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Working Paper 166

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ISSN 1864-6638 Bonn, January 2018

PARI

ZEF Working Paper Series, ISSN 1864-6638
Center for Development Research, University of Bonn
Editors: Christian Borgemeister, Joachim von Braun, Manfred Denich, Till Stellmacher and Eva Youkhana

The cover photos shows Mr. Adane Alemu Timkete, aged 27 and living in Hetosa Woreda, Ethiopia, and his innovation, an eight-row planter for different crops mixed with fertilizer that can be attached to a plough or tractor. Mr. Timkete is the winner of the innovation contest “youth” in 2016.

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Experiences and insights from four African countries

Justice A. Tambo

Acknowledgements

This research was financially supported by the German Federal Ministry for Economic Cooperation and Development (BMZ) through the research project “Program of Accompanying Research for Agricultural Innovation (PARI)”. The author gratefully acknowledges project partners from EDRI, KALRO, DARS, ZARI and the Forum for Agricultural Research in Africa (FARA) as well as stakeholders who supported the implementation of the contests in the four study countries. The author also thanks the participating farmers for their willingness to share their innovations, as well as Evelyn Baraké and Sougrynoma Zainatou Sore for their excellent research assistance.

Abstract

This paper presents the experiences and outcomes of applying contests to elicit farmer-generated innovations and to reward outstanding farmer innovators in selected districts in Ethiopia, Kenya, Malawi and Zambia. The contests attracted 349 eligible entries, most of which were submitted by male innovators. The identified innovations were mainly technically oriented practices, and only very few institutional innovations were recognized. The most common domains of innovations were related to livestock (40%), crop management (26%), storage (10%), soil and water management (8%) and farm tools and implements (5%). In particular, many of the innovators were using local resources to develop plant-based biopesticides and ethnoveterinary medicines in order to reduce production costs and improve food production. The findings of this study suggest that farmers are active experimenters who continuously generate remarkable and locally adapted innovations, which can indirectly contribute to efforts to achieve sustainable agricultural intensification or to make agriculture climate smart. The study concludes that farmers possess valuable ethnobotanical knowledge and innovation-generating potential that need to be harnessed and supported; and contest is an effective means to scout and acknowledge farmer innovators while simultaneously raising awareness of farmer innovation approach among relevant stakeholders.

Keywords: Contest; prize rewards; farmer-generated innovations; biopesticides; ethnoveterinary practices

List of Abbreviations

BMZ	German Federal Ministry for Economic Cooperation and Development
DARS	Department of Agricultural and Research Services
EDRI	Ethiopian Development Research Institute
KALRO	Kenya Agricultural and Livestock Research Organization
NGO	Non-Governmental Organisations
PARI	Program of Accompanying Research for Agricultural Innovation
R&D	Research and Development
ToT	Transfer of technology
ZARI	Zambia Agricultural Research Institute

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1 Introduction

Farmers are a rich source of indigenous knowledge and agricultural innovations (Biggs 1990; Van Huis and Meerman 1997). Driven by economic and environmental changes, curiosity, creativity, serendipity, and desire for social recognition, farmers have continuously been experimenting and generating innovations since the beginning of agriculture (Chambers et al. 1989; Sumberg and Okali 1997; Critchley 2000; Bentley 2006; Leitgeb et al. 2014; Bragdon and Smith 2015). Farmers develop innovations that are suitable for their diverse range of agro-ecological conditions and farming systems, and they make incremental improvements to traditional practices and promoted technologies to adapt them to local realities (Waters-Bayer et al. 2009a). The innovations developed by farmers range from new or modified farm tools, techniques and practices to new ways of organizing, managing resources and communicating (Sumberg and Okali 1997; Reij and Waters-Bayer 2001). These farmer-generated innovations have been found to contribute positively to improved livelihood outcomes and better adaptation to rapidly changing conditions (Tambo and Wünscher 2017a,b).

Unfortunately, farmer-generated innovations have received little attention and are often under-exploited. This is partly due to the dominant agricultural research for development approach — the transfer of technology (ToT) paradigm, which assumes that research scientists produce new knowledge and technologies, which are then transmitted by extension agents to farmers, who are only considered to be mere adopters. This approach excludes farmers from the development and dissemination of new technologies and is argued to undermine farmer innovation processes (Critchley 2000). The ToT model has often fail to take into account farmers' socio-economic and environmental circumstances, and have seldom tried to learn from farmers first before sharing new knowledge or practices, leading to low uptake of externally promoted technologies (Sumberg and Okali 1997; Reij and Waters-Bayer 2001; Letty et al. 2011).

Recognizing the limits of the ToT paradigm and that farmer possess valuable innovation-generating knowledge, there has been a rising interest in participatory approaches to agricultural research and development and in supporting farmer innovativeness. There is a rapidly growing movement of scientists, non-governmental organisations (NGOs), agricultural ministries and farmer organisations that are drawing attention to and supporting farmer-led innovation processes, including scouting and documenting the innovations, as well as building farmers' capacity to test, adapt and develop their own innovations. The starting point for promoting farmer-led innovation processes is recognizing and documenting farmer-generated knowledge and ingenious technologies (Waters-Bayer et al. 2009b). Appreciating farmer innovators is likely to boost self-esteem of farmers as they start to see themselves as people rich in knowledge, thereby stimulating the generation of more innovations. In addition, it enhances mutual respect as it induces the scientific community to begin to see farmers as not mere adopters of promoted techniques but rather as people with valuable knowledge that can complement their own scientific knowledge (Waters-Bayer et al. 2009a). Moreover, identification of farmer innovations provides entry points for participatory innovation development through which the innovations can be verified and further improved (Waters-Bayer et al. 2009b).

Consequently, a number of initiatives and studies have been implemented in recent years to scout and document farmer innovations. For instance, Prolinnova network through its partners has catalogued many local innovations in about 20 countries across Africa, Asia and Latin America (Wettasinha et al.

2008). The Honey Bee network in India has documented over a thousand indigenous knowledge and innovations and also publishes newsletters on grassroot innovations (Gupta 2016). As part of a project that sought to promote farmer innovation in East Africa, Critchley and Mutunga (2003) identified about 120 innovations and presented 18 promising soil and water conservation technologies developed by farmers. Wünscher and Tambo (2016) has also scouted over 90 high-potential farmer innovations in north-east Ghana, while Find Your Feet, an NGO, also highlighted nine remarkable innovations developed by smallholder farmers in their report on farmer innovations in northern Malawi (Find Your Feet 2012).

Here, we present the experience of the Program of Accompanying Research for Agricultural Innovation (PARI) in supporting farmer-led innovation processes in Africa. PARI is a research-focused program funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) that, among other things, aims at promoting and supporting the scaling of proven innovations in the agri-food sector. One of the components of PARI focuses on identifying high-potential farmers' or bottom-up innovations and on recognizing and rewarding the innovators for their creativity. To this end, we implemented innovation contests in four sub-Saharan countries. We expected that the opportunity to win prizes through the contests would incentivize farmers to report their innovations. The objectives of this study is to assess the potential of contests in fostering farmer-generated innovations, and to analyse the characteristics and potentials of innovations identified through the contests.

The remainder of the paper is structured as follows. The next section outlines existing research on the effectiveness of rewards in stimulating innovations and thereby provide context on the potential of contest as a means of identifying farmer-generated innovations. Section 3 describes the study area, followed by a detailed presentation of the implementation of the contests in Section 4. In Section 5, we highlight the findings from the contests, including characteristics of the identified innovations as well as the motives behind and outcomes of the innovations. Finally, Section 6 concludes the paper.

2 Reward-based incentives for innovation

Reward-based mechanisms, specifically prizes and contests, have been used by governments as well as private interests in order to stimulate innovation, address societal challenges and sometimes even generate major breakthroughs. Contests directly stimulate innovation by incentivizing investment in research and development (R&D) (Davis and Davis 2004). Rewards also enrich the public domain by encouraging innovators to make their research public, and in doing so, increase public attention to a specific field and encourage follow-on research. Moreover, technologies for which value capture is costly due to the difficulty of observing the quality of the R&D until after the results are seen are generally underprovided by traditional market mechanisms, and therefore benefit the most from prize rewards (Masters and Delbecq 2008). Prize rewards may take the form of blue-sky prizes, in which rewards are offered ex-post to innovators for research that has already been conducted, or it may take the form of targeted prizes, which rewards solutions to problems that are posted ex-ante and aim to solve specific needs of sponsors (Scotchmer 2004).

A large part of the literature on the effectiveness of rewards as a means of promoting innovation takes a case study or systematic literature review approach. In these studies, historical examples are cited, going as far back as the prizes awarded by the British government in the 16th century for breakthrough innovations, including the lifeboat and vaccine inoculation and including grand prize-type contests put in place by various European governments to tackle historical scientific challenges such as calculating longitude at sea, food preservation (Masters and Delbecq 2008) as well as the oft-cited 19th century examples of the series of prizes offered by the Royal Agricultural Society of England to improve agricultural machinery (Masters and Delbecq 2008; Brunt et al. 2012; Moser and Nicholas, 2013) and the privately funded Orteig Prize, a grand prize for transatlantic flight (Davis and Davis 2004; Kalil 2006; Masters and Delbecq 2008; Adamczyk et al. 2012; Murray et al. 2012). Another strand of research has focused on comparing the efficiency of ex-post rewards and other means of promoting innovation in terms of public welfare (Wright 1983; Shavell and van Ypersele 2001; Penin 2005; Clancy and Moschini 2013; Moser and Nicholas 2013). Most of these studies are, however, based on theoretical models.

The general consensus appears to be that rewards do directly and indirectly spur innovation in a given field, and case studies further show that the monetary incentive is not the main driver for participation. Indeed, scientific curiosity; indirect financial benefits accrued through contest participation, such as publicity, the signal of quality conferred on the innovation, increased access to funding and testing facilities; and intangible benefits such as community-building are suspected to explain why participants often expend resources far exceeding the value of the prize (Davis and Davis 2004; Masters and Delbecq 2008; Brunt et al. 2012; Clancy and Moschini 2013; Moser and Nicholas 2013). The community-building effect can in fact be seen as a particularly interesting social benefit of contests. These can be harnessed as a tool for effective collaboration, because they encourage collaboration between various stakeholders and encourage knowledge exchange by design (Adamczyk et al. 2012).

To date, there is scant research on rewards as a means to promote grassroots innovation. This is an important gap considering the low level of agricultural investment targeted towards small and low-income developing countries (Kalil 2006). Contests are a high-potential means of cost-effectively inducing and spreading well-suited, low-cost agricultural innovations in rural developing country contexts. In the literature, contests are best suited to the following situations: complex societal

challenges that are large in scope and have no single path to a solution (Murray et al. 2012); when the value or benefit of a technology is hard to predict before it is fully developed (Masters and Delbecq 2008); when information transmission costs are high (Clancy and Moschini 2013); and when the "set of possible innovators and the range of approaches they consider" is constrained (Murray et al. 2012, p. 1780). Evidently, rural agriculture in developing countries exhibits these characteristics; notably, agriculture is highly complex and relies on the interaction of many highly localized systems and processes, which means that even large-scale scientific breakthroughs must go through a costly adaptation process to be used locally (Masters and Delbecq 2008). Since grassroots innovations tend to be simple, locally-specific solutions to common problems, developed by resource-constrained actors, they may hold more immediate potential than large innovations developed through industry and formal research processes (Reij and Waters-Bayer 2011).

3 Study sites

Under the German government special initiative, One World - No Hunger, Green Innovation Centres (GICs) have been established in 13 African countries to support the improvement of food and nutrition security and sustainable agricultural value chains in these countries. One of the goals of the PARI project is to **support and enhance investments in the GICs** through research. This meant that the choice of study area was limited to the GIC sites. This study is based on innovation contests that were implemented in 2016 in four of the GIC focus countries, namely Ethiopia, Kenya, Malawi and Zambia. In each of these countries, the contests were carried out in three districts (or counties in the case of Kenya) from the GIC program sites. In Kenya and Zambia, the GICs are being operated in three districts/ counties, which constituted our study sites. These include Bungoma, Kakamega and Siaya counties in western Kenya, as well as Choma district in southern province and Petauke and Katete districts in eastern province of Zambia. In Ethiopia and Malawi, three districts each were selected from the participating districts of the GIC program. Hitosa, Lude Hitosa and Digeluna Tijo in the Arsi Zone of Oromia region were the selected districts in Ethiopia. In Malawi, the selected districts were Rumphi in the north, Salima in central region and Thyolo in the south. Thus, the selected districts encompass significant diversity in farming system and agro-ecological conditions and reflect the possibility of identifying varied innovations. Most households in the districts are smallholder farmers who are involved in the production of traditional food crops (mostly cereals and pulses) and livestock. In some of the districts, farmers also produce cash crops such as tea, tobacco, coffee, cotton and sugar cane.

4 Implementation of the innovation contests

As already mentioned, we employ contests to scout farmer innovations and to recognize and reward the innovators for their creativity. In the contests, farmers competed to win prizes by revealing their independently developed innovations. The contests were implemented in collaboration with the main PARI project partners in the four countries. These are the Ethiopian Development Research Institute (EDRI), Kenya Agricultural and Livestock Research Organization (KALRO), Malawi's Department of Agricultural and Research Services (DARS) and Zambia Agricultural Research Institute (ZARI). The process involved in the contests included scoping visit, publicity and scouting, screening and evaluation, and awarding prizes. We present these steps in detail below.

4.1 Scoping visit

The first step in the contest process involved a visit to the selected districts to sensitize relevant stakeholders about the innovation contests. The stakeholders included leaders and staff of Ministries of Agriculture, research institutes, farmer associations and NGOs. The discussions centered on purpose of the contests and their potential benefits for agricultural development in the districts. We also outlined the process involved in scouting the innovations, the role of agricultural extension officers and the timelines. During the visits, contact persons from the Ministry of Agriculture and PARI partner institutions located within or near the selected districts were appointed to serve as lead persons for all activities pertaining to the contests. The scoping visit also provided an opportunity to obtain useful information to plan the actual implementation of contests in the various districts. This included identification of the best possible mechanisms through which farmers could obtain information about the contests as well as background information about the districts, including the number of sub-divisions and extension officers so as to know the number of people to invite to subsequent training workshops on the contest. In each district, the most appropriate radio stations for disseminating information on the contests were also identified and visited.

4.2 Publicity and scouting

To create awareness about the contests, different information dissemination mechanisms, including extension officers, local radio stations, mobile phone text messages, churches, lead farmers, farmer organizations and community sensitization were considered. However, radio announcements and extension officers were the two main channels employed. Due to the low level of literacy of the farmers in the study regions, extension officers were instrumental in the implementation of the contests. An innovator interested in participating in the contest was required to submit a filled application form that was designed for this purpose. The roles of the extension officers in the contests included: informing farmers located in their operational areas about the contest; identifying those who have developed an innovation and assist them to complete an application form; and returning the completed forms to a designated location.

To this end, a one-day training workshop was conducted at Agricultural Training Centers in each of the participating districts. Depending on the number of zones or wards in a district, about 35 to 70 extension officers attended a training workshop. For instance, consistent with the number of wards in the three counties in Kenya, 45, 60 and 35 ward extension officers from Bungoma, Kakamega and Siaya counties respectively attended the training workshops. In addition to the extension officers, other

stakeholders (such as field officers of Ministries of Agriculture and NGOs, lead farmers, and representations of farmer organizations) who could act as scouters or assist in sharing information about the contests were also trained. Discussions at the training workshops revolved around the concept of farmer innovations; what qualifies as a farmer-generated innovation; examples of farmer innovations; who is eligible to participate in the contest and the value of the prizes on offer; the roles of the scouters and their rewards; how to complete the application forms; and timelines. Soon after the training workshops, the extension officers were given six weeks to scout for innovations in their respective operational zones and to assist interested contestants in submitting an application. The scouters were offered monetary rewards (ranging from 12 to 25 USD) for each qualified application submitted.

Following Wünscher and Tambo (2016), we considered three conditions necessary for an activity to be considered a farmer innovation, i.e. (1) any practice or technique along the food chain; (2) that is done differently from known common or traditional practice; (3) and was developed primarily by a farmer or a group of farmers themselves (without direct support from extension and development agents or formal research). Thus, only practices or technologies that fulfilled the above three criteria were eligible for the contests. The contests were open to men (>35 years), women (>35years) and youth (18-35 years) farmers or groups working in the food value chain in the various study districts.

To ensure that most farmers in the study districts were aware of the contests, about two local radio stations with potential to reach wide audience were contracted in each country to broadcast jingles that were produced in national and various local languages spoken in the study districts.[1] The radio jingles, which were aired 2-5 times daily for about a month, captured information on who is eligible to apply, the prizes to be won, and where the innovators could obtain more information and application forms. In addition to the radio jingles, the contests were also broadcasted via radio programs. For instance, in Malawi, we took advantage of an existing agricultural radio program of one of our local partners, the Department of Agricultural Extension and Services, by featuring information about the contests in their program. The radio program had an interactive format, which allowed interested contestants to call-in and ask clarification questions.

4.3 Evaluation

The scouters (and farmers who filled the application forms themselves) were asked to drop the completed forms at designated points at the district Ministries of Agriculture within six weeks from the launch of the contest for evaluation. To evaluate the innovations, an independent evaluation committee was set up in each of the study countries. The committee members included 9 to 12 local experts who had been working on topics related to agricultural or farmer innovations, and were familiar with the local farming systems. The experts were drawn from Ministries of Agriculture in the study districts, research institutions, extension service providers, farmer organizations and NGOs. The evaluation of the innovations involved three steps. First, the evaluation committee members pre-screened the submitted applications to confirm if all the reported innovations fulfill the three

[1] The radio stations include Zodiak and MBC 1 in Malawi; West FM and Mayienga FM in Kenya; EBC radio in Ethiopia; and Byta FM, Radio Maria and Sky FM in Zambia. The radio jingles were produced in the following languages: Oromiffa and Amharic in Ethiopia; Kiswahili, Luhya and Luo in Kenya; Chichewa and Tumbuka in Malawi; and English, Tonga and Nyanja/Chichewa in Zambia.

aforementioned criteria. The second step involved grading and ranking of all the innovations that passed the pre-screening stage. The multi-criteria decision-making approach suggested by Tambo and Wünscher (2015) was adopted for the grading of the eligible applications. The evaluation committee members first had to agree on the criteria to be used for the evaluation and their respective weights (Table 1).

Table 1: Evaluation criteria and weights.

Criteria	Ethiopia	Kenya	Malawi	Zambia
Originality /uniqueness	✓ (0.35)	✓ (0.25)	✓	✓ (0.25)
Economic potential	✓ (0.25)	✓ (0.30)	✓	✓ (0.20)
Adoption potential		✓ (0.20)		
Ease to practice	✓ (0.15)		✓	✓ (0.15)
Social acceptability			✓	✓ (0.15)
Affordability	✓ (0.10)			
Gender responsiveness	✓ (0.10)	✓ (0.10)	✓	✓ (0.10)
Environmental friendliness	✓ (0.10)	✓ (0.15)	✓	✓ (0.15)
Locally available resources			✓	

Note: Figures in parenthesis are weights assigned to each criterion.

As shown in Table 1, there are commonalities in the criteria agreed upon for the evaluation of the innovations in each country. For instance, originality, economic potential, gender responsiveness and environmental friendliness were chosen as evaluation criteria in all the countries. There are however variations in the weights assigned to each criterion. The weights reflect the importance accorded to the criteria. Originality and economic potential were deemed to be the two most important criteria for evaluating the accepted innovations in Ethiopia, Kenya and Zambia. In Malawi, the experts adopted equal weighting approach, in which all the criteria were considered to be of equal importance. After selecting the criteria and assigning the weights, committee members had to agree on a common definition for each criterion. For instance, originality refers to the degree of uniqueness of the innovation or the extent to which it differs from existing practices; economic potential relates to the potential contribution of the practice to improved livelihood or food security in the region; gender responsiveness implies the innovation can be used by men, women and youth farmers; and innovations that will not create negative environmental externalities when adopted where deemed to be environmentally friendly.

In each country, the evaluation committee members then formed a team of three or four experts, and each team evaluated each innovation on a scale of 1(very low) to 5(very high) against the agreed criteria. We then computed weighted sum of scores for each innovation for each team and averaged them to obtain the overall sum of scores. The weighted sum of scores for each innovation were ranked to identify the most promising innovations. The innovations were sorted into men, women and youth categories and the high-ranking innovations in each category were short-listed for verification. Thus, the third stage in the evaluation process involved visiting the short-listed applicants to verify their innovations. The verification process, which was conducted by the evaluation committee members, involved getting detailed information about the innovations and confirming if the applicants were the

true originators of the reported innovations. Based on satisfactory verifications, the short-listed innovators to be awarded prizes were selected.

4.4 Awarding prizes

The final step in the contest process involved awarding prizes to outstanding innovators. Prizes were awarded at the district level, and there were separate prizes for men, women and youth applicants. In each category of applicants, there were awards for first, second and third best innovators that were worth 1000 USD, 750 USD and 500 USD, respectively. In particular, the innovators were awarded farm inputs and machineries, which were equivalent to the value of the awards, to support them to further improve their innovations or to enhance their farm activities. The award winners together with the innovators whose applications passed the screening step were also given certificates of participation in the contests. The prizes were given out during district agricultural shows or events where stakeholders from the agriculture sector, award winners, and media were present.

5 Results and discussion

The results of the contests are presented and discussed in this section. We first look at the number of entries to the contests and the characteristics of the identified innovations, as well as the motives behind and outcomes of the innovations.

5.1 Outcomes of the contents

Table 2 presents the number of entries to the innovation contests as well as the rejected and eligible applications. Overall, 774 applications were submitted to the contests in the four countries, suggesting high levels of interest in the contests. However, about 425 (55%) of the submitted applications were rejected during the pre-screening stage. This included rejection rates of 68%, 56%, 41% and 53% in Ethiopia, Kenya, Malawi and Zambia, respectively. The rejected applicants were deemed to be reporting common, traditional or externally promoted techniques and practices, which do not conform to the three criteria stipulated as requirements for participating in the contests. It was found that the high rejection rate was partly due to lack of understanding of what constitutes farmer innovation as it was a new concept to a number of extension agents who have been working with the dominant ToT approach for decades. In addition, some farmers who heard about the contests through radio and colleagues and subsequently submitted applications on their own did not understand the details of the requirements. For instance, some of the applicants assumed the contests were meant to reward model farmers who had extensively adopted promoted techniques and thus were reporting the new technologies that they had successfully adopted.

Table 2: Number of applications received and accepted.

Country	District/County	Submitted	Rejected	Accepted
Ethiopia	Hitosa	66	39	27
	Lude Hitosa	65	55	10
	Digeluna Tijo	22	10	12
	Sub-total	**153**	**104**	**49**
Kenya	Bungoma	148	108	40
	Kakamega	115	48	67
	Siaya	75	33	42
	Sub-total	**338**	**189**	**149**
Malawi	Rumphi	71	33	38
	Salima	47	18	29
	Thyolo	26	8	18
	Sub-total	**144**	**59**	**85**
Zambia	Choma	45	25	20
	Katete	37	20	17
	Petauke	57	28	29
	Sub-total	**139**	**73**	**66**
	Total	**774**	**425**	**349**

The number of successful entries received were 49, 66, 85 and 149 for Ethiopia, Zambia, Malawi and Kenya, respectively. The proportionally high number of applications from Kenya is not surprising because, unlike in the other three countries, the contests in Kenya were organised at the county level. Table 2 also shows the number of eligible applications in the study districts across the four countries. The table reveals some interesting insights. In Kenya, for instance, more applications were submitted in Bungoma county but the number of eligible applications were relatively higher in Kakamega and Siaya counties, suggesting limited comprehension of the concept of farmer innovation among the scouters in Bungoma county. The number of innovations identified across the three districts in Malawi seems to epitomize the old adage that necessity breeds invention. Relatively more innovations were scouted in the more remote and rural Rumphi district in northern Malawi. Salima district is in the central part of the country and is closer to the capital city, Lilongwe. Farmers in this district are exposed to a number of agricultural interventions and promoted technologies; hence, they have a high tendency to adopt rather than generate innovations. Thyolo district, which is located in the southern Malawi, is dominated by tea estates. Inhabitants in this district tend to work on estate farms and thus may be less inclined to develop their own innovations.

Table 3: Number of innovations by gender.

		Men		Women		Youth	
Country	District/County	No.	%	No.	%	No.	%
Ethiopia	Hitosa	16	59.26	5	18.52	6	22.22
	Lude Hitosa	9	90.00	0	0.00	1	10.00
	Digeluna Tijo	10	83.33	0	0.00	2	16.67
	Sub-total	**35**	**71.43**	**5**	**10.20**	**9**	**18.37**
Kenya	Bungoma	17	42.50	12	30.00	11	27.50
	Kakamega	43	64.18	21	31.34	3	4.48
	Siaya	28	66.67	12	28.57	2	4.76
	Sub-total	**88**	**59.06**	**45**	**30.20**	**16**	**10.74**
Malawi	Rumphi	26	68.42	9	23.68	3	7.89
	Salima	16	55.17	7	24.14	6	20.69
	Thyolo	14	77.78	4	22.22	0	0.00
	Sub-total	**56**	**65.88**	**20**	**23.53**	**9**	**10.59**
Zambia	Choma	13	65.00	4	20.00	3	15.00
	Katete	10	58.82	3	17.65	4	23.53
	Petauke	18	62.07	8	27.59	3	10.34
	Sub-total	**41**	**62.12**	**15**	**22.73**	**10**	**15.15**
	Total	**220**	**63.04**	**85**	**24.36**	**44**	**12.61**

Table 3 displays the number of identified innovations, disaggregated by gender. We deliberately strived to scout innovations generated by women and youth by creating separate award categories. Nonetheless, these two groups, particularly youth farmers, reported few innovations. Nearly two-thirds of the identified innovations were developed by men. This ranges from 59% in Kenya to 71% in Ethiopia. The women and youth innovators in our sample are about 24% and 13%, respectively. Results show that in Ethiopia, relatively more innovations were generated by youths compared to women. For

instance, in two of the study districts in Ethiopia (Lude Hitosa and Digeluna Tijo), none of the accepted innovations was developed by a woman. With the exception of Bungoma county, the number of innovations scouted from youths in all the study districts were single digits from 0 to 6. The limited number of youth innovators is plausibly because fewer youths are engaging in farming-related activities or because farmer innovations take time to happen and are thus more likely to be developed by older farmers with greater farming experience. These findings are consistent with those of Reij and Waters-Bayer (2001) who reported that majority of farmer innovators are middle-aged men.

5.2 Characteristics and examples of innovations

Table 4 outlines some characteristics of the innovations identified through the contests. We find that a large share (98%) of the innovations were developed by individuals. In Malawi, for instance, none of the innovations was generated by a group. Similarly, about 98% of the innovations were technical in nature, with only 2% institutional innovations. The percentage of group innovations is almost proportionate to the percentage of institutional innovations, and this is because nearly all the institutional innovations were group-based. The results show that about 65% and 35% of the innovations can be categorized into incremental and radical innovations, respectively. Incremental innovations involve modification of existing techniques, tools or practices, whereas radical innovations relate to the generation of practices or technologies that are completely novel. Thus, about two-thirds of the innovations involve adding value to or adapting technologies and practices to make them more appropriate for local conditions. We however find that majority (66%) of the innovators in Ethiopia have developed original innovations.

Table 4: Some characteristics of the identified innovations (%).

	Ethiopia	Kenya	Malawi	Zambia	Overall
Individual innovation	95.74	98.66	100	96.97	98.27
Group innovation	4.26	1.34	0.00	3.03	1.73
Technical innovation	97.87	96.64	98.82	100	97.98
Institutional innovation	2.13	3.36	1.18	0.00	2.02
Incremental innovation	34.04	79.19	55.29	68.18	65.13
Radical innovation	65.96	20.81	44.71	31.82	34.87
Potential for commercialization[a]	-	99.33	91.76	87.69	94.65
Already marketing the innovation[a]	-	62.42	24.71	18.46	42.15
Estimated cost incurred					
0 - 20 USD[b]	80.85	59.31	80.25	70.97	69.55
21 - 100 USD	19.15	22.07	14.81	17.74	19.11
Above 100 USD	0.00	18.62	4.94	11.29	11.34
Estimated number of adopters					
None	39.13	35.62	32.93	47.46	37.54
1 - 50	39.13	57.53	62.19	50.85	54.95
Above 50	21.74	6.85	4.88	1.69	7.51

[a] This information was not collected in Ethiopia

[b] USD = US dollars

Almost 95% the innovators believe that their innovations are marketable or can evolve into commercializable products. The results show that about 42% of the innovators are already marketing their innovations. Commercialization of innovations is particularly common among the Kenyan

innovators as about 62% of them are currently offering products and services in relation to their innovations in exchange for money. The innovators were asked to estimate the costs incurred in developing the innovations, and their responses are also summarized in Table 4. The costs estimates are only suggestive as they mainly reflect the costs of materials used to produce the innovations. We find that it costed less than or equal to 20 USD each to develop about 70 percent of the innovations. This corroborates assertions that farmers develop simple and low-cost technologies using locally available resources (Reij and Waters-Bayer 2001; Reij et al. 2009). When asked about estimated number of adopters of the innovations, about 38% indicated that they were not aware of anyone applying their innovations. This is partly because prior to the contests, some of the innovators were keeping their innovations in secrecy. Thus, the contests can trigger awareness of innovations among potential adopters. Around 62% of the innovators claimed to have observed at least one adopter, suggesting that the innovations are spreading among farmers despite lack of scientific validation. The adoption claims also highlight the potential benefits of the innovations for other farmers in the study regions. However, adoption rate is moderate, with about 55% of the innovators citing between 1 and 50 adopters.

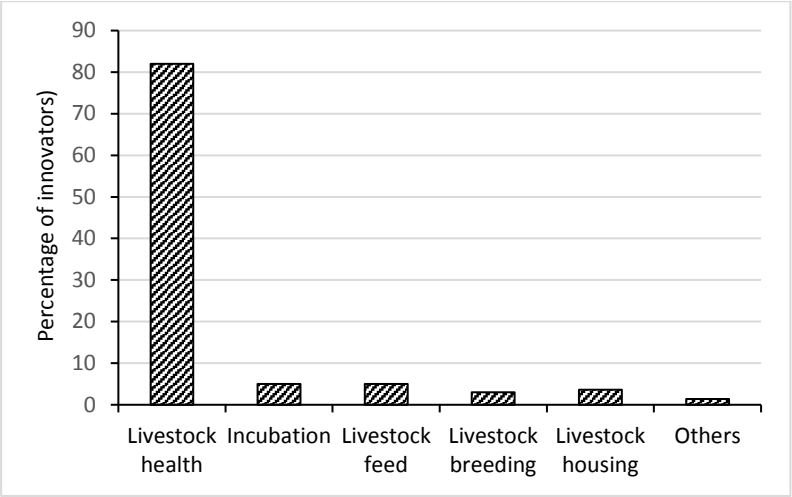
Table 5: Domains of innovations by country.

Domain	Ethiopia	Kenya	Malawi	Zambia	Overall
Crop management	12.77	32.89	25.88	21.21	26.20
Livestock production	34.04	34.90	38.82	56.06	39.80
Soil and water management	6.38	8.05	12.94	4.55	8.30
Farm tool and implement	25.53	2.01	3.53	1.52	5.50
Processing	6.38	4.70	2.35	3.03	4.00
Storage	4.26	10.74	11.76	10.61	10.10
Tree management	0.00	1.34	2.35	0.00	1.40
Apiculture	6.38	1.34	1.18	0.00	1.70
Aquaculture	0.00	0.00	1.18	0.00	0.90
Others	4.26	2.68	0.00	3.03	2.10

Table 5 presents the domains of the identified innovations. As mentioned earlier, we aimed to scout farmer-generated innovations within the food supply chain, hence, the identified innovations range from production to marketing activities. We find that livestock-related innovations dominate in all the study countries, particularly in Zambia where about 56% of the identified innovations are in the domain of livestock production. Overall, innovations in livestock production constitute roughly 40% of the identified innovations. Figure 1 displays the specific topics of the livestock-related innovations. A large share (82%) of the 138 innovations in livestock production involves livestock health management through ethnoveterinary practices. The rest include innovations related to incubation, as well as feeding, breeding and housing of livestock. The high number of innovations in livestock health could be explained by three possible reasons. First, livestock rearing is an important activity in the study regions, but the sector is bedeviled with myriads of challenges, such as pest and disease attack. Second, livestock farmers have limited access to modern veterinary services, and are thereby relying on ethnoveterinary medicines to treat their animals. Finally, veterinary health care methods or drugs are too expensive for many resource-poor farmers; hence, they resort to ethnoveterinary practices, which involve the use of plant parts that are often cheap and locally available.

The innovators prepare dewormers, vaccines, antibiotics or drugs from extracts of roots, leaves and barks of plants, which are used for the prevention and treatment of ectoparasites (e.g. ticks), and diseases such as Newcastle disease, East Coast fever, African swine fever, Anthrax, Pinkeye disease, Foot-and-mouth disease and poultry coccidiosis. The innovations in the area of incubation include the use of local materials such as maize bran to hatch eggs in the absence of electricity or hen. Innovations related to livestock housing mainly involve construction of a combined chick brooder, feeder and waterer using plastic containers, and modification of traditional brooder house to provide more warmth, prevent fungal infestation and reduce chick mortality. The livestock nutrition-related innovations include growing maggots for feeding chickens, and formulation of feeds using local ingredients such as soybean, pumpkin seeds, moringa leaves, cowpea, cowpea husks, maize bran, sunflower and napier grass. Thus, the innovators are able to produce feed additives and low-cost livestock feed, which are particularly useful during periods of feed shortage.

Figure 1: Topics of innovations in livestock production (n=138).

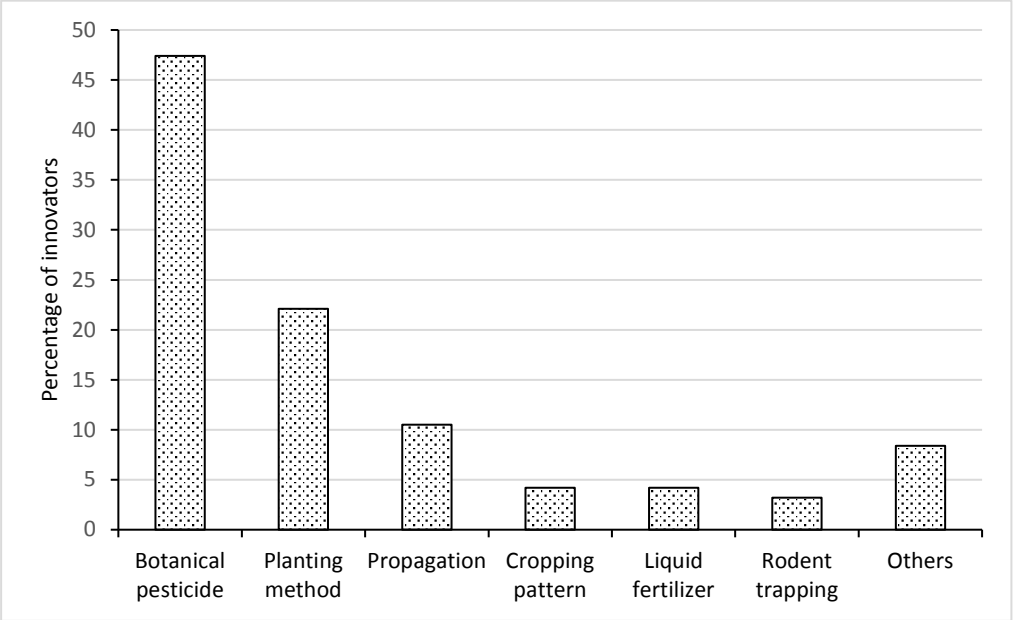


Besides the livestock-related innovations, another important category of innovations identified through the contests is crop management innovations. As shown in Table 5, about 26% of the innovations fall within this domain. Figure 2 indicates the types of practices and techniques that comprise the crop management innovations. Nearly half of this category of innovation is related to crop protection using botanical pesticides, which are concoctions containing extracts of fruits, pods, seeds, roots, barks or leaves of plants or trees with pesticidal properties. The botanical pesticides produced by the innovators are complex mixtures of extracts from three or more different plants or trees, such as Azadirachta indica, Tephrosia vogelii, Khaya nyasica, Acalypha senensis, Euphorbia tirucalli, Swartzia madagascariensis, Senna siamea, Solanum spp, Tithonia diversifolia, Agave sisalana, and Carica papaya. They are prepared in the form of aqueous extracts that are sprayed on crops or weeds or in the form of dried powdered plant materials that are mixed with seeds or broadcasted onto soils and crops. To enhance the efficacy of the biopesticides, a few of innovators mix the plant extracts with other ingredients, including household chemicals (e.g., laundry detergents), powdered pepper and human urine. The innovators are using the biopesticides to repel or control birds and insects, such as ants, termites, stem borers, stalk borers, and aphids as well as to control nematodes and weeds, such as witchweed.

The innovations categorized under the label ‘planting method’ include various modified methods of land preparation and planting in order to optimize land use, quicken growth process, increase nutrient

uptake, prevent lodging and increase yield. Examples include the following: modification of conservation farming techniques by planting in trenches, basins or furrows that are lined with various combinations of organic materials; obtaining the optimal number of maize plants by gapping, using maize seeds planted in a nursery; and reducing the period between onion sowing and harvest through nursing, dormancy induction and transplanting. Other examples are planting of cassava using germinated seedlings instead of cuttings; improving plant spacing to address land shortage problems and to reduce competition among plants for soil nutrients; and staking between planted rows or constructing of racks for plants such as pumpkin and tomatoes to prevent their fruits from touching the ground or being damage by animals.

Figure 2: Topics of crop management innovations (n=95).



A few of the innovators were involved in breeding and grafting activities to generate cultivars that are stress tolerant, fast growing and high yielding. Notable examples include: developing rootstocks from existing roots of local apple plants instead of using normal stem shoots; using stems of citrus fruit as root stock for propagation purposes instead of using seedlings directly sown in tubes; crossbreeding local watermelon with certified watermelon; crossbreeding yellow maize with white maize to obtain an early maturing variety; and domestication of a wild vegetable. Innovations in the domain of cropping pattern mostly involved the introduction of a novel type of intercropping that generate beneficial outcomes in the study districts. These comprise the following: intercropping crawling stinging nettle with maize to prevent soil erosion and preserve soil fertility, with additional benefit of using the stinging nettle as food for humans or feed for animals; intercropping wheat with Avena fatuna to prevent rust disease; providing partial shade for kale plants by planting rows of bananas in kale gardens; and cultivating four different crops in an intercropping system due to land scarcity. Other crop management innovations include using local materials to make simple traps that prevent crop damage by rodents (such as mice and rats) and monkeys; as well as making liquid fertilizers by mixing extracts of plants (such as Tithonia), and human or rabbit urine, which are used as top dressing and foliar spray.

Inspired by modern farm implements, some of the innovators have used local materials to develop simple farm tools and implements in order to save time and labour or decrease cost of production. The results show that a greater share of the innovations in this domain were scouted in Ethiopia. Some examples of these innovations are as follows: a simple machine (which is made from a bicycle rim, a fan belt and a grinding disc) that is used to sharpen farm tools or implements; a maize sheller comprising a wooden frame with wire nails; and an electric sprayer that uses dry cells as power source instead of manpower. Further examples include: a manual chaff cutter for cutting chaff and chopping animal feed; a machine to thoroughly mix animal feed for easy consumption by livestock. A local eight-row planter equipped with adjustable seed and fertilizer hoppers; an enset (false banana) scraper and chopping tool; and a local winnowing machine for separating residues from grains of cereals such as teff, wheat and barley.

The storage innovations mainly involve the use of ashes of plants or pulverized plant materials to protect stored grains and seeds against storages pests, such as larger grain borers and weevils. Some of the plant materials include pods and seeds of Julbernardia globiflora; root of Dolichos kilimandscharicus; leaves of Tephrosia vogelli, Ocimum canum, Lantana camara and Neem; Mexican marigold plant; maize cobs; and dried banana peels. Some of the innovators store the products using ashes of dried animal dung in combination with the plant materials or in isolation. Other interesting innovations in this domain include diverting insects from stored grains using substitutes such as pounded groundnut, as well as extending the shelf life of freshly harvested sweet potatoes for up to 3 months using underground storage pits lined with dry grasses under tree shades. We also identified a few simple processes or tools for adding value to farm products, which we termed processing innovations. Among them are locally-made yoghurt and soymilk; preservation of tomatoes through sun drying; a method of preserving meat for up to 6 months using ash from maize cobs, banana peels and legume crop residues; and a butter churn, which was developed from local materials including plastic can, wood, metal sheet, dynamo and cables.

The soil and water management innovations consist of soil fertility enhancing techniques, irrigation practices and water conservation technologies. Examples include unique methods of preparing and applying organic manure and compost, such as pellet and powdered green manures; growing onions in potholes to reduce labour and water loss; as well as various local water harvesting systems. The innovations dubbed 'apiculture' comprise a bee repellent made from extracts of plants (e.g. Combretum molle) for protection when harvesting honey; an improved traditional beehive by adding a queen excluder, resulting in improved quality and quantity of honey produced; and a temporal cage to adapt or domesticate queen bee. Finally, we identified a few aquaculture innovations, including: a local fabrication of floating fish cages; a process of rapid multiplication of catfish by inducing females and preparing males to fertilize stripped eggs; and a unique method of trapping canal water to fill several fish ponds, and this enhances water supply even in low-water environments.

We also examine if certain categories of innovations are predominantly associated with a gender group by disaggregating the innovation domains by gender. The result (see Table 6) shows that livestock-related innovations remain the most important domain across the three gender groups. We find that innovations related to farm tools and implements were mostly reported by youths, suggesting that youth farmers are relatively more involved in generating time-saving and drudgery-reducing farm implements. Female farmers generated none of the innovations identified in the area of farm tools and implements. Furthermore, women and youth innovators reported most of the innovations related to storage, while men innovators were mostly responsible for the identified soil and water

management technologies. We also find that the few innovations related to aquaculture were largely implemented by women innovators. Similarly, the share of processing innovations in the women category is slightly higher than those in the men and youth categories.

Table 6: Domains of innovations by gender.

Domain	Men	Women	Youth
Crop management	25.23	29.27	25.53
Livestock production	39.91	42.68	34.04
Soil and water management	11.93	1.22	4.26
Farm tools and implement	6.42	0.00	10.64
Processing	3.21	6.10	4.26
Storage	6.88	15.85	14.89
Tree management	1.38	0.00	2.13
Apiculture	2.33	0.00	2.13
Aquaculture	0.05	2.44	0.00
Others	2.29	2.44	2.13

5.3 Motives, sources of ideas and outcomes of the innovations

Table 7 shows the key motives behind the identified innovations. An important motivating factor for developing an innovation is to reduce cost of production, as cited by about 62% of the innovators. The identified innovators are mostly smallholder resource-poor farmers who often face difficulties in accessing affordable modern agricultural technologies, and this may induce them to develop cost-saving practices and techniques. For instance, they save money by using ethnoveterinary medicines instead of modern veterinary medicines; and they reduce expenses on agrochemicals by applying locally made botanical pesticides and soil fertility-improving techniques. Achieving productivity increases in crops and livestock was the ultimate goal of about half of the innovators. Another important driver of the innovations is curiosity. Around 41% of the innovators were curious to find out if a harboured idea will work or not, and this resulted in innovation outcomes. Other driving factors mentioned by the innovators include reduction in the amounts of inputs and labour used, improving the quality of farm products, adaptation to environmental shocks, exploitation of market opportunities, and desire to gain social recognition. A few of the innovators (11%) asserted that their innovations were not intentionally developed, but instead, they occurred serendipitously. Overall, these results corroborate the finding of Sumberg and Okali (1997) that majority of farmers' innovation-generating practices are proactive rather than reactive.

Table 7: Motivation for generating the innovation.

Motive	Ethiopia	Kenya	Malawi	Zambia	Overall
Curiosity	57.45	54.36	18.52	27.27	41.11
Coincidence	14.89	9.40	11.11	12.12	11.08
Reduce inputs	6.38	43.62	24.69	16.67	28.86
Saving labour	29.79	20.81	14.81	9.09	18.37
Reduce expenses	46.81	62.42	69.14	60.61	61.52
Increasing production	38.30	65.10	51.85	28.79	51.31
Improving quality	12.77	49.66	25.93	15.15	32.36
Adaptation to environmental change	4.26	30.87	17.28	16.67	21.28
Market demands	12.77	22.82	7.41	9.09	15.16
Desire for social recognition	2.13	19.46	3.70	4.55	10.50

Note: Multiple responses recorded

At the country level, the Ethiopian innovators cited curiosity and reducing expenses as the main motivations behind their innovations. Similarly, curiosity and reducing expenses, in addition to increasing production and improving product quality, were the important factors that spurred the implementation of the identified innovations in Kenya. We also find that the innovators in Malawi were inspired to innovate mainly because of the desire to increase agricultural production and reduce production costs, which is also the key motive for the innovators in Zambia.

Figure 3 depicts the main sources of ideas for the innovations. Over three-quarters (78%) of the innovators claimed that they developed the innovations based on their own creative ideas. This resonates with Leitgeb et al. (2014) observation that the foremost source of ideas associated with farmer experiments in Cuba is farmers' own idea. Nearly 10% of the innovators tapped into traditional or indigenous knowledge, and this explains why some of the identified innovations are modifications of existing techniques and practices. Some of the innovators built upon ideas learned from other farmers and relatives or were inspired by practices and techniques introduced by NGOs and extension workers.

Figure 3: Sources of ideas for the innovations.

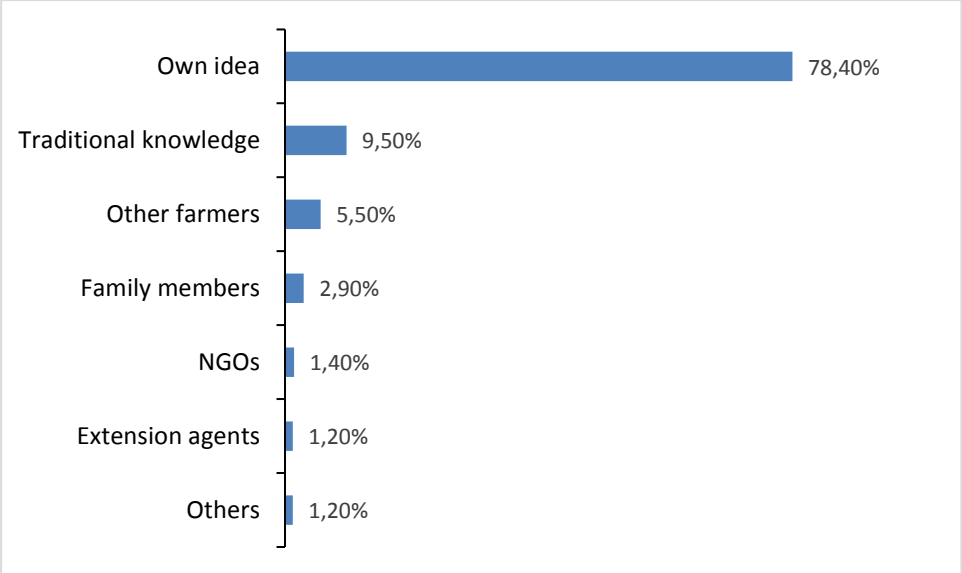
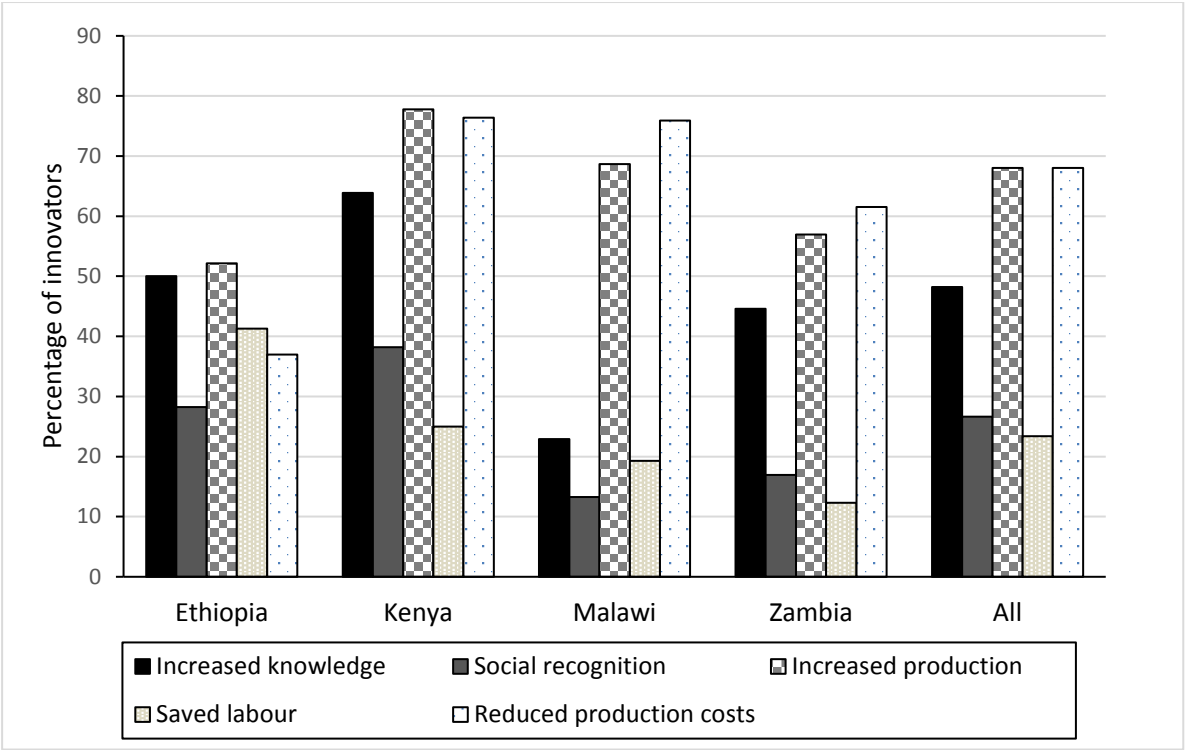


Figure 4 illustrates innovators' perspectives on the outcomes of implementing the innovations. The outcomes attained by the innovators are generally consistent with what spurred them to develop the innovations at the first place, suggesting that implementing the innovations is a worthwhile undertaking. About two-thirds of innovators avowed that their innovations have contributed to yield improvement, ranging from 52% in Ethiopia to 78% in Kenya. Similarly, 68% of the innovators opined that their innovations have resulted in lowered production costs, ranging from 37% in Ethiopia to 76% in Kenya and Malawi. The ingredients or materials used in producing the innovations are mostly cheap and locally available; hence, the farmers considered their innovations to be cost-effective. For example, using the biopesticides developed by the innovators may substantially reduce the cost incurred in accessing inorganic pesticides from agro dealers. As shown earlier, the farmers' innovations encompass a number of farm and non-farm activities; hence, there are several pathways through which the innovations may contribute to increased food production. For instance, applying biopesticides and ethnoveterinary medicines may prevent or reduce pests and diseases problems and thus increase productivity. Furthermore, some of the innovations involve techniques that are adapted to local conditions and thus are more resistant to stresses and shocks that tend to reduce yield. Moreover, the time- and resource-saving advantages of some of the innovations can be invested in other agricultural production activities. The findings are consistent with that of Tambo and Wünscher (2017) who also found related outcomes of farmer innovations in Ghana.

Figure 4: Perceived benefits derived from developing the innovations.



Note: Multiple responses recorded

Nearly half of the innovators also asserted that the process of bringing forth innovations has increased their knowledge and enhance their ability to address challenges they face in farming. This supports the proposition that farmer innovation is a potential vehicle for farmer empowerment (Sumberg and Okali 1997). Around 27% of the innovators claimed that they have gained recognition in their communities and among stakeholders through the development and sharing of their innovations, while 23% of them

perceived that their innovations have been beneficial in saving labour. We find that relatively more farmers in Ethiopia cited saved labour as an outcome of their innovations, and this is expected since proportionally more innovators in this country have generated innovations in the domain of farm tools and implements, which are often labour-saving technologies.

6 Concluding remarks

In this paper, we presented our experiences of applying contests to elicit farmer-generated innovations and to celebrate outstanding farmer innovators in Ethiopia, Kenya, Malawi and Zambia. In the contests, smallholder farmers competed to win prizes ranging from 500 USD to 1000 USD by revealing their own generated innovations. The contests were implemented in three districts each across the four African countries in collaboration with local partners, including NGOs, research institutions, farmer organizations, extension service providers and Ministries of Agriculture.

Overall, the contests attracted 774 entries, out of which 40% were accepted as farmer-generated innovations. The high rejection rate was partly attributed to low prior knowledge of the concept of farmer innovation among scouters and local partners. Despite making conscious efforts to identify women and youth innovators, a large percentage of the entries were received from men. The identified innovations were mainly technically-oriented practices, with very few social innovations. The most common categories of innovations include livestock (40%), crop management (26%), storage (10%), soil and water management (8%) and farm tools and implements (5%). Most of the identified innovations relate to reducing crop losses using plant-based biopesticides and preventing or treating livestock pests and diseases using ethnoveterinary practices. We found that the innovators were mainly driven by economic motives such as reducing production costs and increasing production, but intrinsic motives such as curiosity were also important factors that fostered the development of the innovations.

The implementation and outcomes of the contests yielded some interesting insights. For instance, our findings suggest that contest is a good mechanism to scout farmer-generated innovations while simultaneously acknowledging the ingenuity of the innovators and raising awareness among relevant stakeholders. The contests helped in revealing practices and tools developed by farmers that were hitherto kept in secrecy. Furthermore, this study reaffirms the notion that farmers are active experimenters who continuously generate remarkable and locally adapted innovations. They use local resources to develop low external input technologies in order to reduce production costs and improve food production. Additionally, the farmers' innovations can indirectly contribute to efforts to achieve sustainable agricultural intensification or to make agriculture climate-smart. For instance, the use of synthetic pesticides in smallholder agriculture may create negative externalities such as environmental contamination and toxicity to humans and animals (Van Huis and Meerman 1997). However, the numerous botanical pesticides developed by farmer innovators may help to decrease farmers' dependency on synthetic pesticides, and can thus play a role in addressing environmental and health problems, aside the yield improvement and cost reduction benefits. Moreover, some of the innovators have developed locally adapted and stress tolerant varieties that can help to cushion the effects of climate change.

In conclusion, farmers possess valuable ethnobotanical knowledge and innovation-generating potential that need to be harnessed and supported. Efforts to support farmer innovation processes could involve documenting the innovations, validating and adding value to the innovations, converting those innovations with commercial potential into marketable products, giving recognitions to innovators, facilitating the protection of intellectual property, scaling of high-potential innovations, and mainstreaming farmer innovation approach into agricultural development programs. For instance,

validating the innovations through farmer-led joint research (Wettasinha and Waters-Bayer 2010) or scientific research will help to assess the efficacy, safety and cost-effectiveness of the innovations, as well as to further improve the innovations in order to achieve optimal performance.

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ZEF Working Paper Series, ISSN 1864-6638
Center for Development Research, University of Bonn
Editors: Christian Borgemeister, Joachim von Braun, Manfred Denich, Till Stellmacher and Eva Youkhana

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Germany

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