seasons and particularly the technology's potential to ensure food security, regardless of market conditions, pit planting remains a suitable option.

7. Further Considerations for the RCT

Implementing the pilot study in the second season had the drawback that farmers, in general, had limited land to dedicate to the demos. Also, differences in agroclimatic conditions between the dry and the main season affected the absolute performance of technologies, and, most likely, their relative performance. Relative gains of the different technologies might not be as substantial during the main season.

Farmer demo plots require substantial supervision and monitoring to be successfully implemented. Because farmers have many competing interests and needs, training the farmers and getting a verbal commitment to implement the demos might not be enough to achieve high participation. Farmers who receive inputs may see it as more profitable to use them in their normal fields instead of the demos, for example. To promote participation and reduce input misuse the training ought to be implemented in three steps. First, farmers receive a group training. Second, the extension agent visits farmers to verify the demo has been set up correctly and to recommend corrections. Third, farmers receive the inputs and use them in the presence of the extension agent.

If pit planting is the final choice, an incentive might be advised to increase participation. The main criticism to the technique from farmers was its labour-intensity and the absence of cost subsidies. The concern about possible subsidy-dependence is minimized: pit planting becomes easier and less time consuming each agricultural season. In similar studies, a bag of seeds was shown to be an effective incentive, boosting farmer interest in learning and in disseminating information (see BenYishay & Mobarak (2014)). Such input was in place during the pilot and likely boosted participation in the training sessions. Another study, Beaman et al (2015), established seeds as a subsidy for pit planting in the first of three years and was ultimately successful in promoting pit planting adoption.

Several farmers were enthusiastic about the interventions and the experiment, and stressed the importance of sharing the information with surrounding communities. Peer-to-peer communication and social networks have been shown to play a role in farming technology adoption. If possible, pilot participants could be part of initial awareness campaigns, aimed at increasing potential RCT participation, or also of training sessions. Similarity of disseminators of information and targets builds trust and can promote implementation.

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8. Annex

8.1. Extension Demo

Table 8.1 – Average Leaf Width per Plant

	REML Kenward-Roger			**POLS White Std. Errors**			**Random Effects/POLS**		
	Coef.	SE	p	Coef.	SE	P (t)	Coef.	SE	P (t)
T1	0.520	0.448	0.246	0.545	0.409	0.186	0.545	0.448	0.227
T2	0.702	0.438	0.109	0.742	0.401	**0.068**	0.742	0.439	**0.094**
T4	0.398	0.495	0.422	0.423	0.538	0.434	0.423	0.488	0.388
T5	1.024	0.457	**0.025**	1.039	0.451	**0.024**	1.039	0.453	**0.024**
T6	1.469	0.497	**0.003**	1.546	0.496	**0.002**	1.546	0.498	**0.003**
Control	4.744	0.366	0	4.718	0.324	0	4.718	0.345	0
VAR (Block)	0.0542	0.0989							
VAR (Resid.)	1.5066	0.2284							
Chi-square	0.63								
P-value	0.2139								

8.2. Farmer Characterisation

Table 8.2 – Summary Statistics in Low and High Experimentation Groups

	AUGUST								OCTOBER							
	LOW EXPERIMENTATION				HIGH EXPERIMENTATION				LOW EXPERIMENTATION				HIGH EXPERIMENTATION			
	OBS.	mean	min	max	OBS.	mean	min	max	OBS.	mean	min	max	OBS.	mean	min	max
MALE FARMERS	8	5 (#)	-	-	17	12 (#)	-	-	5	4(#)	-	-	17	11(#)	-	-
AGE	3	55.33	38	66	6	50.67	35	65	1	66	66	66	6	46.5	24	65
YEARS IN POVOADO	3	21.67	7	38	6	17.83	5	47	1	20	20	20	6	25.33	12	47
YEARS FARMING	3	19.33	5	35	6	22.5	9	45	1	5	5	5	6	24	13	45
HOUSEHOLD SIZE (#)	8	6.375	4	8	18	5.777	1	10	6	4.83	1	7	18	6.83	3	20
OTHER INCOME	8	3 (#)	-	-	16	5 (#)	-	-	6	0 (#)	-	-	13	5 (#)	-	-
AGRIC. INCOME	6	30383.3	300	50000	14	32785.7	2000	75000	-	-	-	-	-	-	-	-
AGRIC. INCOME PER HH MEMBER	6	5384.2	375	10000	14	6777.1	200	18750	-	-	-	-	-	-	-	-
NO. OF MACHAMBAS (USUALLY)	8	2.875	2	5	18	2.72	1	5	6	2.33	1	4	16	3.8125	1	7
NO. OF MACHAMBAS (CURRENT)	8	2.625	1	5	16	1.94	1	5	6	2.17	1	4	17	3	1	5

Summary Statistics. Number of observations conditioned by non-response. Male farmers and other income variables state how many individuals are male and have other income besides agriculture. Agric. Income represents agricultural income per campaign, in MZN. Agric. Income per HH member signifies agriculture income per household member per campaign. No. of machambas (usually) states how many machambas are typically cultivated by the farmer surveyed. No. of machambas (current) reflects machambas under use during the season when the pilot took place.

Table 8.3 – Tests of Differences Between Low-Experimentation and High Experimentation Farmers

	August		October	
	Stat.	**p-value**	**Stat.**	**p-value**
GENDER	-	1	-	1
AGE	0.775	0.5476	1.5	0.2857
YEARS IN POVOADO	0.519	0.667	0	1
YEARS FARMING	-0.525	0.7143	-1.528	0.2857
HOUSEHOLD SIZE	0.787	0.4311	-1.078	0.281
OTHER INCOME SOURCE	-	1	-	0.28
AGRIC. INCOME	0	1	-	-
AGRIC. INCOME PER HH MEMBER	-0.454	0.6498	-	-
NO. OF MACHAMBAS (USUALLY)	0.404	0.6861	-1.812	0.07*
NO. OF MACHAMBAS (CURRENT)	1.322	0.1861	-1.014	0.3104
EDUCATION LEVEL	-1.258	0.2083	-1.056	0.2907
MACHAMBA OWNERSHIP	-	0.060*	-	0.738

Two-sided tests for the null hypothesis Variable X is equally distributed in low-experimentation farmers and in high-experimentation farmers. Binary variables and categorical variables assessed through Fisher's exact test. Remaining variables assessed through Mann-Whitney U-test, with asymptotic p-values when the number of farmers in one of the groups exceeds 10. Information on sample size present in Table 8.2

Table 8.4 - Education Level per Experimentatio level

	AUGUST		OCTOBER	
	LOW	HIGH	LOW	HIGH
0	1	2	0	2
1-4	5	5	3	4
5-6	1	6	2	4
7-9	0	4	1	5
10-12	1	2	0	3
TOTAL	8	19	6	18

Education level of surveyed farmers. 0: no formal schooling; 1-4: 1st to 4th grade. 5-6: 5th and 6th grade. 7-9: 7th to 9th grade. 10-12: 10th to 12th grade.

Table 8.5 – Machamba Ownership per Experimentation level

	AUGUST		OCTOBER	
	LOW	HIGH	LOW	HIGH
Respondent	3	15	2	8
Family	5	3	4	8
Rented	0	0	0	1
TOTAL	8	18	6	18

Education level of surveyed farmers. 0: no formal schooling; 1-4: 1st to 4th grade. 5-6: 5th and 6th grade. 7-9: 7th to 9th grade. 10-12: 10th to 12th grade.

8.3. Technology Assessment

8.3.1. Not considering Experimentation Effects

Table 8.6 - Best Choice (Farmer Assessment)

	AUGUST	OCTOBER
T1	9	10
T2	1	2
T3 (CONTROL)	0	0
T4	8	3
T5	6	6
TOTAL	24	21

Farmer's Answers to "If you had to tell us only ONE technique that we can show to other farmers in the regions, which one would you say is the best (taking into account all factors)?"

Table 8.7 - Hardest Technology to Implement (Farmer Assessment)

	AUGUST	OCTOBER
T1	0	3
T2	2	3
T3 (CONTROL)	3	3
T4	6	5
T5	13	7
TOTAL	24	21

Farmer's Answers to " Which of the techniques if you had to choose ONE you would say is the most hardest to implement by yourself?"

Table 8.8 - Most Expensive Technology (Farmer Assessment)

	AUGUST		OCTOBER	
T1	2	9.1%	2	9.1%
T2	1	4.5%	3	13.6%
T3 (CONTROL)	2	9.1%	2	9.1%
T4	5	22.7%	4	18.2%
T5	12	54.5%	11	50.0%
TOTAL	22		22	

Farmer's Answers to " Which of the techniques if you had to choose ONE you would say is the most expensive to implement by yourself?"

Fig. 8.1 – Classification of Technologies in August (Farmer Assessment)

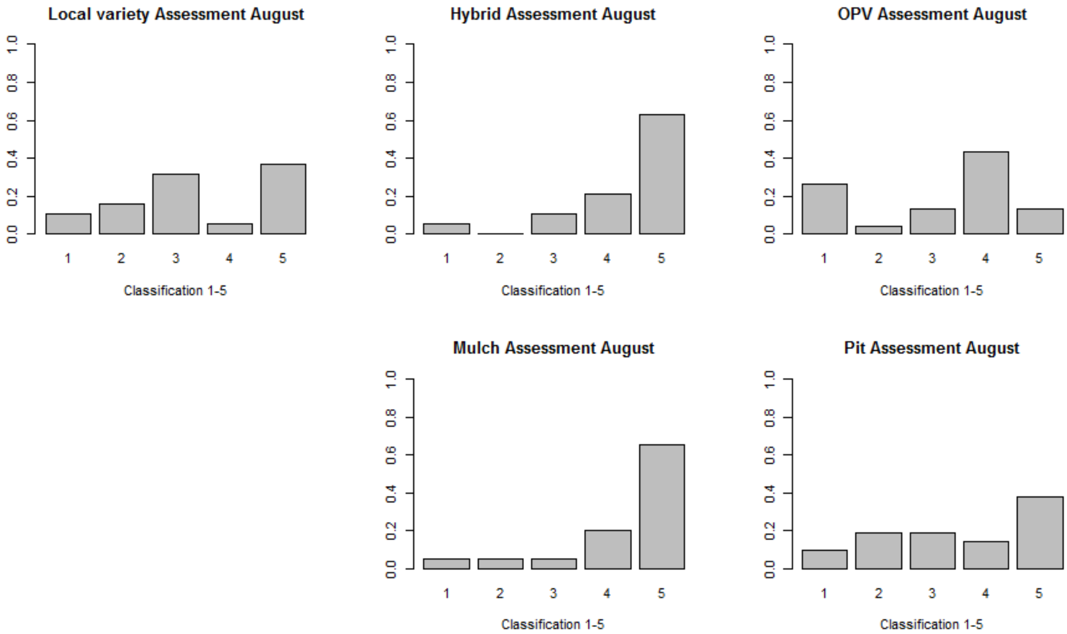
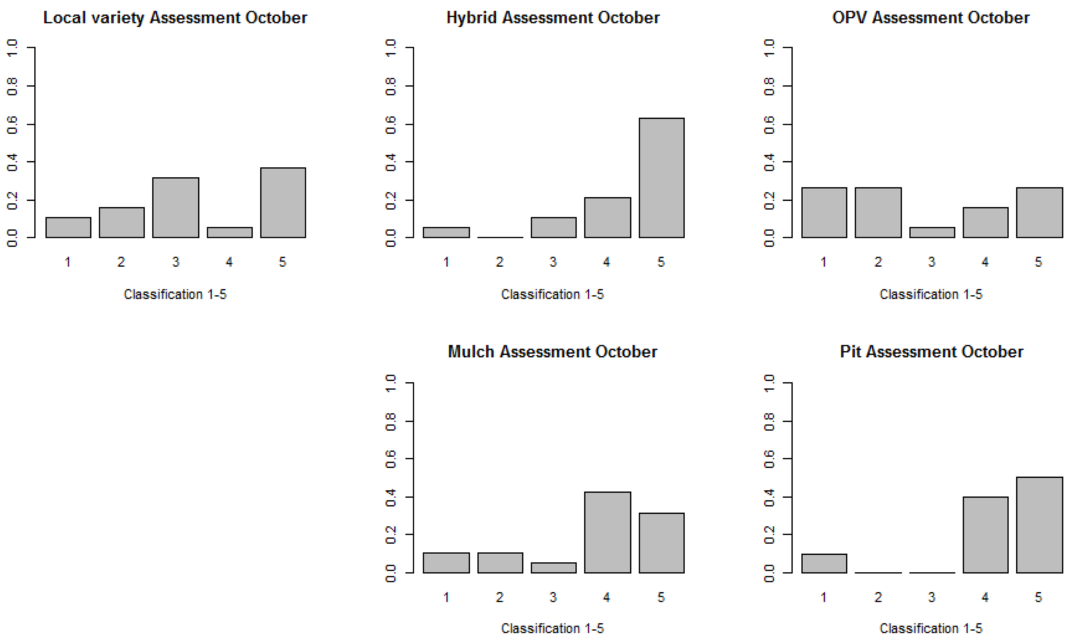


Fig. 8.2 – Classification of Technologies in October (Farmer Assessment)



8.3.2. Considering Experimentation Effects

Figure 8.3 – Farmer Assessment of Worst Choice for future programmes per Experimentation Level

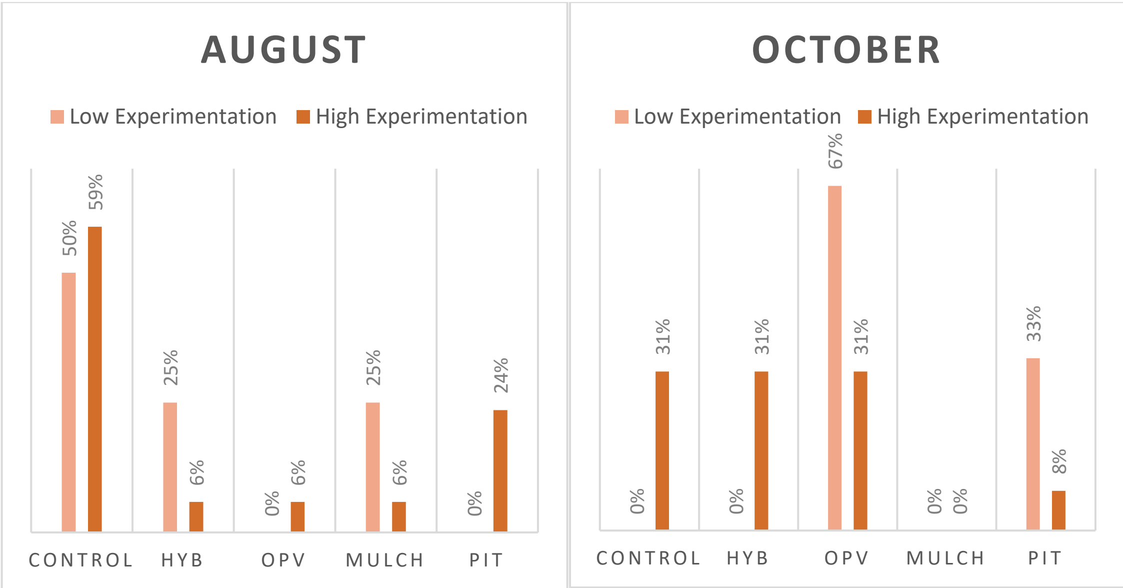


Figure 8.4 – Farmer Opinion on the technique easiest to implement by themselves per Experimentation Level

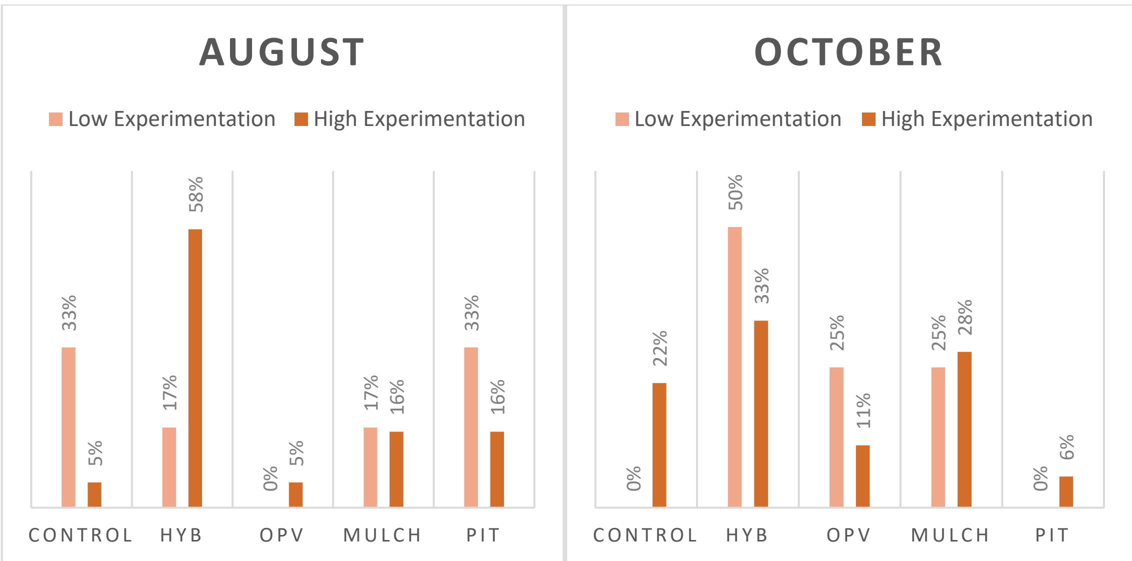


Figure 8.5 – Farmer Opinion on the technique cheapest to implement by themselves per Experimentation Level

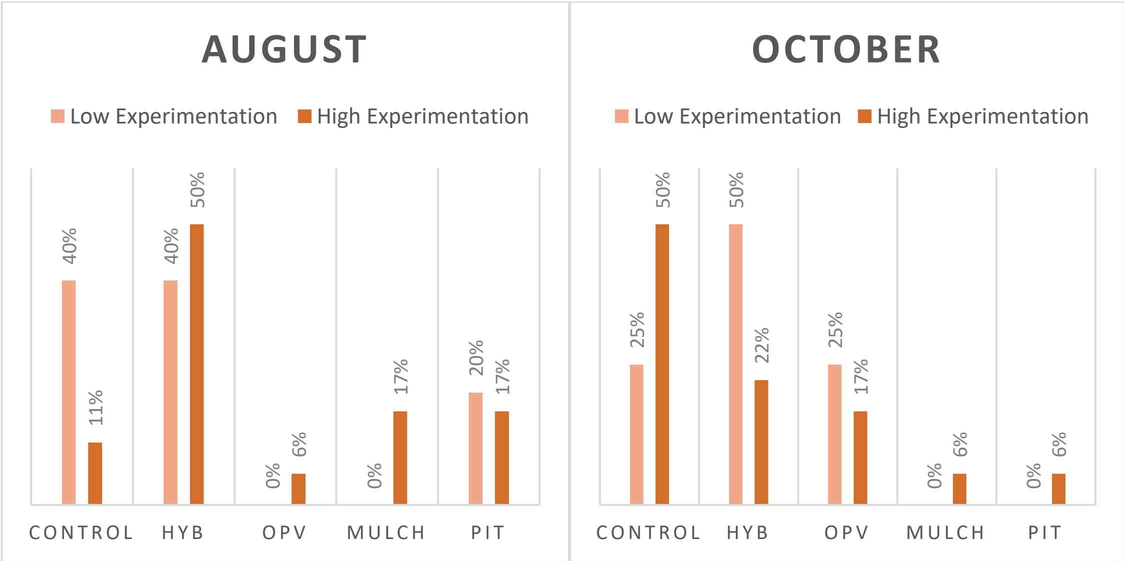
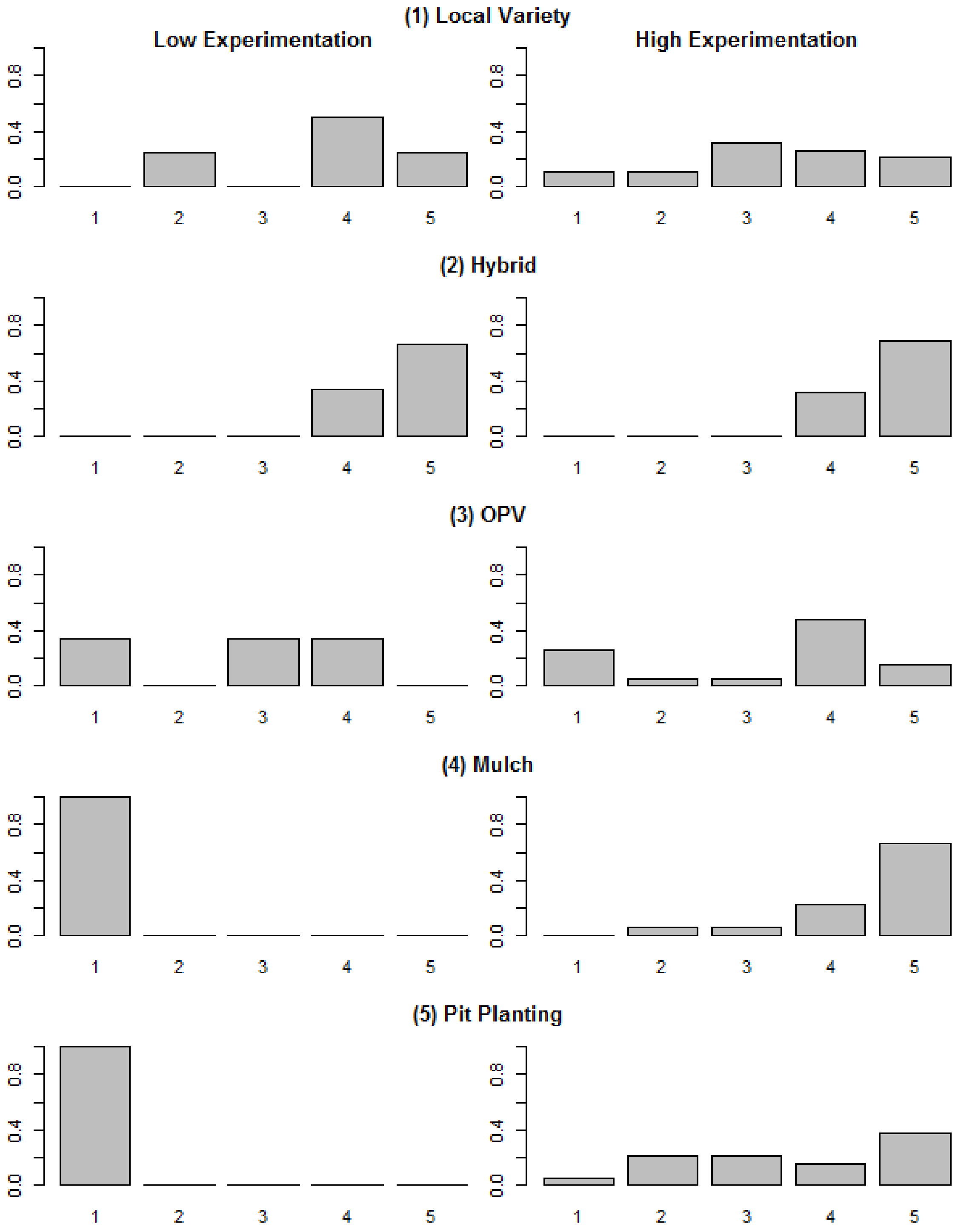


Figure 8.6 – Classification of Technologies (1-5) in August (Farmer Assessment)



8.4. Organisation Assessment

Fig. 8.7 – Classification of Extension Worker and Project Coordinator (Farmer Assessment)