

# Tracing legume seed diffusion beyond demonstration trials: An exploration of sharing mechanisms

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## Abstract

Many interventions are assuming that introduced seeds diffuse. However, the details of this diffusion among farmers are poorly understood. This article presents data from eight sites in four on the diffusion of seed and associated information given to farmers involved in N2Africa's demonstration trials. The study showed that 2–3 years after the trials had been organised, more than 90% of the farmers who had participated in the trial activities and were given a seed-input package with 1–5 kg of legume seed had shared this seed, on average with four other farmers. The farmers who received this seed from these directly involved farmers shared their seed less frequently. Eighty per cent of all the seed sharings were of 1–2 kg of seed given as a gift. Only 5% of the sharings involved a cash transaction. More than half of the seed sharings were with family members and around a third were between friends. Men shared at least as often as women and both men and women shared most with persons of their own sex. Information about rhizobium as an associated input for soya was shared by more than one-third of farmers, almost exclusively by farmers who had participated in the demonstration trials themselves. Extrapolation of data suggest that in addition to the 250,000 farmers who participated directly in the N2Africa demonstration trials, another 1,400,000 farmers may have received seed of a new legume crop or variety. The results show that knowing about the character of the seed sharing mechanisms may offer opportunities to influence the diffusion of seeds. Providing farmers with somewhat larger amounts of seeds, emphasise the importance of sharing seeds and information with relatives and friends could be an important factor in achieving a high multiplier effect.

## Keywords

Seed diffusion, transactions, gender, relationships

## Introduction

Many seed system interventions introduce improved seeds, aiming at a variety of goals that directly contribute to a better livelihood of smallholder farmers who are assumed to adopt these seeds or indirectly to a larger group of beneficiaries. The strategy underlying the introduction of seeds normally assumes that after active introduction at particular intervention points and through activities involving selected beneficiaries, the seeds are diffusing. Generally, we assume that seeds, when they perform well, are spreading among farmers, within and between communities, through sharing. Potentially, we could influence these sharings and reach more farmers within shorter time spans. However, we know relatively little about these sharing mechanisms. Most studies find that sharings are gifts, that is, not involving cash transactions (Tadesse et al., 2017). However, gifts may not represent 'free seeds' because they carry obligations of reciprocity, depending on who gives to whom. Similarly, asking for seed can be constrained because it is

embarrassing or 'not done'; status, sex or age can thus influence the access to seed and other resources be important factors. Also, because in many crops the seeds are also the consumed grains, seed availability – and thus its diffusion – is under pressure when food is scarce in the household (David et al., 2002; Sperling and Loevinsohn, 1993). Having surplus could explain why better-off farmers in Ethiopia were sharing potato seed of improved varieties whereas poor farmers did not (Tadesse et al., 2017). We also know little about the information that is shared together with the seeds: Are they shared with or without

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**Table 1.** The composition of the sample population of interviewed farmers from the first to fourth generation.

	Ghana		Kenya		Malawi		Zimbabwe		Total
	Sung	Pishugu	Butula	Malakasi	Mnusu	Lumwira	Goromonzi	Mudzi	
Women	11	11	26	32	21	21	20	32	174
Men	9	10	23	15	12	7	2	15	93
Groups <sup>a</sup>			1	2					3
Total	20	21	50	49	33	28	22	47	270

<sup>a</sup>These groups of farmers were analysed as a single interviewee.

recommendations and instruction on how to use the seed, and could this influence the diffusion of the seed?

We report on a study in which we explored the sharing and diffusion of seeds as part of a legume technologies following their introduction through the N2Africa-project ([www.n2africa.org](http://www.n2africa.org)) in the years 2009–2013 in a number of selected sites in four countries. Farmers were encouraged to adopt and integrate legumes because of nitrogen fixation capacities. Seed of common bean, cowpea, groundnut and soyabean was disseminated together with phosphate-based fertilizer and, in the case of soyabean, with rhizobium inoculant. The case studies in this report are complementary, and represent a first effort to explore how, and to what extent, seeds of new legume varieties or crops, and associated information (in particular on fertilizer and rhizobium) had spread beyond the farmers who were directly involved in the project. The case studies were carried out simultaneously in Ghana, Kenya, Malawi and Zimbabwe in the second half of 2013.

## Material and methods

### *The design of the studies and the composition of the sampled groups of farmers*

In four countries, Ghana, Kenya, Malawi and Zimbabwe, we identified sites where in 2010, the first season of the N2Africa project, a demonstration trial had been implemented with one of N2Africa's legumes, preferably in one single season and with just one farmer group. The legume-based technologies had been introduced through a lead-satellite farmer model. In most cases, the seed was distributed after farmers had seen a demonstration trial hosted by a lead farmer or by the farmers as a group. The exact combination of technologies and demonstration models varied within and between countries. Most demonstration trials had a standard lay out of 4 plots of 10 by 10 m each with four treatments: (1) the new legume variety without inputs (control); (2) the variety with a phosphate-based fertilizer (P); (3) the variety with inoculants; and (4) the variety with a P-fertilizer and inoculants. The package of seeds and inputs that farmers received varied in terms of crop, variety, type of fertilizer and with or without inoculant, depending on the legume, the purpose of the demonstration and the availability of (the types of) inputs in the country. The amount of seed given to the farmers usually varied between 1 and 5 kg. In addition to the package, farmers also received training on biological nitrogen

fixation, best practices for legume cultivation and post-harvest handling.

The design of data collection was similar in each of the four countries. The researcher identified in each of these sites ca. 10 farmers who had directly participated in visits to and explanations about the N2Africa demonstration trials and treatments and who had received a seed package. These farmers are referred to as 'first-generation' farmers. These farmers were interviewed and an inventory was made of the farmers they had shared seed with (the 'second-generation' farmers). A sample of these farmers were traced within the limited time frame of the study, and they were also interviewed to assess their seed sharing with 'third-generation' farmers. A number of third-generation farmers were traced in Kenya, Malawi and Zimbabwe. In Ghana, however, this was not possible as none of the second-generation farmers shared their seed. In Kenya, the research also traced two fourth-generation farmers.

From the 8 communities in the 4 countries, a total of 270 farmers were interviewed (Table 1), of whom 131 had passed on seed (82 women and 49 men) and 149 had not. We recorded 406 instances of 'seed being shared' from the interviews, that is, 406 sharings. The data from the three farmer groups in Kenya (who were of mixed gender) were not taken into account for a number of variables: (i) the seed transactions, (ii) data on gender, (iii) the type of relationship with those who they shared seed with. Members of these three groups shared seed with 32 individual farmers. Unless indicated otherwise, the averages in the tables are weighted averages: calculated with the aggregated total of farmers and seed sharings over the countries and generations. It should be noted that the time period over which the seed was shared varied for farmers of different generations and between countries: first-generation farmers had obviously had a longer period over which they had been able to share seeds than later generation farmers. When comparing among the different countries, it should also be realised that the western Kenyan sites have two cropping seasons whereas the other sites have one.

Additional information was collected on farmers the use of soyabeans and rhizobium. This data collection was more straightforward as the crop was relatively new with few available varieties as compared to the more widely grown common bean, cowpea or groundnut. Data were collected from a random selection of farmers in sites spaced at 5 to 20 km distance from each of the eight study sites. The researchers based themselves at water points, market places

or bus stops and randomly stopped farmers for interviews. This yielded 414 interviews from Ghana ( $n = 112$ ), Kenya ( $n = 119$ ), Malawi ( $n = 120$ ) and Zimbabwe ( $n = 63$ ). Further details on this data collection can be found in Almekinders et al. (2016), Balele Mgasa (2014), Manyere (2014b), van 't Foort (2014) and Zagenia (2014).

For statistical analysis of the number of seed sharings per farmer as a function of country, generation and gender, we used a generalized linear model with a quasi-Poisson link function. Analysis of the nature of seed sharings in terms of family relations, gender and type of transaction was done using a generalized linear mixed model, with farmer as a random factor and a binomial link function. Significance of explanatory factors (gender, country) was tested by analysis of deviance. The amount of seed involved in the transactions was analysed by a linear mixed model on the log transformed reported amounts.

### Study sites

In northern Ghana, two communities in Karaga District (Sung and Pishugu) were selected. The demonstration trials in the selected communities took place in 2010. As northern Ghana has a single growing season (May–October), data collection took place three growing seasons (and harvests) after the first demonstration trials had taken place. The demonstration trials were planted with soyabean in Sung (two varieties: Jenguma or Quarshie) and soyabean or cowpea in Pishugu. In both places, the demonstration trials with soyabean had the 'standard' trial design, including treatments with inoculum and P-fertilizers. Soyabean was not entirely new in the area at the time of the trials. It was introduced in the area in the early 1990s and it was quite commonly cultivated and consumed. Most common however was the production for selling to the processing factory or traders. The processing factory was closed down at the moment of this study.

The study sites in western Kenya, Butula and Malakasi, have two growing seasons per year: a long rainy season of around 3 months (March–June) and a shorter rainy season of about 2 months (August–October). Farmers plant legumes in both seasons. N2Africa distributed seeds to farmers in those sites in 2010, so five to six growing seasons would have passed since the farmers had participated in the demonstration trials and received seed to sow themselves. There have been many other seed introductions in the area over the years, done by different organisations and involving different types of seed (but predominantly soyabean) and demonstration trials. This complicated the assessment of N2Africa's activities here since it was not possible to precisely document where and when these activities had taken place. All data in this study relate to soyabean, which was relatively new in the area. Its introduction was one of the objectives of the N2Africa project. Other major crops in the area were maize, beans and groundnut.

In Malawi, the study sites Mnusu, in Salima district, and Lumwira in Dedza district, both in the central part of Malawi have one growing season. The N2Africa trials

involved two varieties of soyabean (Makwacha and Nasoko) and two varieties of groundnut (CG7 and Nsinjiro) in combination with inoculant (for the soya) and P fertilizer. The legumes in the trials were planted as mono-crops. Planting in the areas where the study sites are located normally takes place mid-November. The seeds for the trials were distributed after a training session in December 2010. Assuming that – despite the late distribution in the season – farmers may nevertheless have planted some of the seed, three growing seasons had passed when data were collected. Most data in this study concern soyabean, although some cases of common bean have also been included. Soyabean was still not commonly grown in the area. The dominant planting pattern was mixed cropping of maize with legumes.

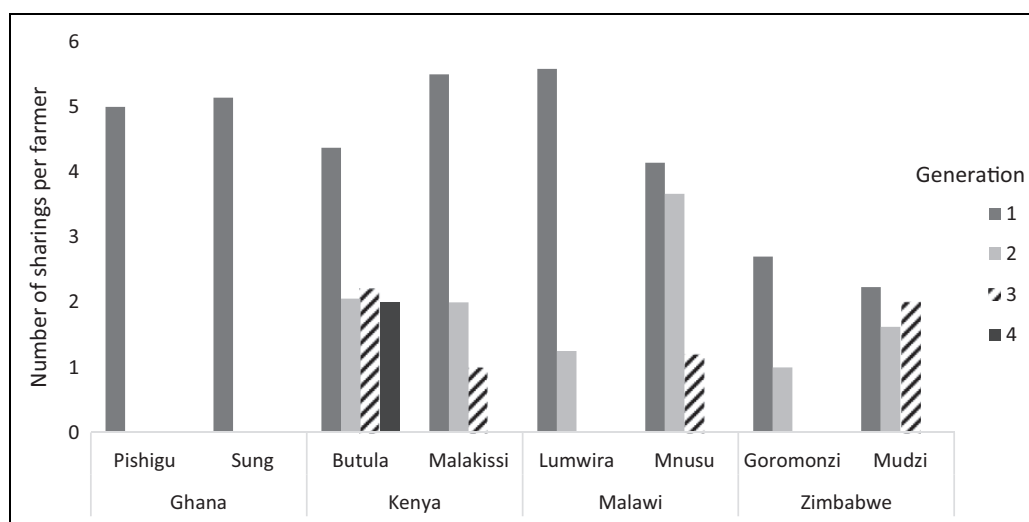
The study sites in northeastern Zimbabwe, Goromonzi in Mashonaland Central Province and Mudzi, in Mashonaland East Province, both have one growing season from November to March. In the study sites in Zimbabwe N2Africa introduced packages of seed of common bean (varieties Cardinal and Variety), groundnut (Natal Common), cowpea (IT18, CBC1 and CBC2) and soyabean (Safari), with and without fertilizer (all crops) and inoculant (for soya). Different crops and varieties were distributed to different groups in 2010, 2011 and 2012, in variable amounts (0.25 kg of cowpea and up to 5 kg of beans, depending on the variety). Thus, at the time of data collection, the number of growing seasons that had elapsed varied by farmer group. Data used in this study relate to soyabean, common bean, cowpea and groundnut. Soyabean was relatively new in the study sites.

## Results

### Seed sharing

*The frequency of sharing.* Table 2 shows the data on sharing of seeds by farmers who had received seeds from the N2Africa program through participating in the demonstration trials and those who we called second-, third- and fourth-generation farmers. A high percentage of first-generation farmers had shared seeds that they initially received from the N2Africa project. On average, farmers shared seeds with four other farmers (i.e. second-generation farmers). Sharing was least frequent in Zimbabwe (2.7 and 2.2 times in Goromonzi and Mudzi, respectively) and most frequent in Malakasi, Kenya (5.7 times) and Mnusu, Malawi (5.6 times). Of the 270 farmers interviewed, 131 (around 50%) shared seed with others, and they did so a total of 406 times.

The average number of sharings and the proportion of farmers who shared decreased significantly with the generations (Figure 1 and Table 2, for both:  $p < 0.001$ ) and also differs between country ( $p < 0.001$ ) and gender ( $p < 0.01$ ). The average number of sharings was highest in Malawi; Ghana was excluded from the analysis as no second-generation farmers shared seed. The average number of sharings by male farmers was higher than by female farmers, although these differences were only significant in the



**Figure 1.** The average number of seed sharings per farmer in the eight study sites in four countries.

**Table 2.** The number of first-, second-, third- and fourth-generation farmers interviewed (#), the percentage of them (%) passing on seed to another farmer by country and the average number of 'sharings'.

Country	Ghana		Kenya		Malawi		Zimbabwe		Average % of farmers passing on seed <sup>a</sup>
	#	%	#	%	#	%	#	%	
First	11	100	15	93	19	100	31	87	95
Second	30	0	60	45	28	36	32	31	28
Third	n.a.	n.a.	20	40	14	36	6	17	31
Fourth	n.a.	n.a.	4 <sup>b</sup>	25	n.a.	n.a.	n.a.	n.a.	25

<sup>a</sup> Average of percentages over the four countries.

<sup>b</sup> One person only.

second generation. These data indicate that the encouragement to pass on seed by N2Africa-staff worked quite well for the first-generation farmers, that is, those who participated in the management of demonstration trials or got the seeds after visited them. The sharing of seed with others by later generation farmers may have been influenced by them having had the seed for a shorter time span. This gave them less time to evaluate the seed and to reproduce it so that they had enough to share. This issue played an important role in Zimbabwe. The first-generation farmers in Zimbabwe said they received relatively large samples of seed, so they could harvest enough to eat as well as to share with others. The second-generation farmers only received on average 0.5–1 kg of seed: not enough to plant and eat. They said that before they could share with others they would need more time to bulk up their stock, assess the crop and its culinary quality. This implies one or two seasons at least before they would consider sharing with others. In addition, farmers in Zimbabwe were not very satisfied with the soyabean performance. In Goromonzi, the climate did not allow for good performance of the soyabean crop whereas in Mudzi farmers, mostly women, said that it was difficult to find a market for small quantities of soyabean and for which they have few household uses. In the Ghana sites, the use and planting of soyabean was more common, but the farmers explained that the low crop productivity in the

region was the reason for not sharing seed: they said they simply did not have enough to share. Of the second-generation farmers in Ghana (most of whom had probably already planted soyabean twice), none had yet shared seed with others at the time of the study.

*The relational aspects of seed sharing: Gender, family and friends.* Considering the total number of interviewed farmers, aggregated over the different generations, the majority we interviewed were women: 65% (36% in Ghana, 58% in Kenya, 69% in Malawi and 75% in Zimbabwe). Of all women in the study ( $n = 156$ ), 52% shared seeds with others (Table 3). The percentage of men in this study ( $n = 82$ ) that shared seed was at least as high (59%), and they shared on average with at least as many other farmers as women (Table 3): on average women shared 2.5 times with others, men did so with on average 3.4 others. The differences between male and female farmers were not significant. This means that the hypothesis that women might share seed more often than men because (1) legumes are often considered a women's crop and (2) women are more reliant on social relationships could not be confirmed through this study.

Another gender aspect of sharing is with whom men and women shared. Sharing took place predominantly between farmers of the same sex ( $p < 0.001$ ). However, women were more likely to share with farmers of the same sex than men

**Table 3.** Percentage (%) of women (n = 156) and men (n = 82) who shared seed, and the number of farmers with whom they shared seed (#).

	Ghana (n = 41)		Kenya (n = 96)		Malawi (n = 61)		Zimbabwe (n = 70)		Average <sup>a</sup> (n = 268)	
	%	#	%	#	%	#	%	#	%	#
Women	18	4.0	45	1.9	57	3.7	53	2.0	52	2.5
Men	36	5.0	55	2.8	53	4.0	59	2.6	59	3.4

<sup>a</sup>Weighted average over 268 farmers. Data from the three farmer groups in Kenya are not included.

**Table 4.** The percentage of seed sharings between farmers of same sex, that is, women with women and men with men (n = 374).<sup>a</sup>

	Ghana (%)	Kenya (%)	Malawi (%)	Zimbabwe (%)	Total (%)
Women who shared with women	87	87	85	91	87
Men who shared with men	95	44	47	35	56

<sup>a</sup>Thirty-two transactions from the three farmer groups in Kenya are not included.

**Table 5.** Percentage (%) of seed sharings with friends, relatives and others, by country and gender.

	Country				Gender		Total (N = 374)
	Ghana (n = 56)	Kenya <sup>a</sup> (n = 107)	Malawi (n = 129)	Zimbabwe (n = 82)	Women (n = 209)	Men (n = 163)	
With relatives (n = 210)	13	62	75	48	61	49	56
With friends (n = 125)	88	11	22	44	30	39	33
With others (n = 39)	0	26	3	9	9	12	10

<sup>a</sup>Thirty-two transactions from the three farmer groups in Kenya are not included.

( $p < 0.001$ ): 87% of all women-sharings were with other women, whereas men shared 55% with men (Table 4). There were significant country-specific differences ( $p < 0.05$ ), with differences between sexes being low in Ghana compared to other countries: in Ghana, the proportion of sharing with members of the same sex was highest for both men and women. The tendency of men in Kenya, Malawi and Zimbabwe to share relatively often with women – as compared to women with men – may be due to legumes and seeds being viewed mainly as female domains (e.g. Bezner-Kerr, 2007; Pircher et al., 2013). We have no explanation for the difference as compared to Ghana.

About 90% of the seed originating from the N2Africa project was shared among relatives and friends; only 10% was shared with others (Table 5). Significant differences in the proportion of sharing with relatives, friends were observed between countries ( $p < 0.001$ ), with sharing with relatives being significantly higher in Malawi compared to the other countries and significantly lower in Ghana. In the latter country, a significantly higher proportion of seed sharing was with friends. However, there was considerable variation in the percentages of those sharing with relatives or with friends between the sites, also within a single country. There was also no consistency when comparing with whom women and men shared their seeds. In some sites women shared more with friends than with family, whereas in others sharing with family dominated. Similarly, men in some sites shared more with friends, in other sites more with family.

**Table 6.** The percentage of women and men who shared seeds with female and male relatives, friends and others.

		Female (n = 209)	Male (n = 165)	Total (N = 374)
With relatives	Female	51	31	43
	Male	10	18	14
With friends	Female	29	5	18
	Male	1	33	15
With others	Female	8	8	8
	Male	1	4	3
Total		100	100	100

The proportion of transactions involving farmers of a different sex differed according to relationship type ( $p < 0.001$ ). This proportion was significantly lower for transaction involving friends, compared to those involving relatives or others. In other words, in the sharing the sharing with a person from the other sex is lowest in the category of sharing between friends. There were also strong variations, both by site and by country, in the gender of the relative or friend with whom women and male farmers shared seed. Nevertheless, the percentage of farmers sharing with farmers of another sex was significant lower when sharing with friends than when sharing with relatives or others ( $p < 0.001$ ). In other words, when women shared seed with men, they were mostly relatives (Table 6). And also when men

**Table 7.** The sharings by women and men on the basis of 'offering' and 'asked for' in the different generations of farmers (% per category, weighted averages).

Generation	Women who passed on seed		Men who passed on seed		Total (N = 371)	
	Gave (n = 70)	Were asked (n = 138)	Gave (n = 79)	Were asked (n = 84)	Gave (n = 149)	Were asked (n = 222)
First	31	69	48	52	38	72
Second	30	70	48	52	41	59
Third	67	33	50	50	62	38
Fourth						
Total	34	66	49	51	40	60

**Table 8.** The transactional characteristics of seed sharing by country and gender (%).

	Country				Gender		Total (N = 352)
	Ghana (n = 34)	Kenya (n = 107)	Malawi (n = 129)	Zimbabwe (n = 82)	Female (n = 205)	Male (n = 147)	
Gift	97	83	63	96	85	73	80
Cash	3	14	2	0	5	5	5
Exchange	0	0	3	3	2	1	2
Return	0	0	24	0	6	12	9
Other	0	3	9	0	1	8	3

shared with a woman it was mostly with a female relative. Men tended to share more often with female rather than male relatives. The relation with relatives is the major seed-sharing-relationship – except for male farmers – and the only one where substantial seed sharing across the gender barrier took place.

### The conditions of sharing

*Offering seed or asking for it?* According to the information given by the farmer who provided the seed, 60% of all the seed sharings were on the basis of 'being asked for seed' and in 40% of the cases the seed was 'offered' (Table 7). There were significant differences between countries ( $p < 0.001$ ): in Kenya and Zimbabwe 'being asked for seed' was more pronounced (72% and 74%, respectively), while in Ghana and Malawi, seed was more often 'offered' than 'being asked for' (76% and 59%, respectively). This concurs with information from women farmers in the Zimbabwe study who said that giving seed without the person asking for it is not a normal practice. Some women farmers in Ghana mentioned this as well, but our data did not confirm this. Although there was no significant difference, totalled over the four countries, in each of the four generations, a larger percentage of women had been asked for the seed, while men gave seed as often they were being asked. The first-generation farmers were encouraged by N2Africa researchers to share seed with others, but this did not express itself in higher percentages of 'giving' (rather than waiting to be asked for) than in other generations: the proportion of seed that was offered increased significantly with generation ( $p < 0.01$ ).

*The transactional characteristics of the seed sharing.* To further explore the character of the seed sharings, we differentiated between gift, exchange and cash payment. Of the total number of seed sharings ( $n = 406$ ), it was not possible to identify the character of 22 transactions in Ghana (Table 8). Of the remaining cases, the large majority of all the transactions were described by the seed providing farmer as 'gifts' ( $p < 0.001$ ). There were no significant differences due to gender or country in the proportion of gifts versus other transaction types. In Kenya, 14% of the seed sharings were in exchange for cash. In Malawi, the implementing N2Africa agencies used a 'loan-based' transaction: the receiving farmers were asked to return the same or twice the amount of seed provided. This is apparently a common practice in the sharing of seeds in central Malawi. In 24% of the seed sharings in Malawi farmers used this transaction form; all were transactions between first- and second-generation farmers. Exchange and paying with labour was only reported for six cases (three in Malawi and three in Zimbabwe). There were 14 cases (4%) reported as 'other transactions'. Of all sharings of seed by women, 81% were reported as gifts, whereas only 70% of men shared as a gift. Both female and male farmers shared seeds with cash payment (i.e. were 'sold') in only 5% of the cases. Because of the variation between countries and sites for the small number of non-gift sharings, it is difficult to see a pattern. All the sharing by the three groups in Kenya ( $n = 32$ ) was in the form of gifts.

Of the 19 cash payments (1 in Ghana, 16 in Kenya and 2 in Malawi, representing 5% of all transactions), there were 11 with 'others' (15% of all transactions with others), 5 with friends (4% of all transactions with friends) and 3 with a relative (1% of all transactions with relatives).

**Table 9.** The percentage of farmers sharing a certain amount of seed with other farmers, by country.

	Ghana (n = 33)	Kenya <sup>a</sup> (n = 137)	Malawi (n = 129)	Zimbabwe (n = 82)	Total (N = 381)
0.25–0.5 kg	–	10	4	17	9
1.0 kg	45	42	73	35	51
1.5–2.0 kg	42	23	18	29	24
3–5 kg	9	17	3	17	12
>5kg	<1	7	2	1	4

<sup>a</sup>Includes data from two farmer groups.

**Table 10.** The average amount of grain/seed (kg) shared with other farmers, by country and gender.

	Ghana (n = 33)	Kenya (n = 105)	Malawi (n = 129)	Zimbabwe (n = 82)	Total (N = 349)
Women	2.6	2.0	1.1	2.0	1.6
Men	1.6	2.6	1.9	1.9	2.5
Average	1.9	2.4	1.7	2.0	2.0

*When and how much did farmers share?* We also wanted to know what the time lapse for sharing was. We tried to find out if farmers mostly shared after the first growing season that they had the new variety, or if sharing took place over several seasons. The first-generation farmers had presumably received the seed between 36 and 48 months before. In the Ghana sites, 60% of the transactions between the first- and second-generation farmers (n = 56) took place 36 months ago, that is, in the season after which the farmers had grown the seed for the first time. Other times of sharing by these first-generation farmers were 24 and 6 months earlier. In Kenya, 70% of the seed sharing of the first-generation farmers (n = 68) took place between 24 and 48 months earlier. The other 30% was spread over the following months. In Malawi, 75% of the sharings of first-generation farmers (n = 96) took place 36 months earlier, and the other 25% 24 months earlier. In Zimbabwe, 50% of the seed sharings of first-generation farmers took place 24 and 36 months earlier. The other seed sharings were spread out thereafter. These data indicate that most seed was shared in the first or second season after farmers first got the seed from N2Africa, but that substantial sharing took place later as well.

Of all the sharings, 75% involved 1–2 kg of grain (Table 9). The overall average amount of seed shared was 2.0 kg. The sharings as gifts were on average 1.7 kg, the cash transactions were on average for 5.5 kg of seed. With an average gift 200–400 m<sup>2</sup> could be planted, depending on the legume and the variety. In only 15 occasions (4%), more than 5 kg of seed was shared: 3 of these were provided by women and 12 by men. These sharings involved seven gifts, five cash transactions and four cases of otherwise exchanged seed (barter or loan), none for labour. On average, men shared more seed than women (2.5 kg as opposed to 1.6 kg) but this difference was not significant: the pattern did not hold in all countries. In Zimbabwe, men and women shared almost equal amounts, and in Ghana, women tended to share more seed than men (Table 10). The

surveys from the four countries indicated that sharing ‘a handful’ of seed was not widely practiced in any of the cases.

### Information sharing

The majority of the farmers (60%) said they had shared information about the seed together with the actual seed itself, others said they first had talked about the new seed with the person they shared it with, and shared the seed later (21%), or they had first given the seed and gave information later (17%). However, it is not clear what information was actually shared, that is, just about the variety or also on fertilizer treatments they had seen in the demonstration trials. Conversations with farmers in Zimbabwe indicated that often the seed is asked for or given (typically 1–2 kg) without specifying whether it was for consumption or sowing (Manyere, 2014a). Overall, 35% of the farmers said they had also given information on rhizobium inoculants to the person they gave the seed to (Table 11). This sharing of information on rhizobium was mostly done by first-generation farmers who shared seed with second-generation farmers, that is, farmers who had received inoculant in the distributed packages of seed and inputs or who had seen it in demonstration trials. Later generation farmers shared information less often (Table 11). In Malawi, none of the first-generation farmers referred to inoculant when sharing seed with others, nor did any of the later generations (Table 11). The differences between generations and countries were however not significant. In all study sites, the only available inoculant, to the farmers’ knowledge, was that in the initial packages provided by N2Africa’s collaborators.

### Soya, information and rhizobium

Of all farmers interviewed at 5–20 km distance from the eight case study sites, the majority knew about soyabean as a (crop) technology: 94% of the farmers in Ghana, and 100% in Malawi, and Zimbabwe said they knew the crop.

**Table 11.** Percentage of sharings of which the farmers said they also talked about the rhizobium inoculum when they shared the seeds (by country and generation of farmers).

Generation	Ghana (n = 56)	Kenya (n = 137)	Malawi (n = 129)	Zimbabwe (n = 82)	Total (N = 404)
First	82	48	0	38	39
Second	0	41	0	7	25
Third	n.a.	14	0	0	9

In Kenya, only 73% of the farmers said they knew soya. There was no difference in this respect between female and male farmers. Not many farmers knew about rhizobium inoculant. Of those interviewed and from whom the researchers got an answer on this question (n = 374 over the four countries), around 52% said they knew about rhizobium inoculant and 48% said they did not. The distance between the place where the demonstration trials had been held (three seasons earlier) and the point where interviews were taken did not seem to influence the answers. In Zimbabwe, women seemed better informed, but in Malawi more men knew about it, in Ghana and Kenya there was no consistent gender difference. In the situations where a gender difference seemed to exist, the effect may be explained by the importance of the crop for either women or men, or because the organisations promoting the use of rhizobium employed differentiated gender targeting for their information campaigns.

Overall, the results showed the same patterns as the results from the interviews in the seed tracing part of the study. Half of the farmers (49%) obtained their first soyabean seed as a gift from relatives and friends. A considerable number of farmers, both male and female, obtained their first seed in return for labour (8%), had to return an agreed amount of seed after harvest (25%) or bought their first seed from the market, an agro-chemical dealer or a middleman (36%).

Most seed sharings (71%) involve seed received from someone of the same gender ( $p < 0.001$ ): men predominantly got their first seed from men and women from women. Although this difference in percentages for male and female farmers was not significant, overall, like in the seed tracing interviews, more women obtained the first seed from another woman. Again Kenya presented another pattern: here the majority of women got the first seed from men, resulting in gender differences being country specific ( $p < 0.001$ ).

In 44% of cases where we have data (n = 250), the first amount of seed was between 1 and 2 kg. In 71% of cases, it was 4 kg or less.

None of the information we collected indicated any obvious spatial trend related to the distance from the demonstration trials. Nor was there a very obvious gender pattern in any of the countries. The data largely support the results from the seed tracing interviews.

## Discussion

### *The spreading of technology: Seeds and information*

The farmers who attended the N2Africa demonstration trials were the best sharers of seed: a larger percentage of

them shared seeds with others (more than 90%) and they shared their seeds with more other farmers than did farmers among the later generations. The diffusion of the seeds is thus strongly shaped by these farmers. The encouragements from N2Africa collaborators for participants to share their seeds with others may have worked well. However, our data are not conclusive on this point because also the amount of time that farmers have had their seeds and the quantity of seed they received may have contributed to farmers proclivity to share seeds. The data collected by the research teams focused on farmers sharing seeds with other farmers. The approach left little opportunity to delve deeper into the sharing of other components that formed, together with the seeds, the 'technology package', that is, information about application of fertilizer and planting distances. The information on rhizobium inoculant did not seem to have spread well. This is perhaps not surprising given the difficulty that farmers might have in understanding its functioning and its limited availability. Only the first-generation farmers seemed to pass on information about it, later generation farmers hardly did so. It is not clear however how the farmers who received the information have understood it.

While the data set has limited explanatory power, it does however allow us to make initial estimates of the extent to which seeds and information are disseminated after the point of introduction and identifying further relevant questions about the diffusion of technology. If we can take these results as being representative, and extrapolate them to other areas in these four countries and other countries where N2Africa is active, we can estimate how many farmers the project may have reached in addition to the farmers who participated in the original demonstration trials. N2Africa has been working in eight African countries and directly reached a total of about 250,000 farmers between 2010 and 2013 (Woomer et al., 2014), with a year-on-year increase (Table 12). Farmers who received seeds in 2010 could have reached three generations (2011, 2012 and 2013) in countries that have one season per year (Ghana, Nigeria, Malawi, Mozambique and Zimbabwe). In countries such as Kenya which, like the Democratic Republic of Congo (DRC) and Rwanda, has two growing seasons per year, we managed to track seed exchanges through to the fourth generations. Some fourth-generation farmers also passed on seeds, but we were not able to trace them in the limited period of data collection. Similarly farmers who participated in trials in 2011 could have reached two generations in countries with one season, and four in countries with two seasons. We assume that the farmers reached



**Table 12.** The number of farmers directly participating in N2Africa, by year, and the estimated number of additional farmers reached (from the season after the first generation's participation until 2013) through the spontaneous diffusion of seed.

Year	Farmers participating directly (#)	Additional farmers reached (#)
Year 1	50,000	–
Year 2	75,000	380,000
Year 3	125,000	500,000
Year 4	–	530,000
Total	250,000	1,400,000

directly were proportionally distributed between countries with one and two growing seasons (i.e. five countries with one growing season and three countries with two growing seasons). If we multiply the number of farmers participating in the project by the percentage of farmers who shared seed and the number of people they shared with (based on Table 2), per generation, and per potential number of generations reached, we calculate that a total of 1.4 million additional farmers might have been reached between 2010 and 2013. This is a rough estimate, which greatly depends on the representativeness of the data. However, it does indicate that many more farmers have benefitted from the improved varieties distributed by the project. In addition, it should be noted these figures are only calculations for the course of the project; sharing of seeds with others may continue over longer periods of time, although this study does not provide evidence on this point.

### Barriers to diffusion

One possible obstacle to the informal spreading of seed is that of social barriers. One of the focal points of this study has been gender which can play an important role since, in many African countries, legumes are considered to be a 'women's crop', and the spreading of the seeds could therefore be mostly limited to female networks. Such a phenomenon presumably has an important implication for the introduction points and activities. The data from this study indicate that this possible gendered-ness of the crop appeared to have had little effect on the spreading of the seed. N2Africa invited male and female farmers to participate in the demonstration trials. Male and female farmers, in different sites and countries, shared their seed with a similar number of others. In contrast to our expectations, the men in this study tended to be 'better seed sharers' than the women: they shared seeds with others more often and they shared them more often with women than that women shared with men. Only in Ghana, men showed a different pattern of sharing and here the number of farmers involved in sharing was very low. This means that even if N2Africa's projects were biased towards male participation, the seeds easily reach women, mostly through men sharing them for free (i.e. as a gift) with their female relatives.

The diffusion process was mostly driven by farmers making gifts of 1–2 kg of seed. The first-generation farmers most frequently shared their seeds in the first and second

seasons after the demonstration trials. It is not clear if these farmers first grew the seed themselves in the same year as the demonstration trials, or the following year. In any case, the assumption that farmers would prefer to evaluate the new crop or variety for several seasons before sharing them did not seem to apply to first-generation farmers (who had also been able to assess the seeds' performance in the demonstration trials), nor for the second- and third-generation farmers who shared their seeds with others. It is not clear how and how much the N2Africa collaborators encouraging the participating farmers to share their seeds with others influenced behaviour of first and possibly later generation farmers. The study does not tell us how many seasons farmers continued to share, but our hypothesis is that they provide relatives and friends with seed in the first few seasons after the first time they planted themselves, obtained some encouraging yields and possibly tested the culinary quality. After this, in later seasons, sharing seeds with others is likely to be more limited because they shared the novelty already with those they regularly meet. Equally we do not know if the quantity of seed that farmers receive in the first exchange influences their sharing behaviour. Farmers who get a small amount of seed can either eat it or sow it. But, if they were short of food (the majority of the farmers who were interviewed had to buy maize every year for 1 month or more), it is unlikely that they will have much surplus to share: the priority would be most is likely to 'bulk up' their supply so they can sow more land themselves or have some for domestic consumption. Sharing seed would only take place in later seasons. It may have helped that many first-generation farmers who had been directly encouraged by the researchers received somewhat larger quantities of seed.

Information from other studies indicates that 'asking for seed' might be something that farmers do not easily do, and that 'giving seed unasked' is, in some cases (in particular in Zimbabwe), associated with the possibility of witchcraft (Manyere, 2014a). The data in this study did not identify any pattern related with these phenomena. It is possible that these cultural issues do not play an important role in the diffusion of seeds of a new variety, that the differences in wealth status between the sharers were small (all were relatively poor), and that the relationship with friends and relatives, who were the main beneficiaries of shared seeds are less subject to such social restrictions.

### Conclusions

Inviting farmers to demonstration trials, providing them with 1–5 kg packages of legume seeds, inputs and information, and encouraging them to share their seeds and newly acquired knowledge across eight sites in four countries where N2Africa collaborators operated, generated considerable diffusion of the seeds and important multiplier effect for access to new legume seeds. An extrapolation made from the data gathered for this study indicates that in addition to the 250,000 farmers reached directly through the N2Africa project, about 1.4 million more farmers may have been reached through the spontaneous diffusion of

seed over the course of the project. Although sharing seeds as a gift was the dominant transaction form, a considerable number of farmers shared seeds through loans or by selling them. These later forms indicate an interest among other farmers to try and plant the new seeds.

Packages of 1–2 kg seem to be sufficient to start farmers off, allowing them to taste some and plant the rest. There are no indications from this study that, with such amounts, farmers require several seasons to evaluate the seed and bulk it up so as to have enough to share. However, in situations of scarcity, it may be more logical to consume (the majority of) the seed rather than keeping it for planting. Overall, this study indicates that, when a new crop variety or crop is interesting for farmers, the diffusion of seeds is not likely to be a limiting factor. If the new crop or variety is only interesting with additional inputs or (knowledge of) management practices, the situation might be more challenging: some information – such as that about rhizobium inoculum – seems to spread reasonably well, but this does not necessarily imply that farmers understand it well or have access to it.

Identifying who are the best sharers and help to diffuse the seed and technology beyond the introduction points is relevant in understanding the multiplier effect. Tadesse et al (2017) found that better-off farmers were better sharers than the poor, and thereby more relevant to reach poor farmers with seed of improved varieties as well. In this study, the demonstration trials and associated training and seed-handouts were the introduction points. And although legume crops are known as women crops, the men contributed substantially to diffusing the legume seeds. Men were at least as good in sharing seeds as women because they shared with at least as many others as women and more often with persons of opposite sex. An unconscious bias or perceived mis-targeting may thus not have been harmful at all. The results show that knowing about the character of the seed sharing mechanisms may offer opportunities to influence the diffusion of seeds. Providing farmers with somewhat larger amounts of seeds, emphasising the importance of sharing seeds and information with relatives and friends could be an important factor in achieving a high multiplier effect.

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### References

- Almekinders CJM, Ronner E and van Heerwaarden J (2016) *Tracing Seed Diffusion from Introduced Legume Seeds Through N2Africa Demonstration Trials and Seed-input Packages*. Available at: <https://library.wur.nl/WebQuery/wurpubs/fulltext/397991> (accessed 21 January 2020).
- Balele Mgasia D (2014) How farmers acquire and share knowledge and technology. A case study on N2Africa-promoted legume technologies in the Salima and Dedza district, Malawi. Internship report for N2Africa/KTI, Wageningen University.
- Bezner-Kerr R (2007) Participatory research on legume diversification with Malawian smallholder farmers for improved human nutrition and soil fertility. *Experimental Agriculture* 43(4): 437–453.
- David S, Mukandala L and Mafuru J (2002) Seed availability, an ignored factor in crop varietal adoption studies: a case study of beans in Tanzania. *Journal of Sustainable Agriculture* 21: 5–20.
- Manyere F (2014a) Understanding female farmers practices with special attention to seed sourcing of legume crops. A case study from Makoni District Zimbabwe. MSc Thesis, Wageningen University.
- Manyere F (2014b) Case studies on non-facilitated diffusion of legume technologies in Zimbabwe. Internship report for N2Africa/KTI, Wageningen University.
- Pircher T, Almekinders CJM and Kamanga BM (2013) Participatory trials and farmers' social realities: understanding the adoption of legume technologies in Malawian farmer community. *International Journal of Agricultural Sustainability* 11(3): 252–263.
- Sperling L and Loevinsohn ME (1993) The dynamics of adoption: distribution and mortality of bean varieties among small farmers in Rwanda. *Agricultural Systems* 41: 441–453.
- Tadesse Y, Almekinders CJM, Schulte RPO, et al. (2017) Tracing the seed: seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia. *Experimental Agriculture* 53(4): 481–491.
- van 't Foort J (2014) Diffusion of N2Africa knowledge and seeds and information in 2 sites in west Kenya. Internship report for N2Africa/KTI, Wageningen University.
- Woomer PL, Huising J and Giller KE (2014) *N2Africa: Final Report of the First Phase 2009-2013*. Wageningen University. Available at: [www.n2africa.org/content/n2africa-final-report-first-phase-2009-2013](http://www.n2africa.org/content/n2africa-final-report-first-phase-2009-2013) (accessed 21 January 2020).
- Zangenia F (2014) Diffusion of N2Africa seeds and information in 2 sites in northern Ghana. Internship report for N2Africa/KTI, Wageningen University.