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Effect of information and communication technology-based loyalty incentives on farmers' use of agricultural inputs and soybean yields: evidence from a field experiment in Uganda

Connetie Ayesiga[a], Esther Ronner[b], Peter Ebanyat[c], Ken E. Giller[b] and Paul T. M. Ingenbleek[a]

[a]Marketing and Consumer Behaviour, Wageningen University, Wageningen, The Netherlands; [b]Plant Production Systems, Wageningen University, Wageningen, The Netherlands; [c]Department of Agricultural Production, School of Agricultural Sciences, Makerere University, Kampala, Uganda

ABSTRACT

To address low yields and contribute to food security in sub-Saharan Africa, policy-makers encourage smallholders to use productivity-enhancing agricultural inputs such as improved seed varieties, fertilisers and inoculants. However, adoption rates among smallholders remain low, partly because farmers are uncertain whether buyers will reliably purchase their higher-quality outputs at premium prices. Loyalty incentives simultaneously encourage input use and signal buyer commitment, which may help reduce this uncertainty. Using survey data from a cluster-randomized field experiment involving 234 soybean farmers in Northern Uganda, this study examines the effects of loyalty incentives delivered viaan Information and Communication Technology (ICT) platform on farmers' use of agricultural inputs and soybean yields. The findings show that both financial and non-financial loyalty incentives significantly ($p < 0.001$) increasedofarmers' use of improved seed and fertiliser compared with no incentives. Correspondingly, soybean yields significantly increased above the control group mean (619 kg ha^{-1}), with increases of 525kg ha−1 for non-financial incentives, 747 kg ha−1 for financial incentives, and 854 kg ha^{-1} for combined incentives. Overall, the results demonstrate that loyalty incentives caneffectively promote the adoption of productivity-enhancing inputs and increase yields in smallholder systems, contributing to sustainable agricultural intensification and advancing understanding of a technology adoption through ICT-enabled interventions.

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1 Introduction

The demand for food is growing globally due to population growth, growing incomes and rapid urbanisation. In Africa alone, food demand is projected to double by 2050 (FAO, 2017; Van Ittersum et al., 2016), yet production remains low due to dependence on rain-fed smallholder agriculture, declining soil fertility and decreasing farm sizes (Lowder et al., 2021). The central tenet of improving food production is using sustainable agricultural practices such as improved seed cultivars, organic and mineral fertilisers, crop rotations with legumes, and other related technologies. Yet, the uptake of these technologies remains low among smallholders in sub-Saharan Africa (Macours, 2019; Stevenson et al., 2019). One factor contributing to farmers' low uptake is limited access to output markets and, more generally, the uncertainty that smallholders face when trying to sell their harvested produce. Such output market uncertainty discourages farmers from investing in productivity-enhancing inputs (Aker & Ksoll, 2016; Simtowe et al., 2019; Suri & Udry, 2022).

Output market uncertainty often stems from the lack of trust and loyalty between farmers and produce buyers (Agyekumhene et al., 2020). While farmers cope with the risks of absent buyers and disappointing prices (Agyekumhene et al., 2020; Barnes et al., 2021), buyers struggle with low quantities and quality due to side-selling and the dishonouring of contractual agreements (Bold et al., 2017; Chavas & Nauges, 2020;

CONTACT Paul T. M. Ingenbleek paul.ingenbleek@wur.nl Marketing and Consumer Behaviour, Wageningen University, Wageningen, The Netherlands

Dubbert, 2019). Furthermore, side-selling by smallholder farmers hinders their power to bargain for better prices from other buyers (Meemken & Bellemare, 2020; Sebhatu et al., 2020), affecting their ability to invest in inputs. As such, high transaction costs and poor infrastructure make it costly for buyers to source from many dispersed smallholders, limiting their willingness to engage directly (Aker et al., 2016; Kilelu et al., 2017b; Krone & Dannenberg, 2018).

In general, African farmers have limited access to quality inputs (Khonje et al., 2018; Mukhtar & Azhar, 2020). Even if they can obtain quality inputs, access to buyers who are willing to pay for the improved farm outputs remains a challenge. Buyers also cope with uncertainty about the produce quality and quantity that farmers can offer, because they cannot be certain that farmers have access to the necessary inputs and, if they do, whether farmers decide to purchase and apply them (Dubbert et al., 2023; Dubbert, 2019). Farmers therefore often sell their produce to middlemen or local traders at low prices (Aggarwal et al., 2018; Aker et al., 2016; Krone & Dannenberg, 2018). Thus, the lack of quality inputs and buyers that are willing to pay for the improved outputs result in low farmer incomes, which in turn forms a negative self-reinforcing loop that further constrains farmers' use of agricultural inputs and productivity (Barnes et al., 2021), and a less-than-optimal contribution to reducing food security.

Enhancing loyalty and marketing relationships between farmers and output buyers can overcome output market uncertainties and increase use of inputs and practices (Dubbert et al., 2023; Ton et al., 2018). The relationship marketing literature suggests loyalty interventions are useful instruments to strengthen market relationships (Agarwal & Mehrotra, 2018; Viswanathan et al., 2022). A loyalty intervention is a system of integrated, structured and personalised marketing actions that offers loyal customers a wide range of financial and/or non-financial incentives (Bombaij & Dekimpe, 2020; Steinhoff & Palmatier, 2016). While loyalty incentives show positive impacts in hospitality and other businesses (Liu & Ansari, 2020; Viswanathan et al., 2017), such loyalty incentives have not been widely applied in smallholder agricultural systems.

Within the existing literature, some studies have looked at incentives within contract farming and their effects on the quality of outputs (Hoffmann et al., 2023; Saenger et al., 2013; Treurniet, 2021), input choices in shared output arrangements (Burchardi et al., 2019), yields, incomes and welfare (Arouna et al., 2021; Bellemare, 2018; Otsuka et al., 2016). These studies have examined contracts in traditional face-to-face arrangements between farmers and buyers. Such loyalty incentives have not been widely applied in smallholder agricultural systems, largely due to operational complexities in coordinating dispersed farmer groups, limited digital infrastructure to track participation and transactions, and the high transaction costs involved in implementing reward mechanisms in rural contexts. These barriers have constrained experimentation with loyalty schemes in agriculture, despite their demonstrated effectiveness in other sectors. As such, arrangements come with high transaction costs and are difficult to enforce in the institutional context of smallholders (Macchiavello & Morjaria, 2021). Studies on loyalty incentives within a relational context, beyond the context of contractual obligations and enforcement are, to the best of our knowledge, absent.

The growing presence of agriculture-related Information and Communication Technology (ICT) platforms in sub-Saharan Africa that can reach farmers efficiently through SMS-messages (cf., Larochelle et al., 2019; Mohammed & Abdulai, 2022; Van Campenhout et al., 2021), offers new opportunities to communicate loyalty incentives. Incentives can be given in the form of financial and non-financial incentives. Financial incentives are rewards in a transaction that include cash, such as discounts, bonuses, or upgrades (Lilien, 2016; Viswanathan et al., 2017), whereas non-financial incentives are rewards that do not include cash such as recognition, gifts, privileges, and special treatment (Brashear-Alejandro et al., 2016). Such loyalty incentives may help build farmers' relationships with output buyers and persuade them to purchase and use inputs (Minkoua Nzie et al., 2018; Minten et al., 2016).

In Uganda, most soybean farmers typically sell their produce to local middlemen at the farm gate, often under spot-market arrangements with fluctuating prices. With the incentive-based production arrangement, this study provides farmers with pre-agreed terms (including access to inputs and guaranteed markets) framing incentives as innovations that form part of motivation tools to strengthen farmer engagement, implemented through an ICT platform. Thus, this study aims to test whether an ICT-coordinated loyalty intervention with an assured produce market creates a change in farmers' use of agricultural inputs and consequently improves crop yields. Specifically, we: 1) Assess effects of financial and non-financial loyalty incentives on farmers' use of agricultural inputs, and 2) Assess effects of financial and

non-financial loyalty incentives on farmers' soybean yields. Our research contributes to the existing literature in three ways. First, by focusing on loyalty, this study introduces a new perspective to the growing body of literature on enhancing the uptake of agricultural technologies and practices among smallholder farmers (e.g., Ronner et al., 2016; van Heerwaarden et al., 2018; van Vugt et al., 2018; Vanlauwe et al., 2019). Second, the study provides empirical evidence of positive effects of an ICT-coordinated loyalty intervention on smallholder farmers' uptake of agricultural inputs and farm productivity. Third, the study distinguishes between two different types of loyalty incentives, financial and non-financial incentives, and shows that the effects are generalisable across the two types.

2 Conceptual framework

Loyalty incentives are any kind of compensation that is given to an individual before or during a transaction with the goal of changing their attitude and behaviour towards the company or business providing the incentives (Keh & Lee, 2006). In the context of smallholders, attitudes and behaviour are changed to the usage of the inputs and practices that are preferred by the output buying company. To date, loyalty incentives for smallholders have only been offered as part of contract farming arrangements (Arouna et al., 2021; Bellemare, 2018). Implementing loyalty incentives through contracts, however, comes with high transaction costs to reach individual farmers or farmer groups through extension or buyer agents. With the rapid development of ICT platforms in agricultural value chains, the implementation of loyalty incentives is becoming more feasible (Purohit & Thakar, 2019). ICT platforms are digital tools that provide scalable channels for delivering incentives, and enable cost-effective monitoring, communication, and coordination between buyers and dispersed farmers (Baryamureeba, 2006; Zahedi & Zahedi, 2012), and other value chain actors (Aker et al., 2016; Orr, 2018). ICT platforms can easily communicate the loyalty incentives and stimulate a change of behaviour among farmers (Purohit & Thakar, 2019).

The literature distinguishes two types of loyalty incentives: financial and non-financial. Financial incentives are defined as rewards in a transaction that includes cash such as discounts, bonuses, or upgrades (Lilien, 2016; Viswanathan et al., 2017). For example, Omar et al. (2015) found that financial incentives attracted individuals to a company and raised their commitment and loyalty to that company (Agarwal & Mehrotra, 2018; Erbschloe, 2017). Non-financial incentives are rewards in a transaction that do not include cash, such as recognition, gifts, privileges, and special treatment (Brashear-Alejandro et al., 2016). Financial and non-financial incentives may also be combined (Lee et al., 2015; Lilien, 2016), because individuals may be attracted by different types of incentives (Alshurideh et al., 2020; Bombaij & Dekimpe, 2020; Brashear-Alejandro et al., 2016; Chen et al., 2021).

In this study, we used both financial and non-financial loyalty incentives, along with interactions and relationship-building between farmers and the buyer, to create a specific market outlet for farmers. Based on theoretical definitions, several options were initially considered for both the financial and non-financial incentives. To refine these choices, we consulted farmers and sector experts to identify incentives that were relevant, feasible, and valued within the local production context. For instance, although formal recognitions such as awards were discussed as potential non-financial incentives, they were ultimately deemed less appropriate and were therefore excluded. These decisions were validated through consultations with experts from an ICT platform (M-Omulimisa), an output buyer (AgriNet), other local organisations, and local government stakeholders.

Following this process, we selected price bonuses as the financial incentive and tarpaulins as the non-financial incentive for the loyalty programme. Price bonuses were intended to increase farmers' earnings from soybean sales, while tarpaulins were chosen because they facilitate improved threshing and winnowing, thereby enhancing grain quality and enabling farmers to secure better prices. Both incentives were available only to farmers who met a minimum sales threshold of 800 kg, established in consultation with buyers to reflect the average yield per acre (average land available to farmers) and the minimum economically viable procurement volume. We acknowledge that this threshold may have unintentionally excluded poorer farmers. However, the threshold was expected to translate into increased use of agricultural inputs among farmers and to increase their produce volumes to sell to this buyer. We hypothesised as follows:

H1: Financial (price bonus) and non-financial (tarpaulins) incentives will have a positive effect on farmers' use of agricultural inputs compared with the control.

The two types of incentives aimed to cater for different types of farmers. On the one hand, non-financial incentives such as gifts for recognition might fit well in an informal, not fully monetised economy in which people generally exchange favours. For instance, Melnyk and Bijmolt (2015) found that, adapting non-financial incentives to individuals' needs confers pride of being recognised, which increases their commitment and loyalty (Brashear-Alejandro et al., 2016). Financial incentives, on the other hand, would appeal to farmers who have a certain degree of access to output markets but are looking for better value (prices) from produce buyers. Thus, non-financial and financial incentives may appeal to different types of farmers but are expected to have similar effects on input use.

As already indicated, the loyalty incentives were expected to enhance farmers' use of inputs, increase farmers' crop yields, and meet the expected volumes for supply to the buyer. Many studies indicate significant improvements in crop yields due to the uptake of improved seed varieties and/or fertilisers for crops such as maize, legumes, and other cereals (Martey et al., 2019; McArthur & McCord, 2017; Nurgi et al., 2023). For soybean specifically, improved seed varieties, fertilisers and the use of rhizobium inoculants (the bacteria responsible for fixing nitrogen from the atmosphere in symbiosis with legumes, applied to legume seeds at planting) are expected to increase crop soybean yields (van Heerwaarden et al., 2018; van Heerwaarden et al., 2023; Vanlauwe et al., 2019). Hence, we hypothesised:

H2: Financial (price bonus) and non-financial (tarpaulins) incentives will have a positive effect on farmers' soybean yields compared with the control.

From the conceptual model described above, the loyalty programme intervention offers a price bonus and tarpaulins as financial and non-financial incentives to farmers, that can be earned in the future during the marketing season. We expected these incentives to result in increased investments in inputs, to increase produce volumes to supply to the output buyer, influenced by household and farm (environment) characteristics (Figure 1). In turn, the loyalty intervention would improve the relationship between farmers and buyers, reducing market uncertainties on both sides, and serving as an incentive for both parties to continue their relationship in future.

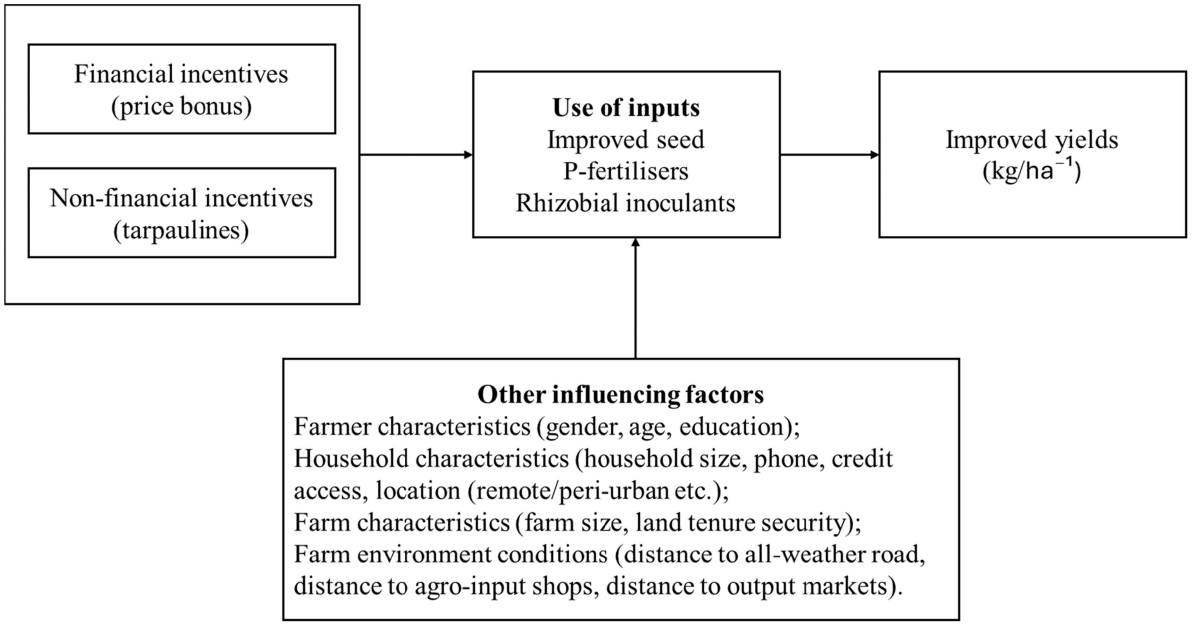

Figure 1. Conceptual framework showing the loyalty incentives and their expected outcomes.

3 Methods and materials

3.1 Study context

We test our hypotheses in the context of a loyalty intervention implemented through an ICT company called M-Omulimisa (www.m-omulimisa.com), with soybean farmers in Lango sub region, Northern Uganda. The intervention was designed by the research team and implemented by M-Omulimisa, that managed the loyalty scheme under researcher guidance.

Soybean production offers significant opportunities for farmers to improve both their incomes and nutrition, as soybean is a relatively affordable source of protein. Beyond its nutritional benefits, soybean enhances soil fertility for subsequent crops through nitrogen fixation (Franke et al., 2018; Giller et al., 2011; Vanlauwe et al., 2019). Farmers in Lango have previously participated in interventions such as the N2Africa project (www.N2Africa.org), which promoted soybean production technologies through the M-Omulimisa ICT platform. These technologies included improved soybean varieties, phosphorus fertilisers such as triple super phosphate (TSP) and single super phosphate (SSP), and rhizobial inoculants. Uganda produces approximately 350,000 metric tons of soybean annually, engaging an estimated 300,000 smallholder farmers (UBOS, 2022). The Lango sub-region was selected for this study because it is among the leading soybean-producing areas, with strong farmer group structures and an active presence of AgriNet, the contracting buyer. The intervention was implemented in close collaboration with AgriNet, the primary buyer of soybean, aligning purchase agreements with the loyalty incentive scheme and ensuring that market access was guaranteed for participating farmers.

At the time of study, the M-Omulimisa platform facilitated farmers with soybean production information, linkages to input suppliers and access to input loans in collaboration with a government microfinance institution, particularly for improved seed. A pre-study was conducted including meetings with experts, stakeholders, company managers to fully understand the research context. The existing ICT platform provided a suitable context to test the impact of financial and non-financial loyalty incentives on farmers' use of agricultural inputs with over 30,000 farmers (who are organised in farmer groups) are registered on the platform and involved in different agricultural value chains.

3.2 Experimental design

We implemented a cluster randomised controlled trial in which 45 farmer groups (clusters) selected from the M-Omulimisa ICT platform database were randomly assigned to treatment groups. Randomisation was conducted using a computerised random number generator in R (version 4.2.3), implemented by the research team, and stratified by farmer group to ensure and maintain balance across treatment arms. The selected farmer groups were those who had access to production information on soybean technologies and linkages to input providers and access to credit through the microloan scheme. The use of independent and geographically dispersed farmer groups (clusters) from different villages helped to avoid contamination across treatment groups. All farmer groups were located in the Lango sub region, with similar geographical features, production conditions, income levels, culture and language.

The 45 clusters were randomised to four treatments, namely: (i) Financial incentives (cash bonuses only); (ii) Non-financial incentives (tarpaulins only); (iii) Both financial + non-financial incentives (both cash bonuses and tarpaulins); (iv) Control (no incentives). All information on the loyalty intervention was communicated through the ICT platform. Farmers in the treatment groups interacted with the buyer through physical meetings and through buyer agents to enhance trust and market certainty. Farmers in the control group only received general information on the presence of the buyer in the area via SMS (Appendix 1). All groups received production information on soybean (when to plant, weed, etc., synchronised with the farming calendar) and contacts of input suppliers (Appendix 1).

In total, we had $n = 11$ groups for each of the control, financial and non-financial treatment groups while both financial + non-financial treatment group had $n = 12$ groups. The unequal number of groups resulted from some groups located in the Eastern region having been entered wrongly in the M-Omulimisa ICT database as located in the Lango sub region. All information shared to all treatment groups was translated in the local language (Langi) and sent to the different treatment groups through mobile phones during the second season of 2021 (August to December 2021). All farmers could ask for clarifications about the

information shared through the platform or the village agents working with the ICT platform. In addition, the village agents were expected to aggregate farmers' produce for the buyer and earn a commission while reducing the transaction costs for both the farmers and the buyer.

The financial incentive comprised a price bonus: farmers would receive a premium price of 0.05 USD for every kilo, if they sold more than 800 kg of soybean to the buyer. Non-financial incentives offered were tarpaulins (used by farmers use to dry their harvest and improve product quality), to be obtained after farmers sold 800 kg of soybean individually, or 20,000 kg as a group, to the buyer. The 800 kg threshold was established in line with buyer procurement requirements and reflects the expected minimum soybean yield per acre achievable by smallholders using improved production technologies.

3.3 Sampling and data collection

While over 30,000 farmers were registered on the platform nationwide, approximately 10,000 were registered from the study region. Our study focused on 45 farmer groups in the Lango sub-region that specialised in soybean production and had access to production information on soybean technologies, input providers, and a microloan scheme. These groups comprised a total of 1,125 farmers. The sampling frame included only households that had engaged in soybean production during the study season. From this frame, 234 households were selected to complete the questionnaire. Although the farmer group (cluster) was the unit of randomisation, the household served as the unit of analysis. Membership lists from each of the 45 groups were used as the basis for household selection.

A stratified random sampling technique was employed, with stratification based on group size to ensure proportional representation. Larger groups therefore contributed more respondents than smaller ones. Within each group, proportional random sampling was applied, and only soybean-producing members were eligible. Non-respondents were replaced by back-up respondents to ensure that farmers were drawn exclusively from the same eligibility pool. On average, 20–30% of the members in each group were selected. In total, 234 households were randomly sampled and distributed across the experimental groups.

Data about farmers' use of inputs (improved seed, fertiliser and rhizobia), social demographics, and other variables such as distance to input and output markets, was collected using a cross-section survey questionnaire, programmed onto a computer tablet using Open Data Kit (ODK). A 5-point Likert scale was used to measure farmers' use of inputs scoring from 1-Very little extent, 2- Little extent, 3-Neutral, 4-Large extent, 5-Very large extent. An additional score of 'Not at all' was added to reflect non-use of inputs by farmers. The use of a Likert scale served to assess farmers' intensity of using inputs from their own behaviour perspective. Soybean yields were based on farmers' estimates, collected in kilograms per acre and translated to kg ha^{-1} during analysis.

Prior to data collection, enumerators were trained covering all aspects contained in the survey questionnaire to ensure understanding of all variables and terms used. The questionnaire was pre-tested among farmers in one of the communities outside the villages covered by this study. To collect the data from respondents, consent was requested before we proceeded with the interviews. M-Omulimisa's village agents were used to mobilise the randomly selected farmers. In cases where these farmers were not available during the day of data collection and a day that followed, other group members were randomly selected to replace them. The interviews lasted between 45 and 60 minutes on average.

3.4 Data analysis

Two data analysis techniques were employed. First, a multivariate analysis of variance (MANOVA) in R version 4.2.3 was used to test the study hypotheses of the effects of loyalty programme incentives on farmers' use of improved seed, fertilisers and rhizobia combined (H1), because of more than one dependent variable. To run the MANOVA, we combined the 'Not at all' scores with the 'Very little extent' score to fit in with the 5-point Likert scale. To account for violations of normality assumptions expected from the Likert-scale data, bootstrapping was conducted to generate a bootstrapped distribution of F-statistics for the MANOVA model. The bootstrapped test yielded the same results as the MANOVA statistic, indicating that our test statistic was dependable. We used a 95% confidence interval for the MANOVA test.

Second, to determine significant differences in medians of the control and treatment groups (H2), the Kruskal–Wallis test for non-parametric data was used, followed by a pairwise comparison to show how the use of inputs (improved seed, fertilisers and rhizobia) was affected by the different treatment groups.

To determine effects of other factors on the relationship between loyalty incentives and outcome variables, we included control variables using the multivariate analysis of covariates (MANCOVA) test at 90% confidence interval, which we assumed to have enough precision about the effect of the control variables on the effect of the loyalty intervention. These control variables included household head's characteristics such as gender, age, education; household characteristics such as household size, phone, credit access, location (remote/peri-urban etc.); farm characteristics such as farm size, land tenure security; farm environment conditions such as distance to all-weather road, distance to agro-input shops, distance to output markets). Secondly, we conducted an ANOVA to test the effects of loyalty incentives on soybean yields obtained by farmers. We used Tukey's HSD test to compare differences in yield between the treatment groups. To determine the contribution of each agricultural input type to soybean yields, we conducted a simple linear regression.

4 Results

4.1 Effects of financial and non-financial loyalty incentives on farmers' use of inputs

Compared with the control, all treatments had a positive and statistically significant effect on the combined use of improved seed, fertiliser and rhizobial inoculants $F(9, 690) = 8.478$, $p < 0.001$; Pillai's Trace = 0.299 (Table 1a); partial $\eta p2 = 0.10$, a large effect size (Cohen, 1988, p.368). The bootstrap analysis further indicated that the observed mean (8.478 in Table 1) fell outside the 95% confidence interval (15.04–16.52), suggesting potential skewness and variability in the resampled distribution. This pattern is likely attributable to heterogeneity in farmers' input-use behaviour and sample size limitations. Nevertheless, the robustness of the multivariate test (Pillai's Trace) confirms the overall result (Table 1b). Therefore, Hypothesis 1 is supported, which predicted that financial and non-financial incentives would significantly increase farmers' input use compared to the control.

If we consider the use of improved seed, fertilisers and rhizobia individually, all treatments had a positive effect on the use of improved seed and fertiliser. About one-third of the farmers who received a combination of both financial and non-financial incentives used improved seeds to a 'large extent', and 12% to a 'very large extent', compared with 41% to a 'very little extent' in the control group (Figure 2). For fertilisers, 6% of farmers who received a combination of both financial and non-financial incentives were 'neutral' in their use of fertiliser, and 11% used fertilisers to a 'little extent', compared with 98% who scored 'very little extent' in the control group (Figure 2). For rhizobial inoculants, although the MANOVA test statistic showed significant differences across treatment groups on farmers' use of improved seed, fertiliser and rhizobial inoculants combined, our results showed absolute numbers of households using rhizobial inoculant were small (Figure 2). The limited uptake of inoculants reduced our ability to evaluate their impact, and this limitation is discussed further below.

The post-hoc test results confirmed that for the use of improved seed and fertiliser, the control group was significantly different from all treatment groups (Table 2). Although the combination of both financial

Table 1. (a & b) MANOVA results summary for the effect of the loyalty incentives on use of inputs (a) and Boot statistics results (b).

a)

	Summary MANOVA						
	df	Pillai approx	F	num df	den df	*P* value	
(Intercept)	1	0.996	18515.3	3	228	<0.001	***
Treatment	3	0.299	8.478	9	690	<0.001	***
Residuals	230						

b)

	Boot statistics					Boot Confidence Intervals (95%)	
	R	original	bootBias	bootSE	bootMed	Lower	Upper
1	1000	8.478	−7.480	0.395	0.939	15.042	16.517)

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.'.1.

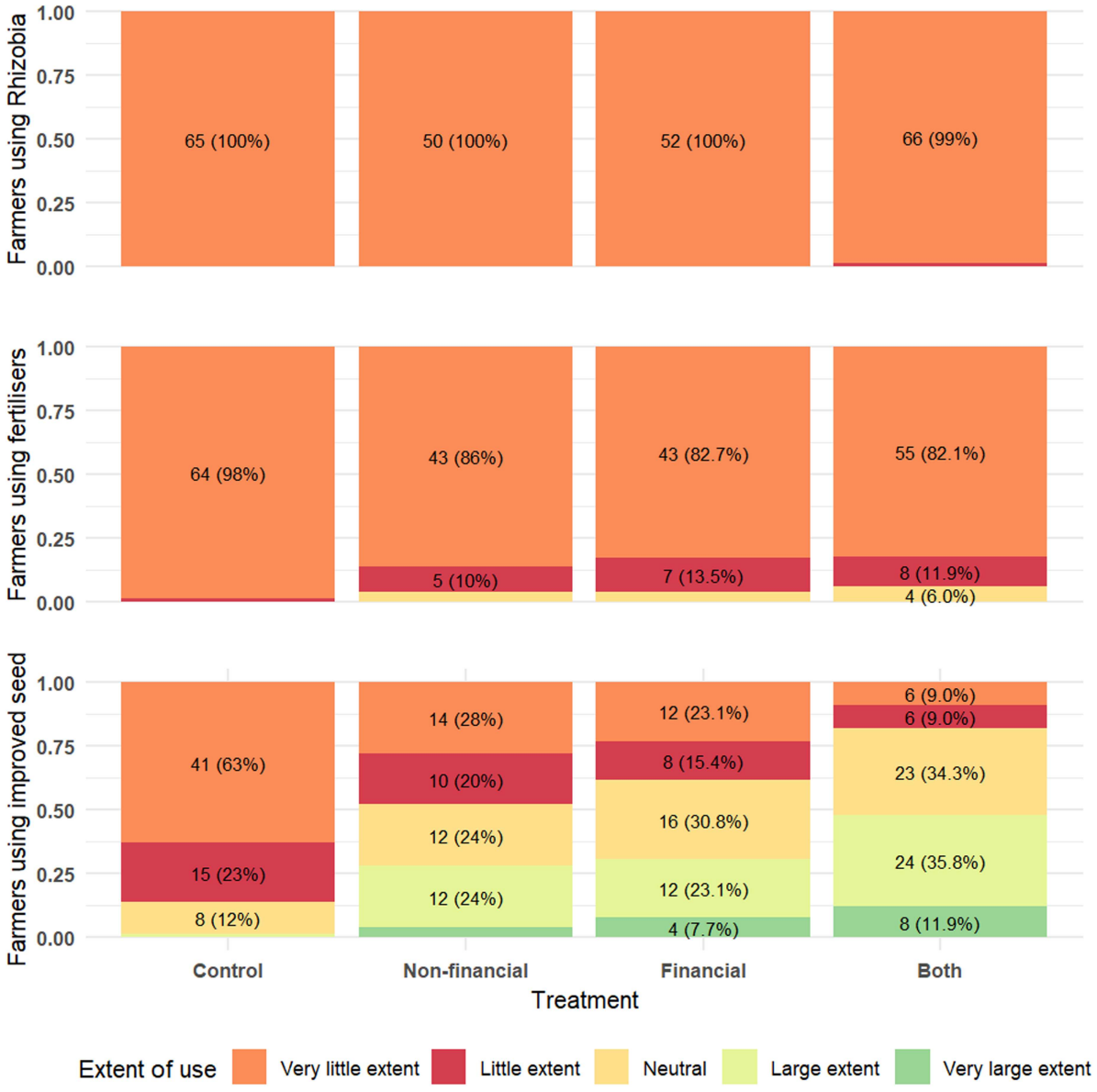

Figure 2. Percentage of respondents using improved seed, fertiliser and rhizobia across control ($n = 65$), non-financial ($n = 50$), financial ($n = 52$), both financial and non-financial ($n = 67$).

Table 2. Pairwise comparison between treatment groups across the use of improved seed and fertiliser.

	Pairwise comparison MANOVA				
	Response variables	Group1	Group2	P.adj	P.adj.signif
1	Improved seed	Control	Financial	0.00	****
2	Improved seed	Control	Non-financial	0.00	****
3	Improved seed	Control	Both	0.00	****
4	Improved seed	Financial	Non-financial	0.83	ns
5	Improved seed	Financial	Both	0.06	ns
6	Improved seed	Non-financial	Both	0.00	**
7	Fertiliser	Control	Financial	0.04	*
8	Fertiliser	Control	Non-financial	0.10	ns
9	Fertiliser	Control	Both	0.01	**
10	Fertiliser	Financial	Non-financial	0.99	ns
11	Fertiliser	Financial	Both	1.00	ns
12	Fertiliser	Non-financial	Both	.93	ns

Significance level codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' .1 ' ' 1.

and non-financial treatment was significantly different from the non-financial treatment, it was not significantly different from the financial treatment. This means that the financial incentives could have attracted farmers to use improved seed more than the non-financial incentives in the treatment with both financial non-financial incentives.

For fertiliser use, similarly, significant differences were only found between the control and financial treatment, and between the control and the combination of both financial and non-financial treatments (Table 2). For rhizobia, the post hoc test results showed that the differences between the control and treatment groups were not significant with $p > 0.05$ (data not presented).

Our results from the pairwise comparison showed that use of improved seed was statistically different between farmers who received non-financial incentives alone and those who received a combination of both financial and non-financial incentives, and between farmers in the control and those who received financial incentives alone. In the use of fertilisers, statistical differences were observed between farmers in the control and those who received financial incentives and between farmers in the control and those who received a combination of both financial and non-financial incentives. There were no significant differences observed between farmers who received financial incentives alone and those who received non-financial incentives alone in the use of both improved seed and fertilisers.

With the control variables added in our MANCOVA, we found that phone ownership of the household head ($p < 0.1$) and area planted with soybean ($p < 0.05$) had a significant effect on farmers' use of improved seed, fertiliser and rhizobial inoculants combined (Table 3). However, the effects sizes were very small with Partial Eta Squared; ηp2 at 0.03 and 0.004 for phone ownership of the household head and land size located to soybean production, respectively.

4.2 Effects of financial and non-financial loyalty incentives on farmers' yields

The average yields per treatment were 619 kg ha^{-1} for the control, 1146 kg ha^{-1} for the non-financial incentives, 1465 kg ha^{-1} for the financial incentives, and 1475 kg ha^{-1} for a combination of both financial and non-financial treatment groups. Results from a one-way ANOVA (Table 4) revealed that there was a statistically significant difference in soybean yields between the treatment groups [$F(3, 230) = 45.71$, $p < 0.001$]. Our results indicated that farmers who used more productivity enhancing agricultural inputs had on average higher yields due the loyalty incentives. Thus, hypothesis 2, predicting a positive and

Table 3. MANCOVA summary results of effects of the loyalty incentives controlling for covariates.

	Mancova summary results						
	Df	Pillai	Approx F	num df	den df	*P* values	
Treatment	3	0.315	8.539	9	654	0.000	***
Age	1	0.011	0.784	3	216	0.504	
Location (peri-urban or rural)	1	0.014	1.039	3	216	0.378	
Education	1	0.005	0.392	3	216	0.765	
Gender	1	0.024	1.768	3	216	0.156	
Household size	1	0.003	0.248	3	216	0.866	
Phone ownership of household head	1	0.030	2.264	3	216	0.081	.
Area planted with soybean	1	0.044	3.290	3	216	0.021	*
Loan access for soy	1	0.011	0.790	3	216	0.500	
Distance to agro input shops	1	0.002	0.167	3	216	0.918	
Distance to output markets	1	0.002	0.138	3	216	0.936	
Land use rights	1	0.022	1.616	3	216	0.186	
Distance to all weather road	1	0.006	0.407	3	216	0.748	
Residuals	218						

Significance level codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Table 4. Anova model results showing effects of treatments on soybean yield.

	Anova model summary					
	Df	Sum Sq	Mean Sq	F value	*P* value	
Treatment	3	30512650	10170883	45.71	0.000	***
Residuals	230	51175441	222502			

Significance level codes: '***' 0.001.

significant effect on farmers' yields by financial and non-financial incentives compared to control, is supported.

Tukey's HSD Test for multiple comparisons showed that the mean value of soybean yields was significantly different between at least two treatment groups (Figure 3, Table 5). These differences were significant between all treatment pairs, except between the financial and both financial and non-financial ($p < 0.99$, 95% C.I. = -216.34, 234.87) treatment groups.

Although the treatments increased farmers' use of agricultural inputs, our multiple linear regression results showed that yield increments were primarily driven by the use of improved seed ($p < 0.001$) and not use of fertiliser (Table 6). This is likely due to the very low adoption rate of fertiliser and, the extent of use being low among those farmers who used fertiliser (Figure 2). We specify the regression model as.

$Y = \beta\_0 + \beta\_1$ (Improved Seed) $+ \beta\_2$ (Fertiliser) $+ \varepsilon\_i$

where:

Y represents soybean yield per hectare; β_0 is the intercept; β_1 and β_2 denote the regression coefficients for Improved Seed and Fertiliser, respectively and ε_i is the random error term.

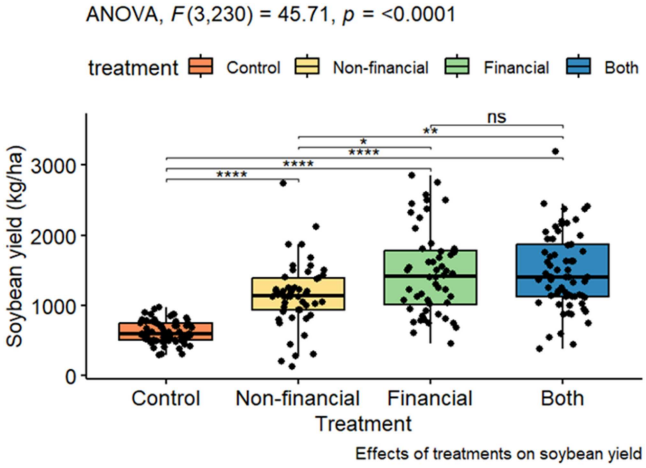

Figure 3. Farmer-reported soybean yields (kg ha^{-1}) in the control and different treatment groups.

Table 5. Tukey's HSD test showing multiple comparisons between treatment groups.

Tukey pairwise comparison results				
Treatment	Difference	Lower	Upper	*P* adj
Non-financial-Control	526.793	297.165	756.42	0.00
Financial-Control	846.392	619.275	1073.51	0.00
Both-Control	855.657	643.132	1068.18	0.00
Financial-Non-financial	319.600	77.814	561.385	0.00
Both-Non-financial	328.864	100.732	556.996	0.00
Both-Financial	9.264	-216.342	234.87	1.00

Table 6. Effects of improved seed and fertiliser to yield increments.

	Coefficients				
	Estimate	Std Error	t value	*P* values	
Intercept	462.86	94.1	4.919	0.000	***
Improved seed	260.45	26.79	9.722	0.000	***
Fertiliser	35.12	76.67	0.458	0.647	

Significance level codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' .1 ' ' 1.
Residual standard error: 337 on 231 degrees of freedom; Multiple R-squared:.6157.
Adjusted R-squared: 0.592; F-statistic: 41.8 on 2 and 231 DF, p-value: <0.000.
VIF: Improved seed =1.503; Fertiliser =1.175.

The regression model demonstrates a reasonably strong fit to the data. The residual standard error is 337, indicating the average distance between the observed and predicted values. The multiple R-squared value of 0.616 suggests that approximately 61.6% of the variability in the dependent variable is explained by the model's predictors, while the adjusted R-squared of 0.592 accounts for the number of predictors, providing a slightly more conservative estimate of explained variance. The F-statistic of 41.8, with 2 and 231 degrees of freedom, is highly significant ($p < 0.001$), indicating that the overall model provides a significantly better fit to the data than a model with no predictors. Together, these results suggest that the model captures a substantial portion of the variation in the outcome variable. Variance Inflation Factor (VIF) values for the predictors indicated no significant multicollinearity, with VIF = 1.503 for improved seed and VIF = 1.175 for fertiliser, both well below the commonly used threshold of 10.

Adding fertiliser together with improved seed led to increased yields in the financial and a combination of both financial and non-financial, but not in the non-financial treatments (Figure 4A). Furthermore, as the extent of use of inputs increased, soybean yield increased in the financial and in the combination of financial and non-financial treatments (Figure 4B).

5 Discussion

The purpose of this study was to assess the effects of financial and non-financial loyalty incentives on smallholders' use of agricultural inputs and resulting crop yields. Our results show that financial and non-financial incentives communicated through mobile phones significantly influenced farmers' use of agricultural inputs (improved seed and fertilisers), and consequently increased farmers' yields.

While our findings show large effects of the treatments on the use of improved seed compared with the control, there were only small differences between the financial and non-financial treatment groups, and the financial and a combination of financial and non-financial treatment groups. As hypothesised, the evidence indicates that farmers are more likely to use agricultural inputs if they expect loyalty incentives from an assured buyer. These findings are consistent with findings by studies on marketing incentives in contract schemes. For instance, Hoffmann et al. (2023) investigated the effect of a modest food safety premium on semi-subsistence farmers' investment in a food safety technology in Eastern Kenya. The authors found that a 5% market premium for produce that met the associated regulatory standard increased doubled maize farmer's investment in the food safety technology. Treurniet (2021) found that

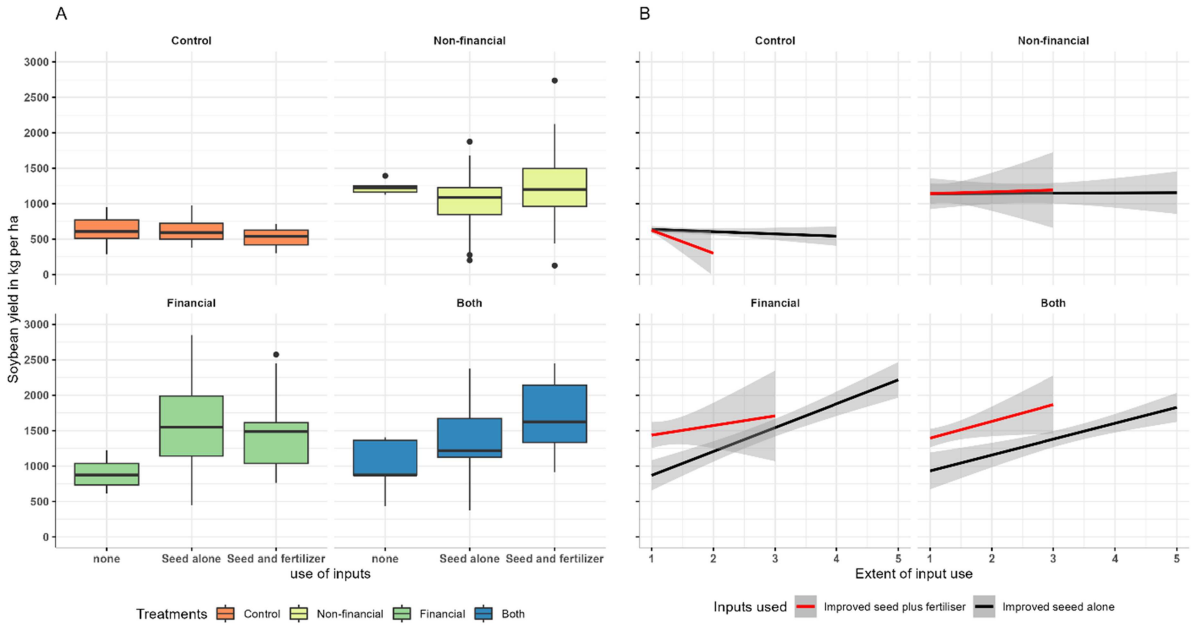

Figure 4. A Box plots of input use on soybean yield across the control and treatments. B Likert scale effects of extent of use of each input type on soybean yield.

an individual price bonus incentive focusing on compositional quality improved the quality of milk among Indonesian dairy farmers. Saenger et al. (2013) showed positive effects of both a higher penalty for low quality milk and a bonus for high quality milk on dairy farmers' use of inputs in Vietnam.

Our study extends the relational marketing strategies to crop farming, particularly for smallholder farmers, and demonstrates how loyalty interventions can help buyers differentiate themselves through competitive price offers to enhance farmers' loyalty (Brashear-Alejandro et al., 2016) and stimulate smallholder uptake of agricultural inputs. Our results show that market uncertainty resulting from a lack of access to market information (available buyers and prices) affects farmers' use of agricultural inputs, as seen from the control groups. Furthermore, our results suggest that interactions and relationship building with the buyer in addition to loyalty incentives communicated through the ICT platform could have increased farmers' market certainty (Ola & Menapace, 2020), stimulating their investments in productivity enhancing agricultural inputs.

Although our findings indicate effects of loyalty incentives on fertiliser use, large differences were only observed between the control and financial treatments, and between the control and the combination of both financial and non-financial treatments. These results suggest that financial incentives appeared to be more attractive than the non-financial. Despite the wide demonstration of productivity enhancing incentives of phosphorus fertilisers (e.g. TSP) among farmers in the region, the lack of access to such types of fertilisers, the high investment costs, the risk of weather shocks, and the variability in response and profitability (Ronner et al., 2016; van Heerwaarden et al., 2023) could have limited farmer's use.

We were unable to test Hypothesis 1 for rhizobia, as few farmers used rhizobial inoculants. Despite efforts in previous projects to enhance awareness on rhizobial inoculants and their benefits in soybean cultivation (Van Heerwaarden, 2018), the supply chain has not been developed, and inoculants are not available in local shops in rural Uganda (Vanlauwe et al., 2019). Rhizobial inoculants are produced at a small scale by Makerere University and not widely distributed, hindered by the lack of effective distribution networks (Ronner et al., 2016; Vanlauwe et al., 2019). This finding was also echoed by Brown et al. (2017) who found that uptake of maize-legume agricultural inputs among farmers in Africa was hindered by unreliable input market infrastructures, failing to meet the input needs of farmers.

Although the effects were small, phone ownership and area planted with soybean increased farmers' use of agricultural inputs. For area planted with soybean, these findings are consistent with studies on different crops who found that an increase in land allocation for a particular crop, including soybean, enhanced farmers' use of agricultural inputs (Anang et al., 2021; Danso-Abbeam & Baiyegunhi, 2018). These results indicate that farmers with a large area planted with a given crop give it more priority and are inclined to invest more resources in it. Hence, as soybean production is regarded as a profitable venture in the study area, farmers who allocate more land to soybean are expected to intensify their investments in agricultural inputs to enhance their yield gains. The effects of phone ownership by the household head on use of inputs indicate that phone access and ICT platforms can enhance farmers' access to information and capacity to use it to invest in agricultural inputs (Aker & Ksoll, 2016).

The increases in yield as an effect of the increased use of inputs were influenced by use of improved seed rather than by fertiliser, due to the limited use of the latter. Although few farmers used fertilisers, our results showed that adding phosphorus fertiliser with improved seed positively influenced yields, in line with van Heerwaarden et al. (2023), Ronner et al. (2016) and Ulzen et al. (2018). Furthermore, our study showed that soybean yield increased with a larger self-reported extent of use of inputs. Despite the beneficial effects of improved seed and phosphorus fertilisers on soybean yield, (physical) access to such agricultural inputs remains a challenge in many countries in sub-Saharan Africa (Sheahan and Barrett, 2017; Bold et al., 2017). There are various reasons for this, including lack of credit to pre-finance the inputs, poor quality inputs available, and lack of physical linkages to agro-input dealers. While farmers could get an input loan in our experiment, only a few farmer groups accessed the loan due to low coverage of the scheme and bureaucratic and non-digitalised application processes.

5.1 Practical implications

From the above discussion, this study draws the following practical implications. First, market certainties related to produce markets in combination with (financial) loyalty incentives emerge as a strong stimulus

for farmers' use of inputs in this study. These results show that farmers' access to output market linkages with competitive prices are necessary for enhancing farmers' investment in agricultural inputs. However, farmers' use of inputs will increase only when these inputs are readily available. Overall, our results suggest that, in addition to improved output market linkages, addressing the low use of inputs and low yields among smallholder farmers necessitates improving farmers' physical linkages to inputs through input loans, quality inputs within their localities and knowledge about the benefits and use of the inputs.

Second, business models for input markets, such as fertiliser and rhizobial inoculants, need to be redesigned to enable greater access for farmers in rural areas. Future research should establish the effects of output market-based loyalty programme incentives within established logistical arrangements for fertilisers and rhizobial inoculants. Such research findings would be relevant for policymakers and value chain stakeholders interested in enhancing uptake of technologies to develop smallholder-based value chains.

Third, while further studies of use of fertilisers and rhizobial inoculants are needed within established logistical arrangements, the increasing use of improved soybean seed varieties in Uganda is evident. Since the launching of N2Africa project in Uganda in 2014, use of improved seed varieties released by Makerere University has expanded resulting in availability of certified and quality declared seed in most rural areas of northern Uganda. Furthermore, efforts of the ICT platform to disseminate soybean technologies have continued after the project ended, with linkages to improved seed through microloans now available to rural farmers, and a growing local demand for soybean for poultry feed and exports to neighbouring Kenya. If input and output markets are coordinated to enable access by smallholders, increased use of inputs for improved soybean production is to be expected.

Fourth, while resources have gone into developing low-cost agricultural innovations such as inoculants to boost smallholders' productivity for soybean, their availability among farmers' communities and knowledge of their benefits is needed to increase their use and yields even more. Thus, ICT platforms could further their roles by aggregating or forecasting input demands and coordinate with the suppliers to arrange logistics in time for farmers.

5.2 Theoretical implications

This study also contributes the following theoretical insights. First, given the importance of loyalty incentives in relationship building and loyalty (Ramaswami & Arunachalam, 2016; Yi & Jeon, 2003), our study shows that the loyalty literature can be broadened to encompass the new context of rural markets in emerging economies with high social relevance. This opens new doors for this body of knowledge: it can help to fix market failures in less affluent parts of the world. The study provided evidence that loyalty incentives, already common among larger firms in the relational marketing literature, are also effective in smallholder-based value chains, thereby advancing knowledge on loyalty interventions for sustainable intensification of agricultural production and technology adoption through ICTs. Notably, this study contributes to the adoption and marketing literature, by highlighting the role of ICT platform in fostering relationships, trust and loyalty between value chain actors, critical for correcting market uncertainties that hinder farmers' uptake of agricultural inputs (Lajoie-O'Malley et al., 2020).

Second, in recent times, the surge in technological advancements in smallholder agricultural market systems have transformed the digital landscape offering opportunities for value chain actors to interact with each other (Sklyar et al., 2019). The positive effects of ICT-based financial and non-financial loyalty incentives on farmers' input use and yields indicated that enhancing relationships through interactions to share information and commit to actions (Mukhtar & Azhar, 2020) is important for enhancing gains from ICT platforms. Our work also demonstrates how output market buyers can leverage digital innovations as a strategic resource to gain competitive advantage (Skarmeas et al., 2016) and implement loyalty instruments that yield loyalty and performance. Our findings suggest that even within more pervasive face-to-face interactions between buyers and sellers, ICT platforms are effective tools that can be used to build actor's relationships in a smallholder context. While our findings suggest positive associations between ICT-based loyalty incentives and soybean outcomes, ICT engagement in this context did not occur in isolation, but rather alongside traditional face-to-face extension support. This interplay underscores the importance of

hybrid extension models, in which digital tools complement rather than replace interpersonal advisory services. Future studies should explicitly test the relative contributions of each modality.

This study extends the literature on loyalty incentives (and related literature in agricultural economics) into the interdisciplinary domain of studies on African smallholders and digital extension by showing how incentive design influences farmers' decision-making. The disciplines themselves are then indeed extended with a new context and new outcome measures. The adoption literature on smallholder farmers on the other hand is extended with a loyalty incentives approach to increase adoption from the relational marketing literature.

5.3 Limitations of this research

Finally, we discuss the limitations and some directions for future research. First, we aimed to test the effect of loyalty benefits on smallholders' use of improved seed varieties, fertilisers and inoculants on soybean in Northern Uganda. Yet, we could not assess effects on the use of inoculants because only 1% of farmers used this input. This is due to logistical challenges in transporting, storing, and distributing inoculants, which constrained access to and use of such inputs. We recognise that institutional gaps and logistic arrangements of such a loyalty intervention may be different for other parts of the country and other countries. Further research could consider testing such interventions in a more developed logistical arrangement to assess the effects of use on inoculants.

Second, the effectiveness of ICT-coordinated loyalty interventions on use of inputs may vary depending on the context and farmers' experience with the ICT platforms. Further research could explore the role of farmers' experiences with the ICT platform and the inputs in farmers' uptake of inputs. Third, loyalty incentives in our study are limited to price bonus and tarpaulins as financial and non-financial incentives, respectively and to a single crop, soybean chosen due to its strategic importance in the study region. These results may vary with other types of incentives, for instance, the use of cash or other types of non-financial incentives, and when they are assessed with staple foods like maize and rice or other farming systems. Fourth, the analysis covers only one cropping season, which limits our ability to capture long-term impacts or seasonal variability. Multi-season data would be required to confirm the sustainability and consistency of the observed effects. Future research should consider developing long-term loyalty interventions, measuring loyalty over time, and determining the long-term effects.

Fifth, the results of this study are based on an experiment with samples drawn from the existing ICT platform within an already established relationship with farmers. These results may differ in settings where ICT tools were not previously used by farmers. While this setting is not unique, it has the unusual feature of long-term interaction between the farmers and the ICT platform. Future research could explore and compare different ICT contexts. Sixth, yield estimates were based on farmer self-reports, which may be prone to over- or underestimation. Future research should complement farmer reports with objective measures such as crop cuts, field measurements, or satellite imagery. Seventh, the negligible adoption of rhizobial inoculants constrained our ability to evaluate their impact and underscores the importance of ensuring supply chain readiness before scaling such interventions. Eighth, we tested only a price bonus and tarpaulin, selected for their local relevance and feasibility. More common digital or cash-based incentives, such as mobile money or vouchers, input discounts, recognition awards, could yield different outcomes among farmers. Future studies should systematically compare a broader range of loyalty mechanisms to better capture farmer preferences and the heterogeneity of responses.

6 Conclusion

This study assessed the effects of financial (price bonus) and non-financial (tarpaulins) incentives, delivered through an ICT platform, on the use of productivity-enhancing inputs and yields among soybean farmers in Uganda. The results indicate that the loyalty incentives enhanced farmers' use of agricultural inputs (improved seed and fertilisers) and soybean yields, as farmers were incentivised to increase their produce volumes for the buyer. Furthermore, our study shows that ICT platforms have the potential to mitigate uncertainties in output markets (prices and buyers) by enabling access to timely and accurate market information, thereby enhancing farmers' investment in agricultural inputs. Although information on inputs,

output market, and expected loyalty incentives enhanced farmers' use of inputs, availability of required inputs remains a barrier to widespread use of inputs among smallholder farmers.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Notes on contributors

Connetie Ayesiga is a PhD graduate from the Marketing and Consumer Behaviour department at Wageningen University. Her main research interests relate to digital innovations in agricultural value chains and agricultural development, with an emphasis on the use of digital platforms in enhancing access to agricultural markets (inputs, outputs, finance), for improved uptake of agricultural technologies among smallholder farmers in sub-Saharan Africa.

Esther Ronner is a researcher at the Plant Production Systems group at Wageningen University. Her research focuses on analysing smallholder farming systems in East Africa, with a specific interest in sustainable intensification, technology adoption, co-design and multi-stakeholder processes.

Peter Ebanyat is a soil scientist at the Department of Agricultural Production, School of Agricultural Sciences, Makerere University. His research focuses on soil science, agronomy, nitrogen cycle, land use, and farming systems.

Ken E. Giller is emeritus professor of Plant Production Systems at Wageningen University. His research focuses on tropical farming systems, particularly the role of legumes and nitrogen fixation on smallholder farms in sub-Saharan Africa.

Paul T. M. Ingenbleek is an associate professor of marketing at the Marketing and Consumer Behaviour department at Wageningen University. His research focuses on the design of businesses, value chains, and business eco- or marketing systems in the agri-food sectors to achieve sustainable development goals. Much of his research is conducted in emerging markets, especially in sub-Saharan Africa.

References

Agarwal, R., & Mehrotra, A. (2018). Understanding what matters to customers: The case of loyalty programs in the Indian context. *Journal of Relationship Marketing*, *17*, 311–334. https://doi.org/10.1080/15332667.2018.1534065

Aggarwal, S., Giera, B., Jeong, D., Robinson, J., & Spearot, A. (2018). *Market access, trade costs, and technology adoption: evidence from Northern Tanzania*. National Bureau of Economic Research.

Agyekumhene, C., de Vries, J. R., Paassen, A. v., Schut, M., & MacNaghten, P. (2020). Making smallholder value chain partnerships inclusive: Exploring digital farm monitoring through farmer friendly smartphone platforms. *Sustainability*, *12*, 4580. https://doi.org/10.3390/su12114580

Aker, J. C., & Ksoll, C. (2016). Can mobile phones improve agricultural outcomes? Evidence from a randomized experiment in Niger. *Food Policy*, *60*, 44–51. https://doi.org/10.1016/j.foodpol.2015.03.006

Aker, J. C., Ghosh, I., & Burrell, J. (2016). The promise (and pitfalls) of ICT for agriculture initiatives. *Agricultural Economics*, *47*, 35–48. https://doi.org/10.1111/agec.12301

Alshurideh, M., Gasaymeh, A., Ahmed, G., Alzoubi, H., & Kurd, B. (2020). Loyalty program effectiveness: Theoretical reviews and practical proofs. *Uncertain Supply Chain Management*, *8*, 599–612. https://doi.org/10.5267/j.uscm.2020.2.003

Anang, B. T., Amesimeku, J., & Fearon, J. (2021). Drivers of adoption of crop protection and soil fertility management practices among smallholder soybean farmers in Tolon district of Ghana. *Heliyon*, *7*, e06900. https://doi.org/10.1016/j.heliyon.2021.e06900

Arouna, A., Michler, J. D., & Lokossou, J. C. (2021). Contract farming and rural transformation: Evidence from a field experiment in Benin. *Journal of Development Economics*, *151*, 102626. https://doi.org/10.1016/j.jdeveco.2021.102626

Barnes, A. P., Muoni, T., Öborn, I., Bergkvist, G., Nziguheba, G., Watson, C., Vanlauwe, B., & Duncan, A. J. (2021). Measuring household legume cultivation intensity in sub-Saharan Africa. *International Journal of Agricultural Sustainability*, *19*, 319–334. https://doi.org/10.1080/14735903.2021.1910418

Baryamureeba, V. (2006). ICT as an engine for Uganda's economic growth: The role of and opportunities. *International Journal of Computing and ICT Research*, *1*(1), 468–483 .

Bellemare, M. F. (2018). Contract farming: opportunity cost and trade-offs. *Agricultural Economics*, *49*, 279–288. https://doi.org/10.1111/agec.12415

Bold, T., Kaizzi, K. C., Svensson, J., & Yanagizawa-Drott, D. (2017). Lemon technologies and adoption: Measurement, theory and evidence from agricultural markets in Uganda. *The Quarterly Journal of Economics*, *132*, 1055–1100. https://doi.org/10.1093/qje/qjx009

Bombaij, N. J., & Dekimpe, M. G. (2020). When do loyalty programs work? The moderating role of design, retailer-strategy, and country characteristics. *International Journal of Research in Marketing*, *37*, 175–195. https://doi.org/10.1016/j.ijresmar.2019.07.003

Brashear-Alejandro, T., Kang, J., & Groza, M. D. (2016). Leveraging loyalty programs to build customer–company identification. *Journal of Business Research*, *69*, 1190–1198. https://doi.org/10.1016/j.jbusres.2015.09.014

Brown, B., Nuberg, I., & Llewellyn, R. (2017). Negative evaluation of conservation agriculture: Perspectives from African smallholder farmers. *International Journal of Agricultural Sustainability*, *15*, 467–481. https://doi.org/10.1080/14735903.2017.1336051

Burchardi, K. B., Gulesci, S., Lerva, B., & Sulaiman, M. (2019). Moral hazard: Experimental evidence from tenancy contracts. *The Quarterly Journal of Economics*, *134*, 281–347. https://doi.org/10.1093/qje/qjy023

Chavas, J. P., & Nauges, C. (2020). Uncertainty, learning, and technology adoption in agriculture. *Applied Economic Perspectives and Policy*, *42*, 42–53. https://doi.org/10.1002/aepp.13003

Chen, Y., Mandler, T., & Meyer-Waarden, L. (2021). Three decades of research on loyalty programs: A literature review and future research agenda. *Journal of Business Research*, *124*, 179–197. https://doi.org/10.1016/j.jbusres.2020.11.057

Cohen, J. (2018). *Statistical power analysis for the behavioral sciences*. Lawrence Erlbaum.

Danso-Abbeam, G., & Baiyegunhi, L. J. (2018). Welfare impact of pesticides management practices among smallholder cocoa farmers in Ghana. *Technology in Society*, *54*, 10–19. https://doi.org/10.1016/j.techsoc.2018.01.011

Dubbert, C. (2019). Participation in contract farming and farm performance: Insights from cashew farmers in Ghana. *Agricultural Economics*, *50*, 749–763. https://doi.org/10.1111/agec.12522

Dubbert, C., Abdulai, A., & Mohammed, S. (2023). Contract farming and the adoption of sustainable farm practices: Empirical evidence from cashew farmers in Ghana. *Applied Economic Perspectives and Policy*, *45*, 487–509. https://doi.org/10.1002/aepp.13212

Erbschloe, M. (2017). *Walling Out the Insiders: Controlling Access to Improve Organizational Security*. Auerbach Publications.

FAO, F. (2017). The future of food and agriculture–trends and challenges. *Annual Report*, *296*, 1–180.

Franke, A., Van den Brand, G., Vanlauwe, B., & Giller, K.E. (2018). Sustainable intensification through rotations with grain legumes in sub-Saharan Africa: A review. *Agriculture, Ecosystems & Environment*, *261*, 172–185. https://doi.org/10.1016/j.agee.2017.09.029

Giller, K. E., Corbeels, M., Nyamangara, J., Triomphe, B., Affholder, F., Scopel, E., & Tittonell, P. (2011). A research agenda to explore the role of conservation agriculture in African smallholder farming systems. *Field Crops Research*, *124*, 468–472. https://doi.org/10.1016/j.fcr.2011.04.010

Hoffmann, V., Kariuki, S., Pieters, J., & Treurniet, M. (2023). Upside risk, consumption value, and market returns to food safety. *American Journal of Agricultural Economics*, *105*, 914–939. https://doi.org/10.1111/ajae.12349

Keh, H. T., & Lee, Y. H. (2006). Do reward programs build loyalty for services?: The moderating effect of satisfaction on type and timing of rewards. *Journal of Retailing*, *82*, 127–136. https://doi.org/10.1016/j.jretai.2006.02.004

Khonje, M. G., Manda, J., Mkandawire, P., Tufa, A. H., & Alene, A. D. (2018). Adoption and welfare impacts of multiple agricultural technologies: Evidence from eastern Zambia. *Agricultural Economics*, *49*, 599–609. https://doi.org/10.1111/agec.12445

Kilelu, C. W., Klerkx, L., & Leeuwis, C. (2017b). Supporting smallholder commercialisation by enhancing integrated coordination in agrifood value chains: Experiences with dairy hubs in Kenya. *Experimental Agriculture*, *53*, 269–287. https://doi.org/10.1017/S0014479716000375

Krone, M., & Dannenberg, P. (2018). Analysing the effects of information and communication technologies (ICTs) on the integration of East African farmers in a value chain context. *Zeitschrift für Wirtschaftsgeographie*, *62*, 65–81. https://doi.org/10.1515/zfw-2017-0029

Lajoie-O'Malley, A., Bronson, K., van der Burg, S., & Klerkx, L. (2020). The future (s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. *Ecosystem Services*, 45, 101183.

Larochelle, C., Alwang, J., Travis, E., Barrera, V. H., & Dominguez Andrade, J. M. (2019). Did you really get the message? Using text reminders to stimulate adoption of agricultural technologies. *The Journal of Development Studies*, *55*, 548–564. https://doi.org/10.1080/00220388.2017.1393522

Lee, J.-S., Tsang, N., & Pan, S. (2015). Examining the differential effects of social and economic rewards in a hotel loyalty program. *International Journal of Hospitality Management*, *49*, 17–27. https://doi.org/10.1016/j.ijhm.2015.05.003

Lilien, G. L. (2016). The B2B knowledge gap. *International Journal of Research in Marketing*, *33*, 543–556. https://doi.org/10.1016/j.ijresmar.2016.01.003

Liu, J., & Ansari, A. (2020). Understanding consumer dynamic decision making under competing loyalty programs. *Journal of Marketing Research*, *57*, 422–444. https://doi.org/10.1177/0022243720911894

Lowder, S. K., Sánchez, M. V., & Bertini, R. (2021). Which farms feed the world and has farmland become more concentrated? *World Development*, *142*, 105455. https://doi.org/10.1016/j.worlddev.2021.105455

Macchiavello, R., & Morjaria, A. (2021). Competition and relational contracts in the Rwanda coffee chain. *The Quarterly Journal of Economics*, *136*, 1089–1143. https://doi.org/10.1093/qje/qjaa048

Macours, K. (2019). Farmers' demand and the traits and diffusion of agricultural innovations in developing countries. *Annual Review of Resource Economics*, *11*, 483–499. https://doi.org/10.1146/annurev-resource-100518-094045

Martey, E., Kuwornu, J. K., & Adjebeng-Danquah, J. (2019). Estimating the effect of mineral fertilizer use on Land productivity and income: Evidence from Ghana. *Land Use Policy*, *85*, 463–475. https://doi.org/10.1016/j.landusepol.2019.04.027

McArthur, J. W., & McCord, G. C. (2017). Fertilizing growth: Agricultural inputs and their effects in economic development. *Journal of Development Economics*, *127*, 133–152. https://doi.org/10.1016/j.jdeveco.2017.02.007

Meemken, E.-M., & Bellemare, M. F. (2020). Smallholder farmers and contract farming in developing countries. *Proceedings of the National Academy of Sciences*, *117*, 259–264. https://doi.org/10.1073/pnas.1909501116

Melnyk, V., & Bijmolt, T. (2015). The effects of introducing and terminating loyalty programs. *European Journal of Marketing*, *49*, 398–419. https://doi.org/10.1108/EJM-12-2012-0694

Minkoua Nzie, J., Bidogeza, J.-C., & Azinwi Ngum, N. (2018). Mobile phone use, transaction costs, and price: Evidence from rural vegetable farmers in Cameroon. *Journal of African Business*, *19*, 323–342. https://doi.org/10.1080/15228916.2017.1405704

Minten, B., Tamru, S., Engida, E., & Kuma, T. (2016). Transforming staple food value chains in Africa: The case of teff in Ethiopia. *The Journal of Development Studies*, *52*, 627–645. https://doi.org/10.1080/00220388.2015.1087509

Mohammed, S., & Abdulai, A. (2022). Do ICT based extension services improve technology adoption and welfare? Empirical evidence from Ghana. *Applied Economics*, *54*, 2707–2726. https://doi.org/10.1080/00036846.2021.1998334

Mukhtar, U., & Azhar, T. (2020). Inter-functional coordination to co-create value within integrated value chains for competitive supply chain. *Operations and Supply Chain Management: An International Journal*, *13*, 11–22. https://doi.org/10.31387/oscm0400249

Nurgi, N., Tana, T., Dechassa, N., Tesso, B., & Alemayehu, Y. (2023). Effect of spatial arrangement of faba bean variety intercropping with maize on yield and yield components of the crops. *Heliyon*, *9*(6), e16751. https://doi.org/10.1016/j.heliyon.2023.e16751

Ola, O., & Menapace, L. (2020). Smallholders' perceptions and preferences for market attributes promoting sustained participation in modern agricultural value chains. *Food Policy*, *97*, 101962. https://doi.org/10.1016/j.foodpol.2020.101962

Orr, A. (2018). Markets, institutions and policies: A perspective on the adoption of agricultural innovations. *Outlook on Agriculture*, *47*, 81–86. https://doi.org/10.1177/0030727018776433

Otsuka, K., Nakano, Y., & Takahashi, K. (2016). Contract farming in developed and developing countries. *Annual Review of Resource Economics*, *8*, 353–376. https://doi.org/10.1146/annurev-resource-100815-095459

Purohit, A., & Thakar, U. (2019). Role of information and communication technology in improving loyalty program effectiveness: A comprehensive approach and future research agenda. *Information Technology & Tourism*, *21*, 259–280. https://doi.org/10.1007/s40558-018-00139-6

Ramaswami, S. N., & Arunachalam, S. (2016). Divided attitudinal loyalty and customer value: role of dealers in an indirect channel. *Journal of the Academy of Marketing Science*, 44(6), 770–790.

Ronner, E., Franke, A., Vanlauwe, B., Dianda, M., Edeh, E., Ukem, B., Bala, A., Van Heerwaarden, J., & Giller, K. v. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. *Field Crops Research*, *186*, 133–145. https://doi.org/10.1016/j.fcr.2015.10.023

Saenger, C., Qaim, M., Torero, M., & Viceisza, A. (2013). Contract farming and smallholder incentives to produce high quality: experimental evidence from the Vietnamese dairy sector. *Agricultural Economics*, *44*, 297–308. https://doi.org/10.1111/agec.12012

Sebhatu, K. T., Gezahegn, T. W., Berhanu, T., Maertens, M., Van Passel, S., & D'Haese, M. (2020). Conflict, fraud, and distrust in Ethiopian agricultural cooperatives. *Journal of Co-operative Organization and Management*, *8*, 100106. https://doi.org/10.1016/j.jcom.2020.100106

Sheahan, M., & Barrett, C. B. (2017). Food loss and waste in Sub-Saharan Africa. *Food Policy*, 70, 1–12.

Simtowe, F., Marenya, P., Amondo, E., Worku, M., Rahut, D. B., & Erenstein, O. (2019). Heterogeneous seed access and information exposure: implications for the adoption of drought-tolerant maize varieties in Uganda. *Agricultural and Food Economics*, *7*, 1–23. https://doi.org/10.1186/s40100-019-0135-7

Steinhoff, L., & Palmatier, R. W. (2016). Understanding loyalty program effectiveness: Managing target and bystander effects. *Journal of the Academy of Marketing Science*, *44*, 88–107. https://doi.org/10.1007/s11747-014-0405-6

Stevenson, J., Vanlauwe, B., Macours, K., Johnson, N., Krishnan, L., Place, F., Spielman, D., Hughes, K., & Vlek, P. (2019). Farmer adoption of plot-and farm-level natural resource management practices: Between rhetoric and reality. *Global Food Security*, *20*, 101–104. https://doi.org/10.1016/j.gfs.2019.01.003

Suri, T., & Udry, C. (2022). Agricultural technology in Africa. *Journal of Economic Perspectives*, *36*, 33–56. https://doi.org/10.1257/jep.36.1.33

Ton, G., Vellema, W., Desiere, S., Weituschat, S., & D'Haese, M. (2018). Contract farming for improving smallholder incomes: What can we learn from effectiveness studies? *World Development*, *104*, 46–64. https://doi.org/10.1016/j.worlddev.2017.11.015

Treurniet, M. (2021). The potency of quality incentives: Evidence from the Indonesian dairy value chain. *American Journal of Agricultural Economics*, *103*, 1661–1678. https://doi.org/10.1111/ajae.12176

Ulzen, J., Abaidoo, R. C., Ewusi-Mensah, N., & Masso, C. (2018). On-farm evaluation and determination of sources of variability of soybean response to Bradyrhizobium inoculation and phosphorus fertilizer in northern Ghana. *Agriculture, Ecosystems & Environment*, 267, 23–32.

Van Campenhout, B., Spielman, D. J., & Lecoutere, E. (2021). Information and communication technologies to provide agricultural advice to smallholder farmers: Experimental evidence from Uganda. *American Journal of Agricultural Economics*, *103*, 317–337. https://doi.org/10.1002/ajae.12089

Van Heerwaarden, J. J. (2018). *Factors influencing grain legume technology adoption across Sub-Saharan Africa* [The MSc Thesis]. The University of the Wageningen and Research.

van Heerwaarden, J., Ronner, E., Baijukya, F., Adjei-Nsiah, S., Ebanyat, P., Kamai, N., Wolde-Meskel, E., Vanlauwe, B., & Giller, K. E. (2023). Consistency, variability, and predictability of on-farm nutrient responses in four grain legumes across East and West Africa. *Field Crops Research*, *299*, 108975. https://doi.org/10.1016/j.fcr.2023.108975

van Heerwaarden, J., Baijukya, F., Kyei-Boahen, S., Adjei-Nsiah, S., Ebanyat, P., Kamai, N., Wolde-Meskel, E., Kanampiu, F., Vanlauwe, B., & Giller, K.E. (2018). Soyabean response to rhizobium inoculation across sub-Saharan Africa: Patterns of variation and the role of promiscuity. *Agriculture, Ecosystems & Environment*, *261*, 211–218. https://doi.org/10.1016/j.agee.2017.08.016

Van Ittersum, M. K., Van Bussel, L. G., Wolf, J., Grassini, P., Van Wart, J., Guilpart, N., Claessens, L., De Groot, H., Wiebe, K., & Mason-D'Croz, D. (2016). Can sub-Saharan Africa feed itself? *Proceedings of the National Academy of Sciences*, *113*, 14964–14969. https://doi.org/10.1073/pnas.1610359113

van Vugt, D., Franke, A., & Giller, K. E. (2018). Understanding variability in the benefits of N2-fixation in soybean-maize rotations on smallholder farmers' fields in Malawi. *Agriculture, Ecosystems & Environment*, *261*, 241–250. https://doi.org/10.1016/j.agee.2017.05.008

Vanlauwe, B., Hungria, M., Kanampiu, F., & Giller, K. E. (2019). The role of legumes in the sustainable intensification of African smallholder agriculture: Lessons learnt and challenges for the future. *Agriculture, Ecosystems & Environment*, *284*, 106583. https://doi.org/10.1016/j.agee.2019.106583

Viswanathan, V., Sese, F. J., & Krafft, M. (2017). Social influence in the adoption of a B2B loyalty program: The role of elite status members. *International Journal of Research in Marketing*, *34*, 901–918. https://doi.org/10.1016/j.ijresmar.2017.08.003

Viswanathan, V., Koetterheinrich, K., Bijmolt, T., Krafft, M., & Sese, F. J. (2022). Quantifying the effect of status in a multi-tier loyalty program. *Industrial Marketing Management*, *104*, 376–383. https://doi.org/10.1016/j.indmarman.2022.04.020

Yi, Y., & Jeon, H. (2003). Effects of loyalty programs on value perception, program loyalty, and brand loyalty. *Journal of the Academy of Marketing Science*, 31(3), 229–240.

Zahedi, S. R., & Zahedi, S. M. (2012). Role of Information and communication technologies in modern agriculture. *International Journal of Agriculture and Crop Sciences (IJACS)*, *4*, 11725–11728.

Appendix 1

Appendix A1. Loyalty programme intervention information sent to individual farmers across the treatment and Control groups.

	Financial	Non-financial	Financial + Non-financial	Control
1st set	Dear (farmer name), as you plan to plant for the new season, m-Omulimisa has brought on-board a new company called AgriNet to ensure that, you have a market for your soybean at the end of season. AgriNet will offer you a guaranteed competitive price for your soybean. Peter from m-Omulimisa. To ensure you benefit from this competitive price offered by AgriNet, we recommend that you use improved production inputs such as improved seed, fertilisers and inoculants. To purchase, contact Denis 0778200390 for seed, Ogwang Isaac on 0781796669 for fertilisers. For an additional improvement in your yield, we highly recommend to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, among others in addition to improved inputs. Send queries to 0800219999 for more information. Because soybean is an important crop as a cheap protein source for humans and animals, we are delighted to partner with you by ensuring you have a good market for your soybean so that those who are not able to grow it, can equally benefit from its protein source _AgriNet To show our commitment to this partnership, we are keen to sign contracts with you as farmer groups as a guarantee to buy your produce at end of season. AgriNet staff will be in touch during the season to make sure you get the best quality harvest. We (m-Omilimisa) are in this together _Paul AgriNet			
	We as AgriNet, guarantee a price bonus of 100 shs per kilo if you deliver 20 tonnes of soybean or more as a group at the end of season _AgriNet.	We as AgriNet, guarantee to reward a tarpaulin for each member of the group that will supply 20 tonnes of soybean or more _AgriNet.	We as AgriNet, will offer a price bonus of 100 shs per kilo and tarpaulins for each member of the group that delivers 20 tonnes of soybean or more _AgriNet.	
2nd set	Hello xxxx (farmer name) To maximise your yields and be able to earn the price bonuses of 100 shs per kilo offered by AgriNet, you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa.	To maximise your yields and be able to earn the gift rewards of tarpaulins offered by AgriNet, you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa	To maximise your yields and be able to earn the price bonuses of 100 shs per kilo and gift rewards of tarpaulins offered by AgriNet, you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa	To maximise your yields, you are reminded to use good farming practices such as timely planting and appropriate spacing, row planting, timely weeding, etc. _m-Omulimisa
3rd set	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce and be able to earn the price bonuses of 100shs per kilo offered by AgriNet. _m-Omulimisa.	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce and be able to earn gift rewards of tarpaulins offered by AgriNet. _m-Omulimisa.	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce and be able to earn the price bonuses of 100shs per kilo and gift rewards of tarpaulins offered by AgriNet. _m-Omulimisa.	As the time for harvesting nears, we remind you to exercise good practices such as harvesting only ripe plants and drying your produce on a tarpaulin to improve the quality and marketability of your produce. _m-Omulimisa.
4th set	The buying season is here, as AgriNet, we are ready to buy your soybean produce. Our bulking centres are located at.,. Contact us on			
	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered price bonuses of 100 shs per kilo if your group brings 20 tonnes and above of soybean produce. _AgriNet	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered gift rewards of tarpaulins if your group brings 20 tonnes and above of soybean produce. _AgriNet	As you bring your produce to the bulking centre, make sure our buying agents record your name, produce supply and your group name, in order for your group to be awarded bonus points that will earn you the offered price bonuses of 100 shs per kilo and gift rewards of tarpaulins if your group brings 20 tonnes and above of soybean produce. _AgriNet	
	To earn your price bonuses, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _AgriNet	To earn your gift rewards of tarpaulins, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _AgriNet	To earn your price bonus and gift rewards of tarpaulins, make sure you receive a supply card indicating your ID number, quantity of produce supplied and the name of your group. _AgriNet	

Appendix 2. Demographics of respondents.

Treatment	Average age	Education (Years)	Household size
Control	30.7	8	5
Non-financial	31.2	8	6
Financial	31.8	8	6
Both	39.9	8	6