

Knowledge heterogeneity: experimental evidence on information barriers to oil seed adoption in Uganda

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Note to readers

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Executive summary

Barriers to commercial farming are probably the most significant frictions to agricultural development in Africa. Moreover, improving agricultural productivity is the most effective way to improving living standards of the poor given their significant dependence on (subsistence) agriculture and the larger productivity gaps between agriculture and other sectors.

The Government of Uganda is committed to vegetable oil development in order to promote a competitive, profitable and sustainable agricultural sector as the basis for job creation, export development and provision of improved livelihoods for the rural population. For this purpose, IFAD supported two phases of the Vegetable Oil Development Project (VODP), joint with local public-private partnership. The first round of Vegetable Oil Development Project (VODP1) was conceived in the mid-1990s and was approved in April 1997 with the aim to reduce Uganda's heavy reliance on imports of vegetable oil, despite good potential for domestic production, and to address the low intake of vegetable oils by the population. VODP1 supports vegetable oil production as well as agro-processing and marketing and is an important thrust in Government's efforts to modernize and commercialize agriculture. The project is highly innovative inasmuch as it introduced a new crop (oil palm) to Uganda and a new form of public-private partnership (PPP). VODP1 has addressed rural poverty by involving smallholder farmers in crop production and small-scale processing, in improving the nutrition of the population through increased consumption of vegetable oil, and improving food security through the growing of alternative cash crops for income generation. Several lessons have been learned from phase 1 and have guided the design of phase 2. Among several factors, it is worth mentioning the important benefits from private-public partnerships (PPP), the crucial role of gradual, bottom-up and flexible capacity-building process in order to affect small-farmers behaviour and actions. The second phase of VODP (VODP2) builds on VODP1 and maintain the two components related to oilseeds and oil palm. The current report focuses only of the former. The oilseeds component of VODP2 has been targeted to reach 136,000 smallholder households in four Uganda macro-regions or agro-industrial hubs, namely West Nile Hub, Gulu Hub, Lira Hub, Eastern Uganda Hub¹. The project is supplied by private providers in different areas and includes both technical services for increased oilseed production and market information (i.e. training about farming as a business, business-oriented group development, marketing). The ultimate goal of the intervention was to contribute to sustainable poverty reduction in rural Uganda regions. The project is innovative inasmuch as it introduced a new form of value-chain approach and boosted the transformation of subsistence farming to commercial agricultural within a competitive market.

In our research study we carry out an impact assessment of the VODP2 extension model on oilseed adoption, farm output, productivity and well-being. We do so by designing a

1 The Lira hubs includes the following districts: Apac, Dokolo, Katakwi, Oyam, Masindi, Serere, Soroti, Kaberamaido, Amuria and Amolatar. The Eastern Uganda hub includes: Mbale, Bududa, Budaka, Bukedea, Bukwo, Kapchorwa, Kamuli, Kumi, Manafwa, Pallisa, Sironko, Bugiri, Busia, Tororo, Butaleja, Iganga, Jinja, Namutumba and Kaliro. The Gulu hub includes: Gulu, Kitgum, Amuru, Adjumani and Pader. The West Nile hub includes Arua, Koboko, Maracha, Moyo, Nebbi, Nyadri, Terego and Yumbe.

randomized control trial and exploiting the phase-in slant of VODP2 and roll-out over time of activities in different areas. By using a random assignment estimation strategy (intention to treatment effect) we find that VODP2 has a positive and significant effects on immediate outcomes, such as farmers' price and yield expectations, vegetable oil seeds adoption and input use. We find more mixed results on intermediate outcomes in terms of productivity and revenue. We do find, though, positive effects on market access (group sale) and value-chain involvement. We find very little effect on final wellbeing outcomes. These effects are consistent in delivering a picture of VODP2 effectiveness in fostering commercial farming, productivity and market engagement. The lesson learned is not distrustful, but it provides a sound basis for further need of medium-term efforts in order to develop a sustainable and profitable vegetable oil subsector, which is able to eventually increase household income and well-being.

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Abbreviations and acronyms

| | |
|---------|--|
| CRDI | Community Resource Development Initiative |
| CSPro | Census and Survey Processing System |
| DRC | Democratic Republic of the Congo |
| EPSEDEC | Eastern Private Sector Development Centre |
| FWER | Family-wise Error Rate |
| GoU | Government of Uganda |
| IA | Implementing Agency |
| IFAD | International Fund for Agricultural Development |
| IIRR | International Institute of Rural Reconstruction |
| IRBs | Institutional review board |
| ITT | Intention to treatment |
| MAAIF | Ministry of Agriculture, Animal Industry and Fisheries |
| PCA | Principal Component Analysis |
| PMU | Project Management Unit |
| PPP | Public Private Partnerships |
| VODP | Vegetable Oil Development Project |
| VODP2 | Vegetable Oil Development Project Phase II |
| VSLA | <i>Village</i> Saving and Loan Association |

Introduction

The Vegetable Oil Development Project-Phase 2 (VODP2), cofounded by IFAD, aims at promoting and consolidating oil seeds value chains in Eastern and Northern Uganda. The project intervention is motivated by national consumption of edible oils and fats being below international standards and by a rising regional demand for oilseed crops, driven by the presence of new-born transformation firms with under-capacity production. The final goal of the project, implemented by the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) of Uganda, is the promotion and consolidation of the oilseed value chain, and hence the increase of households' income and well-being in rural areas of the country. In our research, we focus on the Gulu and Eastern Hub and develop a randomized control design that entails the roll-out of project assignment across 86 clusters (sub-counties) over two years (and four seasons).

Our experimental design aims at assessing the effect of the extension services offered to farmers by private providers, which includes two main technical inputs. The first one is devoted to the promotion of new technologies and products related to oilseed value (sunflower, groundnuts, soya beans and sesame), to the enhancement of local production and agricultural productivity. The second information intervention aims at improving business-oriented activities and marketing conditions of products and promoting better integration of farmers in the oilseed value chain.

This study is related to the literature on the nature and magnitude of the frictions that slow down agricultural technology adoption. Understanding barriers to farm households' innovation behaviour is a critical step towards formulating policies that foster the agricultural sector development in Africa. In principle, potential gains from using micro-level studies in identifying the drivers of technology adoption or its barriers are significant. These include a cleaner identification (especially through randomized control trial studies) and the possibility to explore group specific effects. The existing work has studied the adoption of high yield and genetically modified seeds (Bandeira and Rasul, 2006, Aldana et al., 2012, Liu, 2013, Gine and Yang, 2009), trees (Oliva et al., forthcoming) and fertilizers (Duflo, Kremer and Robinson, 2011). These papers have mostly focused on exploring the importance of informational frictions, risk aversion and access to credit as sources of barriers to the adoption of simple farm technologies by small agricultural firms (often households). Other studies have focused on social learning showing, for example, that farmers only adopt technologies when they know how to use them effectively, and this knowledge, once acquired, is never lost (Foster and Rosenzweig 1995, Jovanovic and Nyarko 1996). On the other hand, though, the learning model is not well equipped to explain why adoption is not sustained beyond initial experimentation. It may be the case that information is underprovided, but it is also possible that observable (access to roads and markets, agro-geological conditions, weather) and unobservable farmer characteristics (skills, knowledge, preferences) make the decision to adopt new crops efficient for some farmers and inefficient for others (Suri, 2011). Despite the fact that extension service and market information programmes have been implemented since decades in many countries (Feder et al., 1985, Evenson 2001), very few works seek to evaluate such programmes with rigorous counterfactual analysis (Ashraf et al. 2009, Dercon et al. 2009, Krishnan and Patnam, 2014, Maffioli et al. 2013, Owens et al. 2003).

Our impact evaluation adds to the literature by offering rigorous evidence of the economic effects of a large-scale extension service project, whose focus is on developing a competitive oilseeds value-chain by concentrating on smallholder producers and market hubs. The project is expected to have impact through a chain of changes, which we group in three main categories of outcomes: immediate, intermediate and final outcomes. Hence, we test the treatment effects on farmers' expectations, input use and oilseed adoption (immediate outcomes), on productivity, market access

and revenues (intermediate outcomes) and household income and well-being (final outcome). By exploiting asymmetries in oilseed crops covered by the extension service provision in different groups, we investigate the possible differential role of the treatment across different crops. This allows the test for the possibility that treatment effects are asymmetric across crops, underlying different technological gaps. For example, sunflower is largely grown for sale and requires slightly higher fertilizer quantities while groundnuts, sesame and soybean can be grown with minimum fertilizer quantities and can also be consumed directly by the household as well as be sold. This heterogeneity in crop attributes may influence farmer's adoption decisions differently.

In addition, by taking advantage of the exogeneity introduced by the random treatment assignment, we explore the heterogeneous effect of technology adoption across different dimensions, which may be relevant for learning and productivity, i.e. familiarity with oilseeds, gender, land size cultivated and wealth.

Under random assignment of the treatment, we run a set of linear specifications which deliver unbiased estimates of the treatment effect on immediate, intermediate and final outcomes. Overall, we find positive and significant effects on immediate outcomes, mixed results for intermediate outcomes (e.g. positive results on market access), and very imprecisely estimated effects on final outcomes.

We find positive and significant results of the treatment effects on average quantity and price expectations and negative and significant results on errors on price expectations with respect to real price retail, suggesting a short-run significant change in farmers' behaviour upon the VODP2 administration. We further find a positive and significant impact of the treatment on both oilseed adoption (extensive margin) and the share of land devoted to that seed (intensive margin). This holds on average for any crop and the latter effect is driven mainly by groundnut and soybean adoption. This is consistent with both more familiarity of farmers with groundnut and soybean than sunflower and sesame (as confirmed by baseline adoption rates) and with more (technical) difficulties in growing some crops such as sunflower. As far as input and farming techniques use are concerned, we find little impact on the latter while we do find significant changes in farm inputs, such as the employment of fertilizers and improved seeds.

By looking at intermediate outcomes, we find little effects on both productivity and revenues, while we find a positive and significant treatment effect on both bulk/group sale of oilseed harvest and farmers' inclusion in the oilseed value-chain (especially for groundnut).

For what concerns final outcomes are concerned, we find very imprecise estimated impact on either household income or wealth. This is not surprising as we are estimating short-run effects of VODP2 farming activities, which may require a longer period of time to translate into higher income and wellbeing.

Overall, we find that there is a relative homogeneity of the treatment effects discussed above across some relevant farming dimensions such as oilseeds familiarity, gender, land size and wealth.

Information generated by our study point to the general effects of the extension project in Uganda. Yet, extra efforts are needed to fully achieve medium- and long-term goals.

The report fully addresses the research questions presented in the Pre-Analysis Plan (PAP), which is included in Annex 2, submitted to 3ie.

The rest of the report unfolds as follows. Section 2 presents the project intervention, theory of change and hypotheses to be tested. Section 3 describes the context, Section 4 shows the timeline, Section

5 describes the evaluation design, data collection and identification strategy. In Section 5 we report descriptive statistics and empirical findings. Section 6 discusses challenges and lessons, and Section 7 concludes.

Intervention, theory of change and research hypothesis

1.1. Intervention description

The second phase of the Vegetable Oil Development Project (VODP2) builds upon the work of its predecessor VODP and use the *value-chain development approach* to promote and consolidate (i) traditional oilseeds (sunflower, soybean, groundnuts and sesame) in eastern and northern Uganda and (ii) oil palm production in Kalangala and Buvuma Islands.

The project is funded by Government of Uganda (GoU), IFAD and private actors with contribution of farmers following public-private partnership arrangement. VODP2 was approved by IFAD's Executive Board in April 2010 and by the Parliament of Uganda on 29 September 2010. The Government signed the loan agreement in Rome on 21 October 2010.

The oilseeds component of VODP2 aims to reach 136,000 smallholder households in four areas within Uganda. The overall goal of the intervention is to contribute to sustainable poverty reduction in the project areas. The development objective is to increase the national production of vegetable oil and its by-products, thus raising rural incomes for smallholder producers and ensuring the supply of affordable vegetable oil products in Ugandan consumer and neighbouring regional market.

Under VODP2 the focus is on developing a competitive oilseeds value chain by concentrating in the hubs and by enhancing smallholder producers' productivity to meet the expanding needs for crushable seeds. Specific objectives are:

- promotion of sunflower, soybean, sesame and groundnuts production;
- improved nutrition, utilization and consumption of locally produced vegetable oil;
- introduction of conservation agriculture for oilseeds production;
- improved capacity of the target group farmers to make informed decisions.

The VODP2 extension service intervention is supplied by private service providers and include the following three components: technical services for increased oilseed production/productivity; group formation and strengthening; market linkages and access.

The research has been realized in areas covered by three service providers contracted by VODP2 to deliver the project, with which the research team interacted during the study period. The providers are:

- Community Resource Development Initiative (CRDI) active in the Eastern Hub
- Eastern Private Sector Development Centre (EPSEDEC) Eastern Private Sector Development Centre (EPSEDEC) active in the Eastern Hub
- International Institute of Rural Reconstruction (IIRR) active in the Gulu Hub

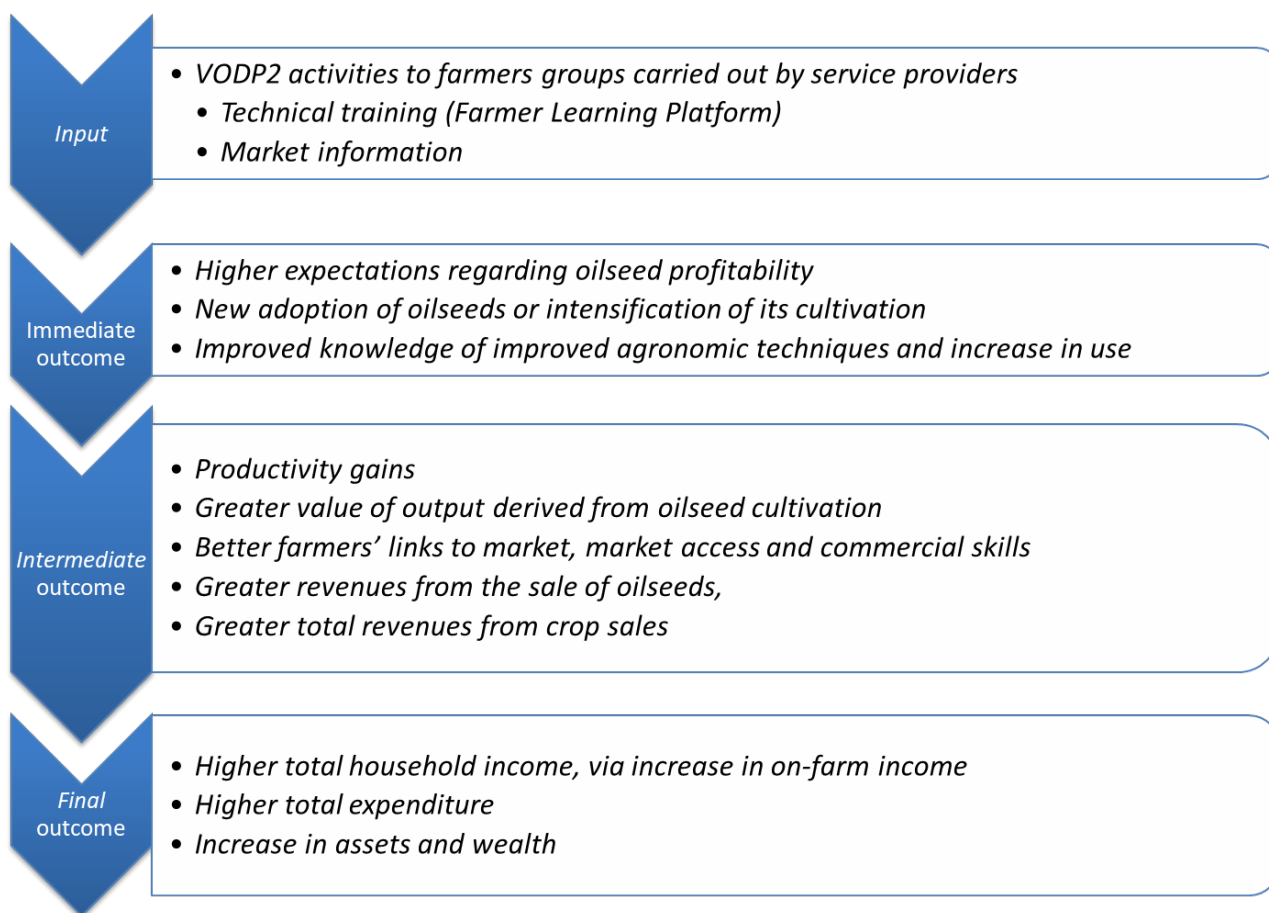
This impact evaluation is primarily aimed at testing the project's main objectives as reported above. In particular, the project is expected to have impact through a chain of changes which we group in

three main categories of outcomes: immediate, intermediate and final outcomes (more details are provided below).

1.2. Theory of change

A chart of the theory of change is showed in Figure 2.

Figure 1: Theory of change



A thorough discussion of its components and underlying assumptions is provided in section 4.1.

Context

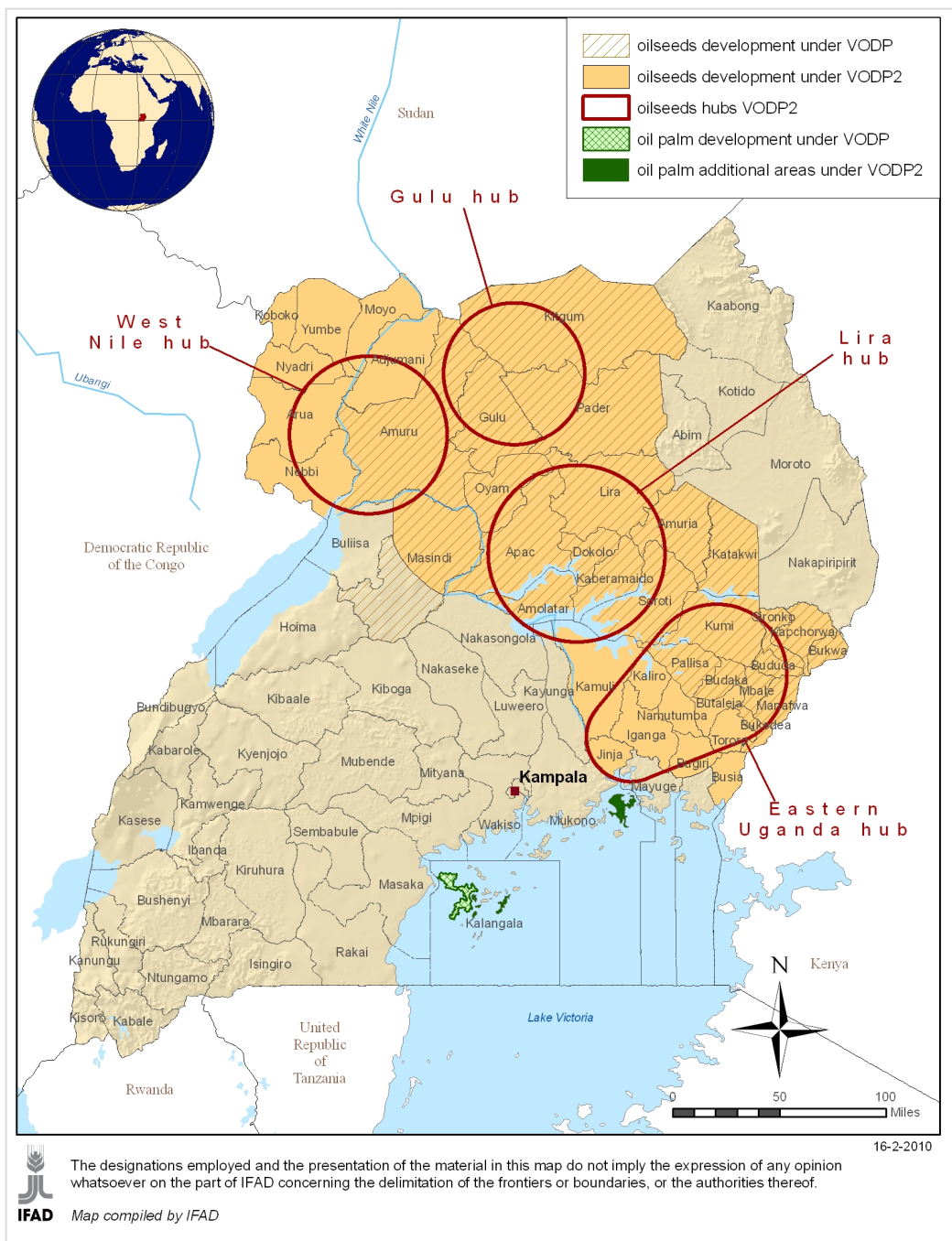
Based on lessons learned from VODP, activities of VODP2 are concentrated in four hubs, including the Lira hub and the emerging Mbale-Jinja hub as well as the new West Nile and Gulu hubs, where there are good prospects for attracting additional private investment in oilseed milling capacity. Figure 1 shows the areas involved by VODP2 project.

The study focuses on two out of the four hubs, namely Mbale-Jinja and Gulu. In particular, we purposely excluded the Lira hub, as it has been the first to start and develop a modern oilseed sector in the history of Uganda, hence presents very different initial conditions and was expected to respond very differently to the project with respect to the other hubs. The other excluded hub is the West Nile, in the areas of Arua, at the border with DRC. The reasons for such exclusion lie in the fact that West Nile and Gulu hubs are very similar under multiple aspects (population, soil, climate, oilseed sector and market development, etc.), hence its inclusion did not appear a cost-effective option. As such,

the study site is a good representation of the project areas at an earlier stage of oilseed sector development.

Given the specific focus of the project on farmer groups interested in the oilseed production, the project population, as well as the study sample, cannot be considered representative of the general rural population. In particular, two endogenous selection processes contribute to the definition of the sample: participation into farmer groups and interest into oilseed production, the latter two being the main eligibility criteria of the project. Our study did not include ineligible farmers, we are thus unable to document neither selection processes. This represent the main impediment to the generalization of our results to the wider population of Ugandan farmers.

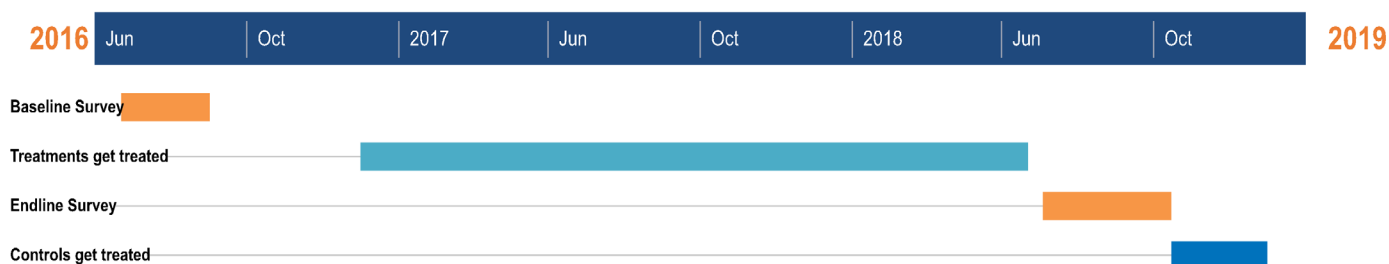
Figure 2: The Republic of Uganda: areas covered by VODP2



Timeline

The figure below depicts the timeline of the study.

Figure 3: Timeline of the study



Evaluation: design, methods and implementation

1.3. Evaluation questions

We divided the research questions into three main blocks, relating to different nodes of the theory of change. In particular, we investigate immediate, intermediate and final outcomes, as well as some key dimensions of heterogeneity.

We expect that the **immediate behavioural changes** resulting from the project interventions include a change in farmers' expectations concerning the opportunity to cultivate oilseeds, the adoption of oilseeds (both traditional and improved varieties), the adoption of recommended agronomic practices in general and for oilseeds in particular, an increased market participation of farmers.

The key assumptions underlying the realization of immediate impacts can be summarized as follows: (i) information on available improved oil seed technologies, best agronomic practices and available marketing opportunities are properly, effectively and adequately disseminated; (ii) the contents of the intervention and the benefits deriving from oilseed adoption, agricultural best practices and better links to market are understood by beneficiaries.

The following hypothesis will be tested:

- 1.1) the intervention will lead to higher and more accurate expectations regarding oilseed profitability
- 1.2) the intervention (and higher expectations) will lead to new adoption of oilseeds or intensification of its cultivation
- 1.3) the intervention will improve the knowledge of improved agronomic techniques and will lead to an increase in their actual use. This will be observed not only for oilseeds, but also for other crops

Intermediate development outcomes reflect changes in the agricultural production and farmers' market participation, eventually leading to greater value of output and revenues from crop sales. Such changes rely on the occurrence of the following hypothesis:

- 2.1) the intervention (and realization of immediate outcomes) will lead to productivity gains
- 2.2) the intervention (realization of immediate outcomes and productivity gains) will lead to greater value of output derived from oilseed cultivation
- 2.3) the intervention will improve farmers' links to market. This will lead to the improvement of market access and commercial skills
- 2.4) the intervention (realization of immediate outcomes, productivity gains) will lead to greater revenues from the sale of oilseeds, eventually leading to greater total revenues from crop sales.

As for **final outcomes**, we expect that the realization of the intermediate outcomes will impact the sphere of household well-being in the dimensions of income, consumption, asset and wealth. In this regard, the following hypothesis will be tested:

- 3.1) the intervention (and realization of previous outcomes) will lead to higher total household income, via increase in on-farm income
- 3.2) the intervention (and realization of previous outcomes) will lead to higher total expenditure (food, non-food and durables)
- 3.3) the intervention (and realization of previous outcomes) will lead to increase in assets and wealth.

A secondary set of hypotheses are related to the extent to which project impacts are expected to vary along different **dimensions of heterogeneity**, measured at the baseline, and sub-groups; the latter are presented below:

- a) farmers' initial level of familiarity with agronomic techniques and with oilseed cultivation lead to differential impacts of project activities. In particular, under the assumption of diminishing (accelerating) returns to learning, bigger impacts should be observed for less (more) knowledgeable farmers and for those who never (already) experienced oilseeds
- b) the decision over the choice of oilseed(s) to be cultivated should be the outcome of a rational process involving the service provider, the farmer group and the individual farmer, considering factors related to the suitability of the different oilseeds to the local geographical and market characteristics. On average, successful implementation of any oilseed (or a combination of them) should bear similar impacts on intermediate and final outcomes
- c) the decision to adopt/intensify oilseed production requires households to either devote some new arable land not previously cultivated, or to switch the destination of some land which was previously cultivated with other crops. We believe that the decision may be easier for households with larger farm size, therefore with more available land
- d) the decision to adopt/intensify oilseed production also requires households to invest both in cash and in-kind inputs. For example, the purchase of seeds, particularly improved ones, require some initial capital. The same applies if one wants to introduce improved productive inputs such as fertilizers and pesticides. Liquidity constraints can represent a strong barrier

to innovation. Therefore, we expect to observe higher treatment effects for wealthier farmers, i.e. in households where liquidity constraints bind less.

e) Whether and how much to grow of oilseeds depend on extant agricultural skills, farm labour inputs and opportunity costs. As long as women are comparatively disadvantaged with respect to the latter, we expect to find higher treatment effects for male farmers. On the other hand (even assuming equal opportunity costs by gender) if either the investment marginal productivity or returns to learning are higher for women, we shall observe a higher impact of information treatment on female farmers.

1.4. Evaluation design

The impact evaluation exercise exploits the roll-out structure of the VODP2 to implement a randomized controlled trial. The project intends to gradually reach the target beneficiaries, given resource constraints in reaching all districts at the same time. The level of randomization is at sub-county level, as it allows to meet activities' implementation issues with research requirements. The phase-in design involves a sample of eligible sub-counties randomly assigned to receive the treatment in different moments of time. In particular, one random group of sub-counties (treated group) is assigned to receive the entire package of project interventions during 2017/early 2018. The second group (control group) started to receive the treatment in 2018, after the endline survey administration. Both groups were administered a baseline survey between June and September 2016, before any project activities have started, and the endline survey between July and October 2018. Figure 3 depicts the timeline of the study.

Treatment assignment, i.e. the moment when the sub-counties receive the intervention, was performed after the baseline, by the research team, through a random number generator (within each district). The list was made available to the PMU and service providers; however it was not publicly communicated. This fact allows us to rule out any type of selection arising from the (in)correct application of eligibility criteria for group inclusion and sampling issues. If any mistake from group selection existed, this would not be a threat to the internal validity of the exercise, as randomization occurred at the later stage.

1.5. Power and sample size determination

Table 1 summarizes the power calculations along with sample sizes, as it was initially calculated at the design stage. The calculations are based on groundnut yield from Uganda reported by the World Bank Living Standard Measurements Surveys (LSMS). We choose groundnut because it is one of the main crops targeted by the project and for which yield information is easily accessible. Based on the parameters used in Table 1, we have enough groups (clusters) to detect a standardized effect of 0.20 at the 5 percent significance level with a statistical power of 0.80. This corresponds to 688 farmer groups in total, i.e. 344 groups per treatment arm and the control. With 4 producers per group, the sample will consist with 3440 farmers.

A minimum detectable standardized effect of 20 percent corresponds to an increase of 26 percent in groundnuts yield (from 565.3 kg/ha to 713.42 kg per ha). For instance, Menale (2010) reports a 35 percent groundnut yield increase (from 649 to 873 kilograms per hectare) when farmers adopted improved varieties. Our decision to be able to detect an increase of 26% in yield appears indeed conservative when compared to the findings of Menale (2010).

In addition, one should keep in mind that these calculations do not take into account the use of control variables that can reduce variance of the point estimates of treatment effects greatly. Finally, the randomized assignment (to treatment groups and to the control) will use blocked randomization, blocked at the sub-county level, further improving statistical inference.

Table 1: Summary of power calculations and sample size

| | Change in groundnuts yield | | | | | |
|---|----------------------------|-------|-----------|-------|-----------|-------|
| | Power (k) | | Power (k) | | Power (k) | |
| | 0.8 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 |
| Cluster size (groups per sub-county) | 8 | 8 | 8 | 8 | 8 | 8 |
| Minimum Detectable Standardized Effect | 0.100 | 0.100 | 0.200 | 0.200 | 0.300 | 0.300 |
| Intra-cluster correlation | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 |
| Significance level (α) | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 | 0.050 |
| $t(1-k) + t_{\alpha}$ | 2.500 | 2.930 | 2.500 | 2.930 | 2.500 | 2.930 |
| Minimum number of clusters (per arm) | 170 | 227 | 43 | 57 | 19 | 26 |
| Total farmer 136groups per arm | 1360 | 1816 | 344 | 456 | 152 | 208 |
| Number of farmers per arm (assuming 4 farmers per farmer group) | 5440 | 7264 | 1376 | 1824 | 608 | 832 |

In the appendix III, we compute the standardized effect size of all the outcomes considered in the report, based on the data collected at the baseline and the design described above. In particular, we use sample means, standard deviations and intra-cluster correlations from the baseline in a design with 43 clusters per treatment arm and 32 individuals per cluster (i.e. eight farmer groups per cluster and four farmers per farmer group). We also use the correlation between baseline measurements and outcome by estimating the model (1) described below on baseline values of the outcomes. Results show that standardized minimum detectable effect sizes for outcomes in the expectation domain range between 0.1 and 0.25, in the domain of oilseed adoption between 0.19 and 0.35, in the domain of technical knowledge between 0.15 and 0.18, in the domain of use of inputs between 0.12 and 0.28, in the domain of productivity between 0.11 and 0.19, farm output and revenues between 0.11 and 0.28, market linkages between 0.13 and 0.24, household well-being between 0.15 and 0.2. Overall, standard minimum detectable effect size for most outcomes are aligned to the one we set in the proposal stage, i.e. 0.2. In that, we believe our study is not underpowered.

1.6. Sampling and data

Sampling occurred at three different levels, for the selection of sub-counties, farmer groups and farmers. In what follows we describe the sampling procedures for each level.

In our study, the unit of randomization is the *sub-county* that is an intermediate administrative level (between districts and villages) with an average population of about 20,000 people (see below for more details on this). Our power calculation suggested to construct a sample of 86 sub-counties to be assigned to the treatment and control group.

The sub-county sampling strategy followed different steps and has experienced changes over the development of the project. Initially, at the beginning of 2016, the research team received a list of

130 expansion or potential expansion sub-counties from 13 districts in 2 hubs (8 districts in Eastern Uganda, 5 districts in Gulu). The eligibility criteria provided by the implementing agency (IA) in accordance with local authorities and service providers mainly included the orographic and soil characteristics of regions in relation to the development and expansion of oilseed production.

After an initial sample proposal by the research team, the list of eligible sub-counties was further reduced to 107 in 13 districts by the IA. Some sub-counties were discarded because they were deemed unsuited for growing oilseeds. Given the new list, we targeted to draw an equal number of sub-counties from each district (6 to 7). However, the number of eligible sub-counties per district varied from 3 to 19. When the number of eligible sub-counties was lower than the target number, we automatically enrolled all of them. When the number of eligible sub-counties was higher than the targeted number per district, sub-counties were randomly selected (through a random number generator). In order to meet the final target of 86 sub-counties, the number of extra sub-counties was assigned proportionally to sub-counties where there were more eligible non-selected sub-counties. Hence, a list of sampled sub-counties was shared with the IA which, in turn, disseminated it to the private service who collaborated with the field research team for the identification of farmer groups. However, after the launch of the baseline survey, service providers realized that some of the selected sub-counties in their area of action were still unsuitable to receive VODP2 activities. This was the case for 21 sub-counties. In some cases, when available, ineligible sub-counties were substituted with eligible ones in the same districts. This was not possible for all districts though. In order to cover the remaining part, two districts, with eight sub-counties each, were newly introduced.

The final distribution of sub-counties per district is reported in Table 2. We end up with the desired sample of 86 sub-counties (23 in Gulu and 63 in Eastern hub), which belong to 15 districts (5 in Gulu and 10 in the Eastern Hub). On average, 5 to 6 sub-counties per district were sampled, ranging from a max of 11 to a min of 3.

Despite of the numerous challenges and problems arising from the selection of sub-counties, the treatment assignment was stratified by district, in order to better guarantee balance between treatment and control groups. This means that in each district we have at least one sub-county per treatment arm. One should also notice that the sampling exercise was not aimed to obtain a representative sample of the broad population. The project was in fact targeted to a selected population living in areas suitable for growing oilseeds.

Table 2: Final sample of sub-counties

| Sub-counties per district | | | | | |
|---------------------------|-----------------|--------------------|-----|-----|-----|
| | N. of districts | N. of sub-counties | Avg | Min | Max |
| Gulu | 5 | 23 | 4.6 | 3 | 7 |
| Eastern Hub | 10 | 63 | 6.3 | 3 | 11 |
| Total | 15 | 86 | 5.7 | | |

The second level of sampling pertains to the selection of farmer groups, within each sub-county. Our power calculations indicated that we should sample 8 farmer groups per sub-county, for a total of 688 groups.

A list of farmer groups meeting the eligibility criteria was obtained from the service providers contracted to deliver VODP2, in collaboration with community development offices. From the list of eligible farmer groups, 8 groups per sub-county were randomly selected. Although the instructions for the random selection of groups were made clear to all stakeholders, since we could not directly oversee the process, we cannot guarantee that this was strictly implemented every time. This should not constitute a threat to our identification of impacts because the random assignment to treatment and control group was performed after the identification and surveying of farmer groups. Yet, if for

instance the selection process was biased towards most promising groups, as long as that was the case in all sub-counties it would cast doubts on the external validity of our results, but not on the internal validity.

We were finally able to successfully reach and administer the baseline survey to 690 farmer groups in 86 sub-counties. The number of farmer groups per sub-counties is always 8, but for two exceptions. Indeed, by mistake in 2 sub-counties we have data on 9 groups each.

The third level of sampling pertains to the selection of farmers within farmer groups. Our power calculations indicated that we should sample 4 farmers per groups, for a total of 2752 farmers.

Once a farmer group was selected, a meeting with the leader or a representative of the group was set up by our survey team. During the meeting, the group level questionnaire and the household level questionnaire were administered. The list of other group participants was obtained, and 3 members were randomly selected to be interviewed. In total, 688 questionnaires were administered to group leaders or representatives and 2064 to farmers; overall our sample should be made by 2752 farmers. However, we were able to collect 2733 farmer level questionnaires. Challenges during the data collection process prevented the team of enumerators from having exactly 4 observations per group. In particular, for 24 groups we administered less than 4 (in the majority of cases the number is 3) farmer questionnaires, while in 5 groups we administered more than 4 questionnaires (5 in most cases). Overall, these mistakes appear minor, as they hold for 4.2% of groups and are not likely to influence the evaluation exercise. However, we performed some formal checks for the balance of over-represented and under-represented group shares by treatment status. While we do not reject the null of equality of means for the share of over-represented groups (0.6 and 0.8% in treatment and control group, respectively, with $p\text{-value}=0.658$), we reject the null for under representation of groups at 10% confidence level (2.3% and 4.6% in treatment and control group, respectively, with $p\text{-value}=0.0997$). Such unbalance will be taken into consideration in the analysis by introducing sampling weights.

Data for the analysis come from two sources: surveys and project administrative data. While the former source is directly collected by the research field-team, the latter is provided by the VODP2 PMU and the service providers working in the study areas.

Surveys represent the main source of data and are collected at different levels: farmer and group level. Household surveys are typically administered to 3 farmer members of the same group and to the representative of the group targeted by the project. The survey collects information on general farm-household characteristics, agricultural production during the two preceding seasons, skills and performance along with several socio-economic variables. Moreover, we collect information on the characteristics of the group (such as size, composition, scope, functioning and activities regularly carried out) from the group representative through a group-level questionnaire.

Baseline data have been collected between June and September 2016 from all farmer groups, before any activity started in any sub-county included in the study. Questionnaires have been administered on paper by a team of 16 enumerators and lasted about one hour and half. One supervisor was in charge of daily checks of questionnaires in order to identify incoherencies or missing answers. In the latter cases, enumerators were requested to re-contact the respondent and amend the answers. The average duration of the questionnaire was around 1 hour. Data entry was done by 4 to 6 operators, using the software CSPro. Random checks on the quality of questionnaire were performed by one research assistant.

The endline data collection has been conducted between July and October 2018. It has been administered on paper by a team of 17 enumerators, most of whom participated to the baseline survey data collection. This helped the team locating households and tracking people. The endline

data collection followed the same procedures followed during the baseline. The questionnaire was very similar to the one administered at the baseline. In order to facilitate respondents' tracking, enumerators were provided with identification sheets including basic contact information. The survey was targeted to the same respondent interviewed at the baseline. In case of impossibility to reach the individual in two attempts, another household member knowledgeable about agricultural was interviewed as replacement. Eventually, we end up with a natural 6% attrition rate in our panel dataset.

The data quality was ensured by implementing a thorough training of the surveyors along with a rigorous and integrity-informed data collection plan. Details about the training of enumerators and data collection is reported in Appendix I.

The secondary source of data is provided by administrative data related to monitoring activities. This pertains to the timing of the launch of activities in the different sub-counties by the service providers.²

1.7. Threats to identification

The characteristics of this study are such that spillover effects, John Henry and Hawthorne effects and contamination should be avoided. First, the randomization at the level of sub-county, a relatively large administrative unit, should limit spillover effects to the minimum. Second, our evaluation exercise did not significantly interfere with the roll-out of the project and was not publicly announced. Hence, none of the groups were aware of being part of an experiment. As for contamination, although we could not perfectly monitor the actual project delivery by service providers in treated areas, we are aware of some degree of contamination (see section 5.1 for more details). However, we estimate the intention to treatment (ITT) using the assignment to the treatment season as the main explanatory variable. By doing that, the estimated effects are not biased, although are likely to represent an underestimate of the true effect. We also present local average treatment effects (LATE) to take into considerations issues related to partial compliance.

1.8. Ethics and transparency

In the absence of IRBs in the researchers' institutions, we requested a letter from the Head of the Department of Agribusiness and Resource Economics at Makerere University stating the absence of any ethics issues related to our study. We did not identify any non-medical ethical review boards, and the approach of obtaining a letter from Makerere University was decided in consultation with 3ie.

At the time of the questionnaire administration, oral consent was asked to respondents, acknowledging that their data would be anonymized, and identification of individuals made impossible by any form.

The pre-analysis plan was sent to 3ie as part of milestone deliverables and can be found in the attachments.

² The research team tried to create a unifying monitoring framework including the PMU and the three different service providers delivering the project activities. In principle the system would collect the following information for each farmer group (using the unique identifier used in the data collection): start and end dates, attendance lists of participants from the group, type of crop introduced, list of activities delivered, list of inputs provided (if any), number of visits, identifier of the training team if more than one. Unfortunately, it proved impossible to obtain constant and timely flows of reliable information from the various partners.

Programme or policy: Design, methods and implementation

1.9. Program design and implementation

The VODP2 extension service intervention is supplied by private service providers and include three following components, whose main contents are described below:

- technical services for increased oilseed production/productivity;
 - technology demonstration and farmer training on best agronomic practices
 - conservation agriculture
 - integrated soil fertility management
 - integrated pest and disease management
 - post-harvest handling and storage
 - farm power and mechanization such as use of ox-ploughs and tractors
 - complementary enterprises such as apiary and livestock
- group formation and strengthening
 - mobilization and sensitization
 - farmer group needs assessment
 - training in group dynamics and management
 - action planning
 - farmer group institutionalization through registration
- market linkages and access:
 - bulking for produce and inputs
 - market information gathering and market intelligence
 - negotiation and negotiation skills development
 - building commercial relationships with the market such as linkages with seed companies, input dealers, oilseed millers, and financial institutions

One of the main tools are Farmer Learning Platforms, a form of applied research and technology transfer system on latest notified/released varieties along with full package of practices on selected farmers' fields with a view to demonstrate the potentiality of the technologies to both attending farmers and neighbouring farmers/agencies.

Project activities are targeted to farmer groups. The latter may be already existing and active groups or they may have been created for the purpose of the project. On average groups are composed by 15-20 members, have a leader and are composed by both men and women. Farmer groups are eligible to receive the VODP2 project and to participate our study when:

- i. They have been already formed for other previous projects and have some degree of formalization (concrete constitution, registration at the level of sub-county or district city office)
- ii. They are interested in oilseed production
- iii. They have available land to implement the learning platforms
- iv. They are not currently benefiting from other development projects³

³ It should be noticed that eligibility criteria for the inclusion in the study are relatively different from the criteria for the VODP2 project. In particular, the study only includes existing farmer groups, while the project also aims at creating new farmer groups. The research team decided to focus on already existent groups only for the following reasons: first, starting a new group is part of the project activities and requires the activation of resources from the service providers, which we

No incentive was provided to participants.

1.10. Monitoring plan

Timely and quality implementation of VODP2 activities by service providers in the study areas was of crucial importance for the success of the impact evaluation exercise. VODP2 and service providers committed to deliver activities according to a particular time schedule, which randomly phased-in the intervention in different sub-counties. A detailed timeline of implementation highlighting when activities should start in each sub-county was shared with the service providers by the research team a few months before the beginning of Season A 2017.

We shared with VODP2 a tool to monitor the activities by service providers. The document included all the necessary information for tracking farmer groups, that is: hub, name and code of the sub-county; name and code of the group; name of the village; name of the parish; name and telephone number of two components of the groups and the expected agricultural season during which the group was expected to receive VODP2 activities. In addition, the following fields are left blank and are expected to be compiled by service providers:

- Name of farmer group reference point;
- Activities start date;
- Whether and which of the three activities planned in the treatment – i) learning platform; ii) farm as business training; iii) value chain activities – have started;
- Number of visits by service provider
- Notes

The Monitoring and Evaluation Officer at VODP2 agreed to send researchers a monthly report on the status of project implementation using such monitoring tool, however this tool proved to be ineffective, due to delays and poor-quality data delivered by service providers.

As a quality check of administrative monitoring data, we set up an independent monitoring system. This was based on the random selection of a subset of individuals, who have been treated according to administrative data, to be reached by phone and interview with a few questions regarding treatment administration. This activity was performed by our field team. Although the delivery of administrative monitoring data did not occur on a regular and timely way, the combination of the monitoring exercises allowed us to spot delays in the implementation in some areas. These have been promptly signalled to the VODP2 Monitoring and Evaluation Officer. A solution to this issue was discussed and implemented. By moving forward toward the endline survey, we ensured service providers to reach all sub-counties assigned to the treatment group, and not to start any project activity in the control group.

could not get at the time when the sampling exercise was carried out. Second, the sampling strategy required the identification of groups to be reached in different agricultural seasons before the launch of VODP2 activities in these areas. These forced us to exclude potentially new groups from the analysis. As a consequence, we acknowledge that the study is not fully representative of the targeted population.

1.11. Implementation fidelity

We faced difficulties in monitoring project delivery. Although we initially aimed at creating a unified monitoring system common to all service providers enabling to track study farmer groups over time, this proved extremely costly and eventually unsuccessful. This prevented us from linking the administrative monitoring data to survey data and to prevent issues of contamination in control areas.

In the absence of reliable monitoring data from service providers, we rely on the information collected through our endline survey. A specific section in both the farmer and group level questionnaires was created in order to assess the extent to which the farmer/the group have been exposed to the VODP2 project and its different activities. The questions referred precisely to the period during which farmers could have been treated by the project, i.e. first and second season of 2017 and first season of 2018. Table 3 reports summary statistics for both the treated and the control sample. One can notice that some degrees of partial compliance occurred: 71.5% and 24% of farmers in the treatment and control group declared to be actually reached by the project, respectively. This seems to apply to most of the variables describing the contents included in the extension package. However, in all cases, the treated group appears significantly more exposed than the control group, with the exception of the distribution of free inputs by service providers⁴. These data have one caveat, though. It can be the case that other extension projects were in place in both treated and control areas during the study period and farmers could not reliably report the source. This may lead to the inability to attribute project activities received to the VODP2 project.

Table 3: Project take-up

| | All | | | Treated | | Control | | p-val |
|---|------|-------|-------|---------|-------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| VODP2 project take-up | 2544 | 0.478 | 0.500 | 0.715 | 0.451 | 0.241 | 0.428 | 0.000 |
| N. of visits to learning platform | 2544 | 1.044 | 3.033 | 1.621 | 3.363 | 0.470 | 2.540 | 0.000 |
| Household received advice on new seed varieties | 2544 | 0.488 | 0.500 | 0.595 | 0.491 | 0.381 | 0.486 | 0.000 |
| Household received advice on oilseed production | 2544 | 0.476 | 0.500 | 0.620 | 0.486 | 0.332 | 0.471 | 0.000 |
| Household received advice on farming techniques | 2544 | 0.682 | 0.466 | 0.767 | 0.423 | 0.598 | 0.491 | 0.000 |
| Household received advice on market activities | 2544 | 0.531 | 0.499 | 0.601 | 0.490 | 0.462 | 0.499 | 0.000 |
| Received free inputs from service providers | 2544 | 0.214 | 0.410 | 0.216 | 0.412 | 0.212 | 0.409 | 0.820 |
| Received any free seeds from service providers | 2544 | 0.004 | 0.063 | 0.006 | 0.074 | 0.002 | 0.048 | 0.202 |
| Oilseed production shown in platform | 2544 | 0.207 | 0.405 | 0.321 | 0.467 | 0.094 | 0.292 | 0.000 |
| Farming techniques shown in platform | 2544 | 0.296 | 0.457 | 0.366 | 0.482 | 0.227 | 0.419 | 0.000 |

In order to further investigate the extent and the intensity of activities delivered within the VODP2 project, we present the main topics of extension programs by main source of delivery. In particular, we group together the cases when such activities are delivered by the three service providers on one side and any other sources on the other (government agricultural extension, private agricultural extension, NGO, cooperatives or farmers associations, farmer field days and field schools, village agricultural extension meetings). The table below shows that activities delivered by VODP2 sources have been almost totally delivered to farmers assigned to the treated group, with all mean differences statistically significant from the control group, with average differences of over 10 percentage points. However, one can notice that shares are far from full take-up from the treated group. In the second

⁴ The latter was not an activity included in the list of extension contents, however we decided to check for it in order to be able to exclude the detection of project impacts on oilseed adoption due to mechanics.

set of results, as far as the extension topics delivered by non-VODP2 actors are concerned, we find non-significant differences between treatment and control group for some topics, while for other, the control group received more. When significant, differences in means do not exceed four percentage points.

Table 4: Extension by source

| | VODP2 source | | | | | Non-VODP2 source | | | | |
|--|--------------|-------|---------|-------|-------|------------------|-------|---------|-------|-------|
| | Treated | | Control | | p-val | Treated | | Control | | p-val |
| | Mean | SD | Mean | SD | | Mean | SD | Mean | SD | |
| Advice on New seed varieties | 0.285 | 0.451 | 0.019 | 0.136 | 0 | 0.155 | 0.362 | 0.172 | 0.378 | 0.246 |
| Advice on Oilseed production | 0.382 | 0.486 | 0.027 | 0.161 | 0 | 0.113 | 0.316 | 0.125 | 0.331 | 0.326 |
| Advice on Pest control | 0.26 | 0.439 | 0.016 | 0.127 | 0 | 0.165 | 0.371 | 0.212 | 0.409 | 0.003 |
| Advice on Fertilizer use | 0.219 | 0.414 | 0.015 | 0.121 | 0 | 0.144 | 0.351 | 0.181 | 0.385 | 0.01 |
| Advice on Pit planting | 0.119 | 0.324 | 0.013 | 0.111 | 0 | 0.074 | 0.262 | 0.071 | 0.256 | 0.726 |
| Advice on Irrigation | 0.119 | 0.324 | 0.009 | 0.092 | 0 | 0.072 | 0.258 | 0.069 | 0.253 | 0.782 |
| Advice on Soil fertility mg/mt | 0.174 | 0.379 | 0.013 | 0.115 | 0 | 0.134 | 0.341 | 0.159 | 0.366 | 0.074 |
| Advice on Composting | 0.128 | 0.334 | 0.01 | 0.1 | 0 | 0.103 | 0.304 | 0.126 | 0.332 | 0.071 |
| Advice on Post-harvest practice | 0.233 | 0.423 | 0.016 | 0.127 | 0 | 0.156 | 0.363 | 0.193 | 0.395 | 0.015 |
| Advice on Mktg/crop sale | 0.2 | 0.4 | 0.014 | 0.118 | 0 | 0.136 | 0.343 | 0.158 | 0.364 | 0.119 |
| Advice on Food process/quality control | 0.118 | 0.322 | 0.011 | 0.104 | 0 | 0.071 | 0.257 | 0.071 | 0.256 | 0.965 |
| Advice on Credit access | 0.134 | 0.341 | 0.012 | 0.108 | 0 | 0.113 | 0.316 | 0.137 | 0.344 | 0.063 |
| Advice on Savings(VSLA) | 0.192 | 0.394 | 0.018 | 0.133 | 0 | 0.164 | 0.37 | 0.207 | 0.405 | 0.005 |

These findings are somewhat supported by the qualitative report on VODP2 project by Kiiza et al. (2018). First, the study highlights several challenges in the implementation of the project such as the i) delayed funding leading to delays in the recruitment of service providers and the consequent reduction of the available time window for the intervention and ii) the impossibility to develop complementary financial products dedicated to farmers, in collaborations with private commercial banks. The report also highlights some obstacles to the realizations of the expected changes in the farmer sphere. In particular, it mentions the unfavourable weather conditions due to of climate change (unexpected prolonged drought, too much rain), farmers' limited access to financial services, unaffordability of quality inputs (fertilizer and improved seeds), sometimes combined with the supply unavailability of quality inputs, finally the high variability of prices of crushing material.

Impact analysis and results of the key evaluation questions

1.12. Identification and empirical specifications

The identification of the causal effects of the project intervention on farm-level outcomes leverages the random assignment of sub-counties to receive the treatment before or after Summer 2018.

The benchmark specification for the impact evaluation exercise aims at obtaining the main effects of the treatment on the immediate, intermediate and final outcomes. Following Emerick et al. (2016),

we exploit variation across treatment and control group by using the endline cross-section and estimating an equation as follows:

$$y_{ijd} = a_0 + \beta Treat_j + \gamma X_{i0} + \delta y_{i0} + \mu_d + \varepsilon_{ijd} \quad (1)$$

Where y_{ijd} is the outcome of interest for farmer i in sub-county j in district d , $Treat$ is a dummy taking the value of one if the sub-county was assigned to the treatment group and μ_d are district fixed effects, where districts are the stratification variable. X_{i0} is a set of individual-level controls at the baseline while y_{i0} is the outcome measured at the baseline, including gender, education, land size, agronomic skills, and household wealth index. Under randomized assignment, OLS estimate of β identifies the causal effects of the treatment.

For a sub-set of outcomes, we have data on two agricultural seasons measured at the endline, namely season B 2017 and season A 2018, such that we can run the impact assessment on the two seasons separately. Another set of outcomes are not seasons-specific and are generally deemed “endline outcomes”.

The previous section on implementation fidelity showed that we incurred in some degree of partial compliance. For each specification, besides the ITT, we estimate the Local Average Treatment Effect (LATE), where the dummy variable “VODP2 project take-up” is instrumented with the treatment assignment. The regression is estimated using instrumental variables with the same set of controls and clustered standard errors as in specification (1).

All of the hypotheses are assessed using two sided tests, at usual significance levels (10, 5, 1%), and on the full sample. The unit of analysis is always the farmer. Standard errors are clustered at the level of the unit of randomization, i.e. at sub-county level. Since we consider several outcomes, we implement Hocheberg step down procedure and p-values adjusted for multiple outcomes inference (Familywise Error Rate Control and False Discovery Rate Control).

In order to test the extent to which project effects vary in different sub-groups, we perform an analysis of heterogeneous effects. These will be estimated through the use of interaction terms in a specification similar to (1).

1.13. Impact analysis

1.13.1. Descriptive statistics and balancing checks

This section provides descriptive statistics of the baseline survey data. In particular, we focus on (a) demographic and other relevant controls; (b) outcome variables and (c) heterogeneous dimensions of the analysis. For all of the categories, we report means and standard deviation for the whole sample, and for the treated and control group separately, joint with the difference between them. We test the hypothesis that the two means are equal across the two sub-samples through a regression where each baseline characteristic is regressed on a dummy variable that is equal to one if the farmer is member of a group in a treated sub-county and zero otherwise. Robust standard errors, clustered at the level of sub-county, are computed. The last column of the tables reports the p-value of a two-sided test on the coefficient attached to the treatment variable. Such test provides evidence of the balance between treatment and control group. Successful randomization should ensure that the two groups do not differ along observable and unobservable characteristics. In the impossibility to test for differences in unobservable, balance tests on observable represents a necessary condition for good randomization.

a. Demographics and household level characteristics

Table 5 reports demographic characteristics of the farmer. The respondent is mostly the household head (61% of the cases), typically the spouse in the remaining cases. More than half of the respondents are male (62%), 73% can read and write, with the majority of people having primary (47%) and secondary education (37%) (11% have no school at all while almost 5% have higher education). All respondents are knowledgeable about agriculture and household production since this was a criterion to be surveyed. Yet, in most cases (93.5%) the respondent has a direct responsibility in decision-making about agricultural production within the household. Access to saving devices may help households buffer health shocks by alleviating credit constraints. In the absence of formal financial tools, participation to Village Saving and Loan Association (VSLA) represents an important opportunity. About 69% of the sample participate to such groups, which allow distributing, on a rotating basis, about 500,000 Ushs (about \$140; \$1=3,624 Ushs).

We collect information on individual risk preferences and define an indicator equal to one for being strongly risk averse (57% of the cases) if the respondent always opts for the certain outcome when presented with a set of hypothetical choices between gambles and certain gains and losses (this was done using a similar methodology as Voors et al. 2012).⁵

Table 6 reports household level characteristics. It can be noted that majority of households (88%) are male-headed and the average household size is about 7 (with 1.7 children below the age of 5, 2.4 between 6 and 15 and about 3 individuals older than 16, on average). In more than 46% of households some members, other than the respondent, participate to a farmer group - in most cases different from the one the respondent belongs to. As far as schooling is concerned, we report the highest level of schooling in the households. In more than half of the sample, the highest education level is secondary school, while in 28% of the cases is primary school. In 11% of sample households some member attended technical or training schools, while in a minority of cases we find no schooling at all (3.7%) or higher education (5.6%). The sample ethnic composition is very diversified. The most represented ethnic group is Acholi (25%), followed by Bagisu (17%), Iteso (9.5%), Japadhola (8%), Basamia (6.7%) and Bagwere (6%). Other ethnic groups, represented by less than 5% of our sample, sum up to 18%. As for religion, our sample appears to be mainly composed by Christians, represented by Catholic (47%), Protestant (34%) and Evangelic (8%), whilst 10% of the sample is Muslim.

Table 7 reports dwellings characteristics and the short-term inelastic assets, which are unlikely to be influenced by the intervention of study within the evaluation time window. Two thirds of houses are built in mud and one third in bricks. Roofs are made of iron sheet (58%) or simpler materials like thatch and straw (42%). The main household source of water is represented by springs or wells (83%), while a minority has access to a public tap (10%). Only 6% of our sample households have access to electricity and only 0.4% have running water inside the house. As far as sanitation is concerned, most households (96%) dispose of pit latrines outside their dwelling.

Table 8 presents some household baseline characteristics related to land and agricultural practices. Land represents a very important asset in our sample of rural households. Average farm size is about 4.6 acres (corresponding to 1.8 hectares; 1 acre=0.404 hectares) but varies significantly across the sample. On average, households own more than two plots with an average size of 2.2 acres. In general, plots may be further divided into parcels, which may be cultivated with different crops or intercropped. People have to walk 25 minutes, on average, to reach their plots. Almost three

⁵ Each individual can choose between certain outcomes (gain/loss of 10,000; 12,500 and 15,000 Ushs) and simple gambles with probability 1/4 to win 50,000 Ushs and probability 3/4 to win nothing. We also ran this exercise with higher stakes, i.e. same amounts multiplied by a factor of ten.

quarters of plots are owned by farmers under customary tenure system, while 16% and 6% of plots are formally owned (freehold) or rented (leasehold), respectively. Land rights do not seem to meet formality requirements, as only one third of plots have some form of written certificate (title, customary ownership or occupancy). Farmers consider the quality of their soils good for two thirds of plots, and fair otherwise (only 3.5% of plots are described as poor).

Table 9 presents a quick overview of the distribution of crop typologies and the intensity of their cultivation in our sample during season A of 2015 (January to June). First, we show the share of farmers growing at least one crop that is associated with the crop type, i.e. the extensive margin. Second, we report the share of total land cultivated with the specific crop, i.e. the intensive margin (the table shows unconditional means; the share of land devoted to the specific crop can be obtained by dividing the share of land by the probability of growing that crop). It can be noted that cereals (wheat, maize, millet, sorghum and rice) are the most widespread crop type, as they are cultivated by 89% of farmers on one third of their total land. Legumes, such as beans and peas, and oilseeds are cultivated by 60% and 54% of farmers, respectively, and each type covers about 17% of their total land. Another important crop type is represented by tubers (potatoes, cassava and yam), which are cultivated by 47% of farmers on 16% of their land. Only a minority of farmers grow fruits (16%), spices (13%) and vegetables (6%); the land devoted to such products appears rather negligible. In general, our survey data show that farmers do not cultivate their entire available land: some land is fallow, natural pasture for breeding while other land parcels may be not arable or may be occupied by bush and forest.

It should be noted that out of the over 90 baseline variables presented in this section only ten appears unbalanced between treatment and control group at 10% significance level. Once again, this confirms the quality of the randomization exercise.

Table 5: Respondent socio-economic characteristics

| | All | | | Treated | | Control | | p-val |
|---|------|-------|-------|---------|-------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Respondent is the HH head | 2733 | 0.606 | 0.489 | 0.608 | 0.488 | 0.604 | 0.489 | 0.802 |
| Respondent is male | 2733 | 0.623 | 0.485 | 0.624 | 0.485 | 0.623 | 0.485 | 0.996 |
| The respondent can read | 2733 | 0.735 | 0.470 | 0.723 | 0.448 | 0.748 | 0.491 | 0.158 |
| The respondent can write | 2733 | 0.732 | 0.472 | 0.723 | 0.448 | 0.741 | 0.495 | 0.316 |
| Respondent is responsible for agric decisions | 2733 | 0.935 | 0.247 | 0.942 | 0.234 | 0.927 | 0.261 | 0.103 |
| Respondent's education: No education | 2733 | 0.104 | 0.306 | 0.113 | 0.316 | 0.096 | 0.295 | 0.152 |
| Respondent's education: (Some) Primary | 2733 | 0.476 | 0.500 | 0.468 | 0.499 | 0.484 | 0.500 | 0.389 |
| Respondent's education: (Some) Secondary | 2733 | 0.373 | 0.484 | 0.368 | 0.483 | 0.379 | 0.485 | 0.570 |
| Member of Village Saving and Loan Association | 2722 | 0.666 | 0.472 | 0.689 | 0.463 | 0.644 | 0.479 | 0.013 |
| Risk averse low stake | 2727 | 0.564 | 0.496 | 0.574 | 0.495 | 0.554 | 0.497 | 0.294 |

Table 6: Household characteristics

| | All | | Treated | | Control | | p-val | |
|---|------|-------|---------|-------|---------|-------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | | SD |
| The HH head is male | 2733 | 0.881 | 0.323 | 0.872 | 0.334 | 0.891 | 0.312 | 0.126 |
| Household size | 2732 | 7.224 | 3.026 | 7.302 | 3.018 | 7.139 | 3.032 | 0.159 |
| Other member of the household participate in a farmer group | 2294 | 0.466 | 0.499 | 0.466 | 0.499 | 0.466 | 0.499 | 0.998 |

| | | | | | | | | |
|--|------|-------|-------|-------|-------|-------|-------|-------|
| Highest value of education in the HH: no formal education | 2733 | 0.037 | 0.189 | 0.036 | 0.186 | 0.038 | 0.191 | 0.758 |
| Highest value of education in the HH: primary school | 2733 | 0.284 | 0.451 | 0.279 | 0.449 | 0.289 | 0.454 | 0.545 |
| Highest value of education in the HH: secondary school | 2733 | 0.520 | 0.500 | 0.516 | 0.500 | 0.523 | 0.500 | 0.716 |
| Highest value of education in the HH: technical/training college | 2733 | 0.105 | 0.307 | 0.111 | 0.315 | 0.098 | 0.298 | 0.264 |
| Highest value of education in the HH: university | 2733 | 0.053 | 0.223 | 0.056 | 0.231 | 0.049 | 0.216 | 0.395 |
| Ethnic group: Acholi | 2733 | 0.254 | 0.435 | 0.263 | 0.440 | 0.244 | 0.430 | 0.257 |
| Ethnic group: Bagisu | 2733 | 0.169 | 0.375 | 0.173 | 0.379 | 0.164 | 0.371 | 0.512 |
| Ethnic group: Bagwere | 2733 | 0.059 | 0.236 | 0.031 | 0.175 | 0.087 | 0.282 | 0.000 |
| Ethnic group: Basamia | 2733 | 0.067 | 0.249 | 0.069 | 0.253 | 0.064 | 0.246 | 0.649 |
| Ethnic group: Iteso | 2733 | 0.095 | 0.294 | 0.097 | 0.297 | 0.094 | 0.292 | 0.750 |
| Ethnic group: Japadhola | 2733 | 0.079 | 0.270 | 0.081 | 0.273 | 0.078 | 0.268 | 0.728 |
| Ethnic group: Sabiny | 2733 | 0.180 | 0.384 | 0.179 | 0.383 | 0.182 | 0.386 | 0.835 |
| Respondent is catholic | 2733 | 0.426 | 0.495 | 0.406 | 0.491 | 0.446 | 0.497 | 0.035 |
| Respondent is Evangelic | 2733 | 0.081 | 0.273 | 0.089 | 0.285 | 0.073 | 0.259 | 0.108 |
| Respondent is Muslim | 2733 | 0.104 | 0.306 | 0.109 | 0.312 | 0.099 | 0.299 | 0.384 |
| Respondent is Protestant | 2733 | 0.341 | 0.474 | 0.342 | 0.475 | 0.341 | 0.474 | 0.947 |

Table 7: Household dwellings and facilities

| | All | | | Treated | | Control | | p-val |
|---|------|-------|-------|---------|-------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Have electricity | 2733 | 0.063 | 0.243 | 0.065 | 0.247 | 0.060 | 0.238 | 0.567 |
| Running water inside house | 2733 | 0.004 | 0.063 | 0.004 | 0.066 | 0.004 | 0.060 | 0.759 |
| Dwelling in mud/straw | 2733 | 0.658 | 0.474 | 0.659 | 0.474 | 0.658 | 0.475 | 0.958 |
| Dwelling in bricks/concrete | 2733 | 0.340 | 0.474 | 0.338 | 0.473 | 0.341 | 0.474 | 0.893 |
| WC with piping | 2733 | 0.006 | 0.076 | 0.007 | 0.085 | 0.004 | 0.066 | 0.317 |
| Dwelling is owned by a member of the family | 2733 | 0.972 | 0.164 | 0.971 | 0.167 | 0.973 | 0.162 | 0.819 |

Table 8: Land and plot characteristics

| | All | | | Treated | | Control | | p-val |
|--|------|--------|--------|---------|--------|---------|--------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Total plot size | 2733 | 4.549 | 9.926 | 4.653 | 12.325 | 4.432 | 6.716 | 0.560 |
| N. of plots | 2733 | 2.240 | 1.227 | 2.186 | 1.208 | 2.293 | 1.245 | 0.023 |
| Average time to reach the plot, in minutes | 2726 | 24.548 | 30.031 | 24.464 | 30.132 | 24.632 | 29.941 | 0.884 |
| Share of plots with: | | | | | | | | |
| certificate of title | 2733 | 0.036 | 0.170 | 0.030 | 0.154 | 0.043 | 0.185 | 0.034 |
| certificate of customary ownership | 2733 | 0.094 | 0.274 | 0.094 | 0.275 | 0.095 | 0.272 | 0.927 |
| certificate of occupancy | 2733 | 0.169 | 0.343 | 0.167 | 0.340 | 0.171 | 0.346 | 0.793 |
| written certificate | 2733 | 0.300 | 0.424 | 0.291 | 0.418 | 0.309 | 0.429 | 0.263 |
| Share of plots with: | | | | | | | | |
| sandy loam soil | 2733 | 0.522 | 0.466 | 0.528 | 0.467 | 0.517 | 0.465 | 0.555 |
| sandy claim and loam soil | 2733 | 0.315 | 0.435 | 0.314 | 0.436 | 0.317 | 0.434 | 0.861 |
| black clay soil | 2733 | 0.127 | 0.294 | 0.122 | 0.290 | 0.132 | 0.298 | 0.386 |
| other soil | 2733 | 0.027 | 0.145 | 0.027 | 0.146 | 0.027 | 0.145 | 0.945 |

| | | | | | | | | |
|----------------------|------|-------|-------|-------|-------|-------|-------|-------|
| Share of plots with: | | | | | | | | |
| good soil quality | 2733 | 0.632 | 0.447 | 0.607 | 0.458 | 0.656 | 0.434 | 0.004 |
| fair soil quality | 2733 | 0.331 | 0.434 | 0.354 | 0.446 | 0.307 | 0.420 | 0.005 |
| poor soil quality | 2733 | 0.035 | 0.168 | 0.037 | 0.171 | 0.033 | 0.164 | 0.576 |

Table 9: Cultivation of crop types, season A-2015 (January to June)

| | All | | | Treated | | Control | | p-val |
|--|------|-------|-------|---------|-------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Cultivate cereals | 2725 | 0.892 | 0.311 | 0.891 | 0.312 | 0.893 | 0.309 | 0.838 |
| Share of land cultivated with cereals | 2720 | 0.375 | 0.258 | 0.380 | 0.262 | 0.369 | 0.254 | 0.292 |
| Cultivate oilseeds | 2733 | 0.540 | 0.499 | 0.531 | 0.499 | 0.549 | 0.498 | 0.345 |
| Share of land cultivated with oilseeds | 2733 | 0.165 | 0.213 | 0.164 | 0.215 | 0.167 | 0.211 | 0.670 |
| Cultivate legumes | 2725 | 0.599 | 0.490 | 0.598 | 0.490 | 0.600 | 0.490 | 0.931 |
| Share of land cultivated with legumes | 2720 | 0.167 | 0.203 | 0.170 | 0.209 | 0.164 | 0.198 | 0.446 |
| Cultivate vegetables | 2725 | 0.067 | 0.250 | 0.070 | 0.255 | 0.064 | 0.244 | 0.529 |
| Share of land cultivated with vegetables | 2720 | 0.019 | 0.090 | 0.019 | 0.089 | 0.019 | 0.090 | 0.988 |
| Cultivate plantation | 2725 | 0.019 | 0.138 | 0.019 | 0.137 | 0.020 | 0.139 | 0.896 |
| Share of land cultivated with plantation | 2720 | 0.005 | 0.044 | 0.004 | 0.039 | 0.005 | 0.048 | 0.583 |
| Cultivate tubers | 2725 | 0.468 | 0.499 | 0.442 | 0.497 | 0.494 | 0.500 | 0.007 |
| Share of land cultivated with tubers | 2720 | 0.146 | 0.202 | 0.133 | 0.194 | 0.158 | 0.208 | 0.001 |
| Cultivate fruits | 2725 | 0.164 | 0.370 | 0.159 | 0.366 | 0.169 | 0.375 | 0.518 |
| Share of land cultivated with fruits | 2720 | 0.034 | 0.097 | 0.033 | 0.093 | 0.036 | 0.102 | 0.346 |
| Cultivate spices | 2725 | 0.123 | 0.328 | 0.118 | 0.323 | 0.127 | 0.333 | 0.497 |
| Share of land cultivated with spices | 2720 | 0.025 | 0.083 | 0.024 | 0.082 | 0.025 | 0.083 | 0.726 |

b. Outcome variables

In this section, we describe the outcome variables of the analysis. We focus on the outcomes presented in the theory of change and described in the PAP, which will be mainly analysed through reduced-form specifications. Along with the estimation of the average treatment effect of the project on final outcomes, the analysis seeks to shed light on the mechanisms and main drivers of changes (if any) by looking at the impact of the project on immediate and intermediate outcomes.

Hence the outcomes variables are organized in the following sets:

- *Immediate outcomes*: farmer's expectations about oilseed returns, input use; access to the market; oilseed adoption/cultivation;
- *Intermediate outcomes*: farm output and productivity, market sales and farm revenues;
- *Final outcomes*: household income, total expenditure, assets and wealth.

Outputs are sorted as presented in the Pre-Analysis Plan documents

Immediate outcomes

- *Farmers' expectations about oilseed returns and price*

Expectations about yield depend on individual characteristics as well as the farmer's stock and access to information. Economic theory suggests that expectations affect risky decision-making, especially in the absence of insurance or safety-net arrangements. Hence, expectations may be affected by the treatment administration and, in turn, influence farmers' technology adoption in response to the treatment. Expectations are elicited by asking households the average yield and price of different crops after the major season harvest, conditional on growing those crops.

We also consider the accuracy of price expectations, by comparing individual expectations to actual retail prices collected by season and district from Info Trade-AGMIS. Hence, we construct a variable for the percentage deviation from the true values and the share of farmers overestimating the retail price. We also compute the change over time in expectations, by taking the difference between the value at the endline and the one at the baseline. Differently from many other variables in the report, expectations have many missing values, as many farmers are not knowledgeable or interested in all oilseeds. This represents a limitation to our external validity. In order to generalize on oilseed, we aggregate the information from the individual crops, following Kling et al. (2007). First, we standardize the variables by using the mean and standard deviation of the control group. Second, we take unweighted averages of the z-scores. By doing that, we are also able to increase sample size available for analysis.

Table 10 reports the z-score for expected yield and price for the four oilseeds targeted by the intervention as described above. Also reports the percentage deviation from the retail price (we call it error) and finally the probability of underestimating the price at the baseline.

Table 10: Oilseed yield and price expectations

| | All | | | Treated | | Control | | p_val |
|---|------|--------|-------|---------|-------|---------|--------|-------|
| | Obs | Mean | SD | Mean | SD_tr | Mean | SD_con | |
| Avg exp yield soyabean (z-score) | 1588 | 0.053 | 1.289 | 0.104 | 1.515 | 0 | 1 | 0.109 |
| Avg exp yield sunflower (z-score) | 792 | 0.016 | 0.896 | 0.031 | 0.784 | 0 | 1 | 0.628 |
| Avg exp yield sesame (z-score) | 1095 | -0.005 | 1.039 | -0.009 | 1.079 | 0 | 1 | 0.881 |
| Avg exp yield groundnuts (z-score) | 2224 | 0.007 | 1.088 | 0.014 | 1.170 | 0 | 1 | 0.754 |
| Avg exp yield for oilseeds | 2432 | 0.011 | 0.946 | 0.026 | 1.011 | -0.003 | 0.878 | 0.443 |
| Avg exp price soyabean (z-score) | 1619 | -0.025 | 1.177 | -0.049 | 1.325 | 0 | 1 | 0.398 |
| Avg exp price sunflower (z-score) | 744 | 0.038 | 1.167 | 0.073 | 1.304 | 0 | 1 | 0.393 |
| Avg exp price sesame (z-score) | 1128 | -0.021 | 0.708 | -0.042 | 0.009 | 0 | 1 | 0.318 |
| Avg exp price groundnuts (z-score) | 2257 | -0.018 | 0.863 | -0.037 | 0.698 | 0 | 1 | 0.312 |
| Avg exp price for oilseeds | 2453 | -0.033 | 0.606 | -0.041 | 0.608 | -0.024 | 0.603 | 0.486 |
| Error in price exp soyabean (z-score) | 1619 | 0.025 | 1.178 | 0.05 | 1.326 | 0 | 1 | 0.395 |
| Error in price exp sunflower (z-score) | 744 | -0.038 | 1.167 | -0.073 | 1.303 | 0 | 1 | 0.394 |
| Error in price exp sesame (z-score) | 1128 | 0.021 | 0.708 | 0.042 | 0.009 | 0 | 1 | 0.318 |
| Error in price exp groundnuts (z-score) | 2257 | 0.009 | 0.88 | 0.017 | 0.739 | 0 | 1 | 0.637 |
| Error in price exp for oilseeds | 2453 | 0.016 | 0.606 | 0.023 | 0.616 | 0.01 | 0.597 | 0.622 |
| Underestimate price of soyabean | 1619 | 0.695 | 0.460 | 0.723 | 0.448 | 0.667 | 0.472 | 0.015 |
| Underestimate price of sunflower | 744 | 0.626 | 0.484 | 0.601 | 0.490 | 0.654 | 0.476 | 0.139 |

| | | | | | | | | |
|-----------------------------------|------|-------|-------|-------|-------|-------|-------|-------|
| Underestimate price of sesame | 1128 | 0.879 | 0.326 | 0.893 | 0.309 | 0.865 | 0.342 | 0.150 |
| Underestimate price of groundnuts | 2257 | 0.618 | 0.486 | 0.609 | 0.488 | 0.627 | 0.484 | 0.371 |

- Oilseed adoption

Table 11 reports our measure of oilseed adoption and intensification (at the extensive and at the intensive margins). Concerning the extensive margins, we show the distribution of oilseeds cultivation during the first agricultural season of 2015 (January to June). The most cropped oilseed is groundnut, which is cultivated by 38% of farmers, while 16% and 10.5% of farmers cultivate soya beans and sesame, respectively. Concerning the intensive margin, we first calculate the share of land devoted to the cultivation of the relevant oilseed, and then as share of total land. On average, 9% of the entire farmland is allocated to groundnuts cultivation, while the percentage decreases to 3%, 2.4% and 1.4% for soya beans, sesame and sunflower respectively. Overall, the share of farmers cultivating at least one oilseed during the first agricultural season equals 54%, covering, on average, an area corresponding to 15.7% of total land.

- Technical knowledge

Here we consider the baseline stock of knowledge and farmer's actual adoption of improved agricultural techniques. Given that one important feature of VODP2 is strictly related to learning and improving technical notions for the cultivation of oilseeds, we test the extent to which the treatment changes the initial level of agricultural 'skills'. Table 12 presents the extent to which farmers make use of advanced farming techniques and improved inputs for oilseeds and, more in general, for all crops. In particular, fertilizer, pesticide and improved seed are used, for oilseeds (at least one crop), by 6%, 5% and 25% of our sampled farmers, respectively. Shifting the analysis to all crops (not just oilseeds), the use of fertilizer, pesticide and improved seed is practiced by 30%, 12% and 49% of farmers respectively.

Table 11: Oilseed adoption, season A-2015 (January to June)

| | All | | | Treated | | Control | | p-val |
|--|------|-------|-------|---------|-------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Cultivate oilseeds | 2733 | 0.540 | 0.499 | 0.531 | 0.499 | 0.549 | 0.498 | 0.345 |
| Share of land cultivated with oilseeds | 2733 | 0.165 | 0.213 | 0.164 | 0.215 | 0.167 | 0.211 | 0.670 |
| Cultivate groundnuts | 2733 | 0.379 | 0.485 | 0.371 | 0.483 | 0.387 | 0.487 | 0.405 |
| Share of land cultivated with groundnuts | 2733 | 0.094 | 0.158 | 0.092 | 0.159 | 0.096 | 0.158 | 0.504 |
| Cultivate soyabean | 2733 | 0.161 | 0.368 | 0.167 | 0.373 | 0.156 | 0.363 | 0.451 |
| Share of land cultivated with soyabean | 2733 | 0.033 | 0.099 | 0.035 | 0.105 | 0.030 | 0.093 | 0.183 |
| Cultivate sunflower | 2733 | 0.050 | 0.218 | 0.050 | 0.217 | 0.051 | 0.219 | 0.920 |
| Share of land cultivated with sunflower | 2733 | 0.014 | 0.074 | 0.014 | 0.075 | 0.014 | 0.072 | 0.997 |
| Cultivate sesame | 2733 | 0.104 | 0.305 | 0.096 | 0.295 | 0.111 | 0.315 | 0.203 |
| Share of land cultivated with sesame | 2733 | 0.025 | 0.088 | 0.022 | 0.083 | 0.027 | 0.094 | 0.185 |

Table 12: Agricultural skills and farming techniques

| | All | | | Treated | | Control | | p-val |
|-----------------------------------|------|-------|-------|---------|-------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Farmer applied water conservation | 2733 | 0.169 | 0.375 | 0.165 | 0.372 | 0.173 | 0.378 | 0.592 |

| | | | | | | | | |
|--------------------------------------|------|-------|-------|-------|-------|-------|-------|-------|
| Farmer applied moisture retention | 2733 | 0.173 | 0.378 | 0.156 | 0.363 | 0.189 | 0.392 | 0.024 |
| Farmer applied zero tillage | 2733 | 0.056 | 0.230 | 0.064 | 0.244 | 0.048 | 0.215 | 0.083 |
| Farmer applied compost making | 2733 | 0.100 | 0.299 | 0.091 | 0.287 | 0.108 | 0.311 | 0.121 |
| Farmer applied post-harvest handling | 2733 | 0.941 | 0.235 | 0.943 | 0.232 | 0.940 | 0.238 | 0.734 |
| Use some fertilizer | 2733 | 0.290 | 0.454 | 0.284 | 0.451 | 0.295 | 0.456 | 0.531 |
| Use some pesticide | 2733 | 0.124 | 0.330 | 0.124 | 0.329 | 0.125 | 0.330 | 0.937 |
| Use some improved seed | 2733 | 0.491 | 0.500 | 0.507 | 0.500 | 0.474 | 0.500 | 0.082 |
| Use of fertilizer for oilseeds | 2733 | 0.055 | 0.228 | 0.050 | 0.217 | 0.060 | 0.238 | 0.234 |
| Use of pesticide for oilseed | 2733 | 0.052 | 0.221 | 0.046 | 0.210 | 0.057 | 0.232 | 0.190 |
| Use of improved seeds for oilseed | 2733 | 0.247 | 0.431 | 0.251 | 0.434 | 0.242 | 0.429 | 0.617 |

The first part of the table shows the use of agricultural techniques on at least one plot, which may contribute to improve productivity. Water conservation, moisture retention, zero tillage and post-harvest handling are implemented by 17%, 17%, 5%, 10% and 94% of farmers, respectively.

Intermediate outcomes

- Productivity

We construct a measure for productivity. The first one measures the fraction of total harvested production for each crop over the amount of land dedicated to its cultivation. The variable is calculated at the farmer level; hence we report mean productivity for the whole sample and for the treated and control sub-samples in Table 13.

Table 13: Productivity

| | All | | Treated | | Control | | | |
|--------------------------------------|------|---------|----------|---------|----------|---------|----------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | p-val |
| Productivity of groundnuts (kg/acre) | 2733 | 228.116 | 1453.478 | 209.839 | 1261.506 | 246.434 | 1623.522 | 0.511 |
| Productivity of soya bean (kg/acre) | 2733 | 102.964 | 1603.544 | 145.903 | 2209.709 | 59.930 | 502.981 | 0.161 |
| Productivity of sunflower (kg/acre) | 2733 | 57.005 | 1665.771 | 94.903 | 2351.547 | 19.024 | 113.600 | 0.234 |
| Productivity of sesame (kg/acre) | 2733 | 19.259 | 168.915 | 19.324 | 223.613 | 19.195 | 83.876 | 0.984 |

- Farm output and revenues

We look at farm output under different angles. First, we estimate net revenues by estimating a value of harvest, netted of market inputs. Second, we consider market sales. For each dimension, we construct oilseed-specific variables as well as overall measures. This allows us to shed light on the role of oilseeds in farmer behaviour and their potential impact on outcomes and performance.

We construct a measure of farm output for the four specific oilseed crops and for all crops in general, so that the role played by the latter can be easily extrapolated. Farm output (or net revenues) is constructed as the harvest of all crops valued at the market price at the time of the harvest, netted of all market inputs. Crop market prices are likely to vary from one geographical area to another;

however such information is not available to us.⁶ We indirectly obtain price information from farmer level questionnaires. In particular, we get average prices at different geographic levels (sub-county, district, hub), by dividing the revenues from sales by the quantities sold, for each crop, at the farmer level. Given the fact that some crops are rarely cultivated and/or sold, in order to avoid high price variability from the use of few observations from sub-county (our smaller geographical unit), we use the average price at higher geographical level if the number of price observations per crop, per sub-county is smaller than five. We estimate the value of market inputs by summing up the expenditure to purchase seeds, fertilizer and pesticide for each crop. Table 14 reports net revenues for the four oilseeds and for all crop. The share of oilseeds over total farm output turns out not to be major (about 20% of the total value). Among oilseeds, groundnuts have the highest value in terms of output.

We also present the revenues from sales for all different crops. Once again, groundnuts are the oilseed which is sold the most, followed by soya beans, sunflowers and sesame. Overall, oilseeds cover 20% of total revenues from crop sale. This result appears in line with the share of oilseeds in output creation.

- Market linkages

Another dimension of VODP2 activities is aimed at creating and strengthening the relationship between farmers and market actors, as well as promoting marketing strategies at the group level. Table 15 describes the usual farmers' source of oilseeds supply and how farmers sell their harvest. In particular, the first set of variables show the share of farmers getting seeds from the market (namely from either agro-dealers, private traders, local market or seed companies).⁷

Table 14: Farm output and revenues

| | All | | | Treated | | Control | | p-val |
|---|------|---------|----------|---------|----------|---------|----------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Net revenue for soya beans (10K Ushs) | 2733 | 9.683 | 165.630 | 15.119 | 231.876 | 4.236 | 31.668 | 0.086 |
| Net revenue for sunflowers (10K Ushs) | 2733 | 9.727 | 339.062 | 16.598 | 478.788 | 2.841 | 20.637 | 0.289 |
| Net revenue for simsim (10K Ushs) | 2733 | 4.220 | 18.804 | 3.280 | 16.160 | 5.161 | 21.088 | 0.009 |
| Total net revenue (10K Ushs) | 2733 | 318.419 | 1563.749 | 285.102 | 1151.957 | 351.809 | 1888.291 | 0.265 |
| Total revenues from sale of groundnuts (10K Ushs) | 2733 | 12.232 | 117.547 | 9.384 | 42.213 | 15.086 | 160.850 | 0.205 |
| Total revenues from sale of soya bean (10K Ushs) | 2733 | 2.990 | 16.626 | 3.574 | 17.267 | 2.406 | 15.944 | 0.066 |
| Total revenues from sale of sunflower (10K Ushs) | 2733 | 2.661 | 26.915 | 3.288 | 34.612 | 2.033 | 15.798 | 0.223 |
| Total revenues from sale of simsim (10K Ushs) | 2733 | 2.191 | 13.113 | 1.410 | 7.968 | 2.974 | 16.719 | 0.002 |
| Total revenues from sale of oilseeds (10K Ushs) | 2733 | 20.074 | 123.373 | 17.655 | 59.333 | 22.499 | 164.154 | 0.305 |

The second half of the table reports the extent to which farmers sell their harvest, making use of group marketing. The sale of oilseeds joints with other farmers (in bulk or through the farmer group) are rare (overall only in 2.3% of cases, as the last line shows): farmers usually prefer to sell their

⁶ In the next final round of deliverables, we plan to collect and use data on crop prices from administrative sources, as much disaggregated as possible, as a robustness check.

⁷ The table shows unconditional means. Conditional means can be obtained by combining information from table 11 and 12, where the shares of farmers ever cultivating the different crops in the past are shown.

harvest individually. In the last part we show the extent to which farmers interact with oilseed value chain actors such as seed buyers, processors, millers and traders.

Table 15: Market linkages and marketing practices

| | All | | | Treated | | Control | | p-val |
|---|------|-------|-------|---------|-------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Access to market actors for oilseed procurement | 2733 | 0.206 | 0.404 | 0.204 | 0.403 | 0.207 | 0.406 | 0.827 |
| Oilseed harvest sold to market | 2733 | 0.100 | 0.299 | 0.105 | 0.306 | 0.095 | 0.293 | 0.381 |
| Bulk/group sale of: | | | | | | | | |
| soyabeans | 2733 | 0.011 | 0.104 | 0.016 | 0.126 | 0.006 | 0.076 | 0.010 |
| sunflower | 2733 | 0.008 | 0.089 | 0.008 | 0.089 | 0.008 | 0.089 | 0.996 |
| sesame | 2733 | 0.004 | 0.066 | 0.004 | 0.060 | 0.005 | 0.071 | 0.560 |
| groundnuts | 2733 | 0.009 | 0.093 | 0.009 | 0.093 | 0.009 | 0.093 | 0.996 |
| oilseed | 2733 | 0.023 | 0.150 | 0.026 | 0.160 | 0.020 | 0.139 | 0.255 |
| Contacts with value chain actors for: | | | | | | | | |
| soyabeans | 2733 | 0.087 | 0.281 | 0.082 | 0.274 | 0.092 | 0.289 | 0.368 |
| sunflower | 2733 | 0.080 | 0.272 | 0.079 | 0.270 | 0.082 | 0.275 | 0.766 |
| sesame | 2733 | 0.049 | 0.217 | 0.056 | 0.229 | 0.043 | 0.203 | 0.137 |
| groundnuts | 2733 | 0.034 | 0.180 | 0.036 | 0.186 | 0.032 | 0.175 | 0.532 |
| oilseeds | 2733 | 0.161 | 0.368 | 0.162 | 0.368 | 0.160 | 0.367 | 0.937 |

Final outcomes

- Household well-being

Improvements in production, productivity and eventually sales are expected to spill-over household economic sphere in several possible ways. In particular, we look at three possible channels: household income, consumption and wealth.

As far as household income is concerned, we construct three different levels of income and we report them in Table 16. The first is represented labour income and pools household level income from labour both farm and off-farm activities (hunting, fishing, own business, on-farm and off-farm dependent labour). The second source, defined as non-labour income, sums up earnings across household members from for pension, inheritance, lotteries and transfers from others. The bottom row reports total household income by summing up all the previous items. All measures are reported in 10.000 Ushs, over the preceding twelve months. We generate a poverty proxy identifying households with total income below 60% of the mean sample income distribution. We find that 58% of the sample lies in such category.

We also report measures of household consumption. In particular, we present measures of food, non-food and durable consumption. The first refers to the monthly average expenditure in the following items: cereals and tubers (maize/cassava/rice/potato), beans and legumes, oilseeds (sunflower, groundnuts, sesame, soybeans), dairy products, meat and fish, eggs, vegetables and fruits. Expenditure on non-food items includes: utilities services (gas electricity...), personal care products (soap, shampoo...), personal care services (barber, beauty shop...), fuel, passenger transport (excluding travel to school and health care facilities), transport to school, saving, interest on loan, newspaper and magazine, cigarettes/tobacco and alcoholic beverages. For these two variables and their constituent items, farmers were asked to report the amount spent in the last 30

days. The third measure of consumption refers to durable items such as doctor and medicines, school fees, school books, adult clothes, children clothes, house improvements, dwelling maintenance/repair, gifts for marriages, birth and funerals, funerals, other ceremonies, durable goods, investments on agriculture or family business, tools and seeds. Given that this question was asked on a different time horizons (yearly), we aligned it on the same time horizon (month) of food and non-food items questions, dividing total expenditure on durable goods by 12. Finally, the household monthly total expenditure is shown in the last row of the table. We built it by adding the sum of food and non-food items to the monthly expense on durable goods. All amounts are reported in 10.000 Ushs. From the data it seems that household total expenditure is rather evenly distributed across food, non-food and

Table 16: Household wellbeing

| | All | | | Treated | | Control | | p-val |
|---|------|---------|---------|---------|---------|---------|---------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Total yearly hh income from labour (USH, x 10,000) | 2733 | 23.798 | 52.070 | 24.048 | 52.581 | 23.548 | 51.571 | 0.802 |
| Total yearly hh income not from labour (USH, x 10,000) | 2733 | 25.650 | 50.159 | 27.056 | 52.510 | 24.242 | 47.664 | 0.143 |
| Total yearly hh income (USHx10,000) | 2733 | 49.449 | 77.346 | 51.104 | 78.652 | 47.790 | 76.007 | 0.263 |
| Tot. hh income <60% of avg income in the sample | 2733 | 0.579 | 0.494 | 0.577 | 0.494 | 0.581 | 0.494 | 0.824 |
| Total HH monthly food expenditure, in 10K Ushs | 2733 | 14.222 | 19.154 | 14.601 | 22.930 | 13.842 | 14.408 | 0.300 |
| Total HH monthly non-food expenditure (Ushs, x10K) | 2733 | 13.519 | 25.184 | 13.060 | 18.773 | 13.978 | 30.277 | 0.340 |
| Total HH yearly expenditure on general items (x 10,000) | 2733 | 185.416 | 261.074 | 188.198 | 263.333 | 182.628 | 258.856 | 0.577 |
| Wealth index | 2733 | -0.058 | 1.876 | -0.053 | 1.715 | -0.062 | 2.025 | 0.899 |

We also consider a set of variables concerning household assets and wealth and aggregate them in a wealth index using the first component obtained with Principal Component Analysis (PCA) as suggested by Filmer and Pritchett (2001), by aggregating the information on the number of livestock and assets which may be present in a house. In particular, the following are considered: livestock ownership (sheep, goats, pack animals, ducks/turkeys, chicken, donkeys and pigs) and other assets and devices. The latter are: fridge, sewing machine, tv, phone, radio, water pot, wooden or metal bed, mattress, bicycle, motorcycle and batteries.

Out of over 62 baseline variables presented above, seven result unbalanced between treatment and control group at 10% significance level. Once again, this confirms the quality of the randomization exercise. In particular, having balance in outcome variables measured at baseline is particularly important, as they are likely to be correlated with the outcomes at the endline.

c. Dimensions of heterogeneity

Dimensions of heterogeneity include the level of knowledge and application of improved agronomic techniques, as presented in Table 12, which refers to farmers' familiarity with oilseeds. As discussed above, farmer groups have been selected to participate to VODP2 based on, among other factors, their willingness to engage with oilseed cultivation. It should be of no surprise the fact that such willingness is rooted in former experience with some oilseed. This seems to be indeed the case, as reported in Table 17. About 50% of farmers planted soya beans in the past, while one fourth planted sunflower. About 41% had some experience in cropping sesame. However, the most widespread oilseed seems to be groundnuts, which have been planted by 80% of the sample. Overall, almost

91% of the sample had some experience with at least one oilseed in the past. It should be also noted that the unconditional mean of the number of oilseeds cultivated by farmers is almost 2.

Table 17: Dimensions of heterogeneity

| | All | | | Treated | | Control | | p-val |
|--|------|--------|-------|---------|--------|---------|-------|-------|
| | Obs | Mean | SD | Mean | SD | Mean | SD | |
| Planted oilseeds (any) in the past, baseline | 2733 | 0.908 | 0.289 | 0.898 | 0.302 | 0.917 | 0.276 | 0.089 |
| Respondent is male, baseline | 2733 | 0.623 | 0.485 | 0.624 | 0.485 | 0.623 | 0.485 | 0.996 |
| The HH head is male, baseline | 2733 | 0.881 | 0.323 | 0.872 | 0.334 | 0.891 | 0.312 | 0.129 |
| Total plot size, baseline | 2733 | 4.549 | 9.926 | 4.665 | 12.323 | 4.432 | 6.716 | 0.540 |
| Wealth index, baseline | 2733 | -0.058 | 1.876 | -0.053 | 1.715 | -0.062 | 2.025 | 0.899 |

Finally, we will look at possible heterogeneous treatment effect along some dimensions, which have been already presented in the section above and which we report again in Table 29. In particular, we will focus on gendered aspects of the project intervention by analysing whether the effects will differ depending on (i) the gender of the household head and (ii) the gender of the group member actually benefitting from the intervention. Moreover, we will look at the extent to which total farm size, as well as wealth determines differential impacts.

1.13.2. Regression analysis, main effects

Here we report the main results of our empirical analysis, which we carry out through the estimation of equation (1) above. As mentioned earlier, we test the impact of the treatment effect on immediate, intermediate and final outcomes (Tables 18-26). Throughout we report results for different outcomes in different columns, while in the last column of all the tables we report the summary index test, which combines multiple outcome variables to reduce the total number of tests conducted (see Section 7.2.4 below for further discussion on this).

Tables 18 and 19 report the results of the impact of the treatment on farmers' expectations about yield and prices of each of the oil seeds and in general for oilseed in major season. Samples include individuals providing the information both at the baseline and endline. The evidence for yields appears mixed. For groundnuts, soya bean and sesame the impacts are negative, though non-significant, for both values and change over time. Instead, we find positive and significant impacts on sunflower yield expectations, which appear to grow over time as a consequence of the treatment. As far as price expectations are concerned, the overall evidence suggests that the treatment had a positive impact and contributed to an upward price expectations upgrade. In particular, we find positive effects on the individual crops price expectations, not significant at 10% level, but mostly below 20%. This results in a positive impact on the oilseed price expectation index. Similar results are found for the change over time in price expectations. Strongest results are found for soya bean. We also find an overall fall in error in the expectations with respect to the retail prices. In order to look at whether the revision of expectations occurs in a rational way, we interact the treatment with a dummy variable which is equal to one if the farmer underestimated the current retail price at the baseline and zero if he overestimated it.

We observe positive and significant results across all average quantity and price expectations -- but for the case of groundnuts, for which we find positive but less precisely estimated results -- which point to a short-run farmers' behavioural change. Yet, it should be noted that groundnuts are the only

seeds farmers know relatively better as, at the baseline, one third of sample farmers report having grown that seed.

In Table 20 we report results on farmers' adoption of oilseeds. We find a positive and significant impact of the treatment on both oilseed adoption (extensive margin) and the share of land devoted to that seed (intensive margin). This holds on average for all crops (columns 1-2), and the latter effect is driven mainly by groundnut and soybean adoption (column.3-6). Results are less precisely estimated for sunflower and sesame (the latter has a very small but negative coefficient). The latter two crops are the least cultivated ones by farmers, following groundnut and soybean. The multiple index test, though, turn out to positive and statistically significant (last column).

Table 21 reports results on the use of farming techniques. We find positive but small and imprecise results for all the techniques but for applied post-harvest handling, which turns out to significantly increase by 5 percentage points upon the treatment. In terms of use of farm inputs, we find positive and significant treatment effects on the use of fertilizers for oil seeds and the use of improved seeds (Table 22).

We now turn to intermediate outcomes for which we report results in Tables 23-24. We report results estimated in two different seasons for both productivity and revenues. Results in Table 23 show that in both seasons there is a positive (but mostly imprecisely) estimated impact of the treatment on oilseed productivity measured as Kgs per acre of land. Similarly, there is a positive but mostly insignificant effect on revenues, with the exception of soybean whose sale revenues significantly increase upon the treatment in both seasons. Finally, we report the impact on farmers' market linkage in Table 25. We find a positive and significant treatment effect on bulk/group sale of oilseed harvest for most of the crops, which is remarkable given the low baseline rate of group sale recorded. We further find a positive effect on farmers' inclusion in the oilseed value-chain, which is significantly triggered by groundnut cultivation (column 9).

As far as final outcomes are concerned, we estimate the treatment effects on farmers' wellbeing as measures by (self-reported) household income and wealth. Results are reported in Table 26 and do not turn out to be significant nor precisely estimated. This is not surprising as we are estimating short-run effect of VODP2 farming activities, which may require a longer period to translate into higher income and wealth.

Table 18: Yield expectations

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|--------------|------------------------|--------------------|---------------------|---------------------|--------------------|--|---------------------|---------------------|---------------------|--------------------|
| | Avg expected yield for | | | | | Change in expected yield over time for | | | | |
| | soyabeans | sunflower | sesame | groundnuts | oilseeds | soyabeans | sunflower | sesame | groundnuts | oilseeds |
| ITT | -0.0192 (0.0808) | -0.0286 (0.132) | 0.201** (0.0830) | -0.0173 (0.0275) | 0.0201 (0.0232) | -0.0163 (0.0686) | -0.0100 (0.0463) | 0.129** (0.0532) | -0.0158 (0.0252) | 0.0265 (0.0199) |
| LATE | -0.0403 (0.166) | -0.0584 (0.255) | 0.481** (0.199) | -0.0381 (0.0605) | 0.0438 (0.0500) | -0.0342 (0.141) | -0.0205 (0.0894) | 0.308** (0.127) | -0.0349 (0.0553) | 0.0577 (0.0424) |
| Observations | 977 | 361 | 648 | 1,614 | 2,014 | 977 | 361 | 648 | 1,614 | 1,933 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 19: Price expectations

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|--------------|------------------------|--------------------|--------------------|--------------------|---------------------|------------------------------|----------------------|---------------------|---------------------|----------------------|
| | Avg expected price for | | | | | Errors on expected price for | | | | |
| | soyabeans | sunflower | sesame | groundnuts | oilseeds | soyabeans | sunflower | sesame | groundnuts | oilseeds |
| ITT | 0.125 (0.0823) | 0.189* (0.0945) | 0.0901 (0.0878) | 0.0762 (0.0500) | 0.0804* (0.0440) | -0.123 (0.0810) | -0.187** (0.0896) | -0.0901 (0.0878) | -0.0762 (0.0501) | -0.0772* (0.0422) |
| LATE | 0.266 (0.178) | 0.371** (0.178) | 0.214 (0.197) | 0.162 (0.105) | 0.174* (0.0953) | -0.261 (0.175) | -0.367** (0.170) | -0.214 (0.197) | -0.162 (0.105) | -0.167* (0.0910) |
| Observations | 1,033 | 310 | 657 | 1,628 | 2,031 | 1,033 | 310 | 657 | 1,628 | 2,031 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

| | (11) | (12) | (13) | (14) | (15) |
|--------------|---------------------------------------|--------------------|------------------------|--------------------|----------------------|
| | Change in expected price overtime for | | | | |
| | soyabeans | sunflower | sesame | groundnuts | oilseeds |
| ITT | 0.0987 (0.0649) | 0.179* (0.0894) | 0.000769 (0.000750) | 0.0294 (0.0193) | 0.0659** (0.0265) |
| LATE | 0.210 (0.141) | 0.351** (0.168) | 0.00183 (0.00168) | 0.0626 (0.0404) | 0.143** (0.0570) |
| Observations | 1,033 | 310 | 657 | 1,628 | 1,965 |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 20: Oilseed adoption

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---------------|-----------------------|---|-------------------------|--|-----------------------|---|------------------------|---|----------------------|---|------------------------------------|
| | Cultivate oilseeds | Share of land cultivated with oilseeds | Cultivate groundnuts | Share of land cultivated with groundnuts | Cultivate soybean | Share of land cultivated with soybean | Cultivate sunflower | Share of land cultivated with sunflower | Cultivate sesame | Share of land cultivated with sesame | Index of dependent variables |
| ITT | | | | | | | | | | | |
| Season B 2017 | 0.0638** (0.0245) | 0.0279** (0.0119) | 0.0414** (0.0194) | 0.00773 (0.00512) | 0.0724*** (0.0233) | 0.0167** (0.00673) | 0.0227 (0.0185) | 0.00373 (0.00687) | -0.00624 (0.0205) | -0.000524 (0.00503) | 0.0855*** (0.0310) |
| Season A 2018 | 0.0487** (0.0235) | 0.0165* (0.00886) | 0.0265 (0.0170) | 0.00214 (0.00551) | 0.0342* (0.0195) | 0.00657 (0.00505) | 0.0156 (0.00964) | 0.00262 (0.00338) | 0.0213 (0.0130) | 0.00488 (0.00312) | 0.0586** (0.0239) |
| LATE | | | | | | | | | | | |
| Season B 2017 | 0.136*** (0.0519) | 0.0596** (0.0251) | 0.0884** (0.0411) | 0.0165 (0.0109) | 0.155*** (0.0490) | 0.0356** (0.0141) | 0.0485 (0.0392) | 0.00798 (0.0145) | -0.0133 (0.0433) | -0.00112 (0.0106) | 0.183*** (0.0656) |
| Season A 2018 | 0.104** (0.0487) | 0.0353* (0.0182) | 0.0566 (0.0355) | 0.00457 (0.0116) | 0.0731* (0.0404) | 0.0141 (0.0105) | 0.0334* (0.0200) | 0.00559 (0.00708) | 0.0455* (0.0275) | 0.0104 (0.00661) | 0.125** (0.0490) |
| Observations | 2544 | 2544 | 2544 | 2544 | 2544 | 2544 | 2544 | 2544 | 2544 | 2544 | 2544 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 21: Agricultural technique use

| | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------|-----------------------|-----------------------|-----------------------|---------------------|------------------------------|---------------------------|
| | Farmer applied | | | | | |
| VARIABLES | water conservation | moisture retention | zero tillage | compost making | post- harvest handling | Index of dep variables |
| ITT | 0.0258 (0.0216) | 0.00527 (0.0237) | -0.00785 (0.00890) | 0.00602 (0.0145) | 0.0549** (0.0228) | 0.0588 (0.0395) |
| LATE | 0.0551 (0.0460) | 0.0113 (0.0501) | -0.0168 (0.0188) | 0.0129 (0.0307) | 0.117** (0.0491) | 0.126 (0.0844) |

| | | | | | | |
|--------------|-------|-------|-------|-------|-------|-------|
| Observations | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 22: Use of inputs

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---------------|----------------------|----------------------|------------------------|--------------------------------|------------------------------|-----------------------------------|------------------------|
| | Use some fertilizer | Use some pesticide | Use some improved seed | Use of fertilizer for oilseeds | Use of pesticide for oilseed | Use of improved seeds for oilseed | Index of dep variables |
| ITT | | | | | | | |
| Season B 2017 | -0.0208 (0.0230) | -0.0398 (0.0244) | 0.0319 (0.0247) | 0.0155** (0.00690) | 0.00594 (0.0214) | 0.0510** (0.0207) | 0.0219 (0.0410) |
| Season A 2018 | - | 0.000590 (0.0278) | -0.0341 (0.0217) | 0.00308 (0.0245) | 0.00594 (0.00922) | -0.00319 (0.0165) | 0.0128 (0.0136) |
| LATE | | | | | | | |
| Season B 2017 | -0.0446 (0.0484) | -0.0849* (0.0508) | 0.0680 (0.0527) | 0.0330** (0.0149) | 0.0127 (0.0453) | 0.109** (0.0447) | 0.0468 (0.0871) |
| Season A 2018 | -0.00126 (0.0588) | -0.0728 (0.0454) | 0.00657 (0.0519) | 0.0127 (0.0195) | -0.00682 (0.0349) | 0.0272 (0.0286) | -0.0211 (0.0766) |
| Observations | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 23: Productivity

| | (1) | (2) | (3) | (4) | (5) |
|--|-------------------------------|-----|-----|-----|-----|
| | Productivity of (kg per acre) | | | | |

| | groundnuts | soya bean | sunflower | sesame | Index of dep variables |
|---------------|------------------|---------------------|-------------------|------------------|---------------------------|
| ITT | | | | | |
| Season B 2017 | 5.084 (14.71) | 26.24*** (7.876) | 9.052 (9.658) | 12.78 (10.09) | 0.00537 (0.00692) |
| Season A 2018 | 5.569 (6.803) | 10.23** (4.157) | -1.373 (6.918) | 1.256 (0.796) | -0.00764 (0.00829) |
| LATE | | | | | |
| Season B 2017 | 10.87 (31.12) | 56.07*** (16.73) | 19.35 (20.37) | 27.31 (21.62) | 0.0115 (0.0147) |
| Season A 2018 | 11.90 (14.35) | 21.85** (8.641) | -2.934 (14.63) | 2.684 (1.653) | -0.0163 (0.0175) |
| Observations | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 |
| Controls | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 24: Revenues

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|----------------------|--|-------------------|---------------------|---------------------|-------------------|------------------------------|-------------------|------------------|-------------------|--------------------|------------------------------|
| | Total revenues from sale of (10,000Ushs) | | | | | Net revenues of (10,000Ushs) | | | | | Index of dep variables |
| | oilseeds | groundnuts | soya bean | sunflower | sesame | total | groundnuts | soya bean | sunflower | sesame | |
| ITT | | | | | | | | | | | |
| Season B 2017 | 2.724 (5.186) | 0.801 (2.097) | 3.869*** (1.240) | -1.880 (3.181) | -0.675 (1.899) | 10.82 (10.61) | 0.0796 (0.740) | 0.254 (0.514) | 0.0437 (2.144) | 0.252 (0.233) | -0.0936 (0.123) |
| Season A 2018 | 1.373 (1.291) | -0.244 (1.007) | 0.675 (0.419) | 0.835*** (0.262) | 0.129 (0.142) | 5.196 (4.630) | 0.170 (1.640) | 0.824 (0.761) | -2.036 (2.366) | 0.382** (0.186) | 0.762 (0.744) |
| LATE | | | | | | | | | | | |
| Season B 2017 | 5.821 (10.94) | 1.713 (4.440) | 8.273*** (2.645) | -4.020 (6.744) | -1.437 (4.010) | 23.10 (22.34) | 0.170 (1.566) | 0.544 (1.081) | 0.0934 (4.529) | 0.539 (0.498) | -0.200 (0.258) |
| Season A 2018 | 2.933 (2.740) | -0.522 (2.123) | 1.443* (0.873) | 1.786*** (0.545) | 0.275 (0.298) | 11.10 (9.984) | 0.363 (3.468) | 1.761 (1.607) | -4.351 (5.009) | 0.817** (0.385) | 1.629 (1.567) |
| Observations | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 |

| | | | | | | | | | | | |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

See notes table 18

*** p<0.01, ** p<0.05, * p<0.1

Table 25: Market linkages

| | (1) | (2) | (3) Bulk/group sale of | | | | | (8) Contacts with value-chain actors for marketing | | | | | (13) |
|--------------|---|--------------------------------|------------------------|-----------------------|------------------------|-----------------------|-----------------------|--|-----------------------|---------------------|-----------------------|-----------------------|---|
| | Access to formal market for oilseed procurement | Oilseed harvest sold to market | oilseeds | groundnuts | soyabeans | sunflowers | sesame | oilseeds | groundnuts | soyabeans | sunflowers | sesame | Index of dep variables: market linkages |
| ITT | 0.0184 (0.0170) | 0.0142 (0.0130) | 0.0205*** (0.00669) | 0.00538* (0.00314) | 0.0121** (0.00474) | 0.00835* (0.00480) | -0.00160 (0.00171) | 0.00290 (0.0151) | 0.0210** (0.00825) | 0.00358 (0.0109) | -0.00341 (0.00872) | 0.000389 (0.00682) | 0.0474** (0.0192) |
| LATE | 0.0394 (0.0353) | 0.0304 (0.0274) | 0.0439*** (0.0143) | 0.0115* (0.00658) | 0.0259*** (0.01000) | 0.0178* (0.0104) | -0.00341 (0.00359) | 0.00620 (0.0319) | 0.0449** (0.0175) | 0.00765 (0.0230) | -0.00729 (0.0185) | 0.000831 (0.0144) | 0.101** (0.0396) |
| Observations | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 26: Wellbeing

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|-------------------------------------|---|---|--|--|---|--------------|--|
| HH yearly labor income (10,000 USH) | HH yearly non-labor income (10,000 USH) | Tot. hh income <60% of avg income in the sample | HH monthly food expenditure (10,000 USH) | HH monthly non-food expenditure (10,000 USH) | HH yearly expenditure on general items (10,000 USH) | Wealth index | Index of dep variables: final outcomes |

| | | | | | | | | |
|--------------|-------------------|-------------------|---------------------|-------------------|-------------------|-------------------|--------------------|---------------------|
| ITT | -8.470 (9.197) | -1.097 (2.246) | -0.0113 (0.0173) | -1.505 (2.256) | -0.903 (1.313) | -6.627 (21.23) | 0.0557 (0.0628) | -0.0567 (0.0572) |
| LATE | -18.10 (19.26) | -2.346 (4.753) | -0.0241 (0.0366) | -3.218 (4.774) | -1.925 (2.763) | -14.16 (44.87) | 0.119 (0.134) | -0.121 (0.120) |
| Observations | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 | 2,544 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

1.13.3. *Regression analysis, heterogeneous effects*

In Tables 27-30 we report heterogeneous treatment effects across a set of relevant dimensions, i.e. familiarity with oilseeds, gender of the farmer, land size and wealth. We do so by adding an interaction term between our treatment dummy and the relevant dimension of heterogeneity to the estimation equation, which allows us to test the differential impact, if any. For the sake of brevity, we report results by using the aggregate index (over multiple outcomes, as in the last column of former tables) as dependent variable. Overall, results point to little heterogeneity in the treatment effects. We find a barely significant negative differential effect on those who have some familiarity with oilseeds (Table 27), which points to a bigger impact of the treatment on those who were fresh to oilseed production.

We do not record any significant differential effect by gender (Table 28), while we do observe a negative interaction effect on income by land size (Table 29), pointing to a bigger treatment effect for smallholders. Yet, by testing heterogeneous effect by wealth, we find again no significant differential effects (Table 30).

Table 27: Heterogeneous treatment effects by familiarity with oilseeds

| | (1) | (2) | (3) | (4) |
|-----------------------------------|--|---|---|--|
| | Index of dep variables: oilseed adoption | Index of dep variables: use of inputs | Index of dep variables: productivity | Index of dep variables: revenues |
| PANEL A | | | | |
| Treat | 0.168*** (0.0583) | 0.198 (0.120) | -0.000388 (0.0123) | -0.317 (0.361) |
| Familiar with oilseeds | 0.210*** (0.0598) | 0.106 (0.0979) | -0.0235** (0.00967) | 0.0550 (0.186) |
| Treat*familiarity - Season B 2017 | -0.0884 (0.0604) | -0.190 (0.121) | 0.00706 (0.0135) | 0.247 (0.287) |
| Treat | 0.153** (0.0622) | 0.0386 (0.0886) | -0.00975 (0.0173) | 0.344 (0.882) |
| Familiar with oilseeds | 0.0902* (0.0471) | 0.0522 (0.0775) | 0.0227 (0.0299) | 1.640 (1.632) |
| Treat*familiarity - Season A 2018 | -0.104* (0.0600) | -0.0528 (0.0892) | 0.00308 (0.0188) | 0.421 (1.029) |
| PANEL B | | | | |
| | Index of dep variables: expectations | Index of dep variables: agricultural techniques | Index of dep variables: market linkages | Index of dep variables: final outcomes |
| Treat | -0.0280 (0.131) | -0.0223 (0.114) | 0.0407 (0.0454) | -0.323 (0.244) |
| Familiar with oilseeds | -0.111 (0.0966) | -0.0950 (0.0966) | -0.0119 (0.0364) | -0.221 (0.199) |
| Treat*familiarity | 0.0832 (0.131) | 0.0866 (0.117) | 0.00933 (0.0479) | 0.292 (0.252) |
| Observations | 2,529 | 2,529 | 2,529 | 2,529 |
| Controls | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes |
| Mean Dep Var at BL | -0.00273 | -0.00198 | -0.00164 | -1.51e-09 |

See notes table 18

Table 28: Heterogenous treatment effects by gender of respondent

| | (1) | (2) | (3) | (4) |
|----------------------------|--|--|---|--|
| | Index of dep variables: oilseed adoption | Index of dep variables: use of inputs | Index of dep variables: productivity | Index of dep variables: revenues |
| PANEL A | | | | |
| Treat | 0.0907** (0.0394) | 0.0507 (0.0557) | 0.00991 (0.0132) | -0.0484 (0.164) |
| Male | 0.00556 (0.0996) | 0.0876 (0.136) | -0.0416 (0.0284) | -0.0136 (0.0476) |
| Treat*male- Season B 2017 | -0.00445 (0.0470) | -0.0420 (0.0704) | -0.00631 (0.0142) | -0.0719 (0.0952) |
| Treat | 0.0420 (0.0328) | 0.000135 (0.0535) | 0.00237 (0.00781) | 0.0777 (0.262) |
| Male | -0.0103 (0.0653) | -0.0518 (0.121) | 0.00799 (0.0133) | -0.0100 (0.285) |
| Treat*male - Season A 2018 | 0.0270 (0.0406) | -0.0155 (0.0655) | -0.0151 (0.0189) | 1.054 (1.082) |
| PANEL B | | | | |
| | Index of dep variables: expectations | Index of dep variables: agricultural techniques | Index of dep variables: market linkages | Index of dep variables: final outcomes |
| Treat | 0.0411 (0.0461) | 0.0533 (0.0471) | 0.0531* (0.0270) | -0.0465 (0.114) |
| Male | -0.0858 (0.0900) | -0.202* (0.110) | -0.0132 (0.0673) | -0.556*** (0.134) |
| Treat*male | 0.0203 (0.0581) | 0.00508 (0.0551) | -0.00625 (0.0372) | -0.0185 (0.129) |
| Observations | 2,529 | 2,529 | 2,529 | 2,529 |
| Controls | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes |
| Mean Dep Var at BL | -0.00273 | -0.00198 | -0.00164 | -1.51e-09 |

See notes table 18

Table 29: Heterogenous treatment effects by land size

| | (1) Index of dep variables: oilseed adoption | (2) Index of dep variables: use of inputs | (3) Index of dep variables: productivity | (4) Index of dep variables: revenues |
|---------------------------------|--|--|---|---|
| PANEL A | | | | |
| Treat | 0.0737** (0.0303) | 0.0280 (0.0436) | 0.00864 (0.00727) | -0.0783 (0.126) |
| Land size | -0.00241 (0.00165) | 0.00196 (0.00410) | 0.000528 (0.000541) | 0.00191 (0.00180) |
| Treat*land size Season B 2017 | 0.00329 (0.00255) | -0.000730 (0.00417) | -0.000604 (0.000554) | -0.00334 (0.00243) |
| Treat | 0.0742*** (0.0229) | -0.0167 (0.0384) | -0.00936 (0.00895) | 0.716 (0.692) |
| Land size | 0.00446** (0.00177) | -0.00107 (0.00163) | -0.000638 (0.000422) | -0.0144 (0.0159) |
| Treat*land size - Season A 2018 | -0.00359 (0.00220) | 0.00169 (0.00194) | 0.000558 (0.000370) | 0.00264 (0.00983) |
| PANEL B | | | | |
| | Index of dep variables: expectations | Index of dep variables: agricultural techniques | Index of dep variables: market linkages | Index of dep variables: final outcomes |
| Treat | 0.0464* (0.0278) | 0.0503 (0.0400) | 0.0457** (0.0193) | -0.0206 (0.0572) |
| Land size | -0.000505 (0.00113) | -0.00215 (0.00226) | 0.000686 (0.00141) | 0.00839*** (0.00301) |
| Treat*land size | 0.00158 (0.00145) | 0.00141 (0.00279) | 0.000823 (0.00175) | -0.00863*** (0.00314) |
| Observations | 2,529 | 2,529 | 2,529 | 2,529 |
| Controls | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes |
| Mean Dep Var at BL | -0.00273 | -0.00198 | -0.00164 | -1.51e-09 |

See notes table 18

Table 30: Heterogenous treatment effects by wealth index

| VARIABLES | (1) Index of dep variables: oilseed adoption | (2) Index of dep variables: use of inputs | (3) Index of dep variables: productivity | (4) Index of dep variables: revenues |
|------------------------------|--|--|---|---|
| PANEL A | | | | |
| Treat | 0.0879*** (0.0313) | 0.0247 (0.0409) | 0.00608 (0.00687) | -0.0924 (0.125) |
| Wealth index | 0.00149 (0.00825) | 0.00831 (0.0104) | 0.000610 (0.00222) | 0.0223 (0.0232) |
| Treat*wealth Season B 2017 | 0.00840 (0.0130) | 0.0184 (0.0176) | -0.00777** (0.00337) | -0.0451 (0.0357) |
| Treat | 0.0587** (0.0239) | -0.00937 (0.0366) | -0.00697 (0.00789) | 0.727 (0.711) |
| Wealth index | -0.00104 (0.00672) | 0.0140 (0.00883) | -0.00237 (0.00226) | -0.0943 (0.0960) |
| Treat*wealth - Season A 2018 | -0.00575 (0.00995) | -0.00390 (0.0141) | 0.00264 (0.00186) | 0.0477 (0.0690) |
| PANEL B | | | | |
| | Index of dep variables: expectations | Index of dep variables: agricultural techniques | Index of dep variables: market linkages | Index of dep variables: final outcomes |
| Treat | 0.0538** (0.0252) | 0.0564 (0.0390) | 0.0491** (0.0194) | -0.0580 (0.0573) |
| Wealth index | 0.00232 (0.00778) | 0.0206* (0.0106) | -0.00691 (0.00539) | 0.0644** (0.0313) |
| Treat*wealth | -0.0107 (0.0139) | 0.000627 (0.0147) | 0.0110 (0.0101) | 0.0198 (0.0346) |
| Observations | 2,529 | 2,529 | 2,529 | 2,529 |
| Controls | Yes | Yes | Yes | Yes |
| Strata FE | Yes | Yes | Yes | Yes |
| Mean Dep Var at BL | -0.00273 | -0.00198 | -0.00164 | -1.51e-09 |

See notes table 18

1.13.4. Robustness checks and internal validity concerns

Attrition

Our sample experiences an attrition rate of 6.9%. The major reasons of this lie in the impossibility to find the respondent (or a competent respondent according to the survey protocol) during the multiple visits conducted, the movement of the respondent/ household and some refusal to conduct the endline.

Table 31: Determinants of attrition

| | Attriter |
|---|-------------------------|
| Treat | 0.0139 (0.0108) |
| Respondent is the HH head, baseline | -0.0371 (0.0513) |
| Respondent is male, baseline | 0.0485 (0.0509) |
| The respondent can read, baseline | 0.0209 (0.0352) |
| The respondent can write, baseline | -0.0104 (0.0380) |
| Respondent is responsible for agric decisions, baseline | 0.00252 (0.0182) |
| Respondent's education: No education, baseline | -0.0293 (0.0316) |
| Respondent's education: (Some) Primary, baseline | -0.0351 (0.0285) |
| Respondent's education: (Some) Secondary, baseline | -0.0403 (0.0267) |
| Member of Village Saving and Loan Association, baseline | -0.0123 (0.0101) |
| Risk averse low stake, baseline | -0.0102 (0.00928) |
| Wealth index, baseline | -0.00215 (0.00298) |
| Total plot size, baseline | -0.000201 (0.000412) |
| N. of plots, baseline | 0.000764 (0.00440) |
| Planted oilseeds (any) in the past, baseline | 0.00263 (0.0190) |
| Constant | 0.101** (0.0393) |
| Observations | 2,716 |
| R-squared | 0.033 |
| Strata FE | Yes |

Standard errors, in parenthesis, are clustered at the level of sub-county. *** p<0.01, ** p<0.05, * p<0.1

In table 31, we analyse the determinants of attrition. One can notice that attrition is not correlated with the treatment assignment and with almost none of the individual characteristics used as controls in the analysis. This lack of systematic differences between the treatment and control group reassures about the internal validity of our findings.

Multiple hypothesis testing

We follow Banerjee et al. (2015) in introducing means of multiple inference correction. First, for each family of outcomes reported in different tables, we create an index of all outcomes in the family. Such family-specific index, proposed by Kling et al. 2007, is constructed as the equally weighted average of z -scores of its components, with the sign of each measure oriented so that more beneficial outcomes have higher scores. The z-scores are calculated by subtracting the control group mean and dividing by the control group standard deviation. Thus, each component of the index has mean 0 and standard deviation 1 for the control group. Second, we test the Family-wise Error Rate (FWER) across indexes by adjusting their respective p-values following the Hochberg procedure (Hochberg, 1988)⁸. Table 32 shows the standard p-values from estimation presented earlier, p-values corrected for multiple hypothesis through the Hocheberg procedure considering 12 (season-specific outcomes are counted twice) and 8 hypotheses in columns 2 and 3, respectively. It turns out that our main results for the family of outcomes related to oilseed adoption remains significant after both corrections, while outcomes related to linkage to market become non-significant.

Table 32: Multiple hypothesis correction

| Outcome index for: | (1) Standard p-value | (2) Hocheberg corrected p-value (m=12) | (3) Hocheberg corrected p-value (m=8) |
|-------------------------------|-------------------------|---|--|
| Expectations | .134 | .787 | .695 |
| oilseed adoption -seas A 2018 | .009 | .099 | .072 |
| oilseed adoption -seas B 2017 | .006 | .072 | |
| agricultural techniques | .139 | .787 | .695 |
| use of inputs - seas A 2018 | .787 | .787 | .787 |
| use of inputs - seas B 2017 | .528 | .787 | |
| productivity - seas A 2018 | .311 | .787 | .787 |
| productivity - seas B 2017 | .434 | .787 | |
| market linkages | .017 | .170 | .119 |
| revenues - seas A 2018 | .31 | .787 | .787 |
| revenues - seas B 2017 | .465 | .787 | |
| final outcomes | .574 | .787 | .787 |

⁸ First, the p-values for the coefficients of the treatment indicator in each of the regressions for the indices are ranked in increasing order. Then, each original p-value is multiplied by $(m + 1 - k)$, where m is the total number of indices (7 in our case) and k is the rank of the original p-value. If the resulting value is greater than 1, we assign an adjusted p-value of “>.999.”

Discussion

In this report we present an overview of the VODP2 project implemented in the context of Uganda, the impact evaluation design and empirical strategy, survey data collection, descriptive statistics and findings. By exploiting the phase-in approach of VODP2 across different areas in Uganda we have designed a randomized control trial at the sub-county level. By using the random assignment estimation strategy (intention to treatment effect), we estimate the causal impact of the VODP2 extension model on oilseed adoption, farm output, productivity and well-being. We find that VODP2 has a positive and significant effects on immediate outcomes, such as farmers' price and yield expectations, vegetable oil seeds adoption and input use. We find more mixed results on intermediate outcomes in terms of productivity and revenue. We do find, though, positive effects on market access (group sale) and value-chain involvement. We find very little effect on final wellbeing outcomes.

Our findings seem to point to a significant VODP2 achievement in fostering oil seeds adoption, especially groundnut and soybean. There is less evidence of sunflower take up, though, which is the most suitable crop for commercial farming and trade. There is also some significant evidence of smallholders' inclusion in the oil seed value-chain through group-sales and market access. Hence, the VODP2 extension model seems to be effective in reducing both informational and market barriers to oilseed adoption. Yet, the mixed evidence of a significant impact on input use, productivity and revenues (for all oilseeds with the exception of soybean) raise concerns about the sustainability of the project. The reason for this may be related to the partial compliance issue: only a fraction of farmers assigned to the treatment actually received the full extension module, as from their self-reported info on extension activities received by VODP2. At the same time, in the academic paper we plan to explore even further the role of expectations in explaining the results. In particular, we want to investigate whether there are heterogeneous effects across ex-ante price and yield expectations of farmers. If those who have biased expectations are those less informed/capable about oil-seeds cultivation and at the same time they are those who adopt more after the VODP2 intervention, finding little impact will be explained by a 'negative selection mechanism'. This is our hypothesis to be tested in the academic paper. Moreover, we would like to further explore heterogeneous effects across different seeds. Indeed, our results are more robust for oilseeds whose value chain is well established such as soya bean. Finally, the supply of quality seed is a fundamental condition, on which we have no data though. Concerning final well-being outcomes, we believe we find little impact because of the short-time window.

Extension service and market information projects have been implemented for decades in many countries in Africa. Yet, there is still much to be learned in the extension field. Our study and experimental design intend to shed new light on the implementation of effective extension systems, able to achieve the objective of agricultural development. So far, the VODP2 extension model that include both technical and market information seem to be effective on immediate outcomes in Uganda, but other barriers (e.g. accessibility of market inputs, capital or available land) may prevent the achievement of sustainable outcomes.

Impact evaluations are usually of specific interventions in a specific context. It remains possible that these results cannot be generalized to different contexts. Yet, they are drawn from a representative sample at the group-level so that they may be generalized to contexts similar to Uganda with farmers working in groups. Moreover, they contribute to provide systematic and causal evidence on the effectiveness of nation-wide agricultural policy in Uganda, which is a big country (both in economic and demographic terms) with one of the highest growth rate in commercial farming in Africa.

Specific findings for policy and practice

We faced several challenges during the impact evaluation as described below.

1. The project involved too many actors (VODP2 funding institutions, Government of Uganda, PMU, hub coordinators, service providers, farmer groups). The research team was not in charge of activities' implementation and hence not in a position to enforce the timeline and protocols of the research exercise to those in charge of activities. In other words, dealing with so many actors, which had not aligned incentives, resulted in a huge challenge throughout the whole impact evaluation study. The way we addressed this challenge has been persistent interaction with PMU, presentation and explanation of our exercise through field visits and skype meetings, development and provision of several monitoring tools, team building and moral suasion. After various exchanges, we managed to have PMU strong commitment but eventually, given the high number of actors still involved downstream the PMU, the call for homogeneity and monitoring of the intervention across regions has been weak.
2. Concerning the study, we faced delays in project implementation, which led to delay in the launch of the study. Given the short study window and the relatively slow implementation schedule, the evaluation window in some cases reduced to one agricultural season, which may be considered too short a time period to assess outcomes besides the immediate ones. For sure, we are not able to investigate any long-term effect on final outcome in this study.
3. The field research team had difficulties in tracking all farmers at the endline, since the baseline sample was not warned or prepared to receive the survey administration by local activities' providers. The endline survey took longer than expected and we ended up with an attrition rate of 6.9%.
4. We face a general problem of partial compliance since, from self-reported indicators, we observe less people treated than initially expected as well as some farmers in the control group reporting to have received project activities. We hope to obtain more precise monitoring data from service providers in order to cross-check self-reported information from our questionnaires.

We learnt two general lessons that can be summarized as follows.

- Planning an impact evaluation of a nation-wide project such as VODP2 in Uganda, needs to be set up with a formal and enforceable agreement between researchers and local activities implementing agencies (both PMU and service providers in this case). Having external researchers in a project with different funding institutions for activities on the one hand, and impact evaluation on the other, proved to be challenging in setting up a common and coordinated platform for the implementation of the intervention and the design of its assessment.
- The time-window over which to observe economic impact needs to be tailored according to the nature of the project and not to standard administrative criteria. Given that VODP2 is an agricultural development project, a two-year window is probably not enough to detect any long-term impact on outcomes such as poverty and well-being, which is a significant gap in such a big impact evaluation that required a huge coordination effort.

Specific lessons for policy and practice about extension services and/or VODP2 type programs are related to targeting. It is important to have in mind the kind of sub-population the program wants to reach, beyond farmer groups available. For example, collecting ex-ante data on willingness, capacity

and expectations in growing a new seed would shed light on those more suitable to be trained for a new farming technology. Farmers, who are in worse conditions, may have the highest incentives to adopt new technologies, but receiving the same treatment as farmers in better conditions, may not be enough to fill the gap and have substantial final outcomes.

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APPENDIX I: Training of the enumerators

The training was structured in two days, both held in Makerere University.

On the first day, the survey coordinator went thoroughly through the English version of the questionnaire with the surveyors; he then discussed with them the most difficult parts to be translated into local languages; eventually the surveyors were given a short home assignment, consisting in translating and rephrasing appropriately the questionnaire in their language. On the second day, a recap of the tool was performed. Then, the enumerators were involved in a role play where groups of two people played alternatively the role of interviewer and interviewee; this was help helpful for a) getting confidence with the questions in the tool; b) rephrasing questions or mark the redundant ones; 3) adjusting some behavioural attitudes of the enumerator (e.g. tone of voice, non-verbal language etc.).

Data collection

Questionnaires were administered on paper. Guidelines on ranges of acceptable/ reasonable levels for key variables were provided (land extensions, yields, price of units, revenues from sales) in order to check the quality of data provided, soon after the survey. Data collected by each enumerator team was monitored daily by the field supervisor, in order to identify mistakes, incoherencies and missed information. Discussions with the enumerator and phone calls with the respondents would then allow to fill such gaps. Moreover, in order to ensure a data collection informed rigorousness, integrity and discipline, the surveyors were divided into subgroups formed by four people each. Each subgroup, in turn, had a head and a deputy; they would make sure that a) the staff was always intact; b) professionalism was respected; c) the group slept in the same area. In this way, it was also possible to cross check for any error or issue as it arose; in addition, the surveyors would feel more responsible in their activity.

APPENDIX II: Pre-analysis plan

Introduction

The VODP2 project

The Government of Uganda has been working to increase the country's production of vegetable oil crops, promote investment in processing and eventually reduce imports of vegetable oil.

The Vegetable Oil Development Project (VODP) supported by IFAD (Rome) was conceived in the mid-1990s to reduce Uganda's heavy reliance on imports of vegetable oil. The project is highly innovative inasmuch as it introduced a new crop (oil palm) to Uganda and a new form of public-private partnership (PPP). The evaluation team confirmed that VODP has been successful in increasing vegetable oil production in Uganda, with substantial positive financial, economic and social impacts. The lessons learned during implementation of VODP provide a sound basis for further development of the vegetable oil subsector.

The second phase of the Vegetable Oil Development Project (VODP2) builds upon the work of its predecessor Project and use the value chain development approach to promote and consolidate (i) traditional oilseeds (sunflower, soybean, groundnuts and sesame) in eastern and northern Uganda and (ii) oil palm production in Kalangala and Buvuma Islands.

The project is funded by Government of Uganda (GoU), IFAD and private actors with contribution of farmers following public-private partnership arrangement. VODP2 was approved by IFAD's Executive Board in April 2010 and by the Parliament of Uganda on 29 September 2010. The Government signed the loan agreement in Rome on 21 October 2010.

The oilseeds component targets to reach 136,000 smallholder households. Based on lessons learned from VODP, activities of VODP2 are concentrated in four hubs, including the Lira hub and the emerging Mbale-Jinja hub as well as the new Arua and Gulu hubs, where there are good prospects for attracting additional private investment in oilseed milling capacity.

The overall goal of the intervention is to contribute to sustainable poverty reduction in the project areas. The development objective is to increase the national production of vegetable oils and its by-products, thus raising rural incomes for smallholder producers and ensuring the supply of affordable vegetable oil products in Ugandan consumer and neighbouring regional market.

Under VODP2 the focus is on developing a competitive oilseeds value chain by concentrating in the hubs and by enhancing smallholder producers' productivity to meet the expanding needs for crushable seeds. Specific objectives are:

- promotion of sunflower, soybean, sesame and groundnuts production;
- improved nutrition, utilization and consumption of locally produced vegetable oil;
- introduction of conservation agriculture for oilseeds production;
- improved capacity of the target group farmers to make informed decisions.

Project activities are targeted to farmer groups. The latter may be already existing and active groups or they may have been created for the purpose of the project. On average groups are composed by 15-20 members, have a leader and are composed by both men and women. Farmer groups are eligible to receive the VODP2 project and to participate our study when:

1. They have been already formed for other previous projects and have some degree of formalization (concrete constitution, registration at the level of sub-county or district city office)
2. They are interested in oilseed production
3. They have available land to implement the learning platforms
4. They are not currently benefiting from other development projects⁹

The VODP2 extension service intervention is supplied by pay-for-service providers and includes both technical services for increased oilseed production/productivity (such as water requirements, land preparation, planting, use of input like fertilizer and pesticides) and market information (i.e. training about farming as a business, business oriented group development, marketing). One of the main tools are Farmer Learning Platforms, a form of applied research and technology transfer system on latest notified/released varieties along with full package of practices on selected farmers' fields with a view to demonstrate the potentiality of the technologies to both attending farmers and neighbouring farmers/agencies. This approach aims at providing direct interface between farmers, extension personnel, input dealers/seed companies and produce buyers who are directly involved in planning, execution and monitoring of the demonstrations. The value chain approach intend to bring in a joint evaluation of the technology's performance both at farm and market/mill levels and get direct feedback from all actors involved. This enables the latter to focus on technologies and practices that will give maximum benefit/returns to all actors along the value chain. The Farmer Learning Platform is developed after the identification of a site of demonstration (0.25- 0.5 acres depending upon the size of plot available) where new technologies and practices are shown against the traditional ones. The site of demonstration normally belongs to one member of the farmer group.

With respect to the information given to the farmers, they will cover the following issues: water requirements, land preparation, planting (time, method, seed rate, spacing, thinning, weed control. Training about the use of inputs, namely seeds, fertilizers, and pesticides will also be provided to the farmers. Prior to the launching of the demonstrations, all group members are informed well in advance about the date and venue (demonstrations host farmers) and are invited to participate. The demonstration events are also open to neighbouring farmers. Trainers are expected to maintain a collaborative and participatory approach, aimed at responding to farmer needs and gaps and to take into consideration farmers' feedback and critiques.

Theory of change and hypothesis under investigation

The current research exercise is primarily aimed at testing project's main objectives as stated in the description above. In particular, the project is expected to have impact through a chain of changes which we group in three main categories of outcomes: immediate, intermediate and final.

We expect that the *immediate* behavioural changes resulting from the project interventions will include a change in famers' expectations concerning the opportunity to cultivate oilseeds, the adoption of oilseeds (both traditional and improved varieties), the adoption of recommended

⁹ The reader should notice that the eligibility criteria for the inclusion in the study are relatively different from the criteria for the VODP2 project. In particular, the study only includes farmer groups which are already formed, while the project also aims at creating new farmer groups. The research team decided to focus only on already existent group for the reasons which follow. First, starting a new group is part of the project activities and requires the activation of resources from the service providers which we could not get at the time when the sampling exercise was carried out. Second, the sampling strategy required the identification of groups to be reached in different agricultural seasons before the launch of VODP2 activities in these areas. These forced us to exclude potentially new groups from the analysis. As a consequence, we acknowledge that the study is not fully representative of the targeted population.

agronomic practices in general and for oilseeds in particular, an increased market participation of farmers.

The key assumptions underlying the realization of immediate impacts can be summarized as follows:

- information on available improved oil seed technologies, best agronomic practices and about available marketing opportunities are properly, effectively and adequately disseminated
- the contents of the intervention and the benefits deriving from oilseed adoption, agricultural best practices and better links to market are understood by beneficiaries

The following hypothesis will be tested:

- *1.1 the intervention will lead to higher expectations regarding oilseed profitability*

The outcome variable is represented by farmer expectations regarding oilseeds' yields cultivated in an hypothetical major season. Expectations are elicited by asking households what the average yield of different oilseeds is expected to be after the major season harvest, conditional on growing those crops. Separate specifications for the four different oilseeds will be run. We expect to find that treated farmers will show higher expectations regarding oilseed profitability than control ones.

- *1.2 the intervention (and higher expectations) will lead to new adoption of oilseeds or intensification of its cultivation*

The outcome variables are represented by the oilseed adoption extensive and intensive margin. In particular we will construct:

- i. a binary variable indicating whether a household planted oil seed (extensive margin)
- ii. the fraction of household total land planted with oil seed (intensive margin)
- iii. the oilseed harvest (intensive margin)

Separate variables for each of the four different oilseeds as well as a general one for any oilseeds will be created. We expect to find positive and significant effects of the treatment variable for all the outcomes under investigation.

- *1.3 the intervention will improve the knowledge of improved agronomic techniques and will lead to an increase in their actual use. This will be observed not only for oilseeds, but also for other crops*

The hypothesis will be tested by using two sets of outcome variables which will shed lights on improvements in the cultivation of oilseeds and of any crop, in general. The oilseed-specific set of outcomes include:

- i. For each of the four oilseed and for oilseeds in general, binary variables for the use of:
 1. Improved seeds
 2. Fertilizer
 3. Pesticide

- ii. Total expenditure for productive inputs (improved seeds, fertilizer, pesticide) for oilseeds

The set of variables for the general agricultural practices include:

- i. For any crop, binary variables for the use of
 1. Improved seeds
 2. Fertilizer
 3. Pesticide
- ii. Binary variables for the application of the following agricultural practices (on any crop):
 1. Water conservation
 2. Moisture retention
 3. Zero tillage
 4. Compost making
 5. Post-harvest handling
- iii. An aggregate index for knowledge and improved practice given by the sum of dummies described at the previous points i. and ii.

We expect that the treatment group performs better on both sets of outcomes than the control group.

Intermediate development outcomes reflect changes in the agricultural production and farmers market participation, eventually leading to greater value of output and revenues from crop sales. Such changes rely on the occurrence of the following hypothesis:

- *2.1 the intervention (and realization of immediate outcomes) will lead to productivity gains*

We construct two measures for productivity. The first measure is the fraction of the total harvested production of each crop over the size of land dedicated to its cultivation. The variable is calculated at the farmer level. The second measure of productivity is constructed by dividing the value of net revenues (described below), by total farm size. Oilseed-specific measures will be created as well as an aggregate measure encompassing all of them. We expect that treated farmers will have higher levels of productivity compared to control ones. The above holds under the assumptions that farmers can access improved inputs (available land, improved seeds, fertilizers, pesticides).

- *2.2 the intervention (realization of immediate outcomes and productivity gains) will lead to greater value of output derived from oilseed cultivation*

Output derived from oilseed cultivation is obtained through the construction of net revenues, i.e. the value of harvest (at local market prices at the time of sales), netted of market inputs. We construct a measure of farm output for the four particular oilseed crops and for all crops in general. We expect that treated farmers will have higher value of output derived from oilseed cultivation compared to control ones.

- *2.3 the intervention will improve farmers' links to market. This will lead to the improvement of market access and commercial skills*

The outcomes variables related to this hypothesis pertain two important phases in which market links may play a role: the supply of seeds and group marketing of harvested crops.

The first outcome is measured through a set of binary variables (one for each of the four oilseed and one for any oilseeds) for the existence of a market link for the supply of seeds. Such variables will be equal to one if farmers obtain seeds from market players such as agro-dealers, private traders, local market or seed companies, and zero otherwise.

The second outcome is measured through a set of binary variables (one for each of the four oilseed and one for any oilseeds) for the participation to joint marketing practices or if the harvest of the particular oilseed is sold together with the other members of the farmer group (in contrast to individual sales).

We expect that the treatment group performs better on these sets of outcomes with respect to the control group.

- *2.4 the intervention (realization of immediate outcomes, productivity gains) will lead to greater revenues from the sale of oilseeds, eventually leading to greater total revenues from crop sales*

The set of outcomes for the test of this hypothesis is represented by revenues from sales of the four different oilseeds, the sum of them and the overall total for all crops. The latter variables will be combined to obtain the share of total crop revenues derived from oilseeds (considered individually and in aggregate).

As for *final* outcomes, we expect that the realization of the intermediate outcomes will impact the sphere of household well-being in the dimensions of income, consumption, asset and wealth. In this regard, the following hypothesis will be tested:

- *3.1 the intervention (and realization of previous outcomes) will lead to higher total household income, via increase in on-farm income*

As far as household income is concerned, we construct three different levels. The first is represented by on-farm income which is assumed to be equal to net revenues (see previous points). The second aggregates the income for all household members engaged in off-farm activities (hunting, fishing, own business, on-farm and off-farm dependent labour). The third source, defined as non-earned income, is the sum of incomes, across household members, for pension, inheritance, lotteries and transfers from others. The hypothesis will be tested by using as dependent variable the share of total income derived from on-farm activities and the total household income itself. We expect to observe positive treatment effects.

- *3.2 the intervention (and realization of previous outcomes) will lead to higher total expenditure*

The hypothesis will be tested using total household consumption as a dependent variable. We will also be able to shed light on the impact of the intervention on its different components (food, non-food and durables). We expect to observe positive treatment effects.

- *3.3 the intervention (and realization of previous outcomes) will lead to increase in assets and wealth*

We consider a set of outcome variables concerning assets and wealth which are likely to be influenced in the relatively short time horizon considered in our study (12 months). In particular aggregate variable indicating the number of livestock and of assets usually present in houses will be used. We expect to observe positive treatment effects.

Heterogeneous impact

A secondary set of hypotheses are related to the extent to which project impacts are expected to vary along different dimensions, measured at the baseline, and sub-groups; the latter are presented below

- *4.1 farmers' initial level of familiarity with agronomic techniques and with oilseed cultivation lead to differential impacts of project activities. In particular, under the assumption of diminishing (accelerating) returns to learning, bigger impacts should be observed for less (more) knowledgeable farmers and for those who never (already) experienced oilseeds*

The level of familiarity with oilseed cultivation is measured at the baseline through five binary variables (one for each oilseed and one for any of them) which are equal to one if the farmers grew the crop in the past and zero otherwise. The initial level of knowledge and use of agronomic techniques is provided by a score, ranging from 0 to 8, given by the sum of binary variables for the use of fertilizer, pesticide, improved seeds, water conservation moisture retention, compost making and post-harvest handling for any crop. A binary variable for farmers scoring above the median will be constructed and employed in regression 2.

The outcome variable we will consider are related to oilseed adoption (see hypothesis 1.2) and all intermediate outcomes (hypothesis 2.1, 2.2 and 2.3)

Negative coefficients of the interaction terms indicate higher effect on farmers at lower levels of 'skills' and highlight the important role of the treatment in filling the informational gap. On the contrary, positive coefficients indicate that the project has reinforcement effects on the ones who have relatively high skills and familiarity with oilseeds. Non-significant coefficients indicate the lack of heterogeneous effects of the project on the skill levels at the baseline. The sign of the coefficients is an empirical question.

- *4.2 the decision over the choice of oilseed(s) to be cultivated should be the outcome of a rational process involving the service provider, the farmer group and the individual farmer, considering factors related to the suitability of the different oilseeds to the local geographical and market characteristics. On average, successful implementation of any oilseed (or a combination of them) should bear similar impacts on intermediate and final outcomes*

We will run specification (1) separately for farmers adopting each of the different oilseed at the endline. The hypothesis will be tested through a comparisons of coefficients δ_1 , to be done through F-tests, across specification using different oilseeds (soya bean vs groundnut vs sunflower vs simsim). We will use the set outcomes previously described as intermediate and final. Non-rejection of the null hypothesis of no difference across coefficients will validate the hypothesis that the project bears relevant impacts, regardless of the type of crop the individual decided to grow, under the assumption that the effectiveness of the project is maximized if the most suitable oilseed production is prompted in different areas. We expect to non-reject the null of equality of coefficients attached to the treatment variable, across different oilseed-specific regressions.

- *4.3 the decision to adopt/intensify oilseed production requires households to either devote some new arable land not previously cultivated, or to switch the destination of some land which was previously cultivated with other crops. We believe that the decision will be easier for households with larger farm size, therefore with more available land*

The hypothesis will be tested on the set of outcomes presented under hypothesis 1.2 (adoption and intensification). X will include a set of dummies for belonging to different quantiles of the distribution of total farm size (e.g. median and quartiles). We expect to find positive coefficients attached to the higher quartiles/ above the median indicator.

- *4.4 the decision to adopt/intensify oilseed production also requires households to invest both in cash and in-kind inputs. For example, the purchase of seeds, particularly improved ones, require some initial capital. The same applies if one wants to introduce improved productive inputs such as fertilizers and pesticides. Liquidity constraints can represent a strong barrier to innovation. Therefore, we expect to observe higher treatment effects for wealthier farmers, i.e. in households where liquidity constraints bind less.*

The hypothesis will be tested on the set of outcomes presented under hypothesis 1.2 (adoption and intensification). X will include a set of dummies for belonging to different quantiles of the distribution of baseline household income and wealth (e.g. median and quartiles). The former is obtained by the sum of on-farm, off-farm and non-earned incomes across all household members. The latter is constructed using a wealth index using Principal Component Analysis (PCA) as suggested by Filmer and Pritchett (2001), by aggregating the information on the number (measured at the baseline) of livestock and assets which may be present in a house (e.g. fridge, tv, radio, bike, etc). We expect to find positive coefficients attached to the higher quartiles/ above the median indicator.

- *4.5 Whether and how much to grow of oilseeds depend on extant agricultural skills, farm labor inputs and opportunity costs. As long as women are comparatively disadvantaged with respect to the former, we expect to find higher treatment effects for male farmers. On the other hand (even assuming equal opportunities costs by gender) if either the investment marginal productivity or returns to learning are higher for women, we shall observe a higher impact of information treatment on female farmers.*

The hypothesis will be tested by interacting the treatment dummy with a dummy variable equal to one if the respondent farmer is a woman. Negative coefficients of the interaction terms indicate lower impact on female farmers while the opposite holds for positive coefficients. We may also run separate regressions by gender and estimate again average as well as heterogeneous treatment effects. This would allow us to shed light on the mechanisms that underlie a potential heterogeneous treatment effect by gender. The sign of the coefficient is an empirical question.

Methods overview

The impact evaluation exercise exploits the roll-out structure of the VODP2 to implement a randomized controlled trial. The project intends to gradually reach the target beneficiaries, given resource constraints in reaching all districts at the same time. The level of randomization is at sub-county level, as it allows to meet organizational issues with research requirements. The phase-in design involves a sample of eligible sub-counties randomly assigned to receive the treatment in different moments of time. In particular, one random group of sub-counties (treated group) is

assigned to receive the entire package of project interventions during 2017. The second group (control group) is expected to receive the treatment in 2018. Both groups are administered a baseline survey between June and September 2016, before any project activities have started. A staggered endline survey is planned to be carried out from January to November 2018: both treated and control groups will be gradually administered an endline survey (staggered endline), just before VODP2 interventions reaches control sub-counties. This will allow us to have a 12 months evaluation window (2 agricultural seasons) obtained from the comparison of early receivers in the treatment group with early receivers in the control group (the same would apply for later receivers in both groups).

1.13.5. *Sampling*

Sampling occurs at different levels, for the selection of sub-counties, farmer groups and farmers. In what follows we describe the sampling procedures for each level.

In our study, the unit of randomization is the *sub-county* that is an intermediate administrative level (between districts and villages) with an average population of about 20,000 people. Our power calculation suggested to construct a sample of 86 sub-counties to be assigned to the treatment and control group. The eligibility criteria provided by the IA in accordance with local authorities and service providers mainly included the orographic and soil characteristics of regions in relation to the development and expansion of oilseed production.

The second level of sampling pertains to the selection of farmer groups, within each sub-county. Our power calculations indicated that we should sample 8 farmer groups per sub-county, for a total of 688 groups.

Farmer groups are eligible to receive the VODP2 project and to participate our study when:

1. They have been already formed for other previous projects and have some degree of formalization (concrete constitution, registration at the level of sub-county or district city office)
2. They are interested in oilseed production
3. They have available land to implement the learning platforms
4. They are not currently benefiting from other development projects

A list of farmer groups meeting the eligibility criteria was obtained from the service providers contracted to deliver VODP2, in collaboration with community development office. From the list of eligible farmer groups, 8 groups per sub-county were randomly selected. We were actually able to successfully reach and administer the baseline survey to 690 farmer groups in 86 sub-counties.

The third level of sampling pertains to the selection of farmers within farmer groups. Our power calculations indicated that we should sample 4 farmers per groups, for a total of 2752 farmers.

Once a farmer group was selected, a meeting with the leader or a representative of the group was set up by our enumeration team. During the meeting, the group level questionnaire and the household level questionnaire were administered. The list of other group participants was obtained and 3 members were randomly selected and were administered the household questionnaire. In total, 688 questionnaires are administered to group leaders or representatives and 2064 to farmers; overall 2752 farmers should form our sample of farmers. However, we were able to collect 2733 farmer level questionnaires (more details and analysis are found in the baseline report).

1.13.6. *Identification*

The identification of the causal effect of the VODP2 project on farmer level outcomes relies on the gradual phase-in of activities in different sub-counties. The treatment group is represented by farmer groups receiving the VODP2 project earlier, i.e. in 2017, while the control group is given by groups receiving the treatment later, i.e. in 2018. By exploiting the double comparison before-after and treatment-control we will measure the impact of the VODP2 project on the outcomes of interest.

Selected sub-counties are randomly assigned to the two arms and allocated across four seasons in two years (two seasons per year). Hence, groups reached by VODP2 during the first two seasons are deemed treated while the latter two are control.

Treatment assignment, i.e. the season during which the sub-counties receive the intervention, is performed after the baseline, by the research team, through a random generator number (within each district). Treatment assignment is stratified by district, in order to get balance. In each district we have at least one sub-county per treatment arm. Overall, we obtain 43 sub-counties in the treatment group and 43 in the control group. Within each arm, sub-counties are further split in two groups, for the first and second agricultural season, respectively. Our final sample is then divided as follows: 22 and 21 sub-counties for the first and second season of 2017 in the treatment group, while 21 and 22 sub-counties for the first and second season of 2018 for the control group.

To guarantee that the randomization was successfully done balance tests, i.e. difference of means between treated and control group, along baseline characteristics is performed both at farmer and group level.

1.13.7. *Data sources*

Data for the analysis come from two sources: surveys and project administrative data. While the former source is directly collected by the research field team, the latter is provided by the VODP2 PMU and the service providers which are working in the study areas.

Surveys represent the main source of data and are collected at different levels: farmer, group and community. Household surveys are administered to four farmers who are member of the same farmer group selected for receiving the project, in order to capture general household characteristics, agricultural skills and decisions and other economically relevant aspects. One of the four members interviewed, as a representative of the farmer group, is also administered a group level questionnaire where questions on the characteristics of the group, such as size, composition, scope, functioning and activities regularly carried out. Community surveys have been administered to community representatives and include information on infrastructures and general characteristics of the community.

Baseline data have been collected between June and September 2016 from all farmer groups, before any activity has started in any sub-county included in the study. The endline data collection will follow a staggered schedule, where treated and control groups are surveyed after two agricultural seasons starting from the time the groups assigned to treatment have been actually reached (i.e. *treatment and control groups are compared after two seasons*). Endline surveys will start being collected from January 2018. The collection will last 9 to 12 months, until all treated and control groups have been surveyed. Procedures for the actual implementation of the endline survey will follow the same adopted for the baseline data collection.

The secondary source of data is provided by administrative data related to monitoring activities. Since VODP2 are delivered by three different service providers, with different monitoring systems, we planned to obtain standard monitoring information on the way the activities have been implemented. In particular, the following information will be recorded for each farmer group: start and end dates, attendance lists of participants from the group, type of crop introduced, list of activities delivered, list of inputs provided, if any, number of visits, identifier of the training team if more than one.

Estimation, hypothesis testing and heterogeneities of interest

Main effects

The benchmark specification for the impact evaluation exercise aims at obtaining the main effects of the treatment on the immediate, intermediate and final outcomes. We exploit both variation across treatment and control group and over time (pre and post treatment). We employ a difference-in-difference strategy with random treatment assignment, which looks as follows:

$$y_{ijt} = \beta_1 y_{ij2016} + \beta_2 \text{Treat}_{ij} + \beta_3 T_{2017} + \delta_1 (\text{Treat}_{ij} * T_{2017}) + \varepsilon_{ijt} \quad (1)$$

In this specification, y_{it} is the outcome of interest for farmer i in sub-county j , y_{i2016} is the outcome measured at baseline (i.e. from the 2016 survey round), the variable Treat_{ij} takes the value one if farmer i lives in a treated sub-county and zero otherwise (in short, if farmer i is treated), T_{2017} is binary variable indicating the year 2017. Under randomized assignment, OLS estimate of δ_1 identifies the causal effects of the treatment. We will use OLS to estimate regression (1). We will also run separate regressions including:

- Baseline covariates. The vector of covariates will include respondent's gender, education, land size, agronomic skills, and household characteristics (e.g. wealth, assets). We will also include a set of farmer group level controls (group size, frequency of meetings, share of members cultivating oilseeds).
- District (strata) fixed effects and district-specific trend among regressors in order to control for underlying difference across districts and district-wide change over the project period.

In case of binary outcomes, we will conduct robustness checks using probit or logit models. All of the hypotheses described in this sub-section will be assessed using two sided tests, at usual significance levels (10, 5, 1%), and on the full sample. The unit of analysis is always the farmer. Standard errors will be clustered at the level of the unit of randomization, i.e. at sub-county level. Since we consider several outcomes, following Anderson (2008), we plan to implement Hocheberg step down procedure and p-values adjusted for multiple outcomes inference (Familywise Error Rate Control and False Discovery Rate Control). As further robustness check, we will also use the procedures suggested by List et al. (2016).

In general, the hypothesis reported in this sub-section imply that the treatment group performs better on the outcomes of interest than the control group. When each of the variables which will be described are used as a dependent variable in regression (1), we expect δ_1 to be positive and statistically significant. Controlling for more covariates (as mentioned above) should affect the precision of δ_1 , but not its magnitude. Due to delays in the implementation, comparisons are done only for the time window of 2 seasons, therefore, long-term impacts cannot be calculated.

In what follows, we present the way each of the main set of hypotheses presented in the section about the theory of change will be tested (in relation to equation 1) and the way outcomes are measured and variables constructed. Further details on the way the variables are constructed together with some descriptive statistics can be found in the baseline report.

Heterogeneous effect

In order to test the extent to which project effects vary in different sub-groups, we perform an analysis of heterogeneous effects. These will be estimated through the use of interaction terms in a specification similar to (1), which will look as follows :

$$y_{ijt} = \beta_1 y_{ij2016} + \beta_2 \text{Treat}_{ij} + \beta_3 T_{2017} + \delta_1 (\text{Treat}_{ij} * T_{2017}) + \delta_2 (\text{Treat}_{ij} * T_{2017} * X_{ij}) + \varepsilon_{ijt} \quad (2)$$

where X_{ij} is a vector of individual baseline characteristics. The coefficient δ_2 will provide the marginal treatment effect for the sub-sample of individuals with the baseline characteristic considered. In general, X_{ij} could be both binary and continuous variable. In the latter case we will split the distribution in quantiles and use binary variables equal to one when the individual belongs to that particular part of the distribution of X . We will use OLS to estimate regression (2). We will also run separate regressions including:

- Baseline covariates. The vector of covariates will include respondent's gender, education, land size, agronomic skills, and household characteristics (e.g. wealth, assets). We will also include a set of farmer group level controls (group size, frequency of meetings, share of members cultivating oilseeds).
- District (strata) fixed effects and district-specific trend among regressors in order to control underlying difference across districts and district-wide change over the project period.

We are aware that testing several (possibly correlated) hypothesis related to heterogeneous effects may lead to an overrated number of false positives. Once again, we will control for multiple hypothesis testing following the same procedures mentioned above for the case of several simultaneous outcomes.

Unaddressed research questions

Due to delays in the project activities development, some research questions included in the initial technical proposal cannot be addressed anymore in the analysis.

1. *Does heterogeneity in returns affect the sustained adoption of such technologies, beyond farmers' initial experimentation?*

This question would need a longer time span for the analysis which, at present, we do not have any more. Indeed, due to delays in the implementation of the VODP2, we are able to assess short term effects only, by comparing treated and untreated farmers for the time window of 2 seasons. Long-term and sustained impacts cannot be assessed.

2. *Is this relationship between heterogeneity in realized returns and sustained technology adoption caused by learning about persistent differences in the suitability of a technology across farms and farmers?*

The same comment as above applies.

Addressing less-than-complete data

Addressing survey attrition

A regression of the probability of attrition on treatment status and individual observable characteristics at the baseline is run in order to check differential or systematic attrition along observable dimension. Should we get differential attrition with respect to the treatment status, we would run Lee Bounds (Lee, 2008) as a robustness check for the impact exercise. We would also assess the nature of the attrition issue and try to argue on the nature of the estimates bias (upward- vs downward-bias).

Yet, some level of attrition is unavoidable in longitudinal surveys. We anticipate a default attrition rate of about 15% per year based on the Uganda's national household panel surveys (UNPS, Basic Information Document, the World Bank). To minimize attrition, we plan on tracking farmers who left the sample villages. In particular, we will implement the following strategies:

- We will actively track farmers who left the sample villages and who reside within 50 kilometres from their original village.
- For farmers who reside more than 50 kilometres away from their original villages, we will administer a limited version of the survey to their neighbours who did not move.

Addressing item non-response (data missingness)

Prevention actions to avoid the issue of item non-response are incorporated in the survey protocol. This includes: (i) most questions require closed and categorized answers; (ii) questions (and coded answers) have been previously piloted; (iii) during the survey, the field supervisor carries out monitoring activities, such as, information cross-checking and daily checks of data quality from questionnaires.

Once data are digitalized and processed, a check for non-systematic data missingness across treatment arms is performed. The likelihood of having any item non-response, as well as the probability of having missing information on particular variables is compared between treatment and control group.

In case of *systematic* item non-response, further field inquiries can be conducted in order to fill the information gap. In the impossibility to do that, a model is postulated, after assessing missing data patterns.

In case on *non-systematic* item non-response, in order not to lose power, multiple imputation would be adopted (robustness checks would be run to assess the extent to which this may influence main results).

Addressing outliers

We intend to test the robustness of our results to the presence of outliers. For continuous variables employed as outcomes, we will use windsorization and trimming. Specifications will be checked using both the original and trimmed/windsorized variables. The stability of coefficients will be tested through standard hypothesis testing (Wald test).

2. References

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APPENDIX III: Additional tables

Table 33: Standardized minimum detectable effects for expectations and adoption outcomes

| | Season 1 baseline | | | Season 2 baseline | | |
|--|-------------------|-------|---------|-------------------|-------|---------|
| | R2 | ICC | Std MDE | R2 | ICC | Std MDE |
| Avg expected yield for soyabeans | 0,07 | 0,061 | 0,183 | | | |
| Avg expected yield for sunflower | 0,19 | 0,151 | 0,253 | | | |
| Avg expected yield for sesame | 0,12 | 0,102 | 0,219 | | | |
| Avg expected yield for groundnuts | 0,05 | 0,054 | 0,177 | | | |
| Avg expected price for soyabeans | 0,08 | 0,078 | 0,199 | | | |
| Avg expected price for sunflower | 0,09 | 0,136 | 0,246 | | | |
| Avg expected price for sesame | 0,02 | 0 | 0,108 | | | |
| Avg expected price for groundnuts | 0,03 | 0,046 | 0,169 | | | |
| Cultivate oilseeds | 0,22 | 0,204 | 0,285 | 0,155 | 0,158 | 0,259 |
| Share of land cultivated with oilseeds | 0,11 | 0,158 | 0,261 | 0,092 | 0,132 | 0,243 |
| Cultivate groundnuts | 0,2 | 0,209 | 0,29 | 0,097 | 0,095 | 0,214 |
| Share of land cultivated with groundnuts | 0,12 | 0,156 | 0,26 | 0,062 | 0,072 | 0,194 |
| Cultivate soya_bean | 0,14 | 0,174 | 0,271 | 0,085 | 0,096 | 0,215 |
| Share of land cultivated with soya_bean | 0,09 | 0,129 | 0,24 | 0,061 | 0,058 | 0,18 |
| Cultivate sunflower | 0,11 | 0,168 | 0,268 | 0,15 | 0,273 | 0,329 |
| Share of land cultivated with sunflower | 0,08 | 0,174 | 0,273 | 0,127 | 0,328 | 0,358 |
| Cultivate simsim | 0,16 | 0,185 | 0,277 | 0,327 | 0,353 | 0,353 |
| Share of land cultivated with simsim | 0,13 | 0,167 | 0,266 | 0,213 | 0,216 | 0,293 |

Table 34: Standardized minimum detectable effects for inputs outcomes

| | Season 1 baseline | | | Season 2 baseline | | |
|--------------------------------------|-------------------|-------|---------|-------------------|-------|---------|
| | R2 | ICC | Std MDE | R2 | ICC | Std MDE |
| Farmer applied water conservation | 0,07 | 0,047 | 0,169 | | | |
| Farmer applied moisture retention | 0,07 | 0,058 | 0,18 | | | |
| Farmer applied zero tillage | 0,04 | 0,034 | 0,154 | | | |
| Farmer applied compost making | 0,06 | 0,053 | 0,176 | | | |
| Farmer applied post-harvest handling | 0,02 | 0,036 | 0,157 | | | |
| Use some fertilizer | 0,16 | 0,19 | 0,28 | 0,053 | 0,057 | 0,179 |
| Use some pesticide | 0,15 | 0,196 | 0,284 | 0,079 | 0,098 | 0,217 |
| Use some improved seed | 0,13 | 0,123 | 0,235 | 0,014 | 0,008 | 0,121 |
| Use of fertilizer for oilseeds | 0,05 | 0,037 | 0,158 | 0,027 | 0,005 | 0,116 |
| Use of pesticide for oilseed | 0,08 | 0,05 | 0,172 | 0,038 | 0,015 | 0,131 |
| Use of improved seeds for oilseed | 0,07 | 0,045 | 0,167 | 0,043 | 0,033 | 0,153 |

Table 35: Standardized minimum detectable effects for productivity and revenues outcomes

| | Season 1 baseline | | | Season 2 baseline | | |
|--|-------------------|-------|---------|-------------------|-------|---------|
| | R2 | ICC | Std MDE | R2 | ICC | Std MDE |
| Productivity of groundnuts, in kg per acre | 0,02 | 0,012 | 0,127 | 0,03 | 0,04 | 0,162 |
| Productivity of soya_bean, in kg per acre | 0,02 | 0,036 | 0,158 | 0,014 | 0,001 | 0,11 |

| | | | | | | |
|--|------|-------|-------|-------|-------|-------|
| Productivity of sunflower, in kg per acre | 0,01 | 0,002 | 0,112 | 0,016 | 0,014 | 0,13 |
| Productivity of simsim, in kg per acre | 0,03 | 0,024 | 0,142 | 0,051 | 0,067 | 0,189 |
| Total revenues from sale of groundnuts, in 10,000 Ushs | 0,01 | 0,018 | 0,135 | 0,055 | 0,042 | 0,164 |
| Total revenues from sale of soya_bean, in 10,000 Ushs | 0,06 | 0,068 | 0,19 | 0,029 | 0,033 | 0,153 |
| Total revenues from sale of sunflower, in 10,000 Ushs | 0,04 | 0,052 | 0,175 | 0,032 | 0,101 | 0,22 |
| Total revenues from sale of simsim, in 10,000 Ushs | 0,13 | 0,181 | 0,275 | 0,11 | 0,104 | 0,221 |
| Total revenues from sale of oilseeds, in 10,000 Ushs | 0,02 | 0,022 | 0,14 | 0,041 | 0,095 | 0,215 |
| Total revenues from crop sale (10K Ushs) | 0,15 | 0,087 | 0,206 | 0,118 | 0,062 | 0,183 |
| Net revenue for groundnuts (10K Ushs) | 0,01 | 0,012 | 0,126 | 0,029 | 0,017 | 0,133 |
| Net revenue for soya beans (10K Ushs) | 0,02 | 0,03 | 0,151 | 0,014 | 0,001 | 0,11 |
| Net revenue for sunflowers (10K Ushs) | 0,01 | 0,003 | 0,112 | 0,021 | 0,039 | 0,16 |
| Net revenue for simsim (10K Ushs) | 0,15 | 0,191 | 0,281 | 0,044 | 0,032 | 0,153 |
| Total net revenue (10K Ushs) | 0,03 | 0,029 | 0,149 | 0,024 | 0,026 | 0,146 |

Table 36: Standardized minimum detectable effects for market linkages and wealth outcomes

| | R2 | Baseline ICC | Std MDE |
|--|------|-----------------|---------|
| Market is the source of seeds for soyabeans | 0,06 | 0,045 | 0,167 |
| Market is the source of seeds for sunflower | 0,07 | 0,055 | 0,177 |
| Market is the source of seeds for sesame | 0,05 | 0,031 | 0,151 |
| Market is the source of seeds for groundnuts | 0,06 | 0,034 | 0,155 |
| Access to market actors for oilseed procurement (no local mkt) | 0,07 | 0,017 | 0,133 |
| Oilseed harvest sold to market | 0,05 | 0,04 | 0,162 |
| Bulk/group sale of soyabeans harvest | 0,03 | 0,029 | 0,149 |
| Bulk/group sale of sunflower harvest | 0,07 | 0,086 | 0,207 |
| Bulk/group sale of sesame harvest | 0,04 | 0,031 | 0,151 |
| Bulk/group sale of groundnuts harvest | 0,02 | 0,013 | 0,128 |
| Bulk/group sale of oilseed harvest | 0,04 | 0,057 | 0,179 |
| Contacts with value chain actors for soyabeans | 0,14 | 0,133 | 0,242 |
| Contacts with value chain actors for sunflower | 0,08 | 0,093 | 0,212 |
| Contacts with value chain actors for sesame | 0,04 | 0,031 | 0,152 |
| Contacts with value chain actors for groundnuts | 0,05 | 0,042 | 0,163 |
| Contacts with value chain actors for oilseeds | 0,11 | 0,099 | 0,217 |
| Total yearly hh income from labour (USH, x 10,000) | 0,09 | 0,041 | 0,162 |
| Total yearly hh income not from labour (USH, x 10,000) | 0,12 | 0,068 | 0,189 |
| Total yearly hh income (USHx10,000) | 0,15 | 0,067 | 0,188 |
| Tot. hh income <60% of avg income in the sample | 0,15 | 0,074 | 0,194 |
| Total HH monthly food expenditure, in 10K Ushs | 0,07 | 0,048 | 0,17 |
| Total HH monthly non-food expenditure (Ushs, x10K) | 0,1 | 0,03 | 0,15 |
| Total HH yearly expenditure on general items (x 10,000) | 0,22 | 0,071 | 0,189 |