Effectiveness of Communication Channels on Level of Awareness and Determinants of Adoption of Improved Common Bean Technologies Among Smallholder Farmers in Tanzania

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Abstract Increased legume productivity contributes to nutritional security as they are a source of cheap proteins. However, there is limited access to information on improved legume technologies among smallholder farmers in resource poor countries such as Tanzania. This chapter is aimed at assessing the effectiveness of communication channels (i.e. demonstration plots, farmer field days, technological briefs) on level of awareness and the determinants of adoption of improved common bean technologies among smallholder farmers in Tanzania. The study on which the chapter is based used a cross-sectional design on 400 households in Gairo and Mvomero districts, Tanzania. Results show that more than a half of the farmers were aware of all the seven improved legume technologies assessed. However, the level of awareness on all the technologies differed across the treatments, with a high level of the awareness recorded in areas with interventions. Among others, intervention included sharing information with farmers on land preparation, legume variety selection, use of quality seed, fertiliser application at planting, planting and spacing, weeding, control of insect and storage pests and diseases, harvesting and storage

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and safe use of chemicals. The awareness was low in areas without intervention. Nonetheless, there was a low level of adoption of the improved legume technologies. This could be due to the fact that the intervention was at its initial stage of implementation; but it was expected to increase with time as knowledge diffuses to the communities. In addition, as pointed out in the focus group discussions, low adoption could be because of difficulties in accessing improved bean technologies (high costs associated), unavailability of improved seeds and absence of seed dealers nearby villages. The factors significantly ($p \leq 0.05$) associated with smallholder farmers' adoption of improved legume technologies were visits by extension officers, age of household head, being member of a farmers' association, revenue from other income-generating activities and household size. Therefore, it can be concluded that a combination of demonstration plots, farmer field days and technological briefs (leaflets and brochures) accounted for the effective communication and awareness creation. Thus, it is recommended that the government and non-governmental organisations should invest more in awareness creation approaches in order to make sure that all smallholder farmers are sensitised on the improved legume technologies. In addition, the government and non-governmental organisations should insist more on visits by extension officers, formation of/joining farmers association and participating in other income-generating activities to enhance adoption of improved legume technologies.

Keywords Effectiveness · Communication channels · Smallholder farmers' adoption · Bean technologies · Tanzania

1 Introduction

Food legumes play important and diverse roles in the farming systems and in the diets of poor people around the world such as reducing poverty, improving human health and nutrition and enhancing ecosystem resilience (Katungi et al. 2010). In sub-Saharan Africa (SSA), legume crops play an important role economically, socially and environmentally by providing jobs, providing the cheap protein consumed mostly at the household level, improving health and nutrition and improving soil fertility through ground cover, weed suppression and nitrogen fixation (Akibode 2011; Sanginga and Bergvinson 2015).

In Tanzania, most small-scale farmers, especially women, participate in legume production. Generally, legumes act as a good and inexpensive protein source compared to meat and fish (Malema 2006; ProFound and Mugenyi 2012). Other significant roles of legumes in Tanzania include their early maturity compared to other staple food crops, being a quick source of income at every stage of their growth such as green leaves, fresh pods and dry grains (Birachi 2012). Generally, legumes excel in human and livestock nutrition, soil fertility improvement and foreign currency earning through export.

The importance of legumes to communities has led to a need for development and dissemination of various improved technologies. As a result of the above, extension agents have used a variety of ways to reach farmers. Generally, a number of delivery approaches and communication channels exist in legume producing areas. These include, but are not limited to, conventional approaches (agricultural extension officers visiting farmers), multimedia approaches (radio, television, mobile phones, newspapers, leaflets, brochures, etc.) and other extension methods such as demonstration plots, farmer field days, etc. However, the conventional agricultural extension services commonly used in Tanzania Morogoro included visits by extension officers to farmers in order to disseminate agricultural technologies. This method is important since it helps extension workers to provide technical assistance directly to farmers. However, the method faces a number of challenges, which include insufficient numbers of extension officers and inadequate resources (finances and transport) (Sanga et al. 2013).

In Tanzania and beyond, multimedia methods such as radio, television, mobile phones, newspapers, leaflets and brochures are also used in disseminating agricultural technologies. A prominent example is the Farmer Voice Radio project which was launched in 2009 and implemented in some of the districts in Tanzania. The project linked extension officers and farmers with a radio-based system. Generally, the multimedia method helps to reach many farmers within a short time in disseminating agricultural technologies (Sanga et al. 2013). Other research conducted in different parts of Africa found that multimedia methods are effective in awareness creation to smallholder farmers pertaining agricultural technologies because less time and costs are incurred while covering large areas (Ango et al. 2013; Ariyo et al. 2013; Kakade 2013; Chapota et al. 2014; Sam and Dzandu 2012). Despite their importance, multimedia methods have limitations. For example, duration of the programme tends to be short for farmers to capture all necessary information. Another limitation is that of language barrier, most facilitators are not fluent in local languages, and there may be lack of communication skills to communicate with the audience (Sam and Dzandu 2012).

Apart from the above extension methods, demonstration plots have been another avenue through which agricultural technologies are disseminated. Generally, demonstration plots help farmers to learn more by seeing and doing/practising. Also they are among the best methods to improve yield and help extension workers to effect desirable changes to smallholder farmers. Demonstration plots are arranged at the best learning locations (rural setting); and they provide opportunities through which useful communication and interaction can take place between extension workers and smallholder farmers (Khan et al. 2009). Nonetheless, the method also has limitations, as only a few farmers can be made to learn at a time.

Tanzania has for a long time been making efforts to scale up crop productivity (legumes included) under the Agricultural Sector Development Strategy 2001. These efforts have included financing agriculture and promoting research activities, improving extension services provided to smallholder farmers, training for updating skills and knowledge of farmers, improving agricultural mechanisation and improving agricultural information systems (URT 2001). Despite the efforts made to increase food productivity, legume yields are low (below a ton per hectare) (Malema 2006; URT 2012). In addition, the cost of obtaining such crops for food is high

(ProFound and Mugenyi 2012). Moreover, poor productivity may either be a result of the ineffective awareness creation approaches used or farmers' unwillingness to adopt improved legume technologies. Generally, the low productivity could be a consequence of farmers' low access to the legume technologies due to the shortfalls of awareness creation approaches.

In the 2015/2016 cropping season, a project on Scaling up Improved Legume Technologies (SILT) through Sustainable use of Input Supply and Information Systems was implemented in Morogoro Region with the support of the International Development Research Centre (IDRC) and the Canadian International Food Security Research Fund. Through the project there was sharing of knowledge with smallholder farming families using multimedia approaches such as technological briefs (leaflets and brochures) and other extension approaches, especially demonstration plots and farmer field days (MLE 2016). The knowledge disseminated included positive contribution of legumes to human and livestock nutrition, livelihoods, soil fertility and the environment, land preparation, legume variety selection, use of quality seed, fertiliser application at planting, planting, spacing and weeding. Others were control of insects and storage pests and diseases, harvesting and storage, and safe use of chemicals.

According to the Productivity Commission (2013), effectiveness is the extent to which stated objectives are met. Indicators of the effectiveness of programmes generally focus on measuring the changes in outcomes that reflect the objectives of the programme. According to SCRGSP (2006) cited in Productivity Commission (2013), the performance of any programme can be measured at two levels: cost-effectiveness performance indicators can be used to estimate unit cost of producing certain output, and programme effectiveness performance indicators can be used to look at agreed measures of access, appropriateness and quality. Therefore, the chapter adopted the definition of Production Commission 2013 by measuring effectiveness of communication channels in terms of awareness raised and determinants of adoption of improved legume technologies as the aim of the study.

2 Methodology

The study was conducted in Gairo and Mvomero districts in Morogoro Region, Tanzania, from February to March 2017. Morogoro Region lies between latitudes 5° 58″ and 10° 0″ South of the Equator and longitudes 35° 25″ and 30° 30″ to the East. Its climate is highly influenced by the Indian Ocean. The Nguru, Uluguru and Udzungwa Mountains as well as the Mahenge Hills form part of the Eastern Arc Mountains (URT 2016a, b).

Gairo District constitutes different agroecological zones with different climatic conditions. Generally, rainfall varies between 600 mm and 1200 mm and between altitudes of 1100 to 2200 metres above sea level (m.a.s.l). Land is characterised by moderately fertile well-drained soils, comprising sandy/clay loam soils. Agriculture is the mainstay of the district residents employing 90% of the households. The main subsistence crops cultivated include maize and beans (URT 2016a).

Mvomero District's climate varies from semi and warm tropical to cool high altitude. The district is characterised by high rainfall between March and May and from October to December. Annual rainfall is between 600 mm and 2000 mm and highest between the altitudes 400 and 2000 m.a.s.l. (URT 2016b). The land is very fertile, and about 90.1% of the district's total population is engaged in agriculture and agricultural-related occupations for their livelihood (URT 2016b). The above districts were purposively selected due to the fact that multimedia approaches (i.e. technological briefs such as leaflets and brochures) and other extension approaches (i.e. demonstration plots and field days) were used to scale up improved legume technologies in the last (i.e. 2015/2016) cropping season in these particular areas.

3 Research Design

The study used a cross-sectional research design, and two wards (Kinda Ward in Mvomero District and Rubeho Ward in Gairo District) that received improved common bean technologies (from November 2015 to April 2016) were purposively selected for data collection. The sampling units were households within the villages (i.e. Ndole and Makate in Kinda Ward as well as Ikenge and Rubeho in Rubeho Ward) with and without intervention. A structured questionnaire was administered to 400 respondents, about two thirds (66.25%) were from the area of intervention (Ndole and Ikenge villages) and the rest were from areas with no intervention (Makate and Rubeho villages). Based on the proportion of the number of respondents in the particular intervention, the research needed to capture at least minimum representation from each group, i.e. out of 66.25% respondents interviewed in the area of intervention, 63% received two interventions (demonstration and farmer field days), while 37% received three interventions (demonstration, farmer field days and technological briefs). Qualitative data were collected using focus group discussions (FGDs) and key informant interviews, which were conducted at the ward level (Table 1).

4 Sample Size

In calculating the sample size, it was assumed that 50% of smallholder farmers in both control and intervention areas are willing to adopt legume technology. This is because, from the reviewed literature, no reference was obtained showing percentage of smallholder farmers who were willing to adopt improved legume technologies; thus in calculating the sample size, the generic proportion, i.e. 50%, was used.

Table 1 Number of respondents selected in Mvomero and Gairo districts

District	Ward	Village	Intervention	People received intervention	Sample
Mvomero	Kinda	1 = Ndole	Farmer field days	82	47
			Farmer field days +Technological briefs	44	30
		2 = Makate	No intervention (control village)	00	69
Gairo	Rubeho	1 = Ikenge	Farmer field days	215	120
			Farmer field days +Technological briefs	120	68
		2 = Rubeho	No intervention (control village)	00	66
Total				**461**	**400**

NB: The non-response rate was 0.7% (3 respondents) which means, out of 403 targeted respondents, authors managed to interview 400 respondents. In addition, the types of data collected from these respondents included socio-demographic characteristics, types of communication channels used to create awareness on legume technologies in the area of study and types of legume technologies

Therefore, using Eq. 1 given by Cochran (1977), the sample size of 403 smallholder farmers was arrived at:

$$n = Z2 \propto /2P\left(1 - P / e2\right) \tag{1}$$

where

n = Sample size
$Z2\alpha/2$ = The probability distribution with level of significance $\alpha = 5\%$
"P" = Proportion of smallholder farmers adopted legume technologies
$(1 - P)$ = Proportion of smallholder farmers not adopted legume technologies
"e" = The level of marginal error

4.1 Data Analysis

The primary data collected through the questionnaire was coded and entered into the SPSS software (version 20) and checked for accuracy, and the anomalies found were corrected. The data was then analysed, computing descriptive statistics including frequencies, percentages, mean and standard deviations (SD). In addition, the binary logistic regression model was used to determine the factors predicting adoption of improved legume technologies. As given by Agresti (2002), it is specified as:

$$\text{Logit}(\text{Pi}) = \log(\text{Pi}/1 - \text{Pi}) = b_0 + b_1x_1 + b_2x_2 + b_1x_1 + \cdots b_kx_k \ldots\ldots \quad (2)$$

Logit (Pi) = In odds (event), that is natural log of the odds of an event (adoption of technologies) occurring
Pi = Prob (event), that is the probability that the event will occur
1−Pi = Prob (no-event), that is the probability that the event will not occur
b_0 = Constant of the equation
b_1–b_k = Coefficient of the independent (predicator, response) variables
k = Number of independent variable
x_1 to x_k = Independent variables entered in the model
x_1 = Household size (total number of people in a household)
x_2 = Sex of household head (male 1, 0 female)
x_3 = Age of household head measured in years
x_4 = Marital status of household head (married 1, 0 otherwise)
x_5 = Education level of household head (primary and above 1, 0 otherwise)
x_6 = Type of intervention (with intervention 1, 0 otherwise)
x_7 = Total income from other income-generating activities (IGA)
x_8 = actual land in hectares cultivated
x_9 = Belonging to farmers association (1 Yes, 0 No)
x_{10} = Access to extension service (1 Yes, 0 No)
x_{11} = Access to credit (ever received credit 1, 0 otherwise)

5 Results and Discussion

5.1 Respondents Socio-demographic Characteristics

The results in Table 2 show that more than three quarters of the households were headed by males. The household head ages ranged from 18 to 79 years. Nevertheless, the majority of household heads were in the age range of 36–60 years (middle-aged household heads) and 18–35 years (youthful heads), which means the majority of household heads were in the economic active group (URT 2015). Study results further show that more than three quarters of the household heads had attained primary school education. This means the level of literacy in the study areas was high to the extent that programmes intended to create awareness in the particular area can be easily delivered and understood by the smallholder farmers through use of different communication channels/methods. Study results also show that almost all of household heads depend on agricultural production as their main occupation. The above is supported by Gairo and Mvomero districts socio-economic profiles which show that agriculture employs over 90% of the district's residents (URT 2016a, b).

Table 2 Demographic and socio-economic characteristics of the respondents ($n = 400$)

Variable	Category	Overall	Mvomero	Gairo
Household size	1–6	343(85.8)	125(85.6)	218(85.6)
	>6	57(14.2)	21(14.4)	36(85.8)
	Mean = 4.75, SD = 1.74			
Sex	Male	348(87)	123(84.2)	225(88.6)
	Female	52(13)	23(15.8)	29(11.4)
Age	18–35	171(42.8)	49(33.60	122(48)
	36–60	209(52.2)	87(59.6)	122(48)
	>60	20(5)	10(6.8)	10(3.9)
	Mean = 39.79, SD = 12.17			
Education level	None	68(17)	20(13.7)	48(18.9)
	Primary education	326(81.5)	120(82.2)	206(81.1)
	Above primary education	6(1.5)	6(4.1)	0(0)
Marital status	Single	11(2.8)	6(4.1)	5(2)
	Married	334(83.5)	114(78.1)	220(86.6)
	Divorced	26(6.5)	13(8.9)	13(5.1)
	Separated	10(2.5)	6(4.1)	4(1.6)
	Widow/er	19(4.8)	7(4.8)	12(4.7)
Main occupation	Crop production	394(98.5)	143(97.9)	251(98.8)
	Others	6(1.5)	3(2.1)	3(1.2)

NB: Number in brackets indicates percentage

Above primary includes secondary education; tertiary (certificate and diploma)

Others refers to livestock production; salaried employment (government); and casual labour (off-farm activities)

5.2 Communication Channels Used to Create Awareness

A number of communication channels are used in dissemination of agriculture technology in Tanzania. In the last production season (2015/2016), the African Fertilizer Agribusiness Partnership (AFAP) established demonstration plots in Gairo and Mvomero districts on common bean production covering one ward and one village in each district (AFAP 2016). In the same cropping season, 299 farmers attended farmer field days on common bean husbandry of which 217 farmers were from Ikenge village Gairo District and 82 farmers were from Ndole village Mvomero District (AFAP 2016). In addition, in the last production season (2015/16), the Centre for Agricultural Biosciences International (CABI) distributed leaflets to 205 farmers which contain all agronomic practices concerning common bean production. One hundred twenty of farmers who received the leaflets were from Ikenge village in Gairo District, and 85 farmers were from Ndole village in Mvomero District (CABI 2016).

5.3 Levels of Awareness of Smallholder Farmers on Improved Legume Technologies

Study results in Table 3 show that more than three quarters of the respondents were aware of improved common bean technologies. Results also show that more than two thirds of the respondents were aware of new planting methods (time of planting and proper spacing). Table 3 further shows that more than a half of the respondents were aware of the type, rate and time of using fertilisers (basal and boosting fertilisers). In addition, the results show that under two thirds of the respondents were aware of the weeding methods (stage, when and number of times to weed).

The results in Table 3 also show that more than a half of the respondents were aware of harvesting methods (stage of maturity and proper time to harvest). In addition to the above, results in Table 3 show that more than a half of the respondents were aware of the type, rate, time and safe use of chemicals. Lastly, the results show that more than a half of the respondents were aware of postharvest and storage management technologies. Generally, the results seem to suggest that there has been an impact of the interventions availed through the SILT project which is dealing with improved legume technologies. The above explanation is mainly based on the observation that the levels of respondents' awareness were high, suggesting communication channels used were effective. Moreover, awareness was very high in areas with demonstration plots + farmer field days and demonstration plots + farmer field days + technological briefs (leaflets and brochures), while for the areas with no intervention, there was low awareness. Further, the study results suggest that most

Table 3 Awareness of improved legume technologies among smallholder farmers in the study area ($n = 313$)

Technology	Aware of technology	No intervention	Demo/FFD	Demo/FFD/tech. briefs	Chi-squire	*P*-value
1. Improved common bean varieties	313 (78)	57 (43)	158 (94)	98 (100)	152.29	$p < 0.001$
2. New planting methods	271 (68)	26 (19)	150 (89)	95 (97)	217.23	$p < 0.001$
3. Type, rate and time of use of fertilisers	231 (58)	11(8)	132 (79)	88 (90)	205.89	$p < 0.001$
4. Weeding method (when and times)	241 (60)	13(10)	141 (84)	87 (89)	215.59	$p < 0.001$
5. Harvesting method (stage and when)	219 (55)	11(8)	124 (74)	84 (86)	179.72	$p < 0.001$
6. Type, rate, time and safe use of chemicals	224 (56)	11(8)	126 (75)	87 (89)	191.55	$p < 0.001$
7. Postharvest and storage management	217 (54)	10(8)	125 (74)	82 (84)	179.87	$p < 0.001$

NB: Number in bracket indicates percentages of the smallholder farmers are in good position to raise their legume production and productivity based on the fact that they have a high level of awareness particularly on improved legume technologies. However, productivity can only be raised through adoption and proper application of the same.

It was also pointed out in the FGDs that farmer field days and demonstration plots are the two most important communication channels for raising awareness on improved legume technologies. One of the participants in the FGDs said:

> Despite the bad weather (drought) which occurred in the last cropping season (2015/2016), common beans planted in the demonstration plot continued to be good, the seeds were of high quality and we saw the required spacing practically and the yields were high. Generally, it was encouraging.

The above views are supported by the feedback from the project implementers: African Fertilizer Agribusiness Partnership (AFAP) who said that farmer field days take less time to deliver information and demonstration plots lessons are easily understood; the other implementers were the Centre for Agricultural Biosciences International (CABI), who said that technological briefs are less expensive and take less time to prepare. Similarly, the results from key informants (District Council Extension Officers) who said farmer field days and demonstration plots take less time to deliver information, and lessons are easily understood. In addition, many people are taught at a time through technological briefs.

In addition, the results in Table 3 conform to those reported by Ariyo et al. (2013), which hold that 90% of smallholder farmers confirmed multimedia methods to be effective in creating awareness of improved agricultural technologies. Moreover, Khan and Akram's (2012) found that farm/home visits, farmer field days and demonstration plots are the most effective communication channels in disseminating agricultural technologies. Generally, results of the study imply that farmer field days + demonstration plots + technological briefs if combined could be effective in disseminating improved legume technologies.

5.4 Farmers Adoption of Improved Legume Technologies

The study results (Table 4) show that only a few farmers adopted improved legume technologies. Generally, it was revealed that the improved legume technologies mostly adopted were weeding methods (proper time and number of weedings) (7.5%) and new planting methods (proper spacing and timely planting) (6.2%). The above figures seem to be low in relation to the respondents using the technologies; this could be due to the fact that the intervention was in its initial stage of implementation. Therefore, the figure may increase with time as knowledge diffuses to the communities in the study area.

During the FGDs participants pointed out that access to improved technologies in particular seeds was difficult due to the associated high costs. It was also pointed out in other FGDs that improved seeds were not available, and there were no seed dealers nearby their villages, hence poor adoption or their dependence on local seeds. The quote below emphasises the above:

Table 4 Smallholder farmers' adoption of improved legume technologies (n = 18)

Technology	Total adopted	Without intervention	With demo/ FFD	With demo/FFD/ Tech. briefs
Improved common bean varieties	11(3.5)	2(3.5)	5(3.2)	4(4.1)
New planting methods	17(6.2)	2(7.7)	2(1.3)	13(13.7)
Type, rate and time of use of fertilisers	7(3)	1(8.3)	4(3)	2(2.3)
Weeding method (when and times)	18(7.5)	2(15.4)	9(6.4)	7(8)
Harvesting method (stage and when)	9(4.1)	1(8.3)	3(2.4)	5(6)
Type, rate, time and safe use of chemicals	7(3.1)	0(0)	4(3.2)	3(3.4)
Postharvest and storage management	8(3.7)	0(0)	2(1.6)	6(7.3)

NB: Number in bracket indicates percentages

> Local seeds are very cheap hence most farmers rely on these. Moreover, nowadays farming is like gambling you may incur huge costs and end up harvesting nothing, like what happened to most of us in the last cropping season (2015/2016), because of the unreliable rains. (FGD participant, Ndole village, Mvomero, 20 March 2017)

The above is supported by Ngwira et al. (2012) who hold that adoption of the best legume technologies requires well-established innovation platforms with multiple stakeholder involvements, sufficient supply of high-quality legume seeds together with farmer training or access to extension services; otherwise adoption or actual use of the technologies is likely to remain low.

5.5 *Factors Associated with Smallholder Farmers' Adoption of Improved Legume Technologies by Type of Intervention*

Study results (Table 5 and Appendices 1, 2, 3, 4, 5, 6, and 7) show that there was a significant (p = 0.032) association between visits by extension officers and smallholder farmers' adoption of improved common bean seeds. Similarly, the results show there was a significant association between visit by extension officers (p = 0.001), household head's age (p = 0.021) and smallholder farmers' proper use of planting method (timely planting and proper spacing). Study results further show existence of a significant association between visits by extension officers (p = 0.011) and farmers' proper use of the type, rate and time to use of fertiliser. The results above conform to those of FAO (2015) and Pan et al. (2015) that access or visits by extension services influences the use of improved crop technologies or modern inputs. The results in Table 5 further show that there was a significant (p = 0.033) association between being a member of a farmer's association, revenue from IGA (p = 0.034) and smallholder farmers' use of proper harvesting methods (stage of harvesting and proper time

Table 5 Factors associated with smallholder farmers' adoption of improved legume technologies by type of intervention

Factor/determinants	Improved common bean varieties	New planting methods	Type, rate and time of use of fertilisers	Weeding method (when and times)	Harvesting method (stage and when)	Type, rate, time and safe use of chemicals	Postharvest and storage management
Household size	0.085 (0.205)	−0.356* (0.208)	−0.052 (0.029)	−0.203 (0.182)	−0.487* (2.850)	−0.522 (2.348)	−0.756** (4.660)
Sex of household head	0.957 (1.389)	−1.868 (2.033)	–	0.797 (1.538)	−1.845 (0.578)	−1.22 (0.313)	−2.542 (1.057)
Age of household head	−0.027 (0.035)	0.060** (0.026)	0.027 (0.457)	0.012 (0.025)	0.033 (0.995)	−0.004* (0.01)	0.110*** (7.314)
Marital status	−0.925 (1.094)	2.110 (2.056)	–	0.074 (1.236)	1.232 (0.247)	1.933 (0.739)	1.095 (0.193)
Education	0.542 (1.093)	1.690 (1.171)	–	1.122 (1.088)	–	–	1.992 (1.882)
Availability of technology intervention (Yes)	−0.093 (0.816)	0.451 (0.937)	0.280 (0.026)	−0.528 (0.886)	−0.07 (0.003)	–	–
Total income from IGA	−0.000 (0.000)	0.000 (0.000)	0.000* (3.227)	0.000 (0.000)	0** (4.477)	0.000** (4.940)	0.000 (1.848)
Total area cultivated	0.199 (0.190)	0.091 (0.205)	0.248 (0.392)	−0.052 (0.219)	0.141 (0.244)	−0.335 (0.478)	−0.765 (0.715)
Being member farmers association	−0.307 (1.102)	0.804 (0.822)	0.784 (0.418)	0.434 (0.724)	1.926** (4.528)	–	–
Visit by extension officer (Yes)	1.680** (0.784)	1.955*** (0.609)	2.413** (6.525)	1.241* (0.646)	0.299 (0.086)	–	–
Borrowing money for farming (Yes)	0.330 (0.730)	0.005 (0.657)	−0.923 (0.543)	0.383 (0.585)	−0.045 (0.002)	–	−0.104* (0.011)

Constant	−3.366 (2.660)	−6.663*** (9.778)	−6.397** (6.131)	−3.733* (3.703)	−3.097 (2.104)	−2.094 (1.549)	−5.304** (4.288)
−2 Log likelihood	88.753	102.903	46.948	117.009	61.310	54.234	50.250
Number of observations	313	272	232	241	220	225	218
Cox & Snell R^2	0.021	0.085	0.066	0.045	0.061	0.035	0.081
Nagelkerke R^2	0.079	0.229	0.278	0.108	0.211	0.147	0.299
Chi-square	6.969	4.011	5.698	8.562	25.804	10.405	8.133
P-value	0.54	0.856	0.681	0.381	0.001	0.238	0.421

The specific logistic regression model results are presented as Appendices 1, 2, 3, 4, 5, 6, and 7
NB: Number outside the bracket refers to B values, while number in bracket indicates Wald statistics
***, ** and * are significance levels at 1%, 5% and 10%, respectively
The '–' are omitted because of collinearity

of harvesting). In addition to the above, the study results (Table 5) show that there was a significant association between a household head's age ($p = 0.007$), household size ($p = 0.031$) and proper use of postharvest and storage management. The results in Table 5 conform to those reported by Ainembabazi et al. (2017), to the effect that smallholder farmers' membership to associations and extension services provided significantly influence smallholder farmers' use of improved legume technologies. The study's observation conforms to Uaiene et al. (2009), Abate et al. (2011) and Katengeza et al. (2015) who have reported that farmers' membership to associations has an impact on their use of improved technologies. The results in Table 5 further conform to those reported by Kasirye (2013) that low education and land holding or small area cultivated does not influence smallholder farmers' adoption of improved agricultural technologies (especially improved seeds and fertilisers).

6 Conclusions and Recommendations

The chapter has assessed the effectiveness of communication channels on level of awareness and adoption of improved common bean technologies among smallholder farmers in Gairo and Mvomero districts, Morogoro Region. Based on the findings, it can be concluded that people in the study area are generally aware of all the improved legume technologies assessed. Nevertheless, the level of awareness was high in areas with the intervention and low in the area with no intervention. It is also concluded that a combination of demonstration plots + farmer field days + technological briefs (leaflets and brochures) was the most effective communication channels in creating awareness, followed by a combination of demonstration plots + farmer field days. It is further concluded that smallholder farmers' adoption of improved legume technologies is influenced by visits by extension officers, age of household head, being member of farmers association, revenue from other income-generating activities and household size.

Based on the study findings and conclusions, the following are recommended:

(i) The government and non-governmental organisations should invest more in awareness creation approaches in order to make sure that all smallholder farmers are sensitised on the improved legume technologies.
(ii) The government and non-governmental organisations should insist more on visits by extension officers, farmers association and participating in other income-generating activities so as to enhance adoption of improved legume technologies. Doing the above will highly impact on the farmer's productivity, food security, incomes and general well-being.

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Appendices

Appendix 1 Factors associated with adoption of improved common bean seeds

Factor/determinants	B	Std. Err.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Household size	0.085	0.205	0.171	1	0.679	1.089	0.728	1.627
Sex	0.957	1.389	0.475	1	0.491	2.604	0.171	39.648
Age	−0.027	0.035	0.599	1	0.439	0.974	0.910	1.042
Marital status	−0.925	1.094	0.715	1	0.398	0.396	0.046	3.385
Education	0.542	1.093	0.246	1	0.620	1.720	0.202	14.659
Availability of technology intervention (yes)	−0.093	0.816	0.013	1	0.910	0.911	0.184	4.516
Total income from IGA	0.000	0.000	0.485	1	0.486	1.000	1.000	1.000
Total area cultivated	0.199	0.190	1.092	1	0.296	1.220	0.840	1.771
Being member of farmers association (yes)	−0.307	1.102	0.078	1	0.780	0.736	0.085	6.376
Visit by extension officer (yes)	1.680	0.784	4.598	1	0.032	5.367	1.155	24.930
Borrowing money for farming (yes)	0.330	0.730	0.205	1	0.651	1.392	0.333	5.822
Constant	−3.366	2.064	2.660	1	0.103	0.035		

Variable(s) entered on step 1: V1_QNB1, V2_QNB2IBb, V3_QNB2IC, V4_QNB2IEb, V5_QNB2IFb, V6_Intervtn_status, V7_TOTALINCOME, V8_TOTAREACULT, V9_FAMERASSOC, V10_EXTOFVISIT, V11_L01

Appendix 2 Factors associated with planting method (timely planting and proper spacing)

Factor/determinants	B	Std. Err.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Household size	−0.356	0.208	2.926	1	0.087	0.701	0.466	1.053
Sex	−1.868	2.033	0.844	1	0.358	0.154	0.003	8.300
Age	0.060	0.026	5.294	1	0.021	1.062	1.009	1.118
Marital status	2.110	2.056	1.053	1	0.305	8.244	0.147	463.767
Education	1.690	1.171	2.084	1	0.149	5.419	0.546	53.749
Availability of technology intervention (yes)	0.451	0.937	0.231	1	0.631	1.569	0.250	9.850
Total income from IGA	0.000	0.000	1.015	1	0.314	1.000	1.000	1.000
Total area cultivated	0.091	0.205	0.196	1	0.658	1.095	0.732	1.638
Being member of farmers association (yes)	0.804	0.822	0.958	1	0.328	2.235	0.447	11.191
Visit by extension officer (yes)	1.955	0.609	10.303	1	0.001	7.064	2.141	23.306
Borrowing money for farming (yes)	0.005	0.657	0.000	1	0.993	1.005	0.278	3.641
Constant	−6.663	2.131	9.778	1	0.002	0.001		

Variable(s) entered on step 1: V1_QNB1, V2_QNB2IBb, V3_QNB2IC, V4_QNB2IEb, V5_QNB2IFb, V6_Intervtn_status, V7_TOTALINCOME, V8_TOTAREACULT, V9_FAMERASSOC, V10_EXTOFVISIT, V11_L01

Appendix 3 Factors associated with adoption of proper type, rate and time to apply fertiliser

Factor/determinants	B	Std. Err.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Household size	−0.052	0.302	0.029	1	0.865	0.95	0.525	1.718
Age	0.027	0.04	0.457	1	0.499	1.028	0.95	1.112
Marital status	0.28	1.74	0.026	1	0.872	1.323	0.044	40.073
Total income from IGA	0	0	3.227	1	0.072	1	1	1
Total area cultivated	0.248	0.257	0.932	1	0.334	1.282	0.774	2.123
Being member of farmers association (yes)	0.784	1.213	0.418	1	0.518	2.191	0.203	23.633
Visit by extension officer (yes)	2.413	0.945	6.525	1	0.011	11.168	1.754	71.131
Borrowing money for farming (yes)	−0.923	1.252	0.543	1	0.461	0.397	0.034	4.626
Constant	−6.397	2.584	6.131	1	0.013	0.002		

Variable(s) entered on step 1: V1_QNB1, V3_QNB2IC, V6_Intervtn_status, V7_TOTALINCOME, V8_TOTAREACULT, V9_FAMERASSOC, V10_EXTOFVISIT, V11_L01

Appendix 4 Factors associated with weeding methods (when to weed and number of times to weed)

Factor/determinants	B	Std. Err.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Household size	−0.203	0.182	1.248	1	0.264	0.816	0.571	1.166
Sex	0.797	1.538	0.269	1	0.604	2.219	0.109	45.201
Age	0.012	0.025	0.218	1	0.640	1.012	0.963	1.063
Marital status	0.074	1.236	0.004	1	0.952	1.077	0.096	12.139
Education	1.122	1.088	1.063	1	0.303	3.070	0.364	25.904
Availability of technology intervention (yes)	−0.528	0.886	0.355	1	0.551	0.590	0.104	3.347
Total income from IGA	0.000	0.000	0.104	1	0.747	1.000	1.000	1.000
Total area cultivated	−0.052	0.219	0.057	1	0.812	0.949	0.618	1.457
Being member of farmers association (yes)	0.434	0.724	0.359	1	0.549	1.543	0.373	6.372
Visit by extension officer (yes)	1.241	0.644	3.715	1	0.054	3.458	0.979	12.210
Borrowing money for farming (yes)	0.383	0.585	0.429	1	0.513	1.467	0.466	4.621
Constant	−3.733	1.940	3.703	1	0.054	0.024		

Variable(s) entered on step 1: V1_QNB1, V2_QNB2IBb, V3_QNB2IC, V4_QNB2IEb, V5_QNB2IFb, V6_Intervtn_status, V7_TOTALINCOME, V8_TOTAREACULT, V9_FAMERASSOC, V10_EXTOFVISIT, V11_L01

Appendix 5 Factors associated with harvesting methods (stage of harvesting and proper time of harvesting)

Factor/determinant	B	Std. Err.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Household size	−0.487	0.288	2.850	1	0.091	0.615	0.349	1.081
Sex	−1.845	2.428	0.578	1	0.447	0.158	0.001	18.407
Age	0.033	0.033	0.995	1	0.319	1.033	0.969	1.102
Marital status	1.232	2.481	0.247	1	0.620	3.428	0.026	443.431
Availability of technology intervention (yes)	−0.070	1.398	0.003	1	0.960	0.932	0.060	14.440
Total income from IGA	0.000	0.000	4.477	1	0.034	1.000	1.000	1.000
Total area cultivated	0.141	0.285	0.244	1	0.622	1.151	0.658	2.012
Being member of farmers association (yes)	1.926	0.905	4.528	1	0.033	6.865	1.164	40.478
Visit by extension officer (yes)	0.299	1.020	0.086	1	0.769	1.349	0.183	9.958
Borrowing money for farming (yes)	−0.045	0.928	0.002	1	0.962	0.956	0.155	5.893
Constant	−3.097	2.135	2.104	1	0.147	0.045		

Variable(s) entered on step 1: V1_QNB1, V2_QNB2IBb, V3_QNB2IC, V4_QNB2IEb, V6_Intervtn_status, V7_TOTALINCOME, V8_TOTAREACULT, V9_FAMERASSOC, V10_EXTOFVISIT, V11_L01

Appendix 6 Factors associated with adoption of the type, rate, time and safe use of chemicals

Factor/determinants	B	Std. Err.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Household size	−0.522	0.340	2.348	1	0.125	0.594	0.305	1.157
Sex	−1.220	2.180	0.313	1	0.576	0.295	0.004	21.190
Age	−0.004	0.039	0.010	1	0.922	0.996	0.923	1.076
Marital status	1.933	2.248	0.739	1	0.390	6.907	0.084	565.961
Total income from IGA	0.000	0.000	4.940	1	0.026	1.000	1.000	1.000
Total area cultivated	−0.335	0.484	0.478	1	0.489	0.716	0.277	1.848
Constant	−2.094	1.683	1.549	1	0.213	0.123		

Variable(s) entered on step 1: V1_QNB1, V2_QNB2IBb, V3_QNB2IC, V4_QNB2IEb, V7_TOTALINCOME, V8_TOTAREACULT

Appendix 7 Factors associated with postharvest and storage management

Factor/determinants	B	Std. Err.	Wald	df	Sig.	Exp(B)	95% CI	
							Lower	Upper
Household size	−0.756	0.350	4.660	1	0.031	0.470	0.237	0.933
Sex	−2.542	2.472	1.057	1	0.304	0.079	0.001	10.003
Age	0.110	0.041	7.314	1	0.007	1.117	1.031	1.210
Marital status	1.095	2.494	0.193	1	0.661	2.989	0.023	396.496
Education	1.992	1.452	1.882	1	0.170	7.327	0.426	126.057
Total income from IGA	0.000	0.000	1.848	1	0.174	1.000	1.000	1.000
Total area cultivated	−0.765	0.905	0.715	1	0.398	0.465	0.079	2.741
Borrowing money for farming (yes)	−0.104	0.975	0.011	1	0.915	0.902	0.133	6.095
Constant	−5.304	2.562	4.288	1	0.038	0.005		

Variable(s) entered on step 1: V1_QNB1, V2_QNB2IBb, V3_QNB2IC, V4_QNB2IEb, V5_QNB2IFb, V7_TOTALINCOME, V8_TOTAREACULT, V11_L01

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