Feed the Future Innovation Lab for Food Security Policy

Research Paper 179 August 2020

Burma Food Security Policy Project (FSPP)

VARIETY ADOPTION AND DEMAND FOR QUALITY SEED IN THE CENTRAL DRY ZONE OF MYANMAR

By

Duncan Boughton, Simrin Makhija, Mywish Maredia, David Mather, David Megill, David L. Ortega, Ellen Payongayong, Lavinia Plataroti, David J. Spielman, Marja Thijssen, and Myat Thida Win

Food Security Policy *Research Papers*

This *Research Paper* series is designed to timely disseminate research and policy analytical outputs generated by the United States Agency for International Development (USAID) funded Feed the Future Innovation Lab for Food Security Policy (FSP) and its Associate Awards. The FSP project is managed by the Food Security Group (FSG) of the Department of Agricultural, Food, and Resource Economics (AFRE) at Michigan State University (MSU), and implemented in partnership with the International Food Policy Research Institute (IFPRI) and the University of Pretoria (UP). Together, the MSU-IFPRI-UP consortium works with governments, researchers and private sector stakeholders in Feed the Future focus countries in Africa and Asia to increase agricultural productivity, improve dietary diversity and build greater resilience to challenges like climate change that affect livelihoods.

The papers are aimed at researchers, policy makers, donor agencies, educators, and international development practitioners. Selected papers will be translated into French, Portuguese, or other languages.

Copies of all FSP Research Papers and Policy Briefs are freely downloadable in pdf format from the following Web site: http://canr.msu.edu/fsp

Copies of all FSP papers and briefs are also submitted to the USAID Development Experience Clearing House (DEC) at: http://dec.usaid.gov/

AUTHORS (are listed in alphabetical order)

Duncan Boughton (boughton@msu.edu) is Professor, Department of Agricultural, Food and Resource Economics, MSU and a policy advisor in the Department of Planning of the Ministry of Agriculture, Livestock and Irrigation (MOALI).
Simrin Makhija (s.makhija@cgiar.org) is Senior Research Analyst, Environment and Production Technology Division, IFPRI.
Mywish Maredia (maredia@msu.edu) is Professor, Department of Agricultural, Food and Resource Economics, MSU
David Mather (matherda@msu.edu) is Assistant Professor, Department of Agricultural, Food and Resource Economics, MSU.
David Megill (davidmegill@yahoo.com) is a private consultant.
David Ortega (dlortega@msu.edu) is Associate Professor, Department of Agricultural, Food and Resource Economics, MSU.
Ellen Payongayong (payongay@msu.edu) is Specialist, Department of Agricultural, Food and Resource Economics, MSU.
Lavinia Plataroti (lavinia.plataroti@wur.nl) is Junior Advisor Seed Systems, Wageningen University & Research, Wageningen Centre for Development Innovation.
David J. Spielman (d.spielman@cgiar.org) is Senior Research Fellow, Environment and Production Technology Division, IFPRI.
Marja Thijssen (marja.thijssen@wur.nl) is Senior Advisor Seed Systems, Wageningen University & Research, Wageningen Centre for Development Innovation.
Myat Thida Win (winmyat@msu.edu) is a graduate research assistant, MSU.

Authors' Acknowledgment:
The authors are thankful for the support of colleagues in the Department of Agricultural Research, the Department of Agriculture, and the Department of Planning of the Ministry of Agriculture, Livestock and Irrigation (MOALI) and the Department of Population, Ministry of Labour, Immigration and Population (MLIP). Financial support for this review was provided by USAID Burma through the Food Security Policy Project, the Program on Integrated Seed Sector Development—Myanmar, funded by the Directorate General for International Cooperation, Government of the Netherlands; the Livelihoods and Food Security (LIFT) Fund, and the CGIAR Research Program on Policies, Institutions, and Markets, led by the International Food Policy Research Institute (IFPRI) and carried out with support from the CGIAR Fund contributors (https://www.cgiar.org/funders/).

This study is made possible by the generous support of the American people through the United States Agency for International Development (USAID) under the Feed the Future initiative. The contents are the responsibility of the study authors and do not necessarily reflect the views of USAID or the United States Government

Published by the Department of Agricultural, Food, and Resource Economics, Michigan State University, Justin S. Morrill Hall of Agriculture, 446 West Circle Dr., Room 202, East Lansing, MI 48824

EXECUTIVE SUMMARY

For countries like Myanmar, where crop production accounts for the largest share of agricultural GDP, improved varieties are an essential source of increased and/or more stable crop yields. The adoption of improved varieties often increases the incentives for farmers to invest in complementary improved crop and soil management practices. For this reason most countries give priority to variety development, and Myanmar is no exception despite the very limited research budget allocated to crop research by the government.

Yet improved varieties only generate benefits for farmers if they are adopted, and farmers only adopt new varieties if they are aware of their existence and benefits. For farmers to evaluate and adopt improved varieties they need access to quality seed (seed which is pure, exhibiting only the true genetic characteristics of the variety, with a high level of germination and uncontaminated by disease, weed seeds or other foreign matter). Access to quality seed is important because the attributes of farmer-saved seed degenerate with multiple seasons of use. Sustained benefits from variety adoption therefore require farmer awareness of, and access to, quality seed which preserves those benefits.

Despite the importance of variety adoption and access to quality seed for crop productivity growth very few survey-based studies have been conducted in Myanmar. Our study focuses on the Dry Zone. This major agro-ecological zone was chosen for the following reasons. First, the Dry Zone is home to approximately 10 million people who are dependent directly or indirectly on farming for their incomes; second, a wide variety of crops are grown in the Dry Zone for which improved varieties have been officially released; third, access to improved varieties is recognized as an important means to adapt to rapid climate change experienced in the Dry Zone over the past thirty years (increased frequency of flooding and drought); and fourth, no previous survey-based studies on this topic have been undertaken for this zone.

The specific objectives of the study are: 1) to determine the level of adoption of improved varieties for eight target crops; 2) to assess farmer preferences for varietal attributes for each of the crops; and 3) to assess the demand for quality seed. Data were collected using community and household surveys in 6 townships, two in each of the three regions that comprise the Dry Zone (Sagaing, Magwe and Mandalay Regions). Interviews were completed for a total of 1,388 households that produced at least one of the eight focus crops: rice, sesame, groundnut, pigeonpea, chickpea, green gram, black gram and sunflower. *The results indicate that lack of awareness, not just lack of access, underlies low levels of uptake of improved varieties and quality seed by Dry Zone farmers.* The good news is that this a problem that can be resolved through more intensive dissemination efforts, especially on-farm demonstrations that allow farmers to compare the performance of improved varieties or quality seed with their existing stock.

The highest level of adoption of varieties perceived by farmers to be improved was 41% in the case of sunflower, and lowest for pigeon pea at 8%. Triangulation of farmer reported use of improved varieties with the opinions of research and extension experts (based on the characteristics of officially released varieties), the actual level of adoption of improved varieties ranges from 6% for groundnut to 79% for chickpea. Compared to other countries in South, Southeast, and East Asia, the estimated adoption rate of improved varieties based on farmers' own assessment is at the lower end of the rates reported in recent years. Furthermore, based on the estimated weighted average age of varieties and varietal turnover rates, farmers on average are growing older varieties (on average 18 years) and growing them for a longer period of time before replacement (on average about 12 years). Peer farmers appear to be the most important source of exposure to new varieties, as well as the main source of seeds of new varieties.

One implication of the key role of peer farmers is that on-farm demonstrations have a potentially important role to play to increase farmer exposure and adoption of new varieties. Although more than half of farmers (57%) in the Dry Zone reported receiving extension information about seed, only 11% received information from a public extension worker. Among farmers who received information about seed only one in six received information about improved varieties. *Only one in twenty farmers had access to a field demonstration of an improved variety.* The low penetration of information about new varieties through demonstrations is probably a reflection of multiple constraints such as limited extension coverage, limited mobility of extension workers, the lack of practical training in how to engage with farmers, the absence of an objective results monitoring system for extension, and the absence of incentives for extension workers to promote variety adoption.

The lack of demand for quality seed is reflected in low seed replacement rates for existing varieties. These rates vary widely by crop but range from once every 6.6 years on average for sunflower to once every 13.2 years for pigeonpea. For rice, the average frequency of seed replacement for a variety in use is once every 6.9 years.

Seed quality is very difficult for farmers to perceive by visual inspection. Hence seed certification schemes are often employed to provide farmers with a guarantee of seed quality. In the absence of effective formal certification schemes, trust in the seed supplier is an important factor. Our survey found three major patterns in farmer seed acquisition. First, own-saved seed and informal seed sources play the largest role in households' acquisition of seed, while the formal system plays a relatively small role, with the exception of rice, sunflower, and black gram. Second, many of the farmer-to-farmer exchanges of seed are monetized: farmers pay for seed purchased from their neighbors or from other informal sources, as well as from the government, and depend far less on free exchanges. Third, there is little evidence of free seed distributions, whether from government or non-governmental sources, which can undermine the development of market-based access to seed. *These findings indicate that a vibrant informal seed market exists in the study area, and hence potential opportunities for growth of local seed businesses.*

Informal sources rarely provide packaging or labelling whereas this is more frequent for formal or intermediate seed sources. For specific varieties of rice, for example, formal sector rates of packaging are 71 percent, labelling 46 percent, and certification 62 percent. High rates are also observed for sunflower (62, 62, and 100 percent, respectively), and similar rates are observed for green gram and chickpea. For groundnut, while packaging and labeling are not observed among formal/intermediate seed sources, seed of the varieties being acquired is reportedly certified. Despite the use of packaging and labeling, seed from formal sources is not perceived by farmers as being significantly better in quality than seed from informal sources or own-saved seed. But given the small number of observations for formal and intermediate sources, there are limits to the interpretation of these findings.

Access and trust are important factors in farmer choice of seed source. For government seed farms and farmer seed producers, lack of access explains about 50 percent of all respondents' reasons for not using these sources. In the case of traders, lack of trust in the quality of seed being sold explains 50 percent of all respondents' reasons. Among agro-dealers and input retailers, farmers responded that a lack of access, a lack of trust in seed quality, and better seed source alternatives equally explain their reasons for not using seed from this source.

In the absence of formal quality assurance mechanisms, the seed from the government stands for good quality and is preferred the most by farmers, followed by seed saved from their own harvests. Seeds from agro-dealers that come in a package and are labeled are also perceived to be of high quality relative to all other sources of seeds that are not packaged or have no labels. Thus, it seems that traceability and quality assurance symbolized by packaging and labeling are important to farmers and are associated by them with good quality seed.

Based on the area cultivated and quantity of seeds planted per unit of land, total quantities of seed required annually for planting the total Dry Zone area of a given crop range from more than 7.45 million baskets for rice, 2.95 million baskets for groundnut, and about 1.25 million baskets for chickpea, to about 200-500 thousand baskets for sun flower, pigeon pea, green gram, and sesame. Of this requirement, the percentage met through purchase from the market (either through informal, semi-formal or formal avenues) is highest at about 78% for sunflower, 74% for rice, 68% for black gram, 60% for chickpea, 58% for green gram, 44% for sesame, 32% for groundnut, and 20% for pigeon pea. The rest is met through own-saved seed.

Overall, data suggest that the seed market for rice, oilseeds, and pulses in the Central Dry Zone region is dominated by grain seed produced by farmers themselves or procured through grain market channels. Although farmers know the attributes of quality seed (i.e., germination rate, seed health, uniformity) their willingness to pay for quality seeds appears to be low (in the range of 5-28%), which may not be enough to cover the cost of producing quality seed and sustaining a seed system based on a private seed company based model.

The findings of this study have important implications for seed sector development in Myanmar. First, our results suggest that expansion of on-farm demonstrations could be an effective approach to increase farmer exposure to improved varieties and quality seed. Increasing farmer awareness of the need for regular seed replacement through extension and education programs are also needed to increase farmer demand and their willingness to pay for quality seed. Second, farmer seed producers (i.e., seed entrepreneurs) may have a competitive advantage in supplying seeds to their communities due to lower costs, and thus need to be strengthened through training and capacity building efforts and developing an appropriate regulatory framework. Finally, for these SMEs to play an increased role in the seed sector, they need access to high quality early generation seed of public varieties to produce quality commercial seeds for farmers in local communities.

TABLE OF CONTENTS

ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
ADS	Agricultural Development Strategy
AFRE	Department of Agricultural, Food, and Resource Economics
AgPER	Agricultural Sector Public Expenditure Review
AIS	Agricultural Innovation System
AVRDC	World Vegetable Center
BLB	Bacterial Leaf Blight
CGIAR	formerly the Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
DAR	Department of Agricultural Research
DOA	Department of Agriculture
DOP	Department of Planning
EGS	Early Generation Seed
FSP	Feed the Future Innovation Lab for Food Security Policy
FTE	Full Time Equivalent
GDP	Gross Domestic Product
HQ	Head Quarter
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
INGO	International Non-Governmental Organization
IRRI	International Rice Research Institute
LIFT	Livelihood and Food Security
MAS	Marker Assisted Selection
MLFRD	Ministry of Livestock, Fisheries and Rural Development
MOALI	Ministry of Agriculture, Livestock and Irrigation
MSU	Michigan State University
M&E	Monitoring and Evaluation
NARC	National Agricultural Research Council
NARES	National Agricultural Research and Extension System
NGO	Non-Governmental Organization
OPV	Open Pollinated Variety
PHI	Post-Harvest Institute
RRC	Regional Research Centre
SPV	Self-Pollinated Variety
SWOT	Strengths, Weaknesses, Opportunities and Threats
USAID	United States Agency for International Development
YAU	Yezin Agricultural University

1. INTRODUCTION

Agriculture is a key sector for Myanmar's economy. In addition to ensuring national food and nutrition security, the sector has a unique advantage for achieving broad-based poverty reduction given that 87% of Myanmar's poor live in rural areas (MOPF, 2017). Growth in the productivity and incomes of Myanmar's farms can help drive growth in the rural economy through farm employment and incomes, as well through service industries such as farm mechanization rental services, transport, value-added processing and retailing. Domestic and regional food markets are growing rapidly, especially for higher value produce like fruits, vegetables, fish, meat, eggs and dairy products. Yet the actual rate of agricultural growth in Myanmar has been less than half that of the overall growth rate of the economy averaged over the past five years (World Bank, 2017). Increased rural incomes and year-round availability of diverse and affordable nutrient sources are essential drivers of improved nutrition outcomes (Mahrt et al., 2019).

Access to improved varieties and quality seed is well known to be a foundation for crop productivity. Varieties that are not well adapted to biotic and abiotic stresses cannot deliver high yields. Similarly, seed of varieties that are genetically degraded, infected with seed-diseases, or have low germination potential also cannot realize potential yields. With the exception of one study on rice in the Delta (Subedi et al., 2017) there are no empirical studies of either variety adoption or the uptake of quality seed in Myanmar.

Three reasons guided the choice of the central Dry Zone for this study. First, it is home to a population of 10 million people who depend primarily on agriculture and the rural economy. Second, the wide range of crops are grown in the Dry Zone allows us to understand farmer preferences and decisions for more crops of interest. Third, the Dry Zone has been subject to rapid climatic changes over the past three decades (Cornish et al., 2018), and varieties that are better adapted could potentially help farmers to reduce losses and improve productivity.

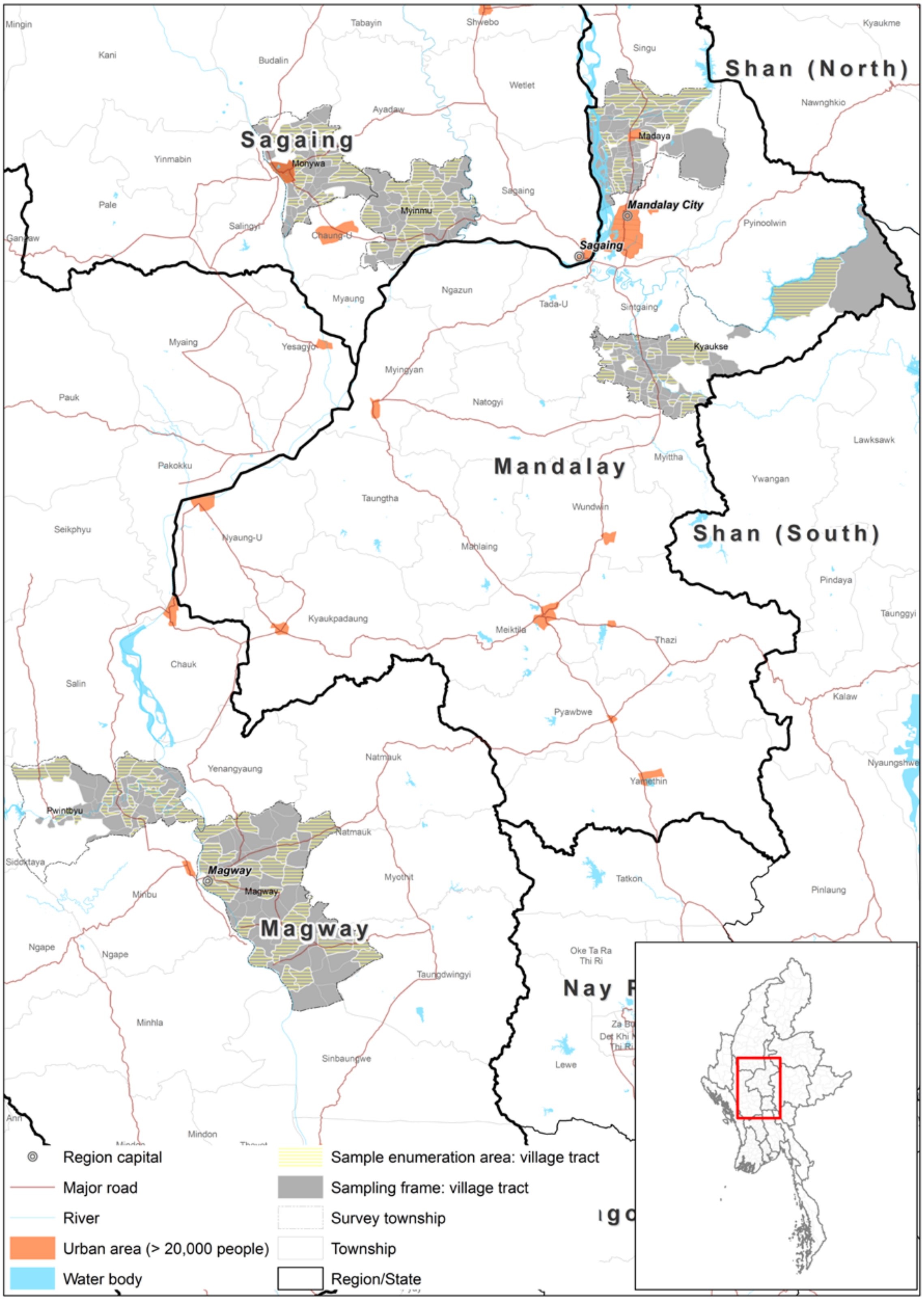
2. SURVEY DESIGN AND SAMPLING METHOD

The survey was conducted in 6 townships of the Dry Zone, in each of the three regions that comprise the Dry Zone (Figure 2.1). They include the townships of Myinmu and Monywa in Sagaing Region, the townships of Magway and Pwint Phyu in Magwe region, and the townships of Madaya and Kyaukse in Mandalay region.

2.1 Sample size and allocation

Since the survey results will be analyzed at the township level, a total of 24 sample EAs were selected within each township at the first sampling stage, for a total of 144 sample EAs. Following the listing in each sample EA to identify all the eligible households growing at least one crop of interest, 10 eligible households were selected in each sample EA. Therefore the maximum sample size would be 1,440 eligible households. However, some EAs had less than 10 households growing one or more eligible crops, in which case all of these households were selected for the survey at the second stage.

Figure 2.1 Map of Survey Townships in the Dry Zone



The 24 sample EAs within each township were first allocated proportionally to the different strata, and then the sample allocation was adjusted to increase the number of sample EAs for the special strata with less frequent crops, with a corresponding decrease in the number of sample EAs allocated to the "other" stratum in the township. This procedure increased the number of sample observations for the less frequent crops.

The allocation of the sample EAs and sample households by stratum for the Dry Zone Seed Survey is presented in Table 2.1.

Table 2.1 Allocation of sample EAs and households by stratum for the Dry Zone Seed Survey in six townships

Stratum code	Stratum	No. of sample EAs	Maximum no. of sample households with crops of interest
11	Myinmu Other	14	140
12	Myinmu Sunflower	7	70
13	Myinmu Chickpea	3	30
21	Monywa Other	12	120
22	Monywa Blackgram	12	120
31	Magway All	24	240
41	Pwint Phyu All	24	240
51	Madaya Other	8	80
52	Madaya Pigeon Pea	9	90
53	Madaya Blackgram	7	70
61	Kyaukse Other	12	120
62	Kyaukse Groundnut	4	40
63	Kyaukse Pigeon Pea	8	80
Total sample		144	1,440

Following the survey implementation, it was found that some of the sample EAs had less than 10 households growing at least one of the crops of interest. There were also two sample EAs where there were no households growing any crops of interest. In one case the main occupation of the village was brick production, and in the other case the agricultural land was confiscated by the army and the university. The final number of eligible households with completed interviews was 1,388.

2.2 Sample selection procedures

At the first sampling stage the sample EAs were selected within each stratum systematically with PPS, based on the number of private households in each EA from the 2014 Census frame. The number of sample EAs selected in each stratum is based on the sample allocation specified in Table 2.1. This selection of sample EAs was conducted by the Department of Population of the Ministry of Labour, Immigration and Population, which is responsible for the national sampling frame based on the 2014 Myanmar Census. They used the Complex Samples module of the SPSS software for the first stage selection of sample EAs using systematic PPS sampling. The EAs in the sampling frame for each stratum were sorted geographically by the village track and EA codes in order to provide implicit stratification and ensure that the sample is geographically representative within each township.

Following the listing operation in each sample EA to identify all the households growing at least one crop of interest, at the second sampling stage a sample of 10 eligible households with the specified crops were selected in each EA using random systematic sampling. In the case of EAs with less than 10 eligible households listed, all of these households were selected with certainty at the second sampling stage.

3. CHARACTERISTICS OF SURVEY HOUSEHOLDS AND CROP PRODUCTION IN THE DRY ZONE

This section provides and overview of the characteristics of survey households and their crop production. It provides the context in which decisions about variety adoption and seed acquisition are made.

3.1 Crop use and main constraints

Given that rice is the staple cereal of Myanmar, it is not surprising that 90% of households live in communities that consider it to be of "high" importance for food (Table 3.1).[1] The other crops which are of "high" importance for food include sesame (43% of households), groundnut and sunflower (39% each). Only 16% of households consider chickpea to have a "high" importance for food, and less than 2% of households rate green gram, black gram or pigeon pea the same.

With the exception of sunflower, approximately half or more of households live in communities in which the other main crops are considered to be of "high" importance for earning income. Groundnut and chickpea appear to be among the most commercialized crops, as 76% (73%) of households live in communities where groundnut (chickpea) is of "high" importance for income. There is also significant variation in a crop's level of importance for income across regions, as between 87% to 99% of households in Sagaing live in communities where chickpea, pigeon pea, black gram and green gram are considered to be of "high" importance for income. Yet, the corresponding percentages of households in the other two regions that consider these crops to be of "high" importance for income is mostly than 50%.

Table 3.1 Percentage of households for which each crop is of "high" importance for income and for food, by crop

	% of Households for which crop is of "high" importance for:							
	---------- Income ----------				---------- Food ----------			
Crop	Sagaing	Magway	Mandalay	Total	Sagaing	Magway	Mandalay	Total
Rice	34	61	55	54	80	87	99	90
Sesame	65	66	33	58	33	50	36	43
Groundnut	75	85	36	76	37	45	19	39
Sunflower	25	0	61	18	63	39	0	39
Green gram	87	25	52	46	3	0	3	2
Black gram	98	27	44	57	0	0	0	0
Pigeon pea	99	41	43	59	0	0	0	0
Chickpea	99	67	57	73	4	24	15	16

Source: All statistics presented in this and other tables or figures in this report are authors' calculations from the Dry Zone Household Seed Survey (2018) unless otherwise noted.

[1] The results presented in Tables 3.1 and 3.2 are based on community-level data from the Dry Zone Community Seed Survey. Because communities are not equally representative of the population in the surveyed townships, we merged this community-level data with household-level data in order to apply households sampling weights.

Two of the most important constraints to production and marketing of the Dry Zone's key crops as noted by community leaders are market prices and labor constraints. For example, 65% of households live in communities where "price too low" is the main constraint for pigeonpea, also cited by 28 to 30% of households for sesame, green gram and chickpea. Likewise, 37% of households live in communities where "labor constraints" were cited as the main constrain for rice, and also cited by 28 and 24% of households for groundnut and green gram, respectively. Only 2 to 8% of households live in communities where "lack of suitable varieties" was considered the main constraint for production of the main crops. Likewise, only 1 to 5% of households live in communities where "seed availability" was considered to be the main constraint. However, insect and disease problems, which are the main constraint for 10 to 31% of households, depending on the crop, appears to be the second-most frequently cited main constraint to crop production (after market prices). This suggests that there are some variety- and seed-related issues of importance even in a community-level assessment of constraints to crop production and marketing.

Table 3.2 Most important constraint to farming, by crop (% of households)

Constraint	Rice	Sesame	Groundnut	Green gram	Pigeon pea	Chick pea
Land constraints	13	2	4	1	2	5
Labour constraints	37	16	28	24	4	8
Cash constraints	18	12	14	4	0	10
Lack of suitable varieties[1]	8	3	4	2	3	6
Seeds not available	1	3	5	1	1	3
Insect & disease problems	15	23	16	31	10	23
Cannot sell the crop	1	2	1	0	6	1
Price too low	5	28	16	30	65	30
No information / technical advice[2]	1	2	9	6	3	10
Other	2	9	3	2	5	5

Notes: 1) Lack of varieties suitable for this area; 2) No information or technical advice on farming practices.

3.2 Household demographics and other characteristics

The average household size is 4.4 individuals, or 3.8 adult equivalents[2] (Table 3.3). The average household dependency ratio of 0.56 implies that for every dependent household member (children age 0-14 and adults age 61 and over), there are two adults age 15 to 60, on average.[3] The average years of education of the household head is 5.8, which is nearly equivalent to finishing the second of six years of secondary education.[4] Given this average level of education, it is not surprising that nearly all household heads (96%) are literate. The percentage of households headed by a female is somewhat

[2] Adult equivalent (AE) is a measure that adjusts the size of a household to reflect its caloric consumption needs based on the age and gender of each individual in the household. AE scale is based on Table A2.4 from MoPF and World Bank (2017).
[3] Dependency ratio calculated as (# of children age 0-14 + # of adults age 61+) / # of adults age 15-60.
[4] Secondary education includes grades 5 through 10.

lower (16%) than the national average of 21% among rural households (MoHS & ICF, 2017), suggesting a lower propensity for male household heads from rural areas of the Dry Zone to migrate.

Most households (80%) own a motorized vehicle. For nearly all households, this is a motorcycle (owned by 79% of households), as relatively few households own other vehicles (5% own a trawlarjee, 2% a car and 1% a truck). Most households (87%) also own a mobile phone, and for most households (84%) these are smartphones. Most households (74%) received agricultural credit in the last year. Fifty-seven percent of households received seed-related agricultural extension information in the last year, while 62% received non-seed-related agricultural extension information. Additional information on agricultural extension access is discussed in section 3.4.

Table 3.3 Household demographics and other characteristics

Household (HH) characteristic	Mean or %	SD	N
Household size (number of resident members)	4.4	1.6	1,383
HH size in adult equivalents	3.8	1.4	1,383
HH dependency ratio	0.56	0.59	1,354
HH head's age (years)	54	13	1,383
HH head's education (years)	5.8	2.2	1,383
HH head is literate (%)	96	21	1,383
HH head is female (%)	16	36	1,383
HH owns any motorized vehicle (%)	80	40	1,383
HH owns smartphone or other cell phone (%)	87	33	1,383
HH received agricultural credit in last year (%)	74	44	1,383
HH received seed-related ag extension information in last year	57	50	1,383
HH received non-seed-related ag exten. information in last year	62	49	1,383

Notes: 1) Adult equivalent scale from GOM-MPF & WB (2017).

3.3 Household landholding and access to irrigation

Nearly every sample household (99%) owned and operated agricultural land in the past year. (Table 3.4). The land rental market is limited in the Dry Zone, with only 6% of sample households operating agricultural parcels that were rented- or borrowed-in. The average (median) of total household agricultural land that is owned and operated was 7 (5) acres, while the average (median) amount of agricultural land that is rented- or borrowed-in is 3.3 (2) acres. The average (median) of total household agricultural land owned, rented- or borrowed-in and operated is 7.2 (5.5) acres.

Table 3.4. Household landholding

Household landholding characteristics	Mean or %	Median	N
% of households that own and operate agricultural land (%)	99		1,383
% of households that operate rented- or borrowed-in ag land (%)	6		1,383
Total agricultural land owned and operated by HH (acres)	7.1	5.0	1,365
Total agricultural land rented- or borrowed in & operated (acres)[1]	3.3	2.0	79
Total agricultural land owned, rented/borrowed in & operated (acres)	7.2	5.5	1,383

Notes: 1) figures only computed for those with non-zero values

Sixty-one percent of agricultural parcels in the sample are rainfed, while 39% receive irrigation from a dam, well/groundwater, river/stream, or pond/lake (Table 3.5). Dam irrigation is the primary source of irrigation, accounting for 71% of irrigated parcels. Access to irrigation varies considerably by the townships in our survey, as those in Mandalay are much more likely to have access to irrigation while those in Sagaing are much more likely to cultivate rainfed parcels.

Table 3.5. Primary water source for agricultural parcels

Primary water source for agricultural parcels	Sagaing	Magway	Mandalay	Total
	---------- % of parcels ----------			
Rainfall	85	66	21	61
Dam irrigation	2	26	60	28
Well / groundwater	8	6	8	7
River / stream	4	2	11	5
Pond / lake	0	0	0.2	0.05

3.4 Household access to agricultural extension

A majority of sample farmers (57%) received seed-related information from one or more sources of agricultural extension within the past year (Table 3.6). The main source of seed-related agricultural extension information received was from Radio/TV/Publication (32% of households), followed by farmer organizations (21%) and agro-dealers (20%). Government extension reached 11% of farmers with seed-related extension information. Only 3% of farmers report having ever attended a training program related to quality seed production, storage, or marketing.

A majority of farmers (62%) also received agricultural extension information not related to seed within the past year (Table 3.6). The main sources of non-seed-related agricultural extension were Radio/TV/publication (34%), agro-dealers (29%) and farmer organizations (20%). Government extension reached 14% of farmers with extension information unrelated to seed.

Among those farmers reporting receipt of agricultural extension information in the last year, a majority received such information more than once when all sources are combined. For example, 34% of households received extension information once in the last year from all sources combined, 32% received such information twice, 26% received it 3 to 5 times, and 8% received it 5 or more times.

Among sample farmers that received extension information in the past year, only 6% report receiving this information by visiting a demonstration plot or attending a field day, while 3% received this information by attending a trade show, seed event, or agricultural fair. Only 6% reported having a household member who participated in any other type of agricultural training within the past 3 years. However, 30% of farmers reported that they used a mobile phone to access agricultural information or crop prices on the internet. Given that most farm households own a smartphone, this finding suggests that internet-based agricultural extension information could potentially be an important source of such information provided by government, NGOs, agro-dealers, etc. for farm households in the Dry Zone.

Table 3.6 Household access to agricultural extension in last year

Source of agricultural extension visit/information	% of HHs receiving extension information by information type	
	Seed-related	Not seed-related
Any source	57	62
Government extension	11	14
NGO	6	9
Agro-dealer	20	29
Seed company	12	14
Farmer organization	21	20
Trader	5	8
Internet	5	5
Radio/TV/publication	32	34
Other farmers	2	2

Among farmers that received seed-related agricultural extension information in the last year, there were six main topics covered. The most frequently noted topics included “how to plant seed” (17% of farmers), followed by “seed outlets” and “new varieties” (15% of farmers for both), “selection of quality seed from harvest” (13%), “the value of using quality seed” (12%), and “seed storage” (9%) (Table 3.7).

Table 3.7 Information obtained from seed-related agricultural extension visit

Among households that received seed-related agricultural extension information in the last year, what % obtained information about:	
The value of using quality seed	12
Seed outlets	15
New varieties	15
Selection of quality seed from harvest	13
Seed storage	9
How to plant seed	17
Chemical inputs	0.2
Prices	0
Paddy cultivation	0.04

3.5 Access to non-farm income sources and remittances

While farming is the primary occupation for 72% of adults in the sample, non-farm employment or own business management is the primary occupation of 23% of adults in the sample. These percentages are similar to the average share of total household income from farm (73%) and non-farm income (27%) sources found in the 2017 Rural Economy and Agriculture Dry Zone (READZ) survey among households that own agricultural land (Boughton et al, 2018). In addition, 14% of sample households report receipt of remittances in the last year from an international migrant, while 2% report receipt of remittances from a domestic migrant.

Household access to non-farm income and remittances has a potentially important role in technology adoption. Among READZ survey farm households with non-farm income, more than half report that non-farm income was either their first or second most important source of financing for their farm production activities.[5] Likewise, among the 12% of READZ farm households that received remittances, 67% report that remittance income served as their first or second most important source of financing for their farm production activities.

3.6 Household crop production and utilization

3.6.1 Average crop area planted

The average acreage planted per household was highest for sesame (14.2 acres), pigeon pea (14.1 acres), and groundnut (10.2 acres) (Table 3.8). However, median acreage planted per household for these three crops was considerably smaller, with 3.8 acres for sesame, 2 acres for pigeon pea and 3.5 acres for groundnut. The average area planted to monsoon rice was 5.2 acres and dry season rice 5 acres.

[5] Statistics in this paragraph were computed by the authors from READZ household survey data.

Table 3.8. Mean and median household area planted, total production, percentage of production that is sold, consumed/retained, and saved for seed, by crop

Variable	Unit	Mon Rice	Dry Rice	Sesame	Groundnut	Sunflower	Green Gram	Black Gram	Pigeon pea	Chickpea
Area planted (acres)	Mean	5.2	5.0	14.2	10.2	2.9	5.7	45.6	14.1	4.2
	Median	3.0	2.5	3.8	3.5	2.0	2.0	2.0	2.0	2.5
	SD	27.5	19.1	73.1	52.5	2.4	43.1	222.0	96.7	14.9
	N	588	247	584	376	39	222	52	305	450
Total production (baskets)	Mean	303	285	28	155	31	20	18	15	30
	Median	150	180	12	80	15	10	10	10	20
	SD	2469	314	165	288	39	42	25	22	34
	N	588	247	584	376	39	222	52	305	450
% of production that is sold (%)	Mean	55	83	84	77	38	93	85	85	71
	SD	40	31	28	29	41	18	29	31	39
	N	579	245	548	369	37	214	47	290	427
% of production consumed or retained (%)	Mean	41	15	12	13	56	3	11	10	17
	SD	39	30	27	27	40	14	28	28	34
	N	579	245	548	369	37	214	47	290	427
% of production saved for seed (%)	Mean	4	2	5	10	6	4	4	5	12
	SD	8	4	9	14	14	10	6	15	20
	N	579	245	548	369	37	214	47	290	427

Note: "Mon" Rice = monsoon rice; "Dry" Rice = post-monsoon rice

3.6.2 Crop utilization

Sunflower, grown by only 3% of sample households, is the least commercialized crop, with a household average of only 38% of total production that is sold, while 56% is retained (Table 3.8). Among the main crops, monsoon rice is the least commercialized, as just over half (55%) of household total production is sold, on average, with 41% retained for consumption. The most commercialized crop is green gram, with an average of 93% of household total production that is sold, and less is retained for consumption (3%) than for seed (4%). The other crops are also predominantly commercialized, with an average percentage of household production that is sold ranging from 71% for chickpea to 85% for pigeon pea.

The highest average rates of household production saved for seed are for chickpea (12% of total production, on average) and groundnut (10%) (Table 3.8). Monsoon and dry season rice have the lowest rates at 3 and 2%, respectively. The rates of other crops range from 4 to 6%.

3.7 Household crop productivity and profitability

3.7.1 Expected crop yields by type of climatic year

Before discussing observed crop yields from the household survey data, we first provide some context by presenting expected yields under different growing conditions based on data from the 2017 READZ community survey. In order to assess the impact of climatic conditions on the variability of crop productivity, the community survey asked local leaders about typical yields of seven major crops in years when climatic conditions were *good, average,* or *bad.*[6]

Crops in the Dry Zone are subject to a significant amount of yield variation depending on weather conditions during a given year. Monsoon and dry season rice have the least amount of expected yield variation between good, average and bad climatic years, which is not surprising given that rice in the Dry Zone is predominantly irrigated, even in the monsoon (Mather et al, 2018). For example, the yield of monsoon rice in a good climatic year is expected to be 34% higher than that of an average year, while yield in an average year is 64% higher than that in a bad year (Table 3.9). By contrast, Dry Zone crops that are predominantly rainfed have considerably more yield variation by type of climatic year, especially when comparing the difference between an average and a bad climatic year. For example, the yield of sesame (groundnut) in a good climatic year is expected to be 56% (45%) higher than that of an average year, while yield in an average year is 124% (114%) higher than that in a bad year.

The expected rice yield in even a good year in the Dry Zone is well below average rice yields of neighboring countries. For example, while rice yield in a good monsoon (dry season) of 3,813 kg/ha (4,982 kg/ha) is better than that of Cambodia (3,200 kg/ha), it is well below that of Thailand (6,090 kg/ha) and Vietnam (6,120 kg/ha) (LIFT 2016).

Given this context, the observed average yield of monsoon and dry season rice from the household survey (59 and 76 baskets/acre, respectively) met the expectation for an average climatic year (Table

[6] Non-climatic factors like fertilizer use and irrigation access that influence crop productivity at the level of individual farms were assumed to be constant across the three different categories of annual climate conditions.

3.10). As expected, rice yields are higher in the dry season relative to the monsoon, given that there is considerably more sunlight during the dry season.

Table 3.9 Average Expected Crop Yields by Type of Climatic Year in the Dry Zone[7]

	Average expected yield by type of climatic year					
	Baskets/acre			Kilograms/hectare		
Crop	Good	Average	Bad	Good	Average	Bad
Monsoon rice	73.8	55.2	33.6	3,813	2,851	1,735
Dry season rice	96.5	74.0	52.7	4,982	3,824	2,719
Sesame	11.3	7.3	3.2	694	446	199
Groundnut[1]	49.8	34.3	16.2	1,405	969	458
Green gram	13.3	8.5	4.1	1,038	664	323
Pigeon pea	11.0	7.1	3.6	882	575	288

Notes: 1) with shell.

3.7.2 Household crop yields from the Seed Survey

The observed average yields of groundnut and green gram (29 and 6.9 baskets/acre, respectively) were somewhat lower than those expected in an average year, while that of sesame (5.3 baskets/acre) was between that of an average and bad year. Pigeonpea and chickpea[8] are the only rainfed crops that met (or exceeded) their yield expectation for an average year, with average yields of 7.1 and 10 baskets/acre, respectively.

Relatively low yields of many of the rainfed crops were due in part to a large percentage of growers reporting pre- and/or post-harvest yield losses for these crops. For example, 61% of sesame growers reported having either pre- and/or post-harvest yield losses, along with 41% of growers of green gram, 38% for chickpea and 26% for groundnut (Table 3.11). These losses result in considerably lower yields, which is particularly noticeable when we compare yields with and without reported yield loss.

For example, median yields for sesame growers not reporting yield loss were 2.6 times higher than those reporting losses, 2.7 times higher for green gram, and 1.6 for groundnut (Appendix Table A5). For nearly all crops, the most frequently cited reason for pre- or post-harvest yield loss was excessive rainfall (Appendix Tables A6 & A7). For example, 42% of sesame growers reported pre-harvest yield loss from excessive rain, compared with 29% of growers of chickpea, 27% for pigeon pea, 22% for green gram and 16% for groundnut. Excessive rain and an inability to control it is also a problem for rice, as 15% (10%) of dry season (monsoon) rice producers reported pre-harvest yield loss from excessive rain, and 13% (7%) experienced flooding.

[7] Although the READZ community survey included villages from 14 townships from the 3 regions of the Dry Zone, the figures in Table 3.9 are calculated using only townships also included in the Seed Survey (Magway & Pwintbu of Magway region) or adjacent townships (Chaung U & Budalin of Sagaing region; and Wetlet, Mytthia & Sintgaing of Mandalay region).

[8] As per Appendix 2, the expected yield of chickpea in a good year is 12 baskets/acre and 7 for a good year.

Table 3.10. Mean and median household yield, value & cost of production, share of seed in total costs, and gross margins, by crop

Variable	Unit	Mon Rice	Dry Rice	Sesame	Groundnut	Sunflower	Green Gram	Black Gram	Pigeon pea	Chickpea
Yield per acre (baskets/acre)	Mean	58.7	75.7	5.3	29.0	12.3	6.9	6.8	7.1	10.0
	Median	60.0	80.0	4.0	25.0	9.0	5.0	5.0	5.0	10.0
	SD	26.2	30.8	4.8	19.4	11.2	6.4	6.9	6.1	6.6
	N	588	247	584	376	39	222	52	305	450
Value of production per acre ('000 MMK / acre)	Mean	439	443	159	239	345	201	190	200	270
	Median	450	463	120	200	252	150	140	133	257
	SD	193	189	146	161	313	184	192	189	181
	N	588	247	584	376	39	222	52	305	450
Cost of production per acre ('000 MMK / acre)	Mean	198	169	135	181	81	125	120	97	127
	Median	200	175	150	200	67	146	100	90	106
	SD	89	77	64	88	43	52	52	63	62
	N	588	247	584	376	39	222	52	305	450
Gross margin per acre ('000 MMK / acre)	Mean	237	272	24	57	165	74	69	87	144
	Median	273	309	(10)	40	154	14	31	47	114
	SD	191	210	149	158	158	178	195	156	189
	N	588	247	584	376	39	222	52	305	450

Table 3.11 Percentage of households reporting pre- or post-harvest yield loss by crop

	% of households reporting yield loss		
Crop	Pre-harvest	Post-harvest	Pre- or Post
Monsoon rice	22	6	24
Dry season rice	27	9	28
Sesame	61	15	62
Groundnut	26	4	26
Sunflower	32	12	33
Green gram	41	6	42
Black gram	55	18	59
Pigeon pea	42	6	43
Chickpea	38	7	39

While each season or year can bring different climatic conditions, the prevalence of pre- and post-harvest yield loss (and the magnitude of their effect on yields) in the Seed Survey is similar to that found in the READZ household survey in 2017 (Mather et al, 2018). According to the READZ community survey, crops like sesame, groundnut, green gram and pigeon pea face "average" climatic years 3 to 5 times out of 10, and "bad" years 2 to 5, depending on the crop (ibid, 2018). The implication is that the prevalence and magnitude of pre- and post-harvest yield losses observed in both the Seed Survey in 2018 and READZ in 2017 appear to occur relatively frequently.

An underlying cause of these excessive rainfall and flooding events is how climate change has affected the distribution of rainfall in the Dry Zone over the past 60 years. A recent study found that while the average amount of rainfall during the monsoon season in the Dry Zone[9] has not changed between 1951 and 2016, the number of rainy days during the monsoon fell from 156 to 69 days during that period—a decline of 56% in days with rain (Cornish *et al.* 2018). Consequently, the average amount of rainfall per rainy day has increased dramatically. With limited capacity for rainwater infiltration in the uplands, and insufficient drainage in the lowlands, intense rains run off the uplands and flood the lowlands (Mather *et al.* 2018). In addition, the number of days with dry surface soil more than doubled from around 20% of the monsoon to greater than 50% (i.e., more days of drought stress) (Cornish *et al.* 2018).

3.7.3 Costs of production

Costs of production collected by the survey include cash costs such as the cost of seeds (if purchased); other inputs such as fertilizer, manure (if purchased) and pesticides; rental costs of machinery (tractors, combines, threshers) and animal draft power; hired farm labor; rental fees and fuel for irrigation pumps; and irrigation fees paid for access to dam irrigation. Monsoon rice has the highest average costs of production, at 198,000 MMK/acre, followed by groundnut at 181,000 MMK/acre and dry

[9] Although the data used by this study is from the central-southern Dry Zone, the general findings should apply across the zone where similar upland cropping systems are practiced and rainfall is similarly variable (Cornish et al. 2018).

season rice at 169,000 MMK/acre (Table 3.10). Crops with the lowest average costs of production include pigeon pea at 97,000 MMK/acre and sunflower at 81,000 MMK/acre.

3.7.4 Share of seed in total input costs

Given the focus on seed, we examine the cost of seed as an input in the production of rice, oilseed and pulse crops in the Dy Zone. Table 3.12 presents the total input and seed cost per household and the percentage share of seed cost in total input cost for different crops.

Table 3.12. Share of seed cost in total input cost per household and percentage paid in cash versus saved seed, by crops

Crop	N	Total input cost (Kyat)	Total seed cost (Kyat)	Seed cost as a % of total cost	Total seed cost paid in cash (Kyat)	Percentage share in total seed cost in the form of: Cash purchase	Value of saved seed
Rice	677	427,288	118,796	29%	80,650	68%	32%
Sesame	595	300,471	53,163	23%	21,633	41%	59%
Groundnut	388	748,242	416,317	52%	128,404	31%	69%
Sunflower	42	328,000	22,968	20%	15,743	69%	31%
Green gram	229	217,362	35,739	20%	18,899	53%	47%
Black gram	56	280,383	52,467	26%	33,395	64%	36%
Pigeonpea	321	142,694	18,856	17%	3,491	19%	81%
Chickpea	462	391,860	225,612	54%	119,950	53%	47%

At the household level, groundnut is the most cost intensive crop with a total investment across all inputs of close to 750 thousand kyat per household, followed by rice, chickpea and sunflower (Table 3.12). In terms of seed input cost, groundnut by far has the highest cost followed distantly by chickpea and rice. Pigeon pea has the lowest total input cost and seed cost per household among all the crops included in this study. The share of seed input in total cost of production is highest for chickpea (54%) and then for groundnut (52%). For other crops, the percentage share of seed cost in total input cost is in the range of 17-30% (Table 3.12).

Table 3.12 also shows the breakdown of total seed cost by how much is in the form of cash purchase versus value of saved seed from previous harvest. In absolute terms, per household cash investment towards the purchase of seed is highest for groundnut (128,404 kyat), followed by chickpea (119,950 kyat) and rice (80,650 kyat). However, the share of seed cost in the form of cash purchase is highest for sunflower (69%), rice (68%) and black gram (64%). For pigeon pea, the use of purchased seed is low with about 19% of total seed cost in incurred by the households in the form of cash purchase and 81% in the form of own saved seed. The value of total seed cost in the form of own save seed is also high for groundnut (69%) and sesame (59%).

3.7.5 Gross margins

We next present gross margins for each crop, which are calculated as the annual gross revenue per acre of each crop less (cash) production costs per acre. Dry season and monsoon rice have the average gross margins at 272,000 and 237,000 MMK/acre, respectively ($200 and $174/acre) (Table 8). The next most profitable crop was chickpea with an average gross margin of 144,000 MMK/acre ($106/acre). Although pigeon pea yields met the expectation for an "average" climatic year, its average gross margin was relatively low at 92,000 MMK/acre ($68/acre) in part due to low prices since 2017.[10] Returns for several of the other rainfed crops were quite low, including green gram at 74,000 MMK/acre ($55/acre), groundnut at 57,000 MMK/acre ($42/acre) and sesame at only 24,000 MMK/acre ($18/acre).

A major reason why the returns for these crops are so low is the relatively high percentage of growers reporting pre- or post-harvest yield loss, and the large negative effect of these losses on yields of these crops. For example, the average gross margin for green gram growers without pre- or post-harvest yield loss is 136,000 MMK/acre, relative to an average of a loss of 7,000 MMK/acre for those with yield loss (Table 3.12). The average gross margin for groundnut growers without yield loss is 75,000 MMK/acre, relative to 18,000 MMK/acre for those with yield loss. Likewise, the average gross margin for sesame growers without yield loss is 99,000 MMK/acre, relative to a loss of 19,000 MMK/acre for those with yield loss. The large negative effect of pre- and post-harvest yield loss on many of these crops – and their relatively frequent occurrence -- may well be a constraint to farmer investment in the additional cost of certified seed or improved varieties (Mather et al. 2018, Proximity Designs 2019).

Table 3.12 Household mean and median gross margins with and without pre- or post-harvest yield loss, by crop ('000 MMK/acre)

	Gross margins ('000 MMK / acre)								
	All cases			**Without** yield loss			**With** yield loss		
Crop	Mean	Median	N	Mean	Median	N	Mean	Median	N
Monsoon rice	237	273	191	271	296	178	131	138	189
Dry season rice	272	309	210	313	321	191	161	140	220
Sesame	24	(10)	149	99	70	160	(19)	(38)	124
Groundnut	57	40	158	75	50	155	18	2	159
Sunflower	165	154	158	225	220	115	83	52	175
Green gram	74	14	178	136	103	185	(7)	(42)	130
Black gram	69	31	195	176	100	223	15	2	155
Pigeon pea	87	47	156	140	92	158	21	(7)	126
Chickpea	144	114	189	184	150	187	83	53	174

Note: Figures in ( ) indicate negative values

[10] In the Dry Zone, pigeon pea is grown almost exclusively for export, and India has historically purchased 90% or more of Myanmar's exports of pigeon pea. Since India imposed an import quota on pigeon pea from Myanmar in 2017 – which significantly reduced the volume of Myanmar's pigeon pea exports to India -- the domestic market price of pigeon pea has fallen dramatically in Myanmar.

4. VARIETY ADOPTION BY CROP

The use of improved crop varieties is an important avenue for increasing productivity and incomes for smallholder farmers. Recognizing this importance of improved genetics, the national agricultural research system in Myanmar has developed, released, and disseminated several new varieties of rice, oil seeds and pulse crops for smallholder farmers in the dry zone and other agro-climatic zones of the country (Table 4.1). Among the focus crops for this study, rice has by far the most number of improved varieties released in the last four decades, with an average release of 2.5 varieties per year. In contrast, pulses and oilseeds have substantially fewer varietal releases in the same time-frame—ranging from 13 for groundnut to only one for pigeon pea. An improved variety (used synonymously in this report with 'released variety') is defined as a variety developed through research (including pure line selection of traditional varieties) and officially released in Myanmar by a public or a private sector.

The number of varietal releases per year across different crops is reflective of the relative importance of these crops in terms of area planted, which ranges from 7.26 ha for rice to 0.28 ha for sunflower (Table 4.1). But in terms intensity of releases as measured by number of varieties released per unit area cultivated, sunflower has the highest number of varietal releases per year (0.55/million ha), followed by chickpea (0.53/million ha), and then rice (0.34/million ha). Among the focus crops, pigeon pea has the lowest intensity of varietal releases per year per unit of land cultivated (0.05/million ha), preceded by black gram (0.10/million ha) and sesame (0.13/million ha) (Table 4.1). Pigeon pea also has the lowest rate of varietal releases per year (0.03) with the last release occurring in 2009 compared to 2016 for all other crops.

Table 4.1. Number of varieties released in Myanmar in the last four decades (since 1978) and rates of varietal releases per year and per unit of area planted, by crop

	Total area planted in 2017-18 (Million ha)	Number of varieties released since 1978	Average number of varieties released per year	Average number of varieties released per year per million ha planted	Year when a variety was last released
Rice	7.26	100	2.50	0.34	2016
Sesame	1.59	8	0.20	0.13	2016
Groundnut	1.04	13	0.33	0.32	2016
Sunflower	0.28	6	0.15	0.55	2016
Green gram	1.24	8	0.20	0.16	2016
Black gram	0.98	4	0.10	0.10	2016
Pigeon pea	0.66	1	0.03	0.05	2009
Chickpea	0.38	8	0.20	0.53	2016

Source: List of released varieties provided by the Department of Agriculture (2018); Area planted from Department of Agricultural Land Management and Statistics.

Irrespective of the number of varieties developed and released by the research system, an important measure of impact and a necessary condition for realizing the productivity gains from improved crop varieties is the adoption of these varieties by farmers. Thus, one of the objectives of this study was to assess what types of varieties farmers are actually growing in the dry zone region for the focused crops, their knowledge of the variety name, and their perception on whether the varieties they are growing are improved or traditional. We were also interested in knowing the sources of farmer exposure to new varieties, sources of seeds of new varieties, how long farmers have been planting a variety on their farms, and the average varietal age and varietal concentration across all the farms.

4.1 Patterns of Varietal Adoption

The list of all the varieties reported being grown by farmers, number of farmers growing those varieties in the three seasons (winter 2018, monsoon 2017, and summer 2017) prior to the survey, and area planted to those varieties extrapolated to the study area is given in Annex Table 4A. As can be seen from this list, there is a diversity of names by which farmers know their varieties (in local language), some referring them by their observable traits (like color), days of maturity (e.g., 90 days), or by the name of a place (e.g., Yangon) or an organization (e.g., Yezin). In the study area, some of the variety names were more common across thousands of farmers and some were unique to only a few farmers (Table 4A). Several farmers also reported not knowing the name of the variety they had planted. For example, 36% of sunflower growing households reported not knowing the name of the sunflower variety they had planted and 19% of green gram farm household didn't know the name of the green gram variety (Table 4.2).

Not knowing the name of the variety was also the case for about 7% of households growing groundnut and between 1-2% of farmers growing pigeon pea, chickpea, and sesame. Rice growing households were the least likely to not know the name of the rice varieties they had planted. As indicated in Table 4.2, except for 2 households surveyed, all the rice growing households had a name to report for the rice variety they had planted.

Survey results indicate that most farmers in the study area focus on growing only one variety of a given crop. As reported in Table 4.2, an average farm household in the study area planted one variety of sunflower, green gram, black gram, pigeon pea, and chickpea, and about 1.3 varieties for rice, 1.2 varieties for sesame, and 1.1 varieties for groundnuts. The higher mean number of varieties for rice is reflects cultivation in different seasons (i.e., monsoon and post-monsoon). Thus, a farmer who grows rice in monsoon as well as summer or winter season may grow one variety in monsoon season and another variety in the non-monsoon season. Annex Table 4b shows the patterns of varietal use for rice by seasons—those that are planted only in monsoon, only in non-monsoon, and in both the seasons. In terms of seasonal distribution, about 58% of area devoted to annual rice production is planted with varieties that are only planted in monsoon, 26% of area to varieties that are only planted in post-monsoon, and 16% of area to varieties that are planted in all seasons (Table 4B). What the data suggest is that, in case of rice there is some overlap of varieties planted across seasons. In other words, households that grow rice in multiple seasons may grow the same varieties in different seasons, or the same varieties are planted in multiple seasons by different households which grow rice only in one season.

Table 4.2. Estimates of varietal adoption, level of confidence, and rate of adoption, by crop

	Rice	Sesame	Ground-nut	Sun-flower	Green gram	Black gram	Pigeon-pea	Chickpea
Number of HHs who 'don't know' variety by name	2	12	73	20	43	0	8	17
% of total area planted to unknown varieties	0.1%	1.0%	7.4%	35.7%	18.6%	--	1.4%	1.9%
Number of varieties planted per HH								
N	679	597	388	42	229	56	321	462
Mean	1.32	1.19	1.09	1.00	1.00	1.00	1.00	1.02
Sd	0.50	0.44	0.32	0	0.09	0	0.06	0.14
Use of traditional varieties (as reported by farmers) as a percentage of total varieties planted across all HHs								
N	895	710	422	42	231	56	322	471
Mean	0.64	0.76	0.81	0.54	0.63	0.61	0.86	0.56
Sd	0.48	0.43	0.40	0.50	0.49	0.49	0.34	0.50
Use of improved varieties (as reported by farmers) as a percentage of total varieties planted across all HHs								
N	895	710	422	42	231	56	322	471
Mean	0.31	0.19	0.15	0.41	0.33	0.29	0.08	0.37
Sd	0.46	0.39	0.35	0.50	0.47	0.46	0.28	0.48
Adoption rate of improved varieties as measured by percentage of total crop area based on farmer self-reported variety type								
Total crop area \a	280,517	294,974	185,710	8,618	63,931	8,884	62,745	104,619
Adoption rate	38%	21%	17%	54%	41%	38%	11%	42%
Use of improved varieties (based on matching reported names with official variety release catalog)								
As a percentage of total varieties planted across all HHs:								
N	895	710	422	42	231	56	322	471
Mean	0.74	0.27	0.06	0.33	0.33	0.13	0.43	0.79
Sd	0.44	0.45	0.24	0.47	0.47	0.34	0.50	0.41
As a percentage of total crop area:								
Total crop area	280,517	294,974	185,710	8,618	63,931	8,884	62,745	104,619
Adoption rate	70%	26%	4%	37%	34%	7%	30%	82%

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

\a Estimated based on sample weights of observed households.

At the population level, there is some level of specialization as some rice varieties (e.g., Kayin Ma, Kyauk Sein) are only planted in monsoon, and some are grown only in non-monsoon (e.g., Pale Thwe, Htike Sa) (Table 4B). In general, in terms of number of households growing or area planted, the most popular varieties (e.g., Ayeyar Padaythar, Manaw Thukha, Yadanar Toe, 110 days, etc.) are grown in all the seasons and the less popular varieties are those that are grown only in one season. Alternatively stated, varieties that are grown in multiple seasons are also grown by a larger number of households and planted to more acres of land than varieties that are only grown in one season (Table 4B). Broad adaptation of varieties across seasons, combined with availability of seeds, could be the reinforce the observed temporal patterns of varietal use in the study area.

In terms of types of varieties planted by farmers, we have two types of data to estimate varietal adoption by categories of improved vs. traditional varieties. First, farmers' self-assessment of the type of variety they reported growing, and second, post-coding of varieties as improved or traditional based on matching the names of varieties reported by farmers with the list of officially released varieties and consulting the experts in interpreting the local variety names. Based on farmers' self-assessment, a majority of farmers in the study area reported growing traditional varieties, ranging from as high as 86% for pigeon pea to 54% for sunflower and 56% for chickpea on the lower side (Table 4.2). The rate of use of improved varieties as a percentage of total household x varietal observations is 31% for rice, 19% for sesame, 15% for groundnut, 41% for sunflower, 33% for green gram, 29% for black gram, 8% for pigeon pea, and 37% for chickpea (Table 4.2). The relatively low level of adoption of improved varieties for pigeon pea is not surprising given the fact that there has been low rate of varietal releases for pigeon pea compared to other crops. In fact the last official release of an improved pigeon pea variety was in 2009, which was the only one in the last 40 years (Table 4.1). For other crops, however, the relative levels of varietal adoption by farmers is not highly correlated with the relative rates of varietal releases per year per unit of area planted.

In terms of area planted to improved varieties as a percentage of total cropped area, the adoption rates based on farmers' self-assessment ranges from 11% for pigeon pea to 54% for sunflower. For other crops the self-reported use of improved varieties in terms of total area planted was 42% for chickpea, 41% for green gram, 38% for rice and black gram, 21% for sesame, and 17% for groundnut.

Compared to other countries in South, Southeast, and East Asia, the estimated adoption rate of improved varieties based on farmers' own assessment is at the lower end of the rates reported in recent years for some of the crops (Table 4.3). For example, the adoption of improved varieties is estimated to be more than 90% in Bangladesh, China, India, Thailand and Vietnam. Similarly, the adoption rate for groundnut, pigeon pea and chickpea in some of these countries is more than double the rate estimated in the Dry Zone based on this survey. Even the national estimates of the adoption of improved varieties for Myanmar based on other survey or based on expert opinion is significantly higher than the estimated adoption level based on farmers own self-assessment.

Notwithstanding the differences in methodology, timeframe, and geographic representativeness of the estimates reported in Tables 4.2 and 4.3 (for e.g., this study is focused on one sub-region of Myanmar vs. national or state level estimates reported in Table 4.3), a general sense is that the adoption of improved varieties in the study area is lower than other countries in the region. The discrepancy in estimated adoption of improved varieties is most stark for groundnut and chickpea, for which adoption rates for Myanmar according to expert opinion is 96% versus 17% and 42% estimated in this study for groundnut and chickpea, respectively, based on farmers' own assessment.

Table 4.3. Estimated adoption rates for crops, Myanmar and selected countries, various years

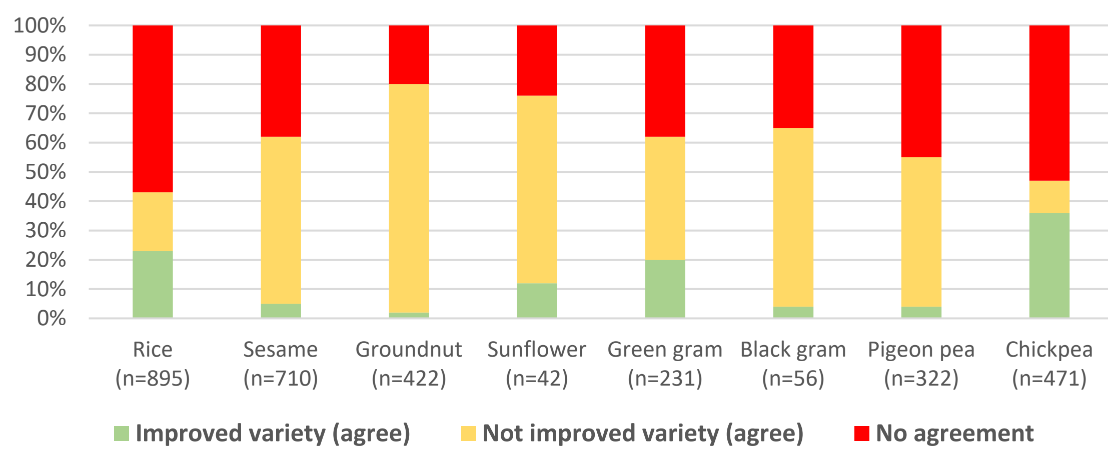
Country	Adoption rate (year)			
	Rice	Groundnut	Pigeonpea	Chickpea
Bangladesh‡	80 (2010)* ; 90 (2010)†			
Cambodia	59 (2013-14)			
China				
-Anhui	100 (2014)			
-Heilongjiang	100 (2014)			
-Henan		85 (2014)		
-Hubei	100 (2014)			
-Hunan	100 (2014)			
-Guangdong		89 (2014)		
-Guangxi	100 (2014)			
-Hubei	100 (2014)	70 (2014)		
-Jiangsu	100 (2014)			
-Jiangxi	100 (2014)			
-Shandong		89 (2014)		
-Sichuan	100 (2014)			
India				
-Andhra Pradesh	100 (2015-16)	40 (2010)‡	70 (2010)‡	99 (2010)‡
-Karnataka		9 (2010)‡		100 (2010)‡
-Madhya Pradesh			65 (2010)‡	48 (2010)‡
-Maharashtra		100 (2010)‡	70 (2010)‡	
-Rajasthan		64 (2010)‡		68 (2010)‡
-Tamil Nadu		56 (2010)‡	70 (2010)‡	
-Uttar Pradesh			25 (2010)‡	65 (2010)‡
Indonesia		70 (2014)		
Lao		71 (2013-14)		
Myanmar	58 (2013)*	96 (2014)	28 (2014)	96 (2014)
Pakistan				100 (2013-14)
Thailand	100 (2014)*			
Vietnam	96 (2015-16)†	89 (2014)		

Sources: * indicates estimates from SIAC that are based on farmer surveys; † indicates estimates from SIAC that are based on farmer surveys and expert elicitations. ‡ indicates estimates from TRIVSA data, which do not specify source (CGIAR 2015). All other estimates are based on expert elicitations (Maredia et al. 2016a).

However, in our study sample itself, the estimates of adoption of improved varieties based on matching the names reported by farmers with the list of released varieties and consulting the experts is significantly different for most of the crops included in this study. According to this method of determining varietal adoption, the adoption of improved varieties (as a percentage of cultivated area) is more than double for rice (70% vs. 38% based on self-assessment) and chickpea (82% vs. 42% based on self-assessment), and close to 3 times for pigeon pea (30% vs. 11% based on self-assessment) (Table 4.2). For sesame also the estimated adoption of improved varieties as a percentage of total area planted, according to matching the names with released varieties is significantly higher (26% vs. 21% based on self-assessment). However, for groundnut, sunflower, green gram and black gram the opposite is the case. Estimated adoption of improved varieties is significantly lower (by 17% vs. 4% for groundnut, 54% vs. 37% for sunflower, 41% vs. 34% for green gram, and 38% vs. 7% for black gram) based on matching the names compared to what farmers self-reported as improved varieties (Table 4.2). This discrepancy is also observed in the adoption rates measured as a percentage of total varieties planted based on farmers' self-assessment and matching the reported names with released varieties (Table 4.2).

So what is the level of adoption of improved varieties of the focused crops in the Dry Zone region? Results presented in Table 4.2 point to the difficulty of addressing this question using farmer survey method. Recent research on testing the effectiveness of different methods of varietal identification against the benchmark of DNA fingerprinting has shown that estimating varietal adoption based on either farmers' self-assessment of whether a variety is improved or traditional or matching the reported names with released varieties can be misleading (Maredia et al. 2016b; Floro et al. 2017; Kosmowski et al. 2018; Wossen et al. 2018).[11] In fact, for some crops (e.g., rice and chickpea) the disagreement between the two methods on whether a variety is improved or not is more than the overlapping agreements (Figure 4.1). For other crops the percentage of varietal observations where there is no consensus between the two methods on whether it is improved or not improved ranges between 20 to 45%. These are large percentages of disagreements, which makes it challenging to confidently estimate the rate of adoption of improved varieties of these 8 crops in the study area.' What this study can confidently estimate is the rate of varietal adoption perceived to be improved varieties by farmers growing a crop. If farmers' input decisions and crop management practices are determined more by his/her perception of the type of variety rather than the name of the variety, then this is an important measure for economic analysis.

Figure 4.1. Percentage agreement and disagreement in the estimates of improved and traditional varieties based on farmer self-assessment and matching the reported names with official list of released varieties, by crop



Source: Myanmar Seed Demand Survey in Dry Zone, 2018

[11] Recognizing this potential problem of estimating varietal adoption based on farmer surveys, we had collected seed samples during the survey to conduct DNA fingerprinting to compare the results with fingerprints of released varieties. Results will be presented in a separate Report.

Recognizing this importance of farmers' own perception on behavioral responses, the survey also included questions on farmers' level of confidence in their self-assessment of a variety and what they would do differently if the real identity of that variety was different from their perception. As reported in Table 4.4, a large percentage of them were either fully or somewhat confident that the variety they were growing was indeed an improved variety. In terms of full confidence, the level was highest for sunflower (61% of farmers) and lowest for groundnut (23%). But adding the 'somewhat confident' category, more than 95% of farmers across all crops are at least somewhat confident that the improved varieties they are growing are indeed improved (Table 4.4). In other words, very few percentage of farmers were dismissive of the idea that what they believe to be an improved variety may not be an improved variety.

Table 4.4. Farmer reported level of confidence in the perceived variety type and what would they do differently if reality was different then perception

	Rice	Sesame	Ground-nut	Sun-flower	Green gram	Black gram	Pigeon-pea	Chick-pea	All
% of farmers who are fully confident that the (self-reported) improved variety is indeed improved variety									
N	307	158	66	11	84	19	32	189	866
Mean	0.46	0.38	0.23	0.61	0.53	0.55	0.36	0.43	0.42
Sd	0.50	0.49	0.42	0.51	0.50	0.51	0.49	0.50	0.49
% of farmers who are somewhat confident that the (self-reported) improved variety is indeed improved variety									
N	307	158	66	11	84	19	32	189	866
Mean	0.54	0.61	0.69	0.39	0.46	0.45	0.60	0.56	0.56
Sd	0.50	0.49	0.47	0.51	0.50	0.51	0.50	0.50	0.50
% of farmers who indicated the following if their (self-reported) improved variety is not an improved variety									
N	307	158	66	11	84	19	32	189	866
--Not change any practices:									
Mean	0.67	0.64	0.65	0.61	0.55	0.49	0.49	0.59	0.63
Sd	0.47	0.48	0.48	0.51	0.50	0.74	0.51	0.49	0.48
--Stop growing a variety:									
Mean	0.22	0.24	0.29	0.20	0.33	0.35	0.31	0.26	0.26
Sd	0.42	0.43	0.46	0.42	0.47	0.49	0.47	0.44	0.44
--Use more/less purchased inputs:									
Mean	0.09	0.10	0.06	0.19	0.13	0.16	0.20	0.12	0.11
Sd	0.29	0.30	0.24	0.41	.034	0.38	0.40	0.33	0.31
% of farmers who indicated they will not change any practices if their (self-reported) traditional variety is in fact not traditional but an improved variety									
N	538	509	340	30	136	32	271	253	2109
Mean	0.72	0.60	0.57	0.73	0.58	0.74	0.58	0.75	0.64
Sd	0.45	0.49	0.50	0.45	0.50	0.44	0.49	0.43	0.48

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Hypothetically, even if their perceived improved variety turned out to be not an improved variety, more than 60% of farmers across all the crops indicated that they would not change anything in terms of the variety or inputs and management practices they were using (Table 4.4). On average about 26% indicated that they would stop growing a variety and 10% indicated that they would either change the inputs or management practices if what they perceived to be an improved variety turned out not to be the case. A similar behavioral (but hypothetical) response was also noted by farmers who self-reported growing traditional varieties. Almost two-thirds of farmers indicated that they would not change any practices if the varieties they perceive to be traditional varieties turned out not to be traditional but improved varieties. These results thus indicate that for a majority of farmers (about two-thirds), the decision to grow a specific variety and the use of inputs and agronomic practices may be less determined by the genetic identity or the name of that variety but more by their perceived value and benefits they provide. Although for some farmers (about one-quarter), their decision to grow a specific variety or use specific inputs/practices is linked with their belief that the variety is indeed improved or traditional.

4.2 Varietal Turnover and Varietal Concentration

As indicated in Table 4.1, over the years the research system has developed and released several improved varieties for rice, oilseeds, and legume crops grown by farmers in the dry zone region. The rate of varietal releases varies across crops, with more options available for sunflower and chickpea growers per unit of time and per unit of area planted, and few for other crops. With more varietal options, one would hypothesize that for these crops there would be more adoption of newer varieties, and more turnover of varieties in farmers' fields. We present three measures to test this hypothesis. First, varietal replacement rate—i.e., number of years since farmers have been growing a variety on their farm. Second, weighted average age of (improved) varieties—i.e., how old are the varieties planted by farmers in 2017-18 agricultural year since their first release, weighted by area planted to those varieties across the study area. For a crop characterized by an active plant breeding program supported by a well-functioning seed system, one would expect more varietal turnover and a low average varietal age. This in turn also implies that more farmers would be dis-continuing a variety as they get better options with new varietal releases. To assess this, we also examine a third measure—i.e., the varietal discontinuation rate by farmers. The estimates of these three measures, and reasons for discontinuing a variety, cited by farmers in the survey are given in Table 4.5.

For varieties that have the year of release information available, the area weighted average varietal age across all study crops is 18 years, ranging from a low varietal age of 8 years for sesame to high varietal age of 27 years for rice (Table 4.5).

On average, a typical household in the study area was growing a variety planted in 2016-17 for about 11.7 years. This length of period since farmers first started growing a variety they had planted in the survey year is highest (i.e., relatively slow varietal turnover) for sunflower (15.9 years) and pigeon pea (15.7 years), and lowest (i.e., relatively fast varietal turnover) for black gram (8.5 years). For all other crops, the number of years since they first started using a variety planted on their farm in 2016-17 is about 11-12 years. What this suggests is that once a farmer decides to grow a variety (either improved or traditional), he/she continues to grow that variety, on average for more than 11 years.

Table 4.5 Varietal age, varietal turnover, varietal dis-adoption, and reasons for dis-adoption, by crop

Sources	Rice	Sesame	Groundnut	Sunflower	Green gram	Black gram	Pigeonpea	Chickpea	All
Area weighted average age of released varieties planted in farmers' field in 2018 ***(age=2018-release year)***									
N	303	186	24	8	91	5	18	139	774
Mean	27.21	8.22	28.90	17.20	11.50	43.00	27.70	16.69	18.00
Sd	14.86	17.22	11.87	5.47	5.96	0	16.82	6.32	16.95
Varietal turnover (number of years farmer has been growing a variety on his/her farm ***(turnover=2018-year of first use)***									
N	863	655	385	35	220	56	295	457	2966
Mean	10.51	10.79	13.21	15.86	11.89	8.49	15.71	11.79	11.72
Sd	10.66	11.26	12.21	15.31	11.00	8.24	12.36	10.58	11.37
N (number of HHs growing a given crop)	*681*	*607*	*398*	*44*	*229*	*57*	*330*	*475*	*1383*
Percentage of HHs who reported not growing a variety anymore that they grew in the past	22.5%	11.3%	1.7%	6.2%	7.1%	4.7%	5.4%	13.1%	23.8%
N (number of HHs who has discontinued at least one variety in the past)	*190*	*102*	*19*	*8*	*31*	*9*	*33*	*95*	*510*
Top 3 reasons cited most frequently on why HHs have discontinued growing a variety									
Found better alternatives	58.5%	55.0%	26.8%	57.2%	34.1%	39.1%	44.6%	67.5%	51.4%
Decreased market demand	55.1%	51.0%	20.8%	71.9%	56.1%	70.8%	43.4%	54.9%	49.2%
Low yield	48.8%	45.5%	51.2%	68.2%	43.9%	39.3%	62.8%	49.4%	45.2%
Susceptible to pests and diseases	22.6%	26.3%	25.1%	0.0%	33.9%	49.2%	23.2%	24.9%	23.3%
Not suitable for soil conditions	13.8%	18.8%	59.9%	17.1%	4.1%	15.8%	11.1%	17.6%	15.4%
High input requirements (e.g., labor)	16.9%	14.2%	45.3%	0.0%	13.7%	15.4%	2.5%	7.0%	13.4%
No availability of seed	4.3%	1.7%	6.3%	0.0%	10.2%	11.6%	0.0%	1.5%	3.3%

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

When asked if the household had ever discontinued growing a variety in the past, about 24% of farmers responded that they had (Table 4.5). The rate of discontinuation was lowest for groundnut, with only 1.7% of households reported discontinuing a variety, to highest for rice, with more than 22% of households reported discontinuing a variety. Among the top three reasons for discontinuing growing a variety were finding a better alternative, decreased market demand, and low yield. These are typical reasons one would expect for abandoning a variety. Lack of availability of seed was not a major reason overall, with only 3.3% of farmers citing that as their top three reasons for discontinuing a variety (Table 4.5).

Next, we examine how many varieties farmers are typically growing in the study area, and what is the share of these varieties in terms of area planted. The list of all the varieties reported being grown by farmers is included in Annex Table 4A. The number of varieties (i.e., reported varieties with unique names) that were grown in the study area in the year prior to the survey were 65 for sesame, 45 for groundnut, 44 for rice, 43 for pigeon pea, 33 for chickpea, 29 for green gram, 15 for black gram, and 12 for sunflower (Table 4.6). However, the popularity of these varieties as measured by area planted is not uniform across the study area. For most of these crops, a few varieties dominate a large percentage of crop area as can be seen from the different varietal concentration indices presented in Table 4.6. For example, in the case of groundnut, only 3 out of 45 reported varieties account for 80% of cropped area. Similarly, only 5 out of 65 varieties for sesame and 6 out of 44 varieties for rice account for 80% of cropped area in the study region. One crop with relatively less concentration of varieties is pigeon pea, with 11 out of 43 varieties accounting for 80% of total area.

Other measures to assess the concentration of varieties in total area planted are the CR4, CR8, and the Herfindahl-Hirschman Index (HHI). These are measures commonly used in the literature to measure market competitiveness of an industry. For example, the CR4 and CR8 ratios, respectively, measure the share of the top 4 and 8 firms in the industry and the Herfindahl-Hirschman Index measures the size of firms in relation to the industry. The HHI is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers. The CR4 and CR8 ratios range from close to zero to 100 and the HHI ranges from close to zero to 10,000. Higher numbers indicate greater degree of concentration of few firms in the industry. As indicated, these are commonly used measures of market concentration. However, since most of the varieties planted by farmers in the study area are public sector varieties or traditional varieties, assessing the 'market competitiveness' of these varieties is not that relevant. In this context, these various indices of varietal concentration presented in Table 4.6 can be used as an indicator of the extent of diversity of genetic materials found in the seed sector (formal + informal) and potentially available to farmers in the study area for a given crop.

Based on these various indicators, the seed sector appears to be relatively more concentrated (i.e., less diverse) for groundnut and sunflower and less concentrated (i.e., more diverse) for pigeon pea. Varietal concentration is moderate in the case of rice, sesame, green gram, black gram and chickpea.

Table 4.6. Varietal concentration indices, by crop

	Rice	Sesame	Groundnut	Sunflower	Green gram	Black gram	Pigeon pea	Chickpea
N (Number of unique varieties reported by farmers by names)	*44*	*65*	*45*	*12*	*29*	*15*	*43*	*33*
Of those with unique names…								
Number of varieties accounting for 80% of area	6	5	3	2	5	6	11	8
CR4- Ratio of varietal concentration (% of total area planted to top 4 varieties)	72.3	79.5	85.3	89	73.8	74.2	56.4	65.9
CR8-Ratio of varietal concentration (% of total area planted to top 8 varieties)	86.7	86.3	93.2	97.4	90	90.2	73.4	82.2
Area-based Herfindahl-Hirschman Index (HHI)	1822	2350	3448	3758	1818	2296	1049	1895

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

4.3. Sources of Exposure to New Varieties and First Source of Seed

The goal of any crop improvement research program is to increase the adoption of new varieties developed through research that hopefully have better characteristics then the existing varieties grown in farmers' fields. To achieve this goal, it is important to understand how farmers get their exposure to new varieties and where do they obtain the seeds of the first planting material for a new variety. We therefore asked the farmers to indicate how did they first became aware of the variety which they were growing on their field in the year prior to the survey, and what was the source of the seed when they first planted that variety on their farm. Tables 4.7 and 4.8 show the summary of responses to these two questions by crop.

Peer farmers appear to be the single most important source of exposure as well as the source of seeds of new varieties across all the crops. In terms of first-time exposure to a new variety, observation seems to be the main mode for nudging farmers to adopt a new variety. Close to 90% of farmers indicated 'observed that variety in other farmers' fields' and about 2-3% indicated 'observed in demonstration fields' as their main source of exposure and awareness of a new variety (Table 4.7). About 5% indicated 'heard from traders' as the main mode of getting exposed to a new variety. There is slight variation in the relative importance of these sources of first-time exposure across crops. First time exposure through observation in other farmers' fields was more important for rice (91.3%) compared to black gram (78.8%). 'Observed in demonstration plots' was cited as the most important source of exposure relatively more by farmers growing sunflower (6.4%) and less by farmers growing pigeon pea (0.6%). On the other hand, proportionately more farmers growing groundnut and blackgram reported traders as the first source of exposure to new varieties compared to other crops (Table 4.7).

In terms of the source of seed for the first time a new variety was planted by the farmer, overall, the sources reported in terms of descending order of importance are: other farmers (71%), traders/grain market (13%), government (8%), seed company or agro-dealers (4%), and other sources (4%) (Table 4.8). The relative importance of these different sources varies slightly by crops. For example, government was reported as the source of first seed by 20% of rice farmers and 30% of sunflower growing farmers and was the second most important source of seed for these crops after 'other farmers.' In the case of black gram, after other farmers, traders, input suppliers, and producer organizations were cited as relatively more important sources of first seed compared to government.

In many other countries, Non-governmental organizations (NGOs) are a major source of exposure and seed of new varieties (often making them available to farmers free or at subsidized price), and they play an important role in the seed system. In the study area, however, NGOs seem to be less important as a source of exposure or a source of seeds of a new variety across all crops (Tables 4.7 and 4.8). In fact, getting the first source of seed from NGOs or free from anyone was rare. Overall 94% of farmers reported purchasing their first seed of a new variety and only 4% reported receiving it free (Table 4.8).

Table 4.7 Sources of exposure to new varieties, by crop

Sources	Rice	Sesame	Groundnut	Sunflower	Green gram	Black gram	Pigeonpea	Chickpea	All
N (farmer × variety observations)	*895*	*710*	*422*	*42*	*231*	*56*	*322*	*471*	*3149*
	Percentage of farmer × variety observations								
Observed in other farmers' fields	91.3%	89.6%	86.9%	88.5%	86.1%	78.8%	87.0%	89.3%	88.9%
Observed in a demonstration plot	4.9%	0.8%	0.3%	6.4%	3.7%	3.2%	0.6%	3.4%	2.4%
Heard from trader	1.1%	5.8%	8.8%	1.0%	5.2%	9.5%	5.6%	4.0%	4.7%
Heard from company agent/input supplier	0.9%	0.4%	0.3%	0.0%	0.6%	0.0%	0.5%	0.4%	0.5%
Other	1.8%	3.2%	3.7%	4.1%	4.4%	8.5%	6.3%	2.9%	3.3%

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Table 4.8. Sources of first seed of a new variety, by crop

	Rice	Sesame	Groundnut	Sunflower	Green gram	Black gram	Pigeon pea	Chickpea	All
N (farmer × variety observations)	*895*	*710*	*422*	*42*	*231*	*56*	*322*	*471*	*3149*
Sources of first seed of a variety	*Percentage of farmer × variety observations*								
Other farmers	67.7%	77.1%	69.4%	53.4%	71.8%	46.3%	84.4%	63.4%	71.4%
Traders/grain market	4.5%	13.7%	21.5%	8.2%	13.2%	24.8%	8.5%	24.3%	13.3%
Government	20.2%	3.3%	0.3%	29.7%	8.5%	7.3%	1.5%	6.4%	8.2%
Company/input suppliers	4.1%	3.7%	5.1%	7.2%	4.7%	13.3%	5.6%	4.1%	4.4%
Producer organizations	5.3%	1.7%	2.6%	0.9%	1.5%	9.1%	1.2%	2.7%	2.9%
NGOs	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
Was the first seed source purchased or free?									
Purchased	94.6%	93.3%	94.6%	94.7%	92.3%	98.5%	89.2%	95.0%	93.7%
Free	4.2%	4.9%	3.4%	4.7%	6.5%	0.0%	9.7%	2.1%	4.6%

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

In summary, the evidence presented in this Section points to some sobering facts with regards to the adoption and use of improved varieties of focused crops in the study area. First, across all eight crops, the level of adoption of varieties perceived by farmers to be improved varieties was at most 41% (for sunflower) and as low as 8% (for pigeon pea). Based on the reported names of the varieties, the level of adoption of varieties that matched released varieties ranged from 6% for groundnut to 79% for chickpea. Compared to other countries in South, Southeast, and East Asia, the estimated adoption rate of improved varieties based on farmers' own assessment is at the lower end of the rates reported in recent years for some of the crops. Second, as reflected in the estimated weighted average age of varieties and varietal turnover rates, farmers on average are growing older varieties (on average 18 years) and growing them for a longer period of time (on average about 12 years). This underestimates the realization of genetic gains embodied in new varietal releases. Third, peer farmers appear to be the most important source of exposure as well as the source of seeds of new varieties across all the crops. An implication of this finding is that doing on-farm demonstrations on a regular basis in different villages for different crops can increase farmer exposure and eventual adoption of new varieties. For the research system this can serve as an important lever to increase farmer demand for new varieties being developed by the researchers.

5. UPTAKE AND USE OF QUALITY SEED BY CROP

The use of quality seed may be as important to increasing crop productivity and incomes for smallholder farmers as the use of improved varieties discussed in the previous section. However, farmers typically cannot fully observe seed quality—a set of attributes that includes the genetic uniformity of seed in a given package as well as its expected germination rate, moisture content, and purity level—if such information is not provided on the packaging, or if the seed is purchased from open packaging. Instead, farmers often rely on proxy indicators for seed quality. These proxies include farmer's own experience with a seed provider or the seed provider's reputation in the community or market. They may similarly draw on information provided by extension agents, neighbors, input retailers, or other actors in the agricultural sector. Or they may draw on indicators such as the price of the seed or the quality of the packaging itself. But ultimately, these proxies provide an incomplete assessment of seed quality to the farmer. For this very reason, governments often invest in regulatory systems designed to provide more credible information on seed quality to farmers.

Seed certification systems are the most conventional form of regulatory system, although the relative value of the signal they provide farmers depends on the credibility of the certification system itself. Other quality assurance systems also exist, including (a) internal quality assurances that are managed by the individual seed producer, (b) internal quality assurances that are managed by individual seed producers and collectively monitored by some form of seed producer organization or cooperative, (c) quality declared seed, which is less technically demanding external quality assurance standard designed to encourage small-scale, farmer-led seed enterprises to enter the seed market, and (d) truthful seed labeling, which legally obliges seed providers to disclose the quality of the seed it sells, and provides farmers with legal recourse if the seed fails to meet the disclosed quality levels.

However, these quality assurance systems are only as effective as the administrative, regulatory, and judicial infrastructure that support them, and depend acutely on the production and distribution capabilities of seed providers themselves. Thus, there is evidence to suggest that for some countries and crops, farmer-saved seed is of comparable quality to government certified seed, while truthful labeling opens the door for entry of fraud in the seed market.

In Myanmar, seed quality can be indicated or signaled to farmers in several different ways, often in combination with each other. First, formal seed certification may indicate to farmers that the seed has been produced under government supervision or tested by the government. Second, packaging may provide farmers with a signal reflecting quality. Third—and most importantly—is the source of seed acquired by farmers. Sources include the formal seed system (a government seed farm, a government seed distribution program, or a private input seller), the informal system, (own-saved seed, neighbors, or other such channels), or some intermediate system (a farmer or farmer organization that produces seed, a non-governmental organization, or a grain miller).

5.1 Sources of seed planted by farmers

Among the focus crops for this study, own-saved seed and informal sources represent the primary source for seed at a variety-specific level during the 2017-18 agricultural year. Tables 5.1 – 5.9 describe the seed sourcing strategies for each of the top 5 varieties of each crop acquired by sampled households. For the top 5 varieties of monsoon rice, 25–43 percent of seed acquired by household respondents came from farmers' own saved seed stocks and 41–63 percent from informal sources, with the latter attributable primarily to seed purchased from neighbors. Just 8–27 percent of seed acquired came from the formal seed system, primarily through purchases from the government. For pre- and post-monsoon rice, 6–24 percent of variety-specific seed acquisitions came from farmers' own saved seed stocks and 41–63 percent from informal sources, while 15 – 38 percent came from the formal system, primarily from purchases from the government.

For the remaining focus crops for this study, own-saved seed and informal seed sources account for the majority of variety-specific seed sourcing strategies. The highest rates of own-saved seed use are observed for pigeon pea (65–84 percent), sesame (36–78 percent), sunflower (58 – 72 percent), and groundnuts (58–72 percent). The lowest rates of own-saved seed use are observed for chickpea (16–61 percent) and black gram (35–61 percent). Variety-specific acquisitions from informal seed sources accounted for a high of 76 percent in the case of chickpea (variety: Tarpon) to just 16 percent for pigeon pea (variety: Yezin – unspecified). In general, among these informal sources, purchases from neighbors accounted for majority of variety-specific seed acquisitions, followed by smaller shares from local markets/traders. Formal sources of seed are observed at relatively high levels for sunflower (50–67 percent) and black gram (11– 100 percent), but at negligible levels for all other crops. Finally, it is worth noting that for no crops did the intermediary system account for a significant (greater than 17 percent of households) source of seed for farmers.

Table 5.1. Seed source for top 5 varieties of rice, 2017 monsoon

Seed source		Magyandall	Manaw Thukha	Ayeyar Padaythar	Ayar Min	110 Days	Other
Formal source of seed	Mean	0.21	0.11	0.27	0.13	0.08	0.08
	Std. dev.	0.41	0.32	0.44	0.33	0.27	0.27
	N	7	12	68	5	5	11
Own saved seed	Mean	0.26	0.39	0.27	0.43	0.25	0.47
	Std. dev.	0.45	0.49	0.45	0.50	0.44	0.50
	N	9	41	69	17	16	65
Informal seed sources	Mean	0.41	0.49	0.49	0.50	0.63	0.49
	Std. dev.	0.50	0.50	0.50	0.51	0.49	0.50
	N	14	51	125	20	40	68
Intermediary source of seed	Mean	0.12	0.03	0.03	0.00	0.05	0.01
	Std. dev.	0.33	0.17	0.17	0.00	0.21	0.12
	N	4	3	8	0	3	2
Entire sample	*N*	34	105	255	40	63	139

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Table 5.2 Seed source for top 5 varieties of rice, 2017-2018 pre- and post-monsoon

Seed source		**Manaw Thukha**	**Yangon Manaw**	**Yadanar Toe**	**Ayeyar Padathar**	**110 Days**	**Other**
Formal source of seed	Mean	0.33	0.20	0.29	0.38	0.15	0.16
	Std. dev.	0.47	0.41	0.46	0.49	0.36	0.37
	N	16	4	21	11	15	15
Own saved seed	Mean	0.18	0.20	0.06	0.10	0.24	0.34
	Std. dev.	0.39	0.41	0.23	0.31	0.43	0.48
	N	9	4	4	3	23	32
Informal seed sources	Mean	0.45	0.60	0.63	0.41	0.58	0.45
	Std. dev.	0.50	0.50	0.49	0.50	0.50	0.50
	N	22	12	45	12	56	42
Intermediary source of seed	Mean	0.04	0.00	0.08	0.17	0.04	0.08
	Std. dev.	0.20	0.00	0.28	0.38	0.20	0.27
	N	2	0	6	5	4	7
Entire sample	*N*	49	20	72	29	97	93

Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Table 5.3 Seed source for top 5 varieties of sesame, 2017-18 agricultural year

Seed source		**Gwa Kyaww Nett**	**Sesame White (Safal 3)**	**Hnan Ni25/160**	**Thake Pan Black**	**White**	**Other**
Formal source of seed	Mean	0.05	0.02	0.29	0.03	0.12	0.03
	Std. dev.	0.22	0.14	0.46	0.19	0.32	0.18
	N	2	3	1	19	5	6
Own saved seed	Mean	0.78	0.56	0.69	0.36	0.44	0.56
	Std. dev.	0.42	0.50	0.47	0.48	0.50	0.50
	N	31	88	20	101	19	99
Informal seed sources	Mean	0.23	0.41	0.28	0.57	0.49	0.44
	Std. dev.	0.42	0.49	0.45	0.50	0.51	0.50
	N	9	65	8	160	21	77
Intermediary source of seed	Mean	0.00	0.01	0.00	0.01	0.00	0.01
	Std. dev.	0.00	0.08	0.00	0.12	0.00	0.11
	N	0	1	0	4	0	2
Entire sample	*N*	*40*	*157*	*29*	*282*	*43*	*176*

Table 5.4. Seed source for top 5 varieties of groundnut, 2017-18 agricultural year

Seed source		Tonn Tar Ni	Vietnam	White	Spain	Yoe yoe	Other
Formal source of seed	Mean	0.06	0.00	0.00	0.00	0.00	0.04
	Std. dev.	0.24	0.00	0.00	0.00	0.00	0.19
	N	10	0	0	0	0	7
Own saved seed	Mean	0.60	0.72	0.63	0.58	0.63	0.44
	Std. dev.	0.49	0.45	0.49	0.50	0.50	0.50
	N	103	36	29	14	10	81
Informal seed sources	Mean	0.33	0.28	0.37	0.42	0.38	0.50
	Std. dev.	0.48	0.45	0.49	0.50	0.50	0.50
	N	57	14	17	10	6	92
Intermediary source of seed	Mean	0.02	0.00	0.00	0.00	0.00	0.03
	Std. dev.	0.13	0.00	0.00	0.00	0.00	0.16
	N	3	0	0	0	0	5
Entire sample	*N*	*171*	*50*	*46*	*24*	*16*	*183*

Table 5.5. Seed source for top 5 varieties of sunflower, 2017-18 agricultural year

Seed source		Ma Hura	Yezin-1	Local variety	Ordinary	Velvet	Other
Formal source of seed	Mean	0.00	0.50	0.00	0.00	0.67	0.11
	Std. dev.	0.00	0.53	0.00	0.00	0.58	0.32
	N	0	4	0	0	2	3
Own saved seed	Mean	0.60	0.72	0.63	0.58	0.63	0.44
	Std. dev.	0.49	0.45	0.49	0.50	0.50	0.50
	N	1	2	2	2	0	16
Informal seed sources	Mean	0.67	0.25	0.50	0.33	0.67	0.33
	Std. dev.	0.58	0.46	0.58	0.58	0.58	0.48
	N	2	2	2	1	2	9
Intermediary source of seed	Mean	0.00	0.00	0.00	0.00	0.33	0.00
	Std. dev.	0.00	0.00	0.00	0.00	0.58	0.00
	N	0	0	0	0	1	0
Entire sample	*N*	*3*	*8*	*4*	*3*	*3*	*27*

Table 5.6. Seed source for top 5 varieties of green gram, 2017-18 agricultural year

Seed source		Zaut Khalay	Yezin-11	Yezin-14	Kyauk Sein	Yoe yoe	Other
Formal source of seed	Mean	0.00	0.12	0.12	0.11	0.00	0.01
	Std. dev.	0.00	0.32	0.33	0.31	0.00	0.10
	N	0	8	2	3	0	1
Own saved seed	Mean	0.46	0.38	0.35	0.61	0.38	0.45
	Std. dev.	0.52	0.49	0.49	0.50	0.51	0.50
	N	6	26	6	17	5	42
Informal seed sources	Mean	0.54	0.49	0.53	0.29	0.62	0.53
	Std. dev.	0.52	0.50	0.51	0.46	0.51	0.50
	N	7	33	9	8	8	50
Intermediary source of seed	Mean	0.00	0.06	0.06	0.00	0.00	0.01
	Std. dev.	0.00	0.24	0.24	0.00	0.00	0.10
	N	0	4	1	0	0	1
Entire sample	*N*	*13*	*68*	*17*	*28*	*13*	*94*

Table 5.7. Seed source for top 5 varieties of black gram, 2017-18 agricultural year

Seed source		Yezin-2	Ordinary	Black Gram (Dwarf)	Black Gram (Long Leaf)	Yezin-unspecified	Other
Formal source of seed	Mean	1.00	0.00	0.00	0.00	0.11	0.18
	Std. dev.	0.00	0.00	0.00	0.00	0.32	0.40
	N	3	0	0	0	3	2
Own saved seed	Mean	0.46	0.38	0.35	0.61	0.38	0.45
	Std. dev.	0.52	0.49	0.49	0.50	0.51	0.50
	N	0	4	3	3	9	4
Informal seed sources	Mean	0.00	0.29	0.00	0.33	0.56	0.45
	Std. dev.	0.00	0.49	0.00	0.52	0.51	0.52
	N	0	2	0	2	15	5
Intermediary source of seed	Mean	0.00	0.14	0.00	0.17	0.00	0.00
	Std. dev.	0.00	0.38	0.00	0.41	0.00	0.00
	N	0	1	0	1	0	0
Entire sample	*N*	*3*	*7*	*3*	*6*	*27*	*11*

Table 5.8. Seed source for top 5 varieties of pigeon pea, 2017-18 agricultural year

Seed source		Local Variety	Medium-Term Variety	Ordinary-red	Taphat Lae – big	Yezin-unspecified	Other
Formal source of seed	Mean	0.00	0.00	0.06	0.00	0.00	0.04
	Std. dev.	0.00	0.00	0.24	0.00	0.00	0.19
	N	0	0	1	0	0	5
Own saved seed	Mean	0.76	0.72	0.65	0.83	0.84	0.71
	Std. dev.	0.44	0.46	0.49	0.38	0.36	0.45
	N	13	13	11	25	103	92
Informal seed sources	Mean	0.24	0.33	0.29	0.23	0.16	0.29
	Std. dev.	0.44	0.49	0.50	0.43	0.36	0.45
	N	4	6	5	7	19	37
Intermediary source of seed	Mean	0.00	0.00	0.00	0.00	0.00	0.01
	Std. dev.	0.00	0.00	0.00	0.00	0.00	0.09
	N	0	0	0	0	0	1
Entire sample	*N*	*17*	*18*	*17*	*30*	*122*	*129*

Table 5.9. Seed source for top 5 varieties of chickpea, 2017-18 agricultural year

Seed source		Yezin-6	Shweni Lone Kyi	B2/V2	929	Tarpon	Other
Formal source of seed	Mean	0.04	0.05	0.06	0.03	0.08	0.09
	Std. dev.	0.20	0.21	0.24	0.17	0.28	0.29
	N	4	1	10	1	2	12
Own saved seed	Mean	0.61	0.36	0.34	0.58	0.16	0.33
	Std. dev.	0.49	0.49	0.48	0.50	0.37	0.47
	N	62	8	57	19	4	43
Informal seed sources	Mean	0.37	0.59	0.63	0.39	0.76	0.57
	Std. dev.	0.49	0.50	0.48	0.50	0.44	0.50
	N	38	13	105	13	19	73
	Std. dev.	0.00	0.00	0.14	0.00	0.00	0.00
Intermediary source of seed	Mean	0.04	0.00	0.01	0.00	0.00	0.02
	Std. dev.	0.20	0.00	0.11	0.00	0.00	0.15
	N	4	0	2	0	0	3
	Std. dev.	0.00	0.00	0.00	0.00	0.00	0.00
Entire sample	*N*	*102*	*22*	*167*	*33*	*25*	*129*

Overall, these figures highlight several findings. First, own-saved seed and informal seed sources play the largest role in households' acquisition of seed, while the formal system plays a relatively small role, with the exception of rice, sunflower, and black gram. Second, many of the farmer-to-farmer exchanges of seed are monetized: farmers pay for seed purchased from the government, their neighbors or from other informal sources and depend far less on free exchanges. This preliminarily suggests that a vibrant informal market in quality seed exists in the study area, further indicating potential for growth of local seed businesses. Third, there is little evidence of free seed distributions from government or non-governmental sources which, in other countries and contexts, can distort long-term efforts to develop seed markets (although such distributions may still be important to protecting vulnerable households from natural disasters and weather shocks).

These findings open the door to questions about farmers' perceptions about quality from these different sources and the possibility of measuring quality in a more robust manner. We address the question of perceptions below and discuss the measurement of quality at the end of this section. Next, we disaggregate seed sourcing strategies by land ownership, where land ownership proxies for wealth. This analysis provides us with insights into whether wealth predicts with farmers' seed sourcing strategies. Annex 5a provides tables and figures on the source of last seed replenishment by land decile. While the number of observations in our data is limiting for certain crops (specifically, sunflower, black gram, and pigeon pea), we find that no immediate pattern emerges, suggesting that seed sourcing strategies are not likely correlated with wealth.

Another way of analyzing the data collected from the survey is to examine their responses to broader questions about seed sourcing strategies. Table 5.10 provides a breakdown of the sources of seeds that have ever used by farmers. While government seed farms and farmer seed producers account for 67 percent of all seed sourcing strategies employed for rice, and 48 percent for sunflower, these sources are far less prevalent for the other focus crops. For these other crops, responses indicate that farmer seed producers, traders, and other sources (presumably own-saved seed or purchases from neighbors, as suggested by Tables 5.1-5.9) are the dominant sources. These figures reinforce our interest in farmers' perceptions about quality from these different sources, which we explore below.

Table 5.10. Sources of seeds ever used by farmers, by crop

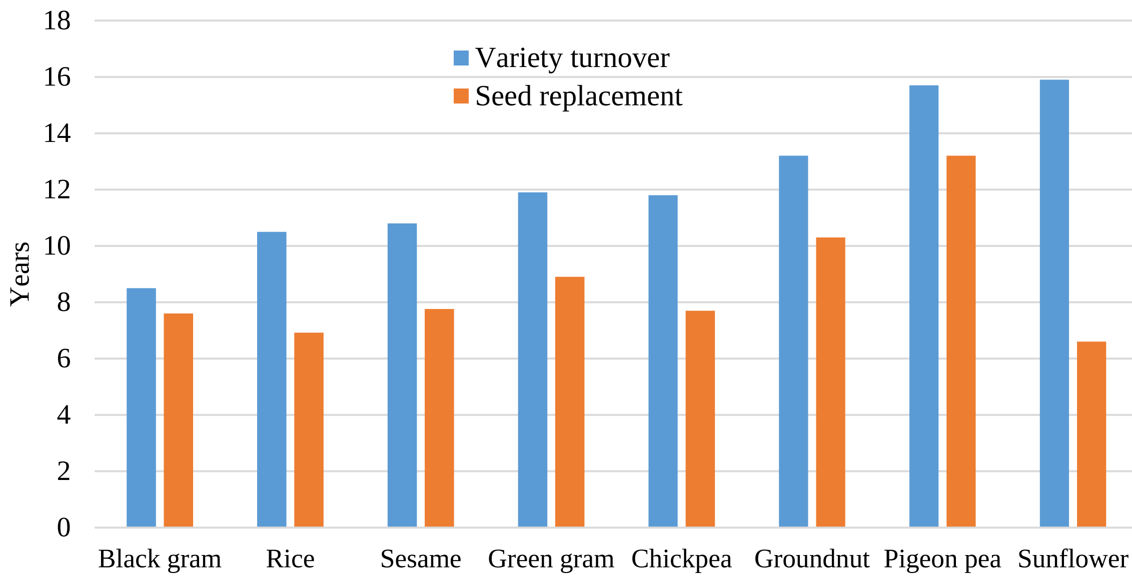
Seed source	Rice	Sesame	Ground-nut	Sun-flower	Green gram	Black gram	Pigeon pea	Chick-pea
N	*681*	*607*	*398*	*44*	*229*	*57*	*330*	*475*
Government seed farm	28.6	6.6	1.5	28.2	6.5	7.0	0.8	6.5
Agro-dealer/input supplier	14.0	12.9	10.0	10.4	13.3	7.4	7.1	12.6
NGO/development program	12.9	0.1	0.0	0.0	0.0	0.0	0.1	0.4
Farmer seed producer	37.5	24.2	16.6	19.5	27.8	32.8	17.2	25.0
Trader	13.4	18.7	28.4	15.4	19.6	25.9	12.9	28.1
Market grain vendor	1.9	1.9	2.4	1.2	0.7	8.5	0.2	2.7
None of the above sources	0.0	35.6	41.1	25.3	32.1	18.5	61.8	24.7

5.2. Seed replacement rate

Next, we turn our attention to the calculation of seed replacement rates for the focus crops in this study. Seed replacement—acquiring new seed of either a new or existing variety—is a potentially important means of acquiring quality seed, assuming that seed provider is indeed supplying a quality product. While it is recommended that seed for hybrids of most crops be replaced each season, seed for many self-pollinating crops can be saved and used as seed in the subsequent season without significant yield loss due to genetic or physical deterioration. Having said that, recommendations on seed replacement tend to emphasize the acquisition of fresh seed every 3-5 years, depending on the crop.

Figure 5.1 indicates the number of years since farmers replaced the seed used in cultivation of the focus crops in this study. This is graphed alongside the number of years since farmers replaced the variety used in cultivation to distinguish between the varietal turnover rate and seed replacement rate. Both are important factors in enhancing productivity, but each is a measurement of a different phenomenon.

Figure 5.1. Number of years that farmers have grown a variety (variety turnover) and last replaced seed (seed replacement), 2017-18 agricultural year, by crop



Note: Varietal turnover rate here is calculated by farmer response to the question of "when did the household first use this variety on its farm," and is not based on years since variety was released.

Findings indicate that farmers tend to replace seed more frequently than they introduce a new variety. This is an important indication that survey respondents likely understood the distinction and provided accurate responses—something that does not always occur in agricultural surveys. Importantly, we observe relatively slow rates of seed replacement, ranging from a low of 6.6 years for sunflower and 6.9 years for rice to 13.2 years for pigeon pea. These low rates of seed replacement may be one contributing factor to the relatively low yields observed for the focus crops in this study, although further analysis is warranted.

5.3 Seed prices

Next, we examine seed price variation across crops, where price can serve as a proxy for unobservable quality. Table 5.11 provides crop-specific seed prices paid by farmers by source. We collapse source into four categories: (a) formal, which denotes seed obtained from a seed company, input supplier, or the government; (b) informal, which denotes seed obtained from neighbors, a local market or trader, or other farmers or villages; (c) intermediary, which denotes seed obtained from farmer seed producers, seed producer organizations, non-governmental organizations, or from a rice or oil mill; and (d) own saved seed.

Note the considerable variation in seed prices from both formal and informal sources for rice, sesame, green gram, and chickpea, as well as the relative lack of variation in groundnut and pigeon pea prices. The variation in rice seed prices may be explained by the co-existence of both inbred and hybrid seed in the market, with the latter typically commanding a higher price. But the variation in sesame, green gram, and chickpea may be attributable to other factors that remain to be seen.

Next, we examine rice seed prices by land ownership decile, again to understand whether wealth correlates with seed price obtained by farmers. Annex 5b shows little evidence of such correlations, although the small number of observations for certain crops limit the analysis. Nonetheless, these figures suggest that farmers may face similar seed prices irrespective of their landholdings.

Another way of analyzing seed price data is to examine the seed-to-grain price ratio. In theory, high-quality seed that embodies desirable genetic traits should command a higher price in a market where farmers can reasonably assess these indicators, either directly or through proxy indicators.

While the number of observations by source is quite limited for certain crops, the seed-to-grain price ratios in Table 5.12 suggests that the market does not convey the value of quality seed and desirable traits to farmers for most crops. Only seed-to-grain price ratios for groundnut indicate some conveyance of value, albeit with considerable variation. Furthermore, rice shows a relatively consistent grain-to-seed ratio across sources, ranging from 1.8 to 2.4. The remaining crops—the pulses—show fairly low seed-to-grain price ratios, suggesting that the market does not convey the value of quality seed and desirable traits to farmers.[12]

[12] Note that when both seed and grain prices from the community-level survey (rather than the household-level survey) are used for the calculations of these same ratios, the high seed-to-grain ratios observed for groundnut and sunflower decrease to below 2 for all crops.

Table 5.11. Seed price paid by farmers, 2017-18 agricultural year, by source and crop

Seed source	Rice	Sesame	Ground-nut	Sun-flower	Green gram	Black gram	Pigeon pea	Chick-pea
N	*301*	*188*	*95*	*15*	*51*	*6*	*48*	*157*
Formal								
Mean	12,494	57,083	47,500	60,000	40,000	0	10,000	26,364
Std. dev.	4,016	25,823	10,607	23,094	22,151	0	1,414	11,483
Min	5,000	6,000	40,000	40,000	8,000	0	9,000	5,000
Max	25,000	96,000	55,000	80,000	72,000	0	11,000	50,000
N	77	12	2	4	7	0	2	11
Informal								
Mean	10,401	51,932	35,873	25,091	45,632	33,240	14,649	29,001
Std. dev.	6,027	18,674	13,885	24,325	17,397	24,845	9,477	10,583
Min	1,000	3,000	6,000	1,000	4,000	14,000	8,000	5,500
Max	70,000	96,000	55,000	72,000	80,000	70,000	48,000	64,000
N	190	148	80	11	38	5	39	137
Intermediary								
Mean	13,796	58,333	0	0	45,000	80,000	0	37,500
Std. dev.	6,462	35,268	0	0	0	0	0	10,536
Min	7,000	10,000	0	0	45,000	80,000	0	22,000
Max	35,000	96,000	0	0	45,000	80,000	0	45,000
N	18	6	0	0	1	1	0	4
Own saved seed[a]								
Mean	13,367	47,238	40,692	0	41,667	0	25,286	33,400
Std. dev.	10,150	11,497	15,467	0	2,887	0	13,099	13,050
Min	6,000	38,000	8,000	0	40,000	0	10,000	22,000
Max	40,000	80,000	55,000	0	45,000	0	48,000	50,000
N	15	21	13	0	3	0	7	5

Note: [a] The price noted here may be interpreted as the farmer's own perception of the seed's market value, i.e., its shadow price.

5.4. Use of packaged, labeled and certified seeds

Next, we examine seed packaging, labeling, and certification across crops, all of which can serve as additional proxies for unobservable quality. The packaging of seed (or its absence) may indicate the extent to which the seed can be adulterated by foreign material or exposed to pests and disease at the point of sale. The labeling of seed, on the other hand, may provide farmers with critical information including the source of the seed (and, implicitly, a signal about the reputation or reliability of the seed provider), the year of production and recommended use, the performance parameters of the seed (specifically, germination rate), and other indicators of quality (moisture content or purity rate). It may not be the case that all labels contain all of this information, but we assume that labeling can potentially provide at least some amount of information on which a farmer can discriminate quality.

Table 5.12. Seed-to-grain price ratio, 2017-18 agricultural year, by source and crop

Seed source	Rice	Sesame	Ground-nut	Sun-flower	Green gram	Black gram	Pigeon Pea	Chick-pea
N	238	157	72	8	46	4	38	115
Formal								
Mean	1.84	1.11	7.86	7.27	1.56	0.00	0.00	1.07
Std. dev.	1.11	0.79	0.00	0.00	1.21	0.00	0.00	0.53
Min	0.40	0.19	7.86	7.27	0.25	0.00	0.00	0.15
Max	3.67	2.40	7.86	7.27	4.00	0.00	0.00	2.17
N	65	9	1	2	7	0	0	9
Informal								
Mean	1.61	1.47	3.28	2.05	1.56	2.40	1.29	1.20
Std. dev.	0.96	0.52	2.47	1.22	0.72	1.43	1.03	0.51
Min	0.13	0.11	0.24	1.00	0.14	1.48	0.36	0.23
Max	10.77	3.20	9.17	3.60	3.50	4.50	5.05	3.06
N	148	128	58	6	37	4	33	100
Intermediary								
Mean	2.09	1.73	0.00	0.00	1.80	0.00	0.00	1.64
Std. dev.	0.60	2.09	0.00	0.00	0.00	0.00	0.00	0.55
Min	1.00	0.25	0.00	0.00	1.80	0.00	0.00	1.00
Max	2.86	3.20	0.00	0.00	1.80	0.00	0.00	1.96
N	16	2	0	0	1	0	0	3
Own								
Mean	2.40	1.31	2.77	0.00	1.80	0.00	2.45	1.23
Std. dev.	1.48	0.38	2.05	0.00	0.00	0.00	1.25	0.38
Min	1.00	1.00	1.00	0.00	1.80	0.00	0.83	1.00
Max	5.00	2.50	6.25	0.00	1.80	0.00	3.69	1.67
N	9	18	13	0	1	0	5	3

Table 5.13 summarizes the share of varieties that were packaged, labeled, or certified when the household last replenished its supply of seed. We compare these shares between informal and formal/intermediate seed sources. Again, it is important to note that these figures are assembled at the variety level, and thus reflect variety-specific—and not household-specific—proxies for seed quality

First, we observe that there are very few household x variety observations for sunflower and black gram across both sources, and also few observations for groundnut, green gram, and pigeonpea among formal/intermediate sources. Second, the acquisition of seed for groundnut, green gram, pigeonpea, and chickpea varieties relies largely on the informal sources in our analysis.

We observe that among informal sources, a relatively large number of respondents indicated that they had purchased certified seed the last time they replenished their seed, ranging from a high of 44 percent for green gram to a low of 18 percent for rice. However, only for sunflower did these informal sources also provide seed for acquired varieties in a packaged (but not necessarily labeled) form at any substantial rate (22 percent). All other varieties of the focus crops were acquired without substantial rates of packaging or labeling.

Table 5.13. Proportion of observations (household x variety) reporting that seed acquired from outside the farm during the last replenishment was packaged, labeled, or certified, by crop and source category

Crop and seed characteristics	Informal sources			Formal/intermediate seed sources		
	N	Mean	Sd.	N	Mean	Sd.
Rice						
Packaged	198	0.05	0.22	104	0.71	0.46
Labelled	198	0.01	0.11	104	0.46	0.50
Certified	198	0.18	0.38	104	0.62	0.49
Sesame						
Packaged	171	0.02	0.15	36	0.17	0.38
Labelled	171	0.00	0.03	36	0.04	0.21
Certified	171	0.20	0.40	36	0.74	0.45
Groundnut						
Packaged	94	0.04	0.20	10	0	0
Labelled	94	0.02	0.14	10	0	0
Certified	94	0.08	0.28	10	0.95	0.24
Sunflower						
Packaged	11	0.22	0.43	3	0.62	0.59
Labelled	11	0.04	0.22	3	0.62	0.59
Certified	11	0.26	0.46	3	1.00	0
Green gram						
Packaged	48	0.03	0.18	12	0.49	0.52
Labelled	48	0.03	0.18	12	0.32	0.49
Certified	48	0.44	0.50	12	0.55	0.52
Black gram						
Packaged	5	0	0	1	1.00	0
Labelled	5	0	0	1	0	0
Certified	5	0.25	0.48	1	0	0
Pigeon pea						
Packaged	39	0.04	0.19	9	0.01	0.11
Labelled	39	0	0	9	0.01	0.11
Certified	39	0.20	0.40	9	0.40	0.52
Chickpea						
Packaged	141	0.04	0.18	20	0.38	0.50
Labelled	141	0	0	20	0.25	0.44
Certified	141	0.26	0.44	20	0.61	0.50

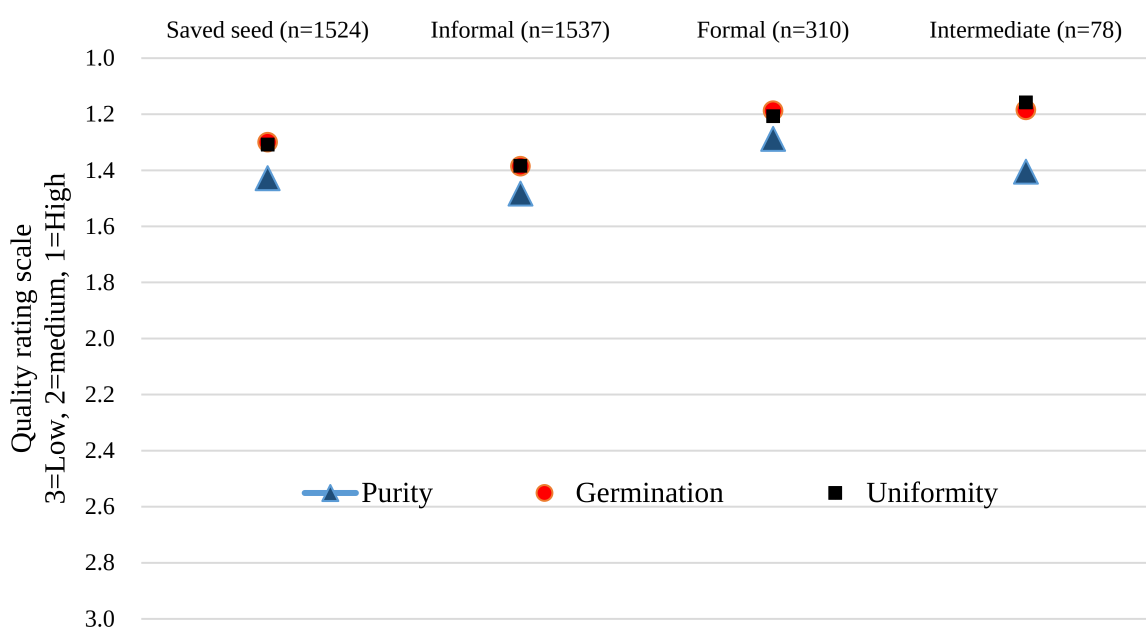
As might be expected, the rates of packaging, labeling, and certification at a variety level are higher when we examine formal/intermediate seed sources. This is true for rice varieties, where rates of packaging (71 percent), labelling (46 percent), and certification (62 percent) are relatively high, and for sunflower, where similar rates (62, 62, and 100 percent, respectively) are observed. Similarly high rates are observed for green gram and chickpea across all three indicators. For groundnut, while packaging and labeling are not observed among formal/intermediate seed sources, the varieties being acquired are reportedly certified.

These findings suggest that there exist important variations in packaging, labeling, and certification practices across crops and seed providers. This, in turn, suggests distinctions in the value chains and seed providers associated with each crop, which points to the need for differentiated, crop-specific strategies to improving seed quality.

5.5. Farmer perception of seed quality from different sources

Next, we turn to an analysis of farmers' own perceptions of seed quality to better understand variations across providers. First, we analyze farmers' rating of seed quality—specifically purity, germination, and uniformity—by crop and source for the 2017-18 agricultural year (Table 5.14). There are few discernible differences across the various sources, apart from slightly higher ratings for both own-saved seed and seed acquired from informal sources as compared to formal sources. Aggregating responses across all crops, we observe similar findings for all three quality indicators (Figure 5.2).

Figure 5.2. Average seed quality rating by source across all crops, 2017-18 agricultural year



Source: Myanmar Seed Demand Survey in Dry Zone, 2018

These findings may suggest that from the perspective of the average farmer, seed from formal sources is no better in quality, and possibly worse in quality, than seed from informal sources and own-saved seed. But given the large number of observations for own-saved seed and informal seed sources for all crops (apart from sunflower and black gram) relative to observations for formal and intermediate sources, there are limits to the precision of these descriptive statistics.

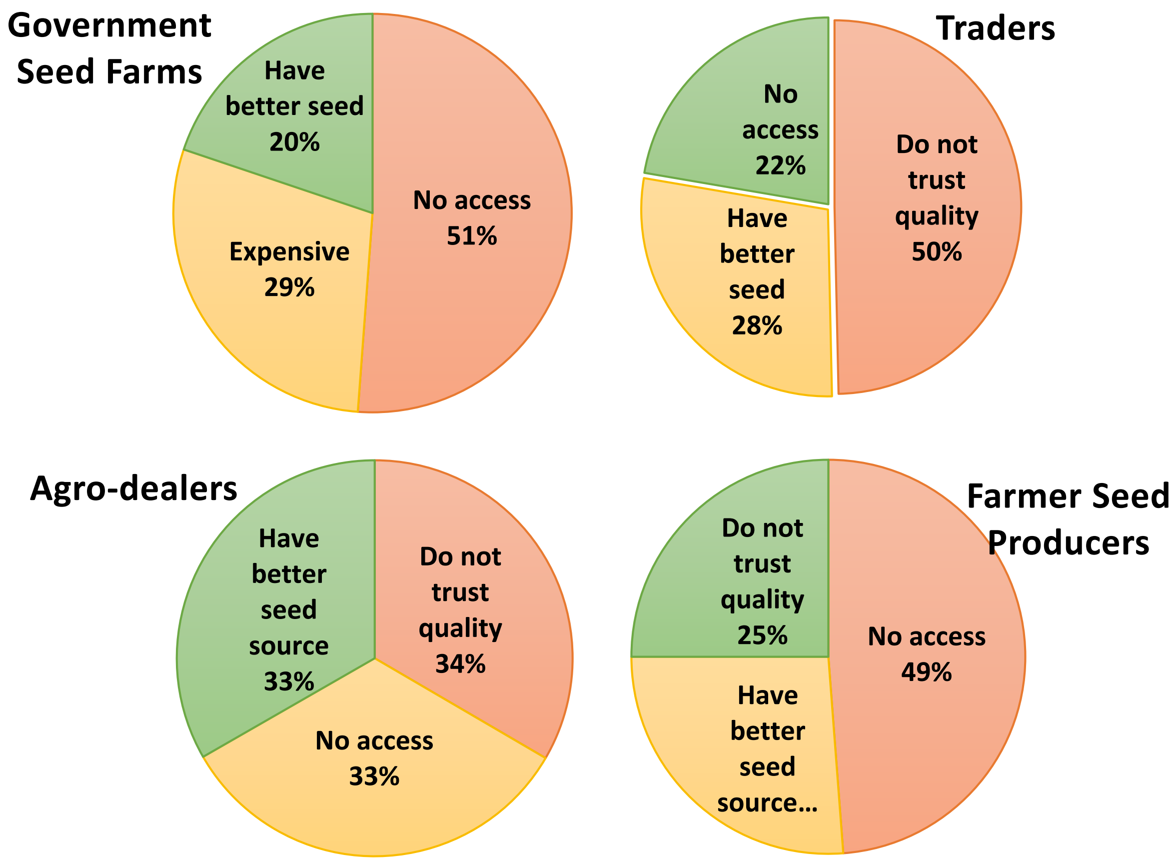
Table 5.14. Average seed quality rating by sources of seeds planted in the agricultural year prior to the survey, by crop[a]

	Own saved seed			Informal			Formal			Intermediate		
	N	Mean	Std. dev.	N	Mean	Std. dev.	N	Mean	Std. dev.	N	Mean	Std. dev.
Rice												
Purity	295	1.44	0.50	503	1.45	0.50	190	1.31	0.49	44	1.41	0.50
Germination	295	1.37	0.48	503	1.34	0.50	190	1.20	0.40	44	1.17	0.38
Uniformity	295	1.32	0.49	503	1.32	0.47	190	1.24	0.45	44	1.15	0.36
Sesame												
Purity	359	1.47	0.52	341	1.55	0.52	36	1.42	0.50	7	1.00	-
Germination	359	1.28	0.46	341	1.45	0.52	36	1.23	0.43	7	1.00	-
Uniformity	359	1.31	0.47	341	1.47	0.53	36	1.23	0.42	7	1.00	-
Groundnut												
Purity	271	1.35	0.48	195	1.48	0.53	17	1.08	0.28	8	1.72	0.48
Germination	271	1.22	0.42	195	1.35	0.48	17	1.03	0.18	8	1.58	0.53
Uniformity	271	1.24	0.44	195	1.37	0.50	17	1.09	0.30	8	1.28	0.48
Sunflower												
Purity	23	1.23	0.43	18	1.29	0.47	9	1.07	0.27	1	1.00	.
Germination	23	1.36	0.49	18	1.18	0.39	9	1.00	-	1	1.00	.
Uniformity	23	1.20	0.41	18	1.26	0.45	9	1.07	0.27	1	1.00	.
Green gram												
Purity	105	1.39	0.49	117	1.47	0.52	14	1.17	0.39	6	1.53	0.55
Germination	105	1.25	0.44	117	1.29	0.48	14	1.28	0.47	6	1.18	0.42
Uniformity	105	1.33	0.47	117	1.32	0.49	14	1.17	0.39	6	1.18	0.42
Black gram												
Purity	23	1.55	0.51	24	1.47	0.51	8	1.39	0.52	2	1.68	0.66
Germination	23	1.43	0.51	24	1.20	0.41	8	1.15	0.38	2	1.00	-
Uniformity	23	1.44	0.51	24	1.41	0.50	8	1.15	0.38	2	1.00	-
Pigeon pea												
Purity	256	1.49	0.51	79	1.54	0.53	6	1.00	-	1	2.00	.
Germination	256	1.41	0.49	79	1.52	0.57	6	1.00	-	1	1.00	.
Uniformity	256	1.39	0.50	79	1.54	0.57	6	1.00	-	1	1.00	.
Chickpea												
Purity	192	1.43	0.50	260	1.44	0.50	30	1.26	0.47	9	1.49	0.64
Germination	192	1.31	0.47	260	1.44	0.51	30	1.20	0.41	9	1.18	0.58
Uniformity	192	1.31	0.46	260	1.39	0.49	30	1.19	0.46	9	1.29	0.63

[a] Quality rating scale: 1=high, 2=medium, 3=low

We explore these findings about farmers' perceptions further by examining their main reasons for not purchasing seed from different sources (Figure 5.3). A rather straightforward lack of access explains about 50 percent of all respondents' reasons for not using seed from government seed farms and farmer seed producers. In the case of traders, a similarly straightforward lack of trust in the quality of seed being sold by traders explains 50 percent of all respondents' reasons. Among agro-dealers and input retailers, farmers responded that a lack of access, a lack of trust in seed quality, and better seed source alternatives equally explain their reasons for not using seed from this source.

Figure 5.3. Top three reasons reported by farmers for not using seed from a given source across all crops



These findings suggest that efforts to improve the supply of quality seed requires a good understanding of farmers' perceptions of quality of seed from different sources which, in turn, necessitate an understanding of demand side preferences. To this end, our survey elicited farmers' preferences for seeds from different sources by understanding their perception of seed quality from these sources using a best-worst scaling (BWS) technique.[13] Specifically, we assessed farmers' perception of seed

[13] BWS questions are preferred to simple ranking or Likert-scale questions because individuals are required to make tradeoffs instead of simply rating the importance of each practice independently. This combats the issue

quality for seven different sources of seed potentially available to them as options to get seeds. These seven seed sources were defined as:

1. Farmer's own saved seed
2. Seed from agro-dealer/company that came in a package with a label
3. Seed from a grain vendor in the market that farmers can buy in bulk and came with no label
4. Seed from a seed producer or a farmer group that is trained to produce seed but seed has no label
5. Seed from a trader that farmers can buy in bulk and came with no label
6. Seed from government seed farm that comes in package or in bulk
7. Seed from an NGO or a development program

Best-worst scaling experiments presented individual respondents (in this case farmers) with multiple experimentally designed answer options (seeds from the various sources). East set included three options of seed sources and asked the respondent to select one option as the "best" seed quality source and one option as the "worst" seed quality source. Through multiple choice scenarios, a cardinal ranking of the seven seed sources was developed. Results are presented in Figures 5.4 and 5.5.

Results reveal that overall, seed from the government was selected as most preferred most often, followed by agro-dealer, farmers' saved seed, and farmer group. For rice, government seed was selected as most preferred 71 percent of the time, dealer seed 50 percent of the time and saved seed 48 percent (Figure 5.4). Similarly, seed from market vendors was selected as least preferred by 84 percent of the sample. Our sample also exhibits bi-polar preferences for rice seed from dealers with 50 percent selecting the dealer source as most preferred and 28 percent selecting it as least preferred (Figure 5.4). A similar pattern is also found for the other crops.

We calculated a normalized best-worst score (BW score)[14] for each seed source in order to compare preference rankings. The rankings of the scores again show that the seed from government and the seed saved from own harvest were preferred most among all type of seed sources (Figure 5.5). For rice, government seed has the highest best-worst score (0.67)[15], while the seeds from trader and vendor have the lowest score (-0.54 and -0.84 respectively) among all seven sources included in the BWS experiment (Figure 5.5). This implies that government seed was perceived to be better quality and likely to be selected as the best quality seed 179 times more than vendor seed.[16] Similarly, saved seed of rice was 159 times more likely to selected as the best quality than seed from a trader.

Overall, the findings suggest that without formal quality assurance mechanisms, the seed from the government stands for good quality and preferred the most, followed by seed saved from their own harvests. Seeds from agro-dealers that come in a package and are labeled are also perceived to be of high quality relative to all other sources of seeds that are not packaged or have no labels. Thus, it

---

of respondents selecting all seed sources as most or least important, for example. Additionally, BWS nullifies the scale subjectivity of various types of ranking questions.

[14] This score was calculated as the number of times a source was selected as best minus the number of times it was selected as worst, divided by the number of times the item appears.

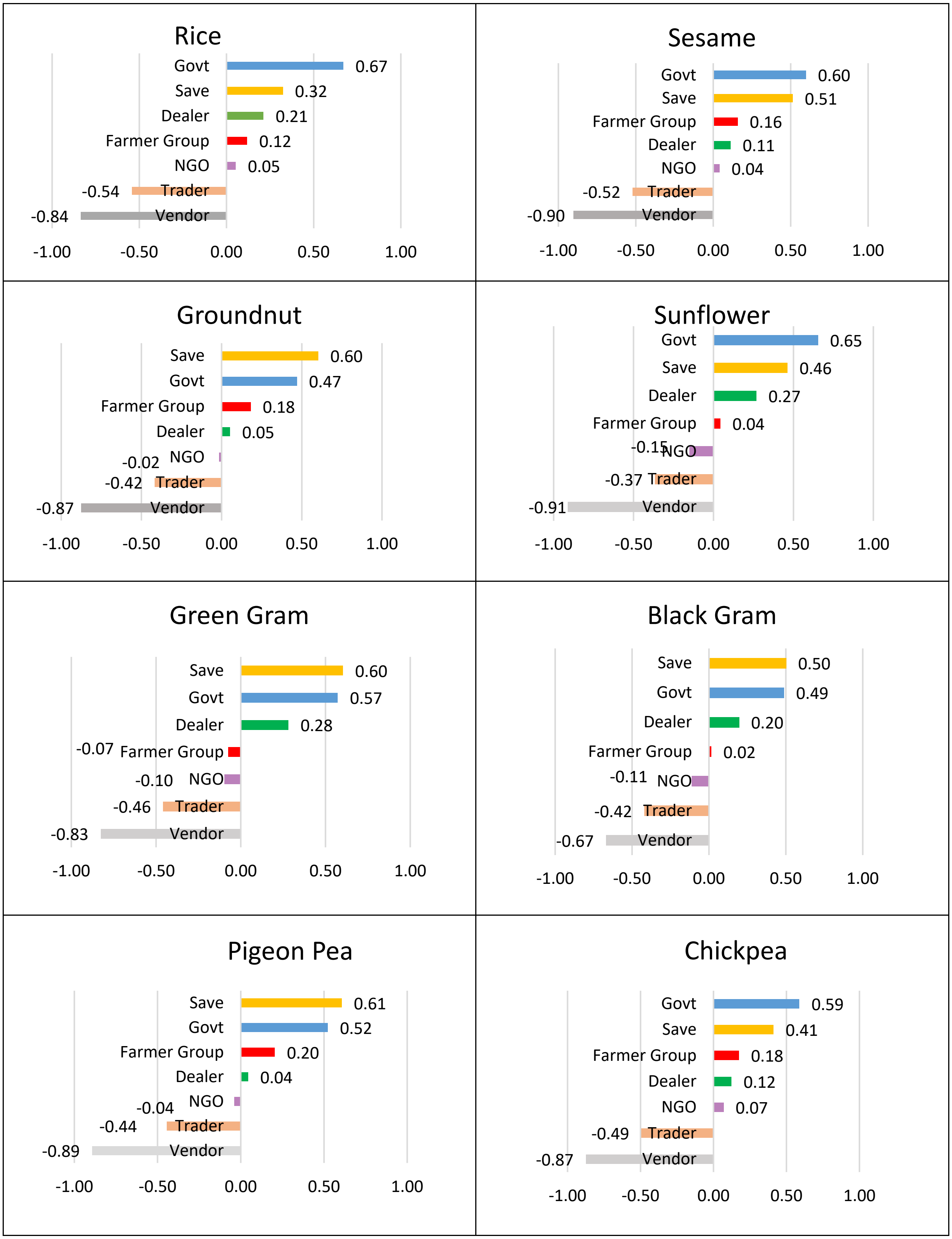
[15] B-W score ranges from 1 to -1 with 1 being perceived best quality and -1 being perceived worst quality.

[16] The number of times differences was calculated as B-W score of source 1 (i.e., government) minus B-W score of source 2 (i.e., vendor), divided by B-W score of source 2 (i.e., vendor), then multiplied by 100.

seems that traceability and quality assurance symbolized by packaging and labeling are important to farmers and are associated by them with good quality seed.

Figure 5.4: Percentage Choosing Best-worst

Figure 5.5: Normalized Best-worst (BW) score



6. FARMER DEMAND FOR VARIETY AND SEED QUALITY TRAITS

An important objective of this study is to understand farmers' demand for seeds as planting materials. Seed is the most essential and necessary input in crop production. In the most basic sense, the annual demand for seed is a function of area cultivated to a crop and quantity of seeds planted per unit of land. However, not all the demand for seed needed for planting translates into market demand, because farmers themselves are seed producers. How much of the total seed demand (based on area planted x seeding rate) is actually met by the market or can potentially be met by the market, and at what price is the focus of this section.

Since seed is a marketed commodity and a private good, its demand can be estimated from actual or revealed behavior. But given the large number of seed producers, seed available in the market is of heterogeneous quality (both in the sense of genetics and seed vigor) and comes with uncertainty of quality. What would be the potential demand for seed if this uncertainty is removed? What would be farmers' willingness to pay (WTP) for seed that has their most preferred varietal and seed quality traits? In this study we are also interested in knowing this potential market demand for seed if such seed products were available to farmers. To assess this potential market demand for seed we use the stated preference approach that relies on answers to carefully worded survey questions. In the survey conducted for this study, we included questions to estimate both the actual seed demand based on farmers' purchase behavior and projected demand for seed based on stated preferences. We first describe the method used for estimating actual and potential demand, followed by results and discussion.

6.1 Methodology

Estimation of actual seed demand is based on farmer reported area planted, seeding rate, seed sources, and price of seed, if purchased. This information is then combined and extrapolated to the study area to get an estimate of total quantity of seed needed for area planted (total seed demand), percentage of seed purchased (i.e., market demand), and price per unit of seed purchased. Seed demand based on this method is estimated for all eight focused crops.

The stated preference method involved first asking farmers their preferred varietal and quality traits, and then posing questions on how much they would be willing to pay, the quantity they would be willing to purchase, and the frequency at which they would purchase the seed at that price and quantity, if seeds with their preferred varietal traits and quality traits were available in the market. This stated willingness to pay (i.e., price), stated quantity willing to purchase, and the stated frequency of seed purchase are then combined and extrapolated to the study area to get an estimate of effective and ineffective demand for quality seed. Effective demand is defined as the quantity of seed farmers are willing to purchase at the price equal to or above the reported current market price. Ineffective demand is defined as the quantity of seed farmers are willing to purchase at the price less than the reported current market price. Unfortunately, the modules for estimating the seed demand based on stated preferences were implemented for up to three crops per household based on the importance of the crop in terms of area planted. Therefore, the estimates of projected effective and ineffective seed demand is presented for only a sub-set of five crops (rice, sesame, groundnut, pigeon pea and chickpea) for which we have adequate number of observations. The other three crops--sunflower, green gram and black gram—are excluded from this analysis due to small sample size.

Below, we present the results of estimated demand for seeds in the study area based on both these methods. The results are presented in four parts. First, we present seed demand estimates for all focused crops using the actual market-based revealed behavior. Second, we present trait preference ranking by farmers for varieties and seed quality, followed by estimated demand for seed based on farmers' WTP for varieties with preferred traits and for quality seeds if they were available in the market. Finally, we present the estimated derived demand for seed based on the stated WTP price, quantity and frequency, and compare that with the market price (i.e., supply curve) to assess effective demand.

6.2 Seed demand estimates based on area planted, seeding rate, and purchase behavior

Table 6.1 shows the estimated total area planted to different crops across the three seasons prior to the survey, farmer reported seeding rate, total quantity of seed required per year based on the area planted and the seeding rate, percentage of these total quantity of seed obtained from outside own farm (i.e., market demand), and farmer reported price of purchased seed at the time of planting. The area planted to each crop are from the official estimates from the Department of Agriculture. For all other variables, the estimates are extrapolated to the study area by using sample weights. Total number of farm households estimated to be growing a given crop that are reflected in these extrapolations of the seeding rate, purchase rate and seed prices are approximately: 54,000 households for rice, 61,000 for sesame, 38,000 for groundnut, 3,000 for sunflower, 21,000 for green gram, 3,000 for black gram, 24,000 for pigeon pea, and 32,000 for chickpea.

Table 6.1 Total acreage, seeding rate and quantity of seed required for planting each year (potential demand), by crop

Crop	Total area planted in study regions ('000 acres)\a	Farmer reported seeding rate (Baskets/acre) Median	Total quantity of seed required per year (estimated potential demand) (Baskets)	% of planted seed purchased (market demand)	Farmer reported price of purchased seed in past year (MMK/Basket) Median
Rice	3,727.35	2.00	7,454.69	74%	10,000
Sesame	2,788.41	0.19	529.80	44%	56,000
Groundnut	1,472.57	2.00	2,945.13	32%	42,000
Sunflower	589.64	0.31	182.79	78%	16,000
Green gram	1,287.96	0.25	321.99	58%	48,000
Black gram	37.53	0.38	14.26	68%	48,000
Pigeon pea	941.68	0.21	197.75	20%	32,000
Chickpea	835.77	1.50	1,253.65	60%	45,000

\a Includes total cropped area in Magway, Mandalay and Sagaing Regions, 2018 (Source: Department of Agriculture)

Rice, is the most extensively grown crop among the eight focused crops with an estimated 3.7 million acres planted to this crop in 2018 in the study regions of Magway, Mandalay, and Sagaing. Sesame is the second most important crop in terms of area planted (2.8 million acres), followed by groundnut, green gram, pigeon pea, chickpea, sun flower, and black gram. Rice and groundnuts have the highest seeding rate based on farmer reported seed quantity planted per acre of land—about 2 baskets/acre. Sesame, pigeon pea, and green gram have some of the lowest seeding rates in the range of 0.2-0.25 baskets/acre (Table 6.1).

The product of the estimated total area planted and the self-reported seeding rate provides an estimate of total quantities of seed required for planting per year. According to these estimates, total quantities of seed required annually for planting the total area of a given crop range from more than 7.45 million baskets for rice, 2.95 million baskets for groundnut, and about 1.25 million baskets for chickpea, to about 200-500 thousand baskets for sun flower, pigeon pea, green gram, and sesame, and about 14,000 baskets for black gram (Table 6.1). If farmer saved grain was not a substitute for seed as a planting material, these quantities would represent the total market demand for seed. However, for all these crops, farmers themselves are producers and suppliers of their own seed; they use grain from previous harvest as seed in the following season. Thus the actual market demand for seed (i.e., seed obtained from other producers at a price) depends on farmers' seed recycling behavior (vis-à-vis trust of seed quality produced by others), seed price, and availability of seeds from other suppliers. This market demand for seed based on the survey data for 2017-18 agricultural year is highest at about 78% of total quantity of seed planted for sunflower, 74% for rice, 68% for black gram, 60% for chickpea, 58% for green gram 44% for sesame, 32% for groundnut, and 20% for pigeon pea. These figures represent the total share of planted seeds sourced from other seed (or grain) producers at a price. These other seed producers can be categorized into three groups— informal (i.e., other grain producing farmers in the community, grain traders and grain vendors), semi-formal (i.e., farmer seed producers, seed producer organizations, individual seed entrepreneurs), and formal (i.e., companies, input dealers, government, etc.).

Since the seed market is characterized by a large number of producers producing varying quality of seed (from grain to certified seed), the price of seed reported by farmers is variable and depends on many factors. The median price for seed purchased from the formal, semi-formal or informal seed market for different crops is reported in the last column in Table 6.1. These range from 10,000 MMK/basket for rice to 56,000 MMK/basket for sesame, and values in between for other crops. Farmer reported price of seed range widely, and differ by type of seed source. With the exceptions of groundnut and chickpea, the average price of seed purchased from the informal sector is lower than the mean price of seed purchased from the formal or semi-formal seed sector (Table 6.2). For rice, sesame, sunflower and green gram, the price difference is statistically significant. For other crops, the sample size is too low to make any generalization. For groundnut, surprisingly, the price of seed purchased from the informal seed sources (i.e, other farmers, traders or vendors) is significantly higher than the price of seed from the formal sources. There is a need for further investigation into the reasons for this significant price difference reported between the formal and informal seed channels for groundnut.

Figure 6.1 shows how the total quantity of seed planted by farmers—i.e., total potential demand based on actual farmer practices (i.e., column 3 in Table 6.1)—was met by different sources or seed suppliers.

Of the six categories of seed suppliers depicted in Figure 6.1, only the top 2 bars (formal and semi-formal) can be characterized as 'seed producers'. The other four sources are essentially grain producers (i.e., own saved seed and obtained from other farmers) or grain sellers (i.e., traders and vendors in the market).

Table 6.2. Comparison of price of seed purchased from informal sources and from formal/semi-formal sources, by crops

	Seed from Informal Sources \a			Seed from Formal / Semi-formal Sources \a			
	N	Mean	sd	N	Mean	sd	t-test \b
Rice	458	10,230	3,366	193	14,376	5,127	***
Sesame	309	56,254	17,737	37	67,226	18,682	***
Groundnut	183	43,692	9,710	24	36,070	15,638	***
Sunflower	16	31,674	27,663	4	58,080	23,058	*
Greengram	107	47,670	17,853	18	56,631	15,372	**
Blackgram	22	45,609	27,603	9	60,371	21,931	
Pigeon pea	61	33,599	13,967	6	39,533	9,888	
Chickpea	239	43,001	9,369	33	40,486	15,671	

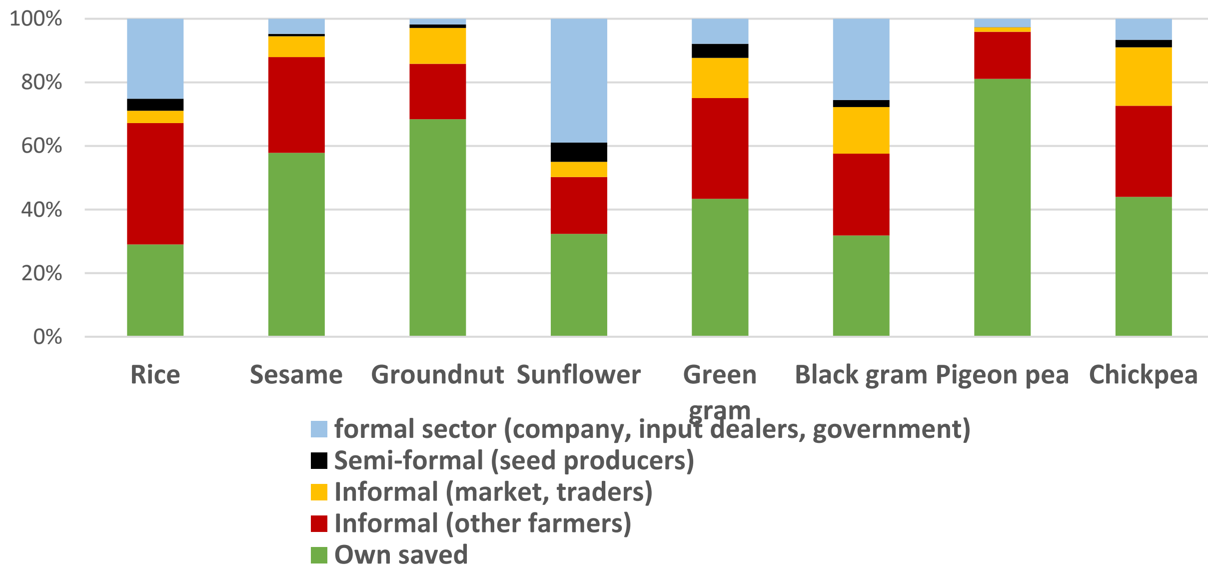
Source: Authors' estimations based on Source: Myanmar Seed Demand Survey in Dry Zone (2018)

\a Informal seed source includes other farmers, grain traders, grain vendors in the market. Semi-formal sources include seed producer organizations, individual seed entrepreneur in a community. Formal source include government, NGOs, seed company, input dealers.

\b *** p<0.01, ** p<0.05, * p<0.1

Except for sunflower and to some extent rice and black gram, the share of seeds procured from the formal or semi-formal sources is limited. For sesame, groundnut, pigeonpea, and chickpea, the share of seeds sourced from the formal and semi-formal sector is less than 10% of potential annual demand for seed. For these crops grain, either saved from own harvest or obtained from the informal sector is the most important source for meeting the required quantity of seeds for planting. Among the informal sources, own saved seed was the most important source for sesame, groundnut, and pigeon pea. For crops like rice, green gram, black gram and chickpea, own saved seed and seed purchased from other farmers (i.e., grain producers) are both equally important (Figure 6.1).

Figure 6.1. Market share of seed procured from the formal, semi-formal and informal seed channels and own saved seed to meet the total annual quantity of seed demand, by crop



Source: Authors' estimations based on Myanmar Seed Demand Survey in Dry Zone (2018)

Overall, what the data suggests is that the seed market for rice, oilcrops, and pulses in the Central Dry Zone region is dominated by grain seed produced by farmers themselves or produced by other farmers and procured through informal transactions or aggregated by traders and procured via grain market. Would farmers demand more 'seed' or purchase seed (instead of using own saved grain) if the seed meets their varietal and seed quality preferences? What would they be willing to pay for such seed? These are the questions we turn next, in the following sub-sections.

6.3 Trait preferences for Varieties and Seed Quality

According to the consumer demand theory, a good in question does not give utility but rather the characteristics possessed by the good provides utility. This is an alternative theoretical approach to the traditional demand theory proposed by Lancaster (1966, 1971) and is based on the principle that all goods possess characteristics or **attributes** that are demanded by the consumers, not the goods themselves. Thus, according to this theory, demand for 'seed' as a product is determined by how much utility farmers derive from its attributes, while keeping within their budget constraint. There are many approaches to estimate the demand for a product based on this theory. In this study, we used the simple 'stated preference' method to estimate farmer's WTP for seed if it possessed attributes they liked.

As a first step, farmers were asked about their preferred attributes in terms of varietal traits. These are attributes that are genetically programmed in the seed product either by nature or by breeders. Farmers were presented with the following hypothetical scenario to elicit their varietal trait preferences:

> *We would now like to ask you about your preferences for varietal characteristics for [..CROP..] to guide breeding research and future development of new and improved varieties. We would like to know which*

characteristics you prefer that researchers should target in their breeding programs. I am going to read you the characteristics and ask you to put them in order of their importance to you.

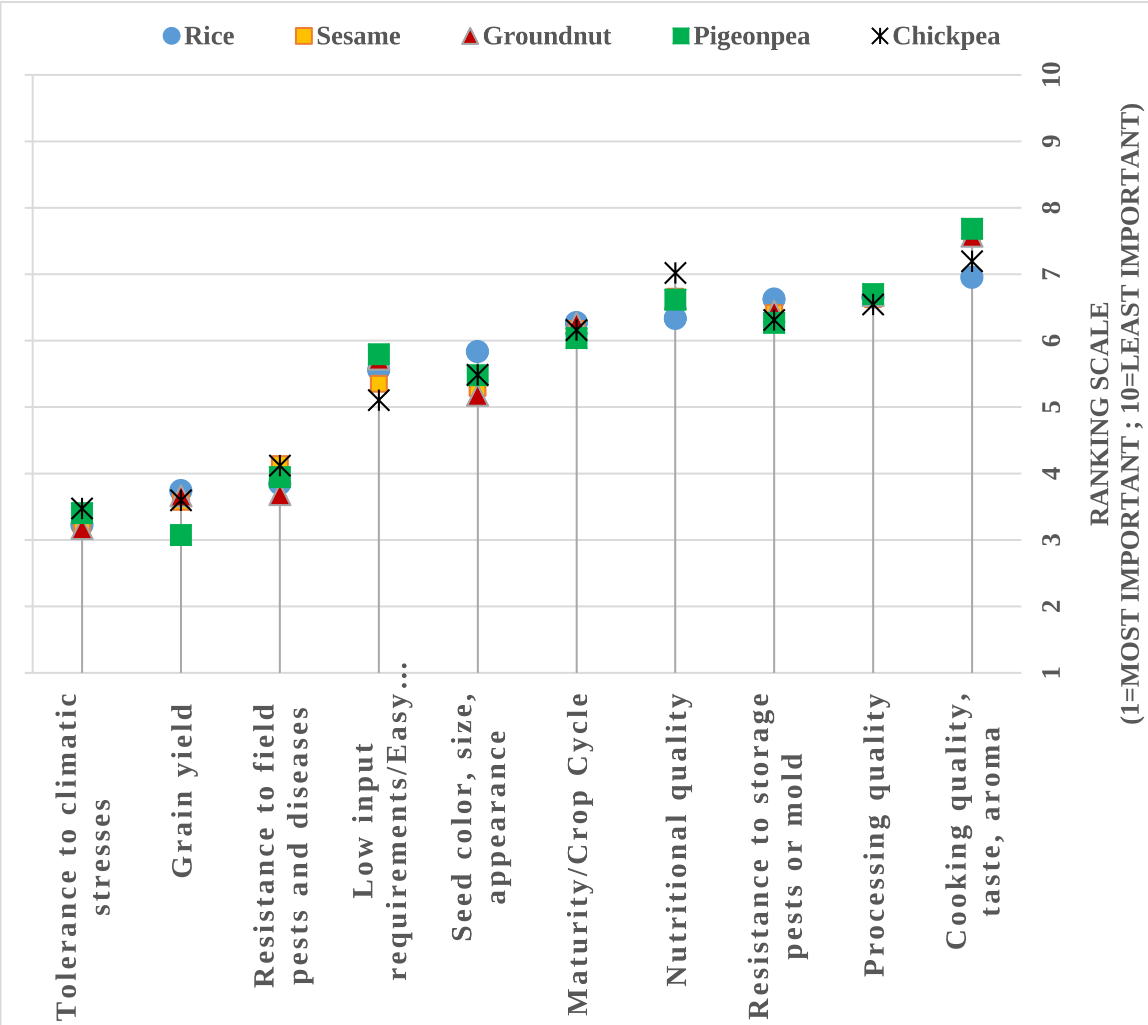
Farmers were then shown nine cards (placed on a surface in a random order), each with a varietal trait written on it, and asked to order them from the most to least important. The nine traits include: seed color, size, appearance, tolerance to climatic stresses (e.g., drought, flood), resistance to field pests and diseases, resistance to storage pests or mold, cooking quality, taste, aroma, grain yield, maturity/crop cycle, low input requirements/easy to grow, nutritional quality, and processing quality (e.g., oil content). After reading (or showing the cards), farmers were asked if there were any other characteristic not in the list that were important, and if so they were included in the ranking as 'other, specify.'

Figure 6.2 shows the preference ranking of these varietal traits across the sampled households for the five crops for which we have enough number of observations. In general, the ranking of varietal traits preferred by farmers or considered most to least important are consistent across crops. For all the five crops, varietal attributes associated with performance of seed during production are considered most important by farmers, and attributes associated with post-production are ranked as least important. Thus, varieties with attributes such as tolerance to abiotic and biotic stresses and produces higher grain yield are ranked more important than varieties that store well or have good processing quality and cooking quality. Note that except for the color, size and appearance, which is ranked in the middle, all other attributes are non-observable that can be experienced only after planting the seed.

Same method was used to elicit farmers' preferences for seed quality traits. Farmers were shown cards with seven seed quality attributes and asked to rank them in the order of most important to least important (Figure 6.3). These quality attributes included: 1) Seeds should all look same (in size, color) and are not broken or damaged; 2) Seeds are free from any inert material (e.g., stones, weed seeds); 3) Seeds are free from pests and diseases; 4) Seed has high germination when planted; 5) Plants grow uniformly after planting; 6) Plants look healthy and vigorous in growth stage; 7) Plants have high yield and good quality grain at harvest. Unlike varietal traits, the emphasis in this exercise was on qualities that predict or are associated with the vigor and health of the seed as a planting material, and not its genetic makeup. Also, unlike the varietal traits where some attributes can be mutually exclusive (e.g., cooking quality and tolerance to weather shocks or early maturity and nutritional quality), in the case of seed quality, most of these attributes are closely related with each other and together define quality seed product. In other words, there is a high degree of multi-collinearity among these traits—some of which are observable before planting (e.g., physical appearance of seed) and some only experienced after seeds are planted (e.g., germination, vigor, and uniformity of plant growth). Nevertheless, for the sampled farmers and the focused crops, this ranking exercise does reveal what farmers view as important attributes of seed quality relative to each other.

For all crops, on average, farmers consider high germination as the most important attribute of seed quality, followed by seed health (i.e., seed should be free from pests and diseases), and then the physical characteristic of seed in terms of size/color, and not broken or damaged (Figure 6.3). Interestingly, although high yield was one of the second most important attribute of a variety, the quantity and quality of harvested yield was considered least important when it came to seed quality. This shows that farmers do understand the concept of seed quality as distinct from the concept of varietal traits and have distinctive preferences for what they want in a variety vs. seed.

Figure 6.2. Varietal trait preferences, by crop



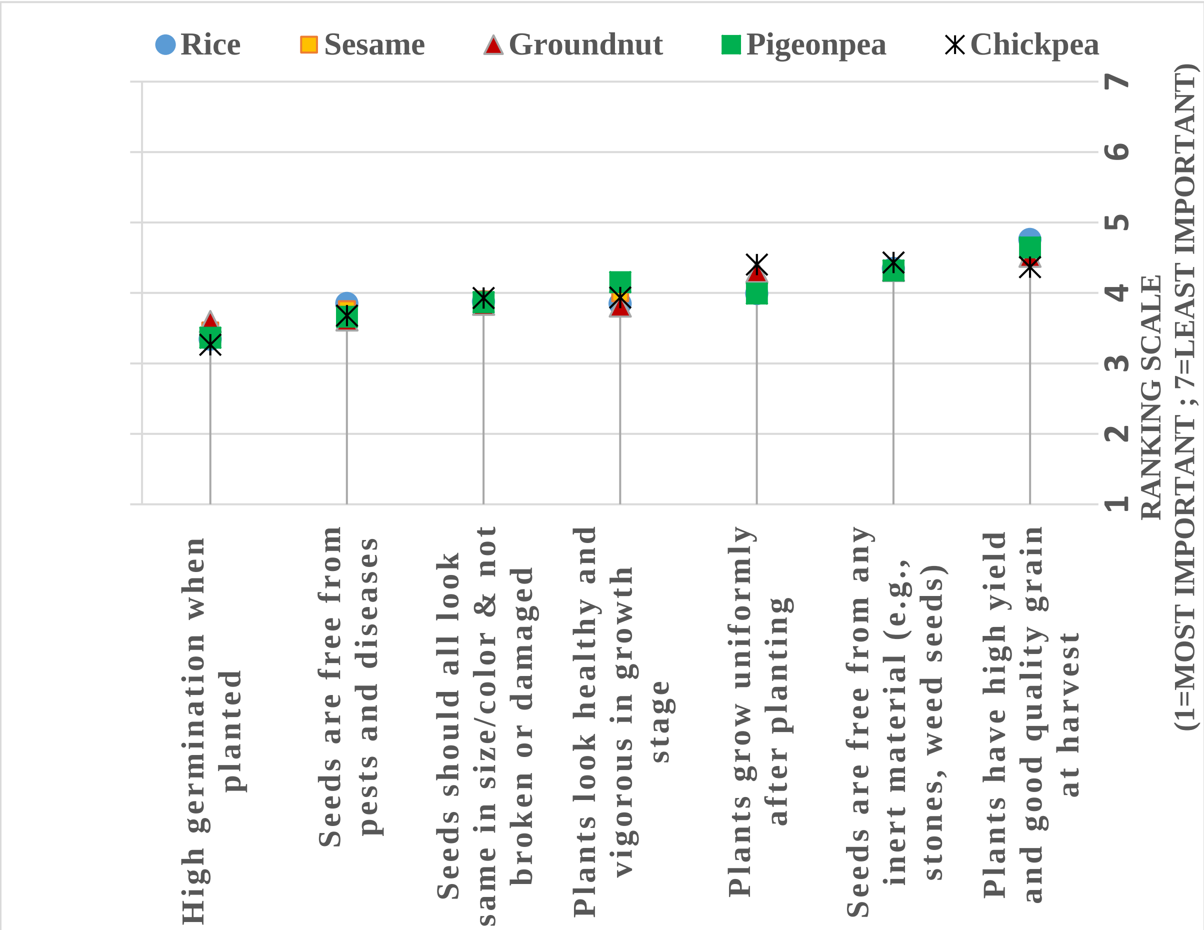
Source: Myanmar Seed Demand Survey in Dry Zone, 2018

6.4 Farmers' Willingness to Pay for Varieties with Preferred Traits and for Quality Seeds

After eliciting the preference ranking for varietal traits, farmers were asked how much they would be willing to pay for seed of a variety that had their most preferred attributes, what quantity they would be willing to purchase at that price, and how frequently they would purchase the seed at that price and quantity. Similarly, after eliciting the preference ranking for seed quality traits, farmers were asked the same set of questions about the price, quantity and frequency of seed they would be willing to purchase if seeds with their preferred quality were available in the market. Before eliciting farmers' WTP, they were also asked about the current market price of seed, which is used as an anchor to estimate the premium farmers are willing to pay relative to this self-reported price of seed.[17] The results of this 'stated preference' method of estimating farmers' demand for seed are presented in Tables 6.3 & 6.4.

[17] Note that the price reported by farmers relate to price at the time when the survey took place. Due to seasonal variation in the price of seed (and grain), this price may be different from the seed price at planting time reported in Table 6.1. Also, when eliciting the information about current price of seed, no reference was made on type of seed.

Figure 6.3. Seed quality trait preferences, by crop



Source: Myanmar Seed Demand Survey in Dry Zone, 2018

For most crops, the median values of farmers' WTP for seed with preferred varietal traits and preferred quality traits are same or in similar range, and on average reflect about from 5% to 28% premium above the reported median seed price. On average, the WTP a premium above the current seed price was highest for chickpea (28% for varietal traits and 24% for seed quality traits), and lowest for sesame (4% for both varietal traits and seed quality) and groundnut (5% for both varietal traits and seed quality) (Table 6.3). The mean values of the estimated price premium differ slightly from the median values for most of the crops for both seeds with preferred varietal attributes and seed quality. For crops such as rice and chickpea, the mean WTP premium is lower than median, which indicates that for these crops, the distribution is skewed towards the lower end of the WTP spectrum with some farmers with extremely low WTP for seeds of these crops. For sesame and pigeon pea, on the other hand, the mean values are greater than the median WTP, which suggests that the distribution is dominated by some farmers with extremely high WTP price for seeds of preferred varietal traits and seed quality.

Table 6.3. Farmers' willingness to pay for seeds with preferred varietal traits and seed quality traits, by crop \a

		Farmer reported current seed price ('000 MMK/Basket)	WTP for seed with preferred varietal traits ('000 MMK/Basket)	WTP for seed with preferred seed quality traits ('000 MMK/Basket)	Average price premium farmers are WTP above the reported market price for preferred…	
					Varietal traits	Seed quality traits
Rice	N	631	631	629		
	Mean	12.1	14.1	13.1	17%	9%
	Sd	12.7	25.2	7.8		
	Median	10.0	12.0	12.0	20%	20%
Sesame	N	454	454	452		
	Mean	50.2	58.8	56.5	17%	13%
	Sd	25.6	57.0	39.7		
	Median	48.0	50.0	50.0	4%	4%
Groundnut	N	253	253	251		
	Mean	40.6	42.7	45.3	5%	12%
	Sd	12.5	14.4	47.7		
	Median	43.0	45.0	45.0	5%	5%
Pigeon pea	N	292	292	289		
	Mean	29.1	33.8	34.6	16%	19%
	Sd	27.0	31.1	28.9		
	Median	22.0	23.0	25.0	5%	14%
Chickpea	N	313	313	312		
	Mean	36.5	41.3	38.3	13%	5%
	Sd	58.0	59.3	41.3		
	Median	25.0	32.0	31.0	28%	24%

\a Stated willingness to pay (hypothetical scenario)

In Figure 6.4 we present the derived demand curves based on the WTP for seed with preferred varietal traits and seed quality traits. The downward sloping curves relate the willingness to pay a stated price per basket of seed with the percentage of farmers that are willing to pay at least that price. The WTP for seeds with preferred varietal traits and preferred quality traits is very similar and almost overlap with each other. Assuming that farmers' would be willing to pay at least the same for seeds that had both preferred varietal traits and seed quality traits, we can consider the WTP for one of these attributes as the lower bound estimates of demand curve for seeds with both those attributes together. Figure 6.4 also includes a horizontal line to depict the reported median value of current price as reported by farmers. Any point above the horizontal line indicates that the corresponding percentage of farmers are willing to pay more than the current price of seed if seeds of preferred varietal traits or quality seed was available in the market. For example, in the case of rice, about 60% of farmers surveyed were willing to pay more than the current seed price (Figure 6.4). On the other hand, points below the horizontal line indicate that the farmers' stated WTP for seed of their preferred varieties is less than the current reported median market price of seed. In the case of rice, about 20% fall in this category (lowest among the five crops) and for pigeon pea about 50% fall in this category (highest among the five crops). For rice, the WTP of about 20% of farmers is exactly the same as the current seed price, indicating that they are not willing to pay more or less than the current seed price even if seeds of preferred varieties or quality were available.

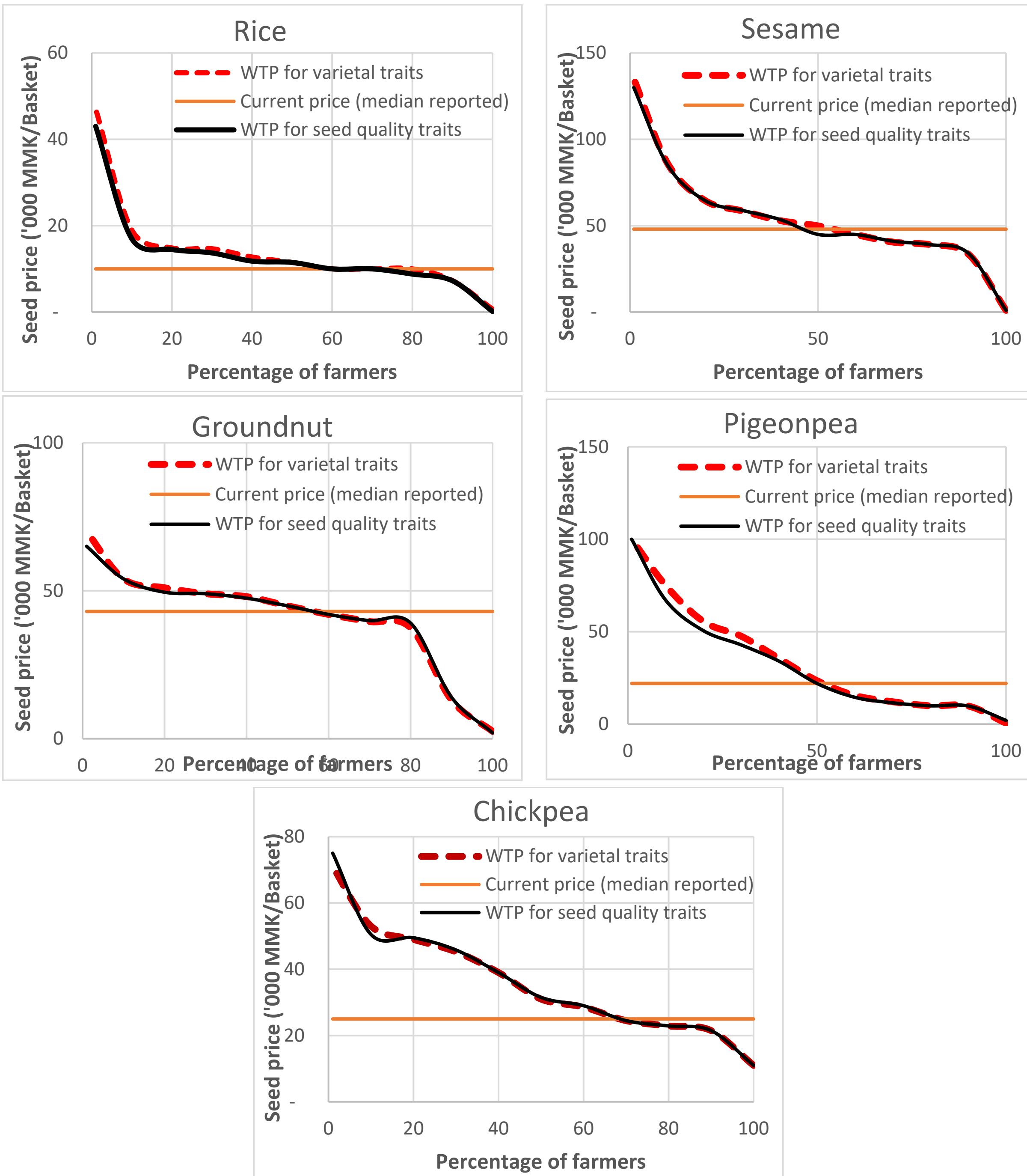
Table 6.4. Frequency and quantity of seed a farmer on average is willing to purchase and area that can be planted with purchased seeds (Average across all the farmers, including farmers with zero demand)

		Frequency (number of years)	Total willing to purchase (Baskets/farmer)	Average annual seed demand per farmer (Baskets/year)	Area that can be planted each year with purchased seed (Acres/farmer)
Rice	N	627	630	592	600
	Mean	1.5	5.5	3.5	1.6
	Sd	3.0	5.0	3.6	1.7
	Median	2.0	3.0	2.0	1
Sesame	N	472	455	418	416
	Mean	1.9	0.8	0.4	1.8
	Sd	2.7	0.8	0.6	1.7
	Median	2.0	0.5	0.2	1.0
Groundnut	N	263	265	229	226
	Mean	2.1	5.3	2.9	1.0
	Sd	2.5	8.9	5.6	1.1
	Median	3.0	2.0	1.0	0.7
Pigeon pea	N	291	278	250	242
	Mean	2.5	0.3	0.3	0.8
	Sd	2.7	0.6	0.6	0.7
	Median	6.0	0.1	0.1	0.5
Chickpea	N	315	316	294	297
	Mean	1.7	3.0	1.9	1.4
	sd	2.6	2.3	2.1	1.4
	Median	2.0	2.0	1.3	1.0

\a Stated willingness to purchase (hypothetical scenario)

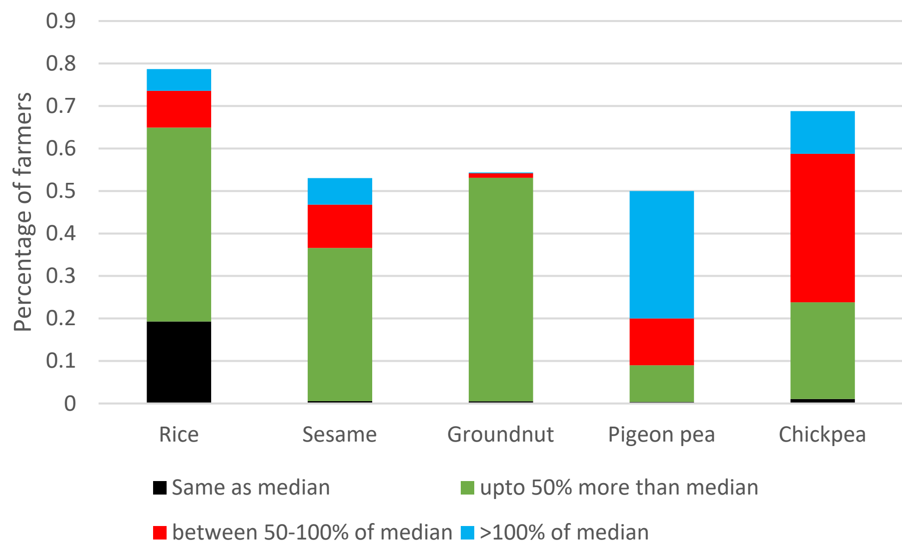
In Figure 6.5 we show the percentage of farmers who stated their WTP for seed of preferred varieties for a given crop to be greater than or equal to the median seed price (i.e., points on or above the horizontal lines in Figure 6.4) and among them, percentage of farmers that were willing to pay: a) the same price as the current median price, b) up to 50% of the current median price, c) between 50-100% of the current median price, and d) more than double the current median price. This essentially represents potential market demand for seeds if the seed system is able to deliver varieties preferred by farmers. The distribution of stated WTP in these ranges is similar to market demand for quality seeds, so the discussion of Figure 6.5 applies both to potential demand for seeds of preferred varieties and preferred quality.

Figure 6.4. Derived demand curves for seed with improved varietal traits and quality traits based on farmers stated willingness to pay, by crop



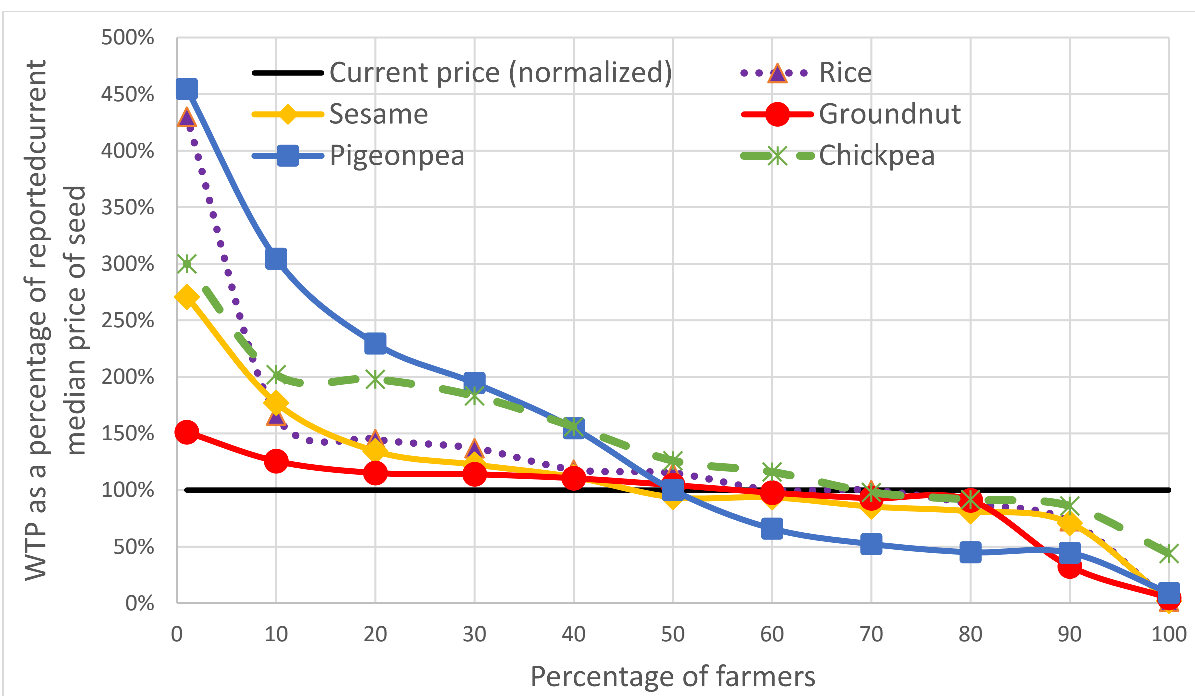
Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Figure 6.5. Percentage of farmers who are willing to pay for seed at least the reported seed market price and x% more than the reported seed price, by crop



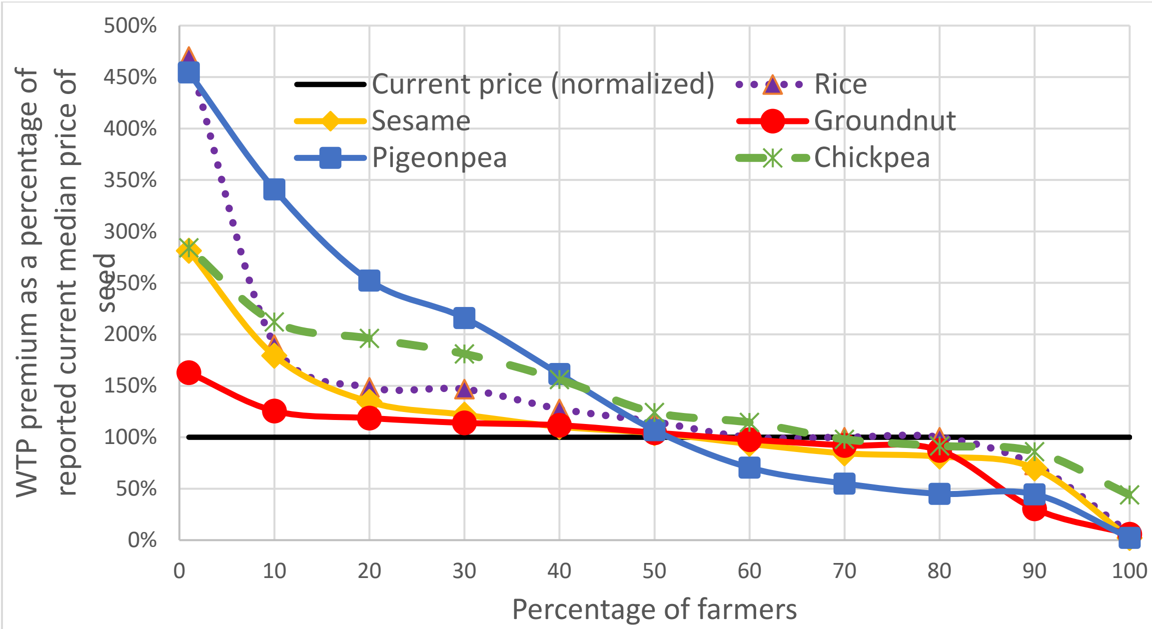
Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Figure 6.6 Derived demand curves for seed with <u>improved varietal traits</u> based on farmers' stated willingness to pay, by crop



Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Figure 6.7. Derived demand curves for seed with seed quality traits based on farmers' stated willingness to pay, by crop



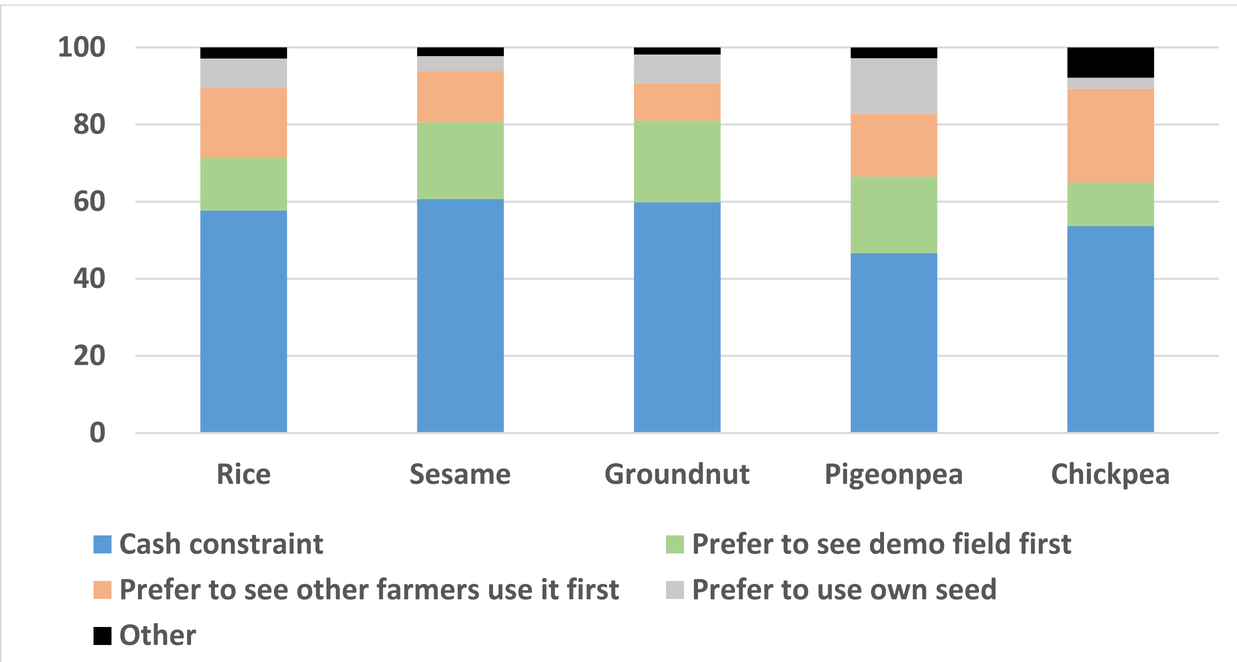
Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Among the five crops for which we have data, rice has the largest potential market demand with almost 80% of farmers WTP at least the current reported median price (i.e., 10,000 MMK/basket), followed by chickpea with almost 70% of farmers willing to pay at least the current median price (i.e., 25,000 MMK/basket). For sesame and groundnut, a little over 50% of farmers are willing to pay more than the median reported seed price (i.e., 48,000 MMK/basket and 43,000 MMK/basket, respectively). For pigeon pea, just about 50% of farmers are willing to pay more than or equal to the median seed price of 22,000 MMK/basket for seeds of preferred variety or preferred quality (Figure 6.5). For rice, sesame and groundnut, the WTP for the majority of farmers is in the range of up to 50% of the median price. Only a small percentage of farmers are willing to pay more than 50% of the current price of seed. For chickpea, a majority of farmers are willing to pay between 50-100% of the current seed price, and for pigeon pea a majority of farmers are willing to pay more than double the current price of seed if seeds of preferred variety or quality were available to them.

An alternative way of comparing the cumulative distribution of WTP for seeds of preferred varietal traits and quality traits across the five crops is depicted in Figures 6.6 and 6.7. For each crop, the WTP is expressed as a percentage of the median reported seed price. Thus, the horizontal line at 100% represents current price as the base relative to which the WTP is expressed cumulatively for farmers distributed from 0-100% of observations for a given crop. At any given point on the x-axis, one can see the range of WTP for different crops as a percentage of their current price of seed. For example, at 20% mark on the x-axis, the WTP is highest for pigeon pea and lowest for groundnut, when expressed as a percentage of current seed price. At the 90% mark, the WTP as a percentage of current seed price is highest for chickpea and lowest for groundnut, although both are lower than their respective current seed price.

To all the farmers who expressed their WTP for seed of their preferred varieties (or quality seeds) less than or equal to the reported current market price for seed (i.e., about 50% of sesame, groundnut and pigeon pea farmers, 40% of rice farmers, and 30% of chickpea farmers) a follow up question was asked to provide the main reason for not willing to pay for seed more than the market price. As reported in Figure 6.8, the top reason cited by farmers across all five crops was lack of cash. For some crops, especially those with high seeding rate (e.g., rice, groundnut, and chickpea), seed can be a costly input at the time of planting, and cash constraint can limit farmers' ability to pay a higher price for seed. For about one-third of the farmers, the main reason for not willing to pay a price more than the market price was their desire to first see the performance of the seed in a demonstration or other farmers' fields. A small percentage of farmers simply preferred to use their own saved seed and thus not willing to pay a higher price.

Figure 6.8. Top reasons for not willing to pay for seed more than the current reported price



Source: Myanmar Seed Demand Survey in Dry Zone, 2018

Overall, the top three reasons given by farmers for low WTP for seed provide some justification for programmatic interventions to address these constraints. Programs implemented in some countries to address the cash constraint for purchase of seed include seed-for-grain exchange (at different seed-to-grain ratios). Establishing more community based seed demonstration plots or some way of reducing the information asymmetry on varietal and seed quality traits can also potentially increase seed demand. However, more research is needed to test the effectiveness of some of these programmatic options of increasing farmer demand for seeds of new varieties and quality traits.

6.6 Projected Demand for Seeds of Preferred Varietal Traits and Quality Seeds Based on Stated Willingness to Pay

We use data on farmers' stated WTP, quantity, and frequency of seed purchase reported in Table 6.4 to estimate total demand for seed at the population level. This extrapolated total demand for seed per year for the study population in the Central Dry Zone encompasses three regions –Magway, Mandalay, and Sagaing, and is reported in the last column in Table 6.5 for the five crops. Based on the stated preferences, the total demand for seed to be purchased is about 2.5 million baskets for rice, 241 thousand baskets for sesame, 862 thousand baskets for groundnut, 109 thousand baskets for pigeonpea and 468 thousand baskets for chickpea.

Table 6.5. Estimates of seed demand by crop extrapolated to the farmer population in the study area—effective, ineffective, and total seed demand per year \a

	Effective demand			Ineffective demand \b		
	At the following cut-off price (MMK/ basket)	% of farmers with WTP equal/above cut-off price	Quantity of seed demand per year at cutoff price ('000 Baskets)	% of farmers with WTP below cut-off price	Quantity of seed demand per year below cutoff price ('000 Baskets)	Total seed demand per year ('000 Baskets)
Rice	10,000	79%	2,002.80	21%	483.04	2,485.84
Sesame	48,000	58%	125.07	42%	116.06	241.14
Groundnut	43,000	57%	305.12	43%	556.52	861.64
Pigeon pea	22,000	51%	61.70	49%	47.69	109.38
Chickpea	25,000	77%	397.68	23%	70.57	468.24

\a The demand estimates are representative of six townships, which cover the study area
\b Excludes farmers with WTP=zero (i.e., not willing to purchase seed)

However, not all this demand for seed is effective demand, as a significant proportion of farmers' WTP for seed is less than the reported market price of seed. Thus, the total demand for seed for each crop can be divided into total effective demand and total ineffective demand based on whether the stated WTP price for seed is above or below the price at which the formal or semi-formal seed system is able to supply quality seeds. Using the median reported price as the cut-off price, the total effective demand for seed is in units of baskets is estimated to be about 2 million for rice, 125 thousand for sesame, 305 thousand for groundnut, 62 thousand for pigeon pea and 397 thousand for chickpea. Of course, a decrease in the cut-off price at which the seed system can supply quality seed as preferred by farmers will increase effective demand, and an increase in the supply price of quality seed will reduce the effective demand. More research is need to determine the cost of producing quality seeds that farmers will trust as having their preferred varietal and quality traits to estimate this cut-off point in the demand curve, and to understand what portion of the demand for seed the formal and semi-formal seed system is able to meet effectively.

7. CONCLUSIONS AND RECOMMENDATIONS

As in many developing countries, crop production in Myanmar accounts for a significant share of the total agricultural GDP. Access to quality seeds of improved varieties are thus critically important to increase crop yields. This study focused on Myanmar's Dry Zone, an important agroecological zone and home to about 10 million people, to better understand the current state of farmer adoption of improved varieties, farmer preferences for varietal attributes, and farmer demand for quality seed for rice, sesame, sunflower, groundnut, green gram, black gram, pigeonpea, and chickpea. These targeted crops reflect the importance of the diversity of cereal, pulses and oilseed crops grown in the Dry Zone. Our findings, based on a survey of 1,388 farmers in six Dry Zone townships in three regions, follow.

First, farmers' self-reported use of improved varieties is low, ranging from 8% for pigeonpea to 37% for chickpea among the pulse crops, 15% for groundnut to 41% for sunflower among the oilseed crops, and 30% for rice. Traditional varieties remain the most prominent type of variety planted by farmers in the Dry Zone, indicating that varietal technology could contribute more to increase crop yields.

Second, farmers' exposure to new varieties is predominantly through observation in other farmers' fields, not through government extension or agents of private seed companies. As a result, the varietal turnover in farmers' fields is quite low-averaging 12 years across all the crops. Among farmers that reported growing an improved variety, these varieties were released 18 years ago on average. In order to increase farmer awareness of, and the subsequent adoption and turnover of improved varieties, more efforts are needed by the government and the private sector to promote improved varieties. This can be done through on-farm demonstrations to show the value of new varieties vis-à-vis traditional/older varieties.

Third, informal (i.e., traders, market grain vendors) and formal (i.e., government seed farm, agro-dealers) sources of seed together account for a significant share of the seed market, with variations observed across crops. The formal system plays a relatively larger role for rice, sunflower and black gram than for other crops. Among these formal and informal seed sourcing strategies, exchanges tend to be monetized purchases, implying that in-kind exchanges or barter do not seem to be common market mechanisms. This suggests that a vibrant informal market for seeds exists in the study area. We observe considerable price variation in these seed markets. Yet prices do not seem to embody physical or genetic quality, as evidenced by low seed-to-grain ratios for most crops.

Fourth, free seed distributions from government agencies or non-governmental organizations as well as seeds from rice or oil mills are far less relevant to farmers' seed sourcing strategies. Own saved seed plays plays a smaller role in the case of rice relative to informal and formal seed sources, and a larger role in the case of oilseeds and pulses. Although, own saved seed for 3-4 seasons for self-pollinated crops (like most of the targeted study crops) is an acceptable practice, relying only on own-saved seed implies planting seeds of low quality, which undermines the yield potential of that variety. Increasing farmer awareness of the need for regular seed replacement (i.e., accessing seed from other reliable sources) is thus warranted.

Fifth, farmers perceive the government's seed supply system as a preferred source of quality seed, at least for those crops in which it plays a major role in seed supply relative to other sources. Farmers also perceive packaged and labeled seed from private sources as preferable. This suggests that farmers are sensitive to quality assurance signals such as packaging and labeling. This offers an opportunity for further analysis of quality through testing of samples from multiple sources to quantify quality differences which, in turn, can help better understand variation in the market and suggest where in the supply chain seed system regulations and investments might be most productively targeted.

Sixth, we note that farmers rely on different types of seed providers by crop even if where they tend to source from formal sources. This suggests that there are important distinctions in the value chains for each crop, and for seed providers associated with each crop. This points to the need for differentiated, crop-specific strategies to identifying partners and investments around improving seed quality.

Finally, although farmers know the attributes of quality seed (i.e., germination rate, seed health, uniformity) and good variety (i.e., stress tolerant, resistant to pests and diseases, high yield), and have preferences for seeds that have such quality and varietal attributes, their willingness to pay for quality seeds of improved varieties appears to be low (in the range of 5-28%). More research is needed to estimate the cost of production of quality seeds to better understand the supply side economics and to assess whether these levels of price premium above the current market price would be enough to sustain the supply of quality seeds.

In terms of implications for seed sector development, this study makes following recommendations. First, government should establish on-farm demonstrations to increase farmer exposure to improved varieties and quality seed. They should also increase farmer awareness of the need for regular seed replacement through extension and education programs. Increasing farmer awareness and knowledge on the importance of quality seed is a necessary step to increase farmer demand (and their willingness to pay) for quality seed. Second, farmer seed producers (i.e., seed entrepreneurs) may have a competitive advantage in supplying seeds to their communities due to lower costs. More efforts by government and/or NGOs to increase the capacity of small- and medium-sized (SMEs) seed producers and appropriate seed quality assurance system are needed to strengthen this semi-formal seed sector. Finally, for these SMEs to play an increased role in the seed sector, they need access to high quality early generation seed to multiply and produce commercial seed. This will in-turn require increased efforts and focus by the government in producing adequate quantities of quality early generation seeds of public varieties that can be sold to farmers as planting material.

8. REFERENCES

Boughton, D., N. Aung, B. Belton, M. Filipski, D. Mather and E. Payongayong. 2018. "Myanmar's rural economy: A case study in delayed transformation." Feed the Future Innovation Lab for Food Security Policy Project Research Paper #104. East Lansing: Michigan State University.

CGIAR. 2015. CGIAR's TRIVSA Project: A consolidated database of crop varietal releases, adoption, and research capacity in South Asia. Accessed (April 2020): https://www.asti.cgiar.org/trivsa

Cornish, P.S., C. Birchall, D.F. Herridge, M.D. Denton, and C. Guppy. 2018. "Rainfall-Related Opportunities, Risks and Constraints to Rainfed Cropping in the Central Dry Zone of Myanmar as Defined by Soil Water Balance Modelling." *Agricultural Systems* 164: 47–57.

Floro, I.V., Victorino, O., Labarta, R., López-Lavalle, L.A.B., Martinez, J.M., and Ovalle, T.M. 2017. Household determinants of the adoption of improved cassava varieties using DNA fingerprinting to identify varieties in farmer fields: A case study in Colombia. Journal of Agricultural Economics,. 68(4). doi: 10.1111/1477-9552.12247

Kosmowski, Frederic, Abiyot Aragaw, Andrzej Kilian, and Alemayehu Ambel. 2019. Varietal identification in household surveys: Results from three household-based methods against the benchmark of DNA fingerprinting in Southern Ethiopia. Experimental Agriculture 55(3): 371-385. https://doi.org/10.1017/S0014479718000030

Livelihoods and Food Security Trust Fund (LIFT). 2016. *Myanmar: Analysis of Farm Production. Economics.* Economic and Sector Work Report No. 100066-MM. Washington, DC: The World Bank.

Mahrt, K., David Mather, Anna Herforth and Derek Headey. 2019. Household Dietary Patterns and the Cost of a Nutritious Diet in Myanmar. Feed the Future Innovation Lab for Food Security Policy Research Paper 135. East Lansing: Michigan State University

Maredia et al. 2016a. Varietal Release and Adoption Data for South, Southeast, and East Asia: SIAC Project (2013-2016), Rome: Independent Science and Partnership Council. Retrieved from https://www.asti.cgiar.org/siac

Maredia, Mywish K., Byron A. Reyes, Joseph Manu-Aduening, Awere Dankyi, Petan Hamazakaza, Kennedy Muimui, Ismail Rabbi, Peter Kulakow, Elizabeth Parkes, Tahirou Abdoulaye, Enid Katungi, and Bodo Raatz. 2016b. Testing Alternative Methods of Varietal Identification Using DNA Fingerprinting: Results of Pilot Studies in Ghana and Zambia. MSU International Development Working Paper No. 149. Department of Agricultural Economics, Michigan State University.

Mather, D., and B. Belton. 2018. "Mechanization and crop productivity, profitability and labor use in Myanmar's Dry Zone." Feed the Future Innovation Lab for Food Security Policy Project Research Paper 103. East Lansing: Michigan State University.

Mather, D., N. Aung, A. Cho, Z. M. Naing, D. Boughton, B. Belton, K. Htoo and E. Payongayong. 2018. "Crop production and profitability in Myanmar's Dry Zone." Feed the Future Innovation Lab for Food Security Policy Project Research Paper 102. East Lansing: Michigan State University.

Ministry of Health and Sports (MoHS) and ICF. 2017. "Myanmar Demographic and Health Survey 2015-16." Nay Pyi Taw, Myanmar, and Rockville, Maryland USA: Ministry of Health and Sports and ICF.

MoPF (Ministry of Planning and Finance) & World Bank. 2017. *Technical poverty estimation report: Myanmar Poverty and Living Conditions Survey.*

Proximity Designs. 2019. *When It Rains It Pours: Challenges and Opportunities in Sesame Farming in Myanmar.* Tokyo: Field Institute.

Subedi, A., M.H. Thijssen, G. Audet-Belanger, Tin Maung Shwe and Naing Lin Oo. The Rice Seed Supply and Demand System in the Delta, Myanmar. Study report. Wageningen: Wageningen Centre for Development Innovation, Wageningen University & Research.

Wossen, T, Abdoulaye, T., Alene, A., Nguimkeu, P., Feleke, S., Rabbi, I., Haile, M.G., and Manyong, V. 2019. Estimating the productivity impacts of technology adoption in the presence of misclassification. American Journal of Agricultural Economics, 101(1), 1-16. https://doi.org/10.1093/ajae/aay017

ANNEX 1. CALCULATION OF SAMPLE WEIGHTS

For the sample estimates from the Dry Zone Seed Survey to be representative of all the households growing the crops of interest in the six townships, it is necessary to multiply the data by a sampling weight, or expansion factor. The basic weight for each sample household would be equal to the inverse of its probability of selection (calculated by multiplying the probabilities at each sampling stage). A stratified two-stage sample design was used for the Dry Zone Seed Survey. At the first stage the EAs were selected within each stratum with PPS based total number of households in each EA from the 2014 Census frame. However, at the second sampling stage only the households growing at least one of the six crops of interest were eligible to be selected. The overall probability of selection for eligible sample households can be expressed as follows:

$$p_{hi} = \frac{n_h \times M_{hi}}{M_h} \times \frac{m_{COIhi}}{M_{COIhi}}$$

where:

p_{hi} = probability of selection for the sample households with crops of interest in the i-th sample EA of stratum h

n_h = number of sample EAs selected in stratum h

M_{hi} = number of private households in the 2014 Census frame for the i-th sample EA of stratum h

M_h = total number of private households in the 2014 Census frame for stratum h

m_{COIhi} = number of sample eligible households with crops of interest selected in the i-th sample EA of stratum h (generally equal to 10)

M_{COIhi} = total number of eligible households with crops of interest listed in the i-th sample EA of stratum h

The two components of this probability of selection correspond to the individual sampling stages. The basic sampling weight for the sample households is calculated as the inverse of this probability of selection. Based on the previous expression for the probability, the basic weight for the eligible sample households can be simplified as follows:

$$W_{hi} = \frac{M_h}{n_h \times M_{hi}} \times \frac{M_{COIhi}}{m_{COIhi}}$$

where:

W_{hi} = basic weight for the sample households with crops of interest in the i-th sample EA of stratum h

Following the data collection for the Dry Zone Seed Survey, these basic weights were adjusted for nonresponse at the sample EA level. The final weight for the eligible sample households in each sample EA were adjusted as follows:

$$W'_{hi} = \frac{M_h}{n_h \times M_{hi}} \times \frac{M_{COIhi}}{m_{COIhi}} \times \frac{m_{COIhi}}{m'_{COIhi}} = \frac{M_h}{n_h \times M_{hi}} \times \frac{M_{COIhi}}{m'_{COIhi}}$$

where:

W'_{hi} = final adjusted weight for the eligible sample households with crops of interest in the i-th sample EA of stratum h

m'_{COIhi} = number of eligible sample households with completed interviews in the i-th sample EA of stratum h

The sampling probabilities at each stage of selection and the final weights for the sample households were calculated in an Excel spreadsheet with the information from the sampling frame and the final survey results for all sample EAs.

ANNEX 2. ADDITIONAL INFORMATION ON COMMUNITY AND HOUSEHOLD CHARACTERISTICS

Community Infrastructure and Public Services

Most sample villages have relatively good access to markets and services that are related to agricultural production and marketing. For example, the average (median) distance from the village center to the nearest paved road is only 2.6 (1.5) miles (Table A1). One reason why this average distance is relatively low is because 25% of sample households live in villages that are within zero to one-quarter of a mile from the nearest paved road.

Table A2.1 Median distance and travel time from village center to nearest infrastructure or service

Village access to:	Distance from village to service (miles)	Travel time from village to service (minutes)
Paved road	1.5	15
Main commercial town	13	45
Private bank service	10	40
Rural bank	11	45
Government extension office	7	30
Research farm	10	40
Agro-input dealer	6	30

Source: Authors' computations using the Dry Zone Seed Survey (Community Survey)

The median distance from the village center to the nearest main commercial town (where residents of this village buy and sell goods and services) is 13 miles. However, the median travel time to the nearest such town is only 45 minutes. There are two main reasons for this relatively short travel time, the first being the relatively short distance from most villages to the nearest paved road noted above. Second, 95% of households live in villages where the most typical form of transport from the village to the nearest main commercial town is motorized (i.e. by motorcycle, car, truck or bus). Access to private bank service or a rural bank is also relatively good, with a median travel time of 40 to 45 minutes from the village to these services. Access to agro-input dealers or a government extension office is even better, with a median travel time of 30 minutes. All sample households live in villages that receive radio and mobile phone service, and 99% live in a village that receives television signals.

Household assets

Although a majority of Dry Zone farmers use tractors (power tillers or four wheel tractors) for initial plowing for main crops such as rice, sesame, groundnut and pigeon pea, many continue to use animal draft power for subsequent harrowing (Mather and Belton, 2018). Most tractor services are rented in, whereas most draft animals are owned by the household using them (ibid, 2018). Consistent with results from the READZ survey, only 16% of sample households owned a tractor, though 81% had access to one (Table A2). Likewise, a majority of sample households (57%) owned one or more draft animals, and 30% had access to them

Table A2.2 Household ownership of or access to farm or household assets

Household asset	% Households owning asset	% Households with access to asset
Draft animals	57	30
Combine	1	61
Tractor	16	81
Thresher/Cutter/Reaper	6	69
Trawlarjee	5	79
Car	2	73
Truck	1	76
Motorcycle	79	17
Any motorized vehicle	80	95
Bicycle	43	24
Radio	57	9
TV	58	8
Smartphone	84	5
Other cell phone	19	21
Any cell phone	87	24

Source: Authors' computations using the Dry Zone Seed Survey (Household Survey).

While more than two thirds of Dry Zone paddy farming households used either a combine or mechanized thresher to harvest and thresh their paddy in 2017 (ibid, 2018), very few sample farmers own these machines as they are primarily rented in (Table A2). No other major crops in the Dry Zone use mechanized harvesting, and apart from paddy and green gram (37% of which uses a mechanized thresher), very few crops are mechanically threshed (Filipski et al, 2018).

Household access to agricultural extension

A majority of sample farmers (57%) received seed-related information from one or more sources of agricultural extension within the past year (Table A3). The main source of seed-related agricultural extension information received was from Radio/TV/Publication (32% of households), followed by farmer organizations (21%) and agro-dealers (20%). Government extension reached 11% of farmers with seed-related extension information. Only 3% of farmers report having ever attended a training program related to quality seed production, storage, or marketing.

A majority of farmers (62%) also received agricultural extension information not related to seed within the past year (Table A3). The main sources of non-seed-related agricultural extension were Radio/TV/publication (34%), agro-dealers (29%) and farmer organizations (20%). Government extension reached 14% of farmers with extension information unrelated to seed.

Among those farmers reporting receipt of agricultural extension information in the last year, a majority received such information more than once, from all sources combined. For example, 34% of households received extension information once in the last year from all sources combined, 32% received such information twice, 26% received it 3 to 5 times, and 8% received it 5 or more times.

Table A2.3 Household access to agricultural extension in last year

Source of agricultural extension visit/information	% of HHs receiving extension information by information type	
	Seed-related	Not seed-related
Any source	57	62
Government extension	11	14
NGO	6	9
Agro-dealer	20	29
Seed company	12	14
Farmer organization	21	20
Trader	5	8
Internet	5	5
Radio/TV/publication	32	34
Other farmers	2	2

Among those sample farmers that received extension information in the past year, only 6% report receiving this information by visiting a demonstration plot or attending a field day, while 3% received this information by attending a trade show, seed event, or agricultural fair. Only 6% reported having a household member who participated in any other type of agricultural training within the past 3 years. However, 30% of farmers reported that they used a mobile phone to access agricultural information or crop prices on the internet. Given that most farm households own a smartphone, this finding suggests that internet-based agricultural extension information could potentially be an important source of such information provided by government, NGOs, agro-dealers, etc. for farm households in the Dry Zone.

Among farmers that received seed-related agricultural extension information in the last year, there were six main topics covered. The most frequently noted topics included "how to plant seed" (17% of farmers), followed by "seed outlets" and "new varieties" (15% of farmers for both), "selection of quality seed from harvest" (13%), "the value of using quality seed" (12%), and "seed storage" (9%) (Table A4).

Table A2.4 Information obtained from seed-related agricultural extension visit

Among households that received seed-related agricultural extension information in the last year, what % obtained information about:	
The value of using quality seed	12
Seed outlets	15
New varieties	15
Selection of quality seed from harvest	13
Seed storage	9
How to plant seed	17
Chemical inputs	0.2
Prices	0
Paddy cultivation	0.04

Table A2.5 Household mean and median crop yields with and without reported pre- or post-harvest yield loss (baskets/acre)

			Yield (baskets / acre)								
	Potential yield[1]		All cases			**Without** yield loss			**With** yield loss		
Crop	Good	Average	Mean	Median	N	Mean	Median	N	Mean	Median	N
Monsoon rice	74	55	58.7	60.0	588	64.3	70.0	442	41.9	41.8	146
Dry season rice	97	74	75.7	80.0	247	82.3	85.0	185	57.8	60.0	62
Sesame	11	7	5.3	4.0	584	8.0	7.0	240	3.7	2.7	344
Groundnut	50	34	29.0	25.0	376	31.4	26.7	245	23.7	16.7	131
Sunflower			12.3	9.0	39	15.9	10.0	23	7.3	4.0	16
Green gram	13	9	6.9	5.0	222	8.9	7.0	129	4.2	2.5	93
Black gram	13	9	6.8	5.0	52	11.0	10.0	20	4.7	4.4	32
Pigeon pea	11	7	7.1	5.0	305	9.2	7.5	156	4.5	3.0	149
Chickpea	12	7	10.0	10.0	450	11.3	10.0	277	8.0	7.0	173

Notes: 1) Expected yield from READZ community survey (for a "good" or "average" climatic year), pre-survey scoping or expert opinion.

Table A2.6 Percentage of households reporting pre-harvest yield loss by crop & cause of loss

Crop	Flooding	Lack of rain	Excessive rain	Pests	Disease	Other
Monsoon rice	7	3	10	3	1	2
Dry season rice	13	1	15	2	0	4
Sesame	8	8	42	11	3	3
Groundnut	2	1	16	9	1	2
Sunflower	5	6	26	3	1	0
Green gram	4	3	22	14	2	3
Black gram	10	2	28	16	2	4
Pigeon pea	1	4	27	15	2	2
Chickpea	4	1	29	8	1	2

Note: Summation of percentages by row (by crop) exceeds those in Table 6 because some households report more than one type of pre-harvest loss (by crop)

Table A2.7 Percentage of households reporting post-harvest yield loss by crop & cause of loss

Crop	Flooding	Lack of rain	Excessive rain	Pests	Spoilage	Other
Monsoon rice	2	0	5	0	1	1
Dry season rice	3	0	8	0	0	3
Sesame	4	1	11	3	0	3
Groundnut	0	0	3	1	0	1
Sunflower	5	0	12	1	0	0
Green gram	0	1	0	4	1	2
Black gram	4	0	9	5	0	4
Pigeon pea	0	0	2	3	0	2
Chickpea	2	0	5	1	0	1

Note: Summation of percentages by row (by crop) exceeds those in Table 6 because some households report more than one type of post-harvest loss (by crop).

ANNEX 3. ADDITIONAL INFORMATION ON VARIETY ADOPTION

Table A3.1 Names of varieties reported by farmers in the survey, and number of farmers and acres of land planted to a given variety across study area, by crop

				Across study population (extrapolated)	
Crop	#	Variety name	# of observations	Number of HHs growing a variety	Acres of land planted
Rice	1	Ayeyar Padaythar (local name)	275	26,707	101,475.90
Rice	2	110 (days)	100	5,238	39,287.66
Rice	3	Manaw Thukha	144	9,742	32,320.80
Rice	4	Yadanar Toe	75	8,326	29,451.98
Rice	5	Ayar Min	42	3,266	14,698.88
Rice	6	Yangon Manaw	39	3,348	11,851.31
Rice	7	Magyandall (local name)	41	2,224	7,841.45
Rice	8	90 (days)	25	1,249	6,811.08
Rice	9	Kayin Ma	7	1,146	6,002.92
Rice	10	Shwe Manaw	18	1,059	4,057.80
Rice	11	Won Gyi Ayeyar	21	1,157	3,629.77
Rice	12	Sin Thukha	23	1,315	3,055.95
Rice	13	Thukha Padaythar	5	721	2,355.27
Rice	14	Shwe Thwe Yin (local name)	13	684	2,263.99
Rice	15	Wun Gyi	11	558	2,220.47
Rice	16	Ayeyar Kyauk Sein	7	679	1,938.91
Rice	17	Kyauk Sein	4	529	1,633.92
Rice	18	Shal Thukha	2	432	1,579.72
Rice	19	Pwintphu Thukha	1	266	798.16
Rice	20	Ayeyar KyaukSe (local name)	3	337	779.48
Rice	21	Sinn Padaythar (local name)	3	266	773.94
Rice	22	PC	3	554	646.29
Rice	23	Thukha	4	208	604.15
Rice	24	Mercury	2	116	473.47
Rice	25	Pathein sticky rice	1	144	431.06
Rice	26	God	1	56	389.34
Rice	27	Kauk Gyi 90	1	38	376.13
Rice	28	SiMiTa 2	2	111	333.72
Rice	29	Does not know	2	259	332.94
Rice	30	Htike Sa	1	166	332.61
Rice	31	Shwe Pyi Thukha	1	98	293.54
Rice	32	Shwe Myanmar	1	185	276.98

				Across study population (extrapolated)	
Crop	#	Variety name	# of observations	Number of HHs growing a variety	Acres of land planted
Rice	33	Kyauk Gyi	1	25	224.71
Rice	34	San Mhway	1	97	193.75
Rice	35	Taminar 2	2	73	189.13
Rice	36	Ma Naw	1	55	137.59
Rice	37	Yay Paw Ni	3	82	108.93
Rice	38	Pale Thwe	1	185	92.33
Rice	39	Shwe Ayeyar (local name)	1	128	63.85
Rice	40	Shwebo Pawsann (local name)	1	53	53.12
Rice	41	Khun Wah Gyi	2	54	40.85
Rice	42	Bay Kyar	2	38	40.15
Rice	43	Black rice	1	27	27.23
Rice	44	Lone Thwal Mhway	1	26	26.18
Sesame	1	Thake Pan Black Sesame / Sahmone Nett	270	29,828	117,004.40
Sesame	2	SESAME WHITE (SAFAL 3)	156	16,390	67,702.42
Sesame	3	Gwa Kyaww Nett	40	7,467	38,808.75
Sesame	4	Hnan Ni25/160	29	4,210	8,623.39
Sesame	5	White	43	3,346	8,430.16
Sesame	6	Satt Pu	7	1,085	5,000.31
Sesame	7	Khway Le Ni	5	1,212	3,272.39
Sesame	8	White Sesame (Japan)	11	597	3,144.52
Sesame	9	Shwe Tasoke (Black)	2	323	3,018.12
Sesame	10	Japan	15	1,118	3,015.18
Sesame	11	Does not know	12	962	2,951.43
Sesame	12	A Phyu Patlal	11	911	2,698.17
Sesame	13	Shwe Tasoke	3	494	2,660.92
Sesame	14	Brown	4	310	2,600.32
Sesame	15	Yellow sesame	6	602	2,114.68
Sesame	16	Salat Phyu	3	350	2,023.19
Sesame	17	Khat Phyu (Aung Kyaw/ Chone Kyaw)	13	696	1,681.01
Sesame	18	Salat	3	469	1,480.50
Sesame	19	Manager	4	343	1,420.25
Sesame	20	Kan Shi	4	398	1,345.90
Sesame	21	Yezin 7	1	126	1,263.75
Sesame	22	Black Sesame	6	338	953.49
Sesame	23	Yay Kyaw (White)	2	189	845.35

				Across study population (extrapolated)	
Crop	#	Variety name	# of observations	Number of HHs growing a variety	Acres of land planted
Sesame	24	Shat Kalay	4	224	744.67
Sesame	25	Yathae Kyaw	1	242	727.20
Sesame	26	Copper	1	87	699.23
Sesame	27	Pearl White	2	333	665.22
Sesame	28	Hnan Yin	9	267	643.83
Sesame	29	Pat Lal Phyu	2	214	640.57
Sesame	30	2 La Khan	2	304	607.68
Sesame	31	War Shaw Net	1	126	593.96
Sesame	32	Zalat Phyu	2	166	581.83
Sesame	33	Phyu Ma Lay	1	105	526.01
Sesame	34	Yoe Yoe (ordinary)	1	87	437.02
Sesame	35	Ba Pan (Khaing Thin Kyi)	1	125	427.40
Sesame	36	Shwe Phalar	1	185	369.31
Sesame	37	White (Manager)	1	91	362.58
Sesame	38	Kan shi (Black)	2	189	341.99
Sesame	39	Pauk Phyu	2	223	335.10
Sesame	40	Sin Yadanar 5	1	74	297.53
Sesame	41	Magway-2/21	1	74	294.32
Sesame	42	Bamar Phyu	1	56	279.25
Sesame	43	Improved Variety (Yellow)	1	127	254.33
Sesame	44	Red Sesame	1	127	254.33
Sesame	45	Su Pataung	1	23	236.81
Sesame	46	Black Seasame (Pyinmana)	1	39	231.73
Sesame	47	Sin Yadanar 4	1	74	223.15
Sesame	48	Nat Pu	1	125	212.45
Sesame	49	Yezin-unspecified	1	105	210.12
Sesame	50	Set Gyi	1	127	190.38
Sesame	51	Phoe Pan	1	76	188.98
Sesame	52	Mel Thila	1	63	172.35
Sesame	53	June White	1	105	157.80
Sesame	54	Thein Kyima	1	94	141.68
Sesame	55	65	1	139	138.51
Sesame	56	Nat Pyar	1	83	124.31
Sesame	57	Short-term Variety	1	97	97.13
Sesame	58	White Sesame (Nandar Hlaing)	1	38	95.88
Sesame	59	Improved variety (White)	1	31	92.31
Sesame	60	Ah Phyu Nyut	1	45	90.62
Sesame	61	Yoe Sein	1	79	79.22

				Across study population (extrapolated)	
Crop	#	Variety name	# of observations	Number of HHs growing a variety	Acres of land planted
Sesame	62	Pote Pyae	1	51	51.03
Sesame	63	Yay Kyaw	1	38	30.19
Sesame	64	Sesame (Big)	1	27	27.23
Sesame	65	Char Hnan	1	14	27.05
Sesame	66	Nyit Phyu	1	17	13.42
Groundnut	1	Tonn Tar Ni	137	20,066	94,197.36
Groundnut	2	Vietnam	37	5,869	31,755.17
Groundnut	3	White	44	3,734	14,898.20
Groundnut	4	Does not know	73	3,812	13,737.51
Groundnut	5	Spain	21	1,444	5,604.80
Groundnut	6	Magway Pin Pyant	14	1,552	4,803.55
Groundnut	7	Yoe yoe (ordinary)	16	1,128	4,469.80
Groundnut	8	Magway Toe Ni	9	513	2,377.91
Groundnut	9	Impoved Variety (Red)	5	360	2,124.34
Groundnut	10	S1	8	488	1,779.20
Groundnut	11	Big	2	151	1,172.59
Groundnut	12	Local Variety	2	172	847.88
Groundnut	13	6-months	2	307	844.46
Groundnut	14	Magway-16	1	91	725.16
Groundnut	15	Groundnut (A kwat gyi)	1	114	681.21
Groundnut	16	120-days variety	3	321	545.42
Groundnut	17	Khin Aye, 3 month	1	94	472.37
Groundnut	18	Magway-unspecified	2	160	434.51
Groundnut	19	Ka Tote	2	163	405.34
Groundnut	20	Improved variety	3	188	392.25
Groundnut	21	Hnga Sett Myo (2-generation)	1	97	290.62
Groundnut	22	3-months	3	144	259.36
Groundnut	23	Sin Paday Thar-12	1	86	256.59
Groundnut	24	Sp	8	152	254.31
Groundnut	25	Magway -12	1	114	227.07
Groundnut	26	Sin Paday Thar-7	1	91	226.61
Groundnut	27	Sin Paday Thar-1	1	113	226.07
Groundnut	28	Magway -11	3	98	220.12
Groundnut	29	Nga Shan	1	38	217.01
Groundnut	30	Magwe-20	1	73	183.71
Groundnut	31	Sin Paday Thar-11	2	83	160.42
Groundnut	32	Pyi Taw Thar	2	138	147.95
Groundnut	33	Son Tar Ni	1	94	141.71

Crop	#	Variety name	# of observations	Across study population (extrapolated) Number of HHs growing a variety	Acres of land planted
Groundnut	34	Khar Thain	1	30	89.12
Groundnut	35	August	1	53	88.71
Groundnut	36	S2	1	74	73.57
Groundnut	37	Burma	1	56	67.04
Groundnut	38	Ka Tat	1	66	66.39
Groundnut	39	S3	1	74	58.85
Groundnut	40	C4	1	139	34.63
Groundnut	41	Small	1	27	27.23
Groundnut	42	Groundnut (Red)	1	27	27.23
Groundnut	43	Baw Gyi	1	27	27.23
Groundnut	44	Red	1	27	27.23
Groundnut	45	'Marked-up color'	1	23	23.22
Groundnut	46	Yezin 11	1	38	18.87
Sunflower	1	Does not know	20	1,320	3,080.46
Sunflower	2	Yezin-1	4	785	2,945.16
Sunflower	3	Velvet	2	320	1,652.30
Sunflower	4	Local variety	4	120	173.65
Sunflower	5	Improved variety	1	53	159.36
Sunflower	6	Sunflower (White & Black)	1	128	127.71
Sunflower	7	Ma Hura	3	115	114.52
Sunflower	8	Ordinary	3	74	112.81
Sunflower	9	Yezin 11	1	53	106.24
Sunflower	10	Pearl Nat	1	53	79.68
Sunflower	11	Sin Shwe Kyar-1	1	50	50.22
Sunflower	12	Sunflower (Oil)?	1	15	15.47
Green gram	1	Yezin-11	66	5,264	16,863.66
Green gram	2	Does not know	43	4,797	11,910.40
Green gram	3	Kyauk Sein	27	2,880	11,486.04
Green gram	4	Zaut Khalay	13	1,971	6,164.75
Green gram	5	Yoe yoe (ordinary)	13	863	3,870.92
Green gram	6	Pyaung Sein	12	1,247	3,321.80
Green gram	7	Yezin-14	18	745	2,249.32
Green gram	8	Short-term vareity	4	534	1,743.28
Green gram	9	Site Pyo Yae-1	4	411	1,108.17
Green gram	10	Zut Kalay	3	271	837.80
Green gram	11	Medium-Term Variety	2	304	647.16
Green gram	12	Improved variety	3	362	475.11
Green gram	13	Mya Kyaemone-1	1	105	420.80
Green gram	14	Boan Khon Na Sint	3	308	406.62

				Across study population (extrapolated)	
Crop	#	Variety name	# of observations	Number of HHs growing a variety	Acres of land planted
Green gram	15	Goat Wae	2	230	405.03
Green gram	16	Yezin, unspecified	1	40	404.24
Green gram	17	Small	1	97	290.62
Green gram	18	Yezin-2	2	117	253.77
Green gram	19	Mya Kyay Hmone	1	127	190.38
Green gram	20	Yezin 12	2	138	157.56
Green gram	21	Htin Paw	1	57	141.65
Green gram	22	Yezin 16	1	112	111.70
Green gram	23	Sein War Nu (Yezin)	1	40	101.06
Green gram	24	Black	1	97	96.87
Green gram	25	Gaw Yar	1	66	66.39
Green gram	26	Dog variety	1	63	62.67
Green gram	27	Gote Thein	1	55	55.04
Green gram	28	Yezin 1	1	40	40.42
Green gram	29	Taiwan	1	17	34.62
Green gram	30	Green Gram (Big)	1	13	12.87
Black gram	1	Yezin-unspecified	26	1,356	3,857.63
Black gram	2	Ordinary	7	374	997.79
Black gram	3	Black Gram (Long Leaf)	6	356	986.29
Black gram	4	Black Gram (Dwarf)	3	141	752.68
Black gram	5	Kan Yar	1	47	470.43
Black gram	6	Black Gram Yezin (Long Leaf)	1	97	339.95
Black gram	7	Yezin-2	3	169	325.54
Black gram	8	Yezin-1	2	228	291.50
Black gram	9	Pin Pu Ywat Shwan	1	53	265.54
Black gram	10	Medium-Term Variety	1	81	243.22
Black gram	11	Pin Htaung	1	53	212.43
Black gram	12	Long-term variety	1	27	53.00
Black gram	13	Kan Swon	1	75	37.74
Black gram	14	Black Gram Broad Leaf)	1	27	26.50
Black gram	15	Improved variety	1	48	23.88
Pigeon pea	1	Yezin-unspecified	120	7,823	14,256.36
Pigeon pea	2	Medium-Term Variety	16	1,503	9,638.05
Pigeon pea	3	Local variety	15	1,218	5,737.14
Pigeon pea	4	Ordinary - red	16	2,011	5,251.45
Pigeon pea	5	Taphat Lae	30	1,047	3,088.76
Pigeon pea	6	Ordinary	8	683	2,668.99
Pigeon pea	7	Short-term variety - red	8	1,862	2,511.92

Crop	#	Variety name	# of observations	Across study population (extrapolated) Number of HHs growing a variety	Acres of land planted
Pigeon pea	8	Kywe Shan Shwe Dingar	7	533	2,258.74
Pigeon pea	9	Yezin-6	7	1,238	2,025.18
Pigeon pea	10	Pa Khwat	4	256	1,708.50
Pigeon pea	11	Small	8	788	1,661.17
Pigeon pea	12	Improved variety - white	1	56	1,117.01
Pigeon pea	13	Shwe Dingar	1	113	1,016.57
Pigeon pea	14	Kar Yar	5	270	986.94
Pigeon pea	15	Does not know	8	457	882.14
Pigeon pea	16	Big	6	254	683.94
Pigeon pea	17	Long and Medium variety	1	113	677.72
Pigeon pea	18	Ordinary - white	1	97	676.67
Pigeon pea	19	Jat Lat	2	146	582.41
Pigeon pea	20	UNDP	1	105	578.61
Pigeon pea	21	Shwe Ni	7	339	523.64
Pigeon pea	22	Circular Leaf	1	47	470.43
Pigeon pea	23	Improved variety	5	261	444.56
Pigeon pea	24	Yezin-1	4	338	405.27
Pigeon pea	25	Long-term variety	1	79	396.09
Pigeon pea	26	Yellow	2	235	325.25
Pigeon pea	27	Short-term variety	3	178	283.92
Pigeon pea	28	Burma	9	164	278.33
Pigeon pea	29	Sat Kyar	1	45	226.55
Pigeon pea	30	Improved variety - red	5	186	209.67
Pigeon pea	31	Ngone Kyar	1	66	198.86
Pigeon pea	32	Shwe Ta Sauk	4	86	174.40
Pigeon pea	33	Medium-Term Variety - red	1	113	169.43
Pigeon pea	34	Yezin 11	1	53	106.24
Pigeon pea	35	Monywa Shwe Dingar	2	29	87.00
Pigeon pea	36	Lone Lat	1	27	79.51
Pigeon pea	37	Taphat Lae - big	1	17	68.72
Pigeon pea	38	Improved variety - big	2	133	66.29
Pigeon pea	39	Long Leaf	1	30	59.41
Pigeon pea	40	Improved variety - yellow	1	56	58.08
Pigeon pea	41	Ordinary - yellow	1	56	55.85
Pigeon pea	42	Paday Thar	1	13	32.17
Pigeon pea	43	Pin Kar	1	17	16.97
Pigeon pea	44	Sin Paday Thar 11	1	45	-
Chickpea	1	B2/V2	166	12,068	40,369.54
Chickpea	2	yezin-6	103	4,709	12,256.69

				Across study population (extrapolated)	
Crop	#	Variety name	# of observations	Number of HHs growing a variety	Acres of land planted
Chickpea	3	Tarpon	25	1,985	8,838.65
Chickpea	4	929	31	1,654	6,274.90
Chickpea	5	Hla Gyi Tarpon	15	1,205	5,106.27
Chickpea	6	Golden yellow	12	1,360	4,059.20
Chickpea	7	Shweni Lone Kyi	21	1,196	3,826.44
Chickpea	8	Taiwan	10	809	3,622.29
Chickpea	9	Theik pan	6	658	2,532.18
Chickpea	10	Golden yellow (small)	8	924	2,459.61
Chickpea	11	Golden yellow (big)	6	669	2,315.60
Chickpea	12	Does not know	17	1,007	1,968.70
Chickpea	13	Big	7	785	1,908.76
Chickpea	14	Red	4	380	1,581.91
Chickpea	15	Sin Kalapae-2	7	283	1,182.28
Chickpea	16	Small	2	293	835.54
Chickpea	17	Tarpon small	2	246	800.68
Chickpea	18	Shwe Ni (big)	1	138	691.90
Chickpea	19	Yezin-1	2	118	635.09
Chickpea	20	Yoe yoe (ordinary)	2	261	521.43
Chickpea	21	Theik pan shwe war gyi	1	95	477.10
Chickpea	22	Taiwan-small	1	184	368.99
Chickpea	23	Taiwan Yellow	5	110	345.24
Chickpea	24	White	2	138	333.05
Chickpea	25	Awwlan	1	185	276.98
Chickpea	26	Yezin-8	2	32	241.87
Chickpea	27	Two-seed myo	1	127	126.74
Chickpea	28	Japan	2	83	125.43
Chickpea	29	Sin Kalapae-1	1	125	125.28
Chickpea	30	B7/V7	3	52	123.74
Chickpea	31	Yezin-12	2	31	122.24
Chickpea	32	Improved variety - yellow	1	21	85.53
Chickpea	33	Yellow	1	127	63.37
Chickpea	34	Yezin-11	1	6	15.92

Source: Myanmar Seed Demand Survey in Dry Zone (2018)

Table A3.2 Patterns of varietal use for rice in monsoon and non-monsoon season by farm households in study area \a

VARIETY	NUMBER OF HHS GROWING A VARIETY				TOTAL AREA PLANTED (ACRES)			
	AT LEAST IN ONE SEASON	ONLY IN MONSOON	ONLY IN NON-MONSOON	BOTH SEASONS	ACROSS ALL SEASONS	MONSOON	NON-MONSOON	BOTH SEASONS
AYEYAR PADAYTHAR	26,707	24,240	1,510	956	101,476	89,170	4,549	7,757
MANAW THUKHA	9,742	6,089	2,743	910	34,741	21,865	9,528	3,348
YADANAR TOE	8,326	395	7,630	301	29,452	721	27,349	1,382
110 DAYS	5,443	419	2,088	2,936	41,017	2,424	10,983	27,610
YANGON MANAW	3,348	1,414	1,695	239	11,851	3,907	5,194	2,750
AYAR MIN	3,266	3,130	53	83	14,699	14,341	27	331
MAGYANDALL	2,224	1,829	369	27	7,841	6,626	1,096	119
SIN THUKHA	1,315	657	658	-	3,056	1,616	1,440	-
90 (DAYS)	1,249	122	900	228	6,811	381	4,431	2,000
WON GYI AYEYAR	1,157	1,083	73	-	3,630	3,514	115	-
KAYIN MA	1,146	1,146	-	-	6,003	6,003	-	-
SHWE MANAW	1,059	370	690	-	4,058	1,270	2,788	-
THUKHA PADAYTHAR	721	363	319	39	2,355	635	1,546	174

VARIETY	NUMBER OF HHS GROWING A VARIETY				TOTAL AREA PLANTED (ACRES)			
	AT LEAST IN ONE SEASON	ONLY IN MONSOON	ONLY IN NON-MONSOON	BOTH SEASONS	ACROSS ALL SEASONS	MONSOON	NON-MONSOON	BOTH SEASONS
SHWE THWE YIN	684	27	636	21	2,264	186	1,993	86
AYEYAR KYAUK SEIN	679	573	105	-	1,939	1,771	168	-
WUN GYI	558	520	38	-	2,220	2,182	38	-
PC	554	-	369	185	646	-	369	277
KYAUK SEIN	529	529	-	-	1,634	1,634	-	-
SHAL THUKHA	432	432	-	-	1,580	1,580	-	-
AYEYAR KYAUKSE	337	337	-	-	779	779	-	-
PWINTPHU THUKHA	266	266	-	-	798	798	-	-
SINN PADAYTHAR	266	127	139	-	774	254	520	-
DOES NOT KNOW	259	74	-	185	333	148	-	185
THUKHA	208	155	53	-	604	495	109	-
SHWE MYANMAR	185	-	-	185	277	-	-	277
PALE THWE	185	-	185	-	92	-	92	-

VARIETY	NUMBER OF HHS GROWING A VARIETY				TOTAL AREA PLANTED (ACRES)			
	AT LEAST IN ONE SEASON	ONLY IN MONSOON	ONLY IN NON-MONSOON	BOTH SEASONS	ACROSS ALL SEASONS	MONSOON	NON-MONSOON	BOTH SEASONS
HTIKE SA	166	-	166	-	333	-	333	-
PATHEIN STICKY RICE	144	-	144	-	431	-	431	-
SHWE AYEYAR	128	128	-	-	64	64	-	-
MERCURY	116	61	55	-	473	364	110	-
SIMITA 2	111	-	111	-	334	-	334	-
SHWE PYI THUKHA	98	98	-	-	294	294	-	-
SAN MHWAY	97	97	-	-	194	194	-	-
YAY PAW NI	82	82	-	-	109	109	-	-
TAMINAR 2	73	-	73	-	189	-	189	-
MA GYAN TAW	70	70	-	-	352	352	-	-
GOD	56	-	56	-	389	-	389	-
MA NAW	55	-	55	-	138	-	138	-
KHUN WAH GYI	54	54	-	-	41	41	-	-
SHWEBO PAWSANN	53	53	-	-	53	53	-	-
YEZIN, UNSPECIFIED	40	40	-	-	162	162	-	-

VARIETY	NUMBER OF HHS GROWING A VARIETY				TOTAL AREA PLANTED (ACRES)			
	AT LEAST IN ONE SEASON	ONLY IN MONSOON	ONLY IN NON-MONSOON	BOTH SEASONS	ACROSS ALL SEASONS	MONSOON	NON-MONSOON	BOTH SEASONS
KAUK GYI 90	38	-	-	38	376	-	-	376
KAUK GYI (5 MONTH)	38	38	-	-	113	113	-	-
BAY KYAR	38	38	-	-	40	40	-	-
BLACK RICE	27	27	-	-	27	27	-	-
LONE THWAL MHWAY	26	26	-	-	26	26	-	-
KYAUK GYI	25	-	-	25	225	-	-	225
TOTAL	**72,379**	**45,111**	**20,913**	**6,356**	**285,293**	**164,138**	**74,259**	**46,896**
PERCENTAGE OF TOTAL		**62%**	**29%**	**9%**		**58%**	**26%**	**16%**

\a numbers are extrapolated across study area using sample weight

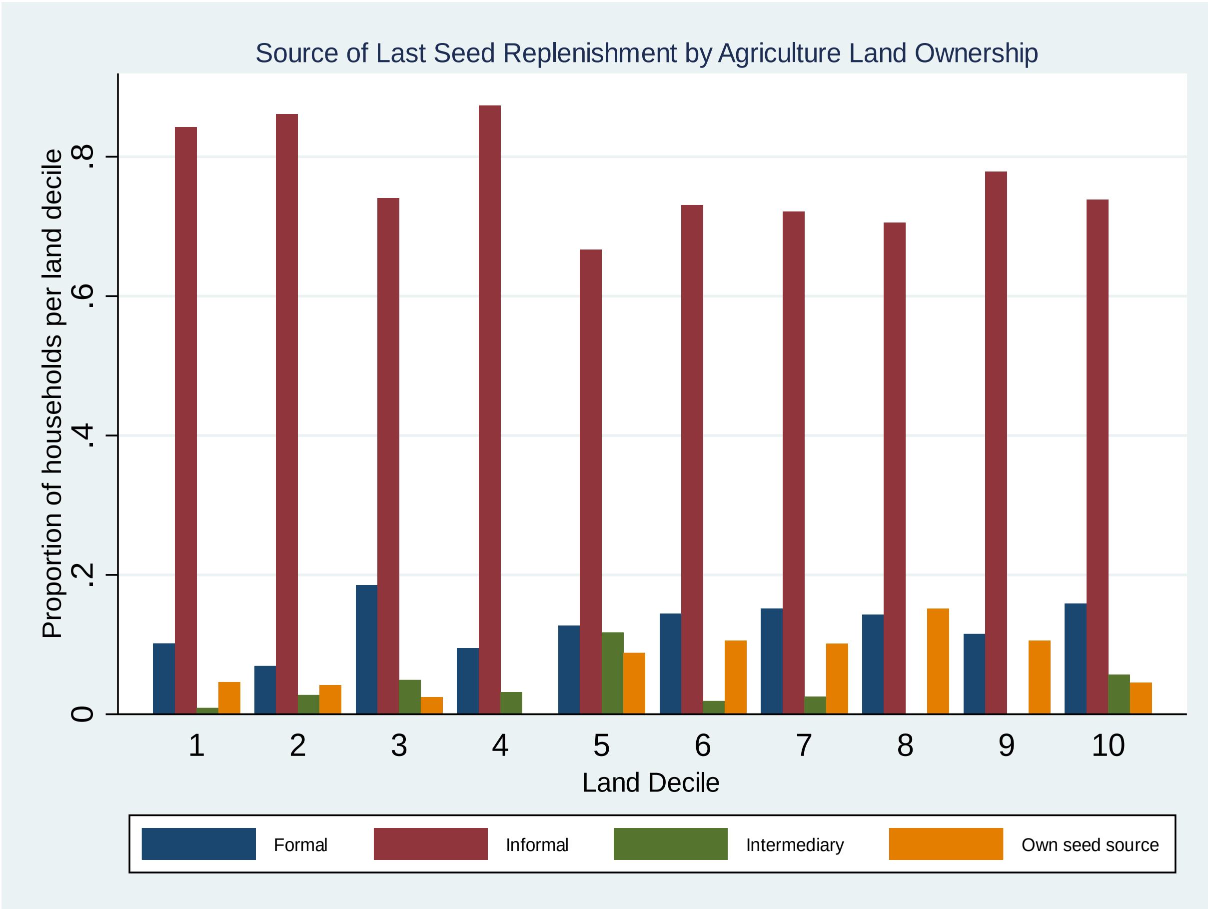
ANNEX 4. ADDITIONAL INFORMATION ON QUALITY SEED UPTAKE AND USE

Table A4.1 Sources of last seed replacement, by crop and agriculture land ownership decile

Land decile	Seed source	Rice	Sesame	Ground-nut	Sun-flower	Green Gram	Black Gram	Pigeon Pea	Chick-pea
	N	*320*	*213*	*117*	*17*	*61*	*6*	*50*	*161*
1 (smallest)	Formal	6	2	1	0	1	0	0	1
	Informal	39	22	3	0	7	0	1	19
	Intermediary	1	0	0	0	0	0	0	0
	Own	2	1	2	0	0	0	0	0
2	Formal	3	0	0	0	0	0	0	2
	Informal	19	10	7	2	7	1	2	14
	Intermediary	2	0	0	0	0	0	0	0
	Own	2	1	0	0	0	0	0	0
3	Formal	15	0	0	0	0	0	0	0
	Informal	22	12	6	0	5	1	4	10
	Intermediary	1	2	0	0	0	0	0	1
	Own seed	1	1	0	0	0	0	0	0
4	Formal	3	2	0	2	1	0	0	1
	Informal	19	20	14	1	10	0	3	16
	Intermediary	2	1	0	0	0	0	0	0
	Own	0	0	0	0	0	0	0	0
5	Formal	7	4	0	0	1	0	0	1
	Informal	25	17	8	0	0	0	3	15
	Intermediary	7	2	0	0	1	1	0	1
	Own	0	2	3	0	1	0	3	0
6	Formal	12	1	0	0	0	0	1	1
	Informal	23	23	10	0	5	0	5	10
	Intermediary	2	0	0	0	0	0	0	0
	Own	3	3	2	0	0	0	2	1

Land decile	Seed source	Rice	Sesame	Ground-nut	Sun-flower	Green Gram	Black Gram	Pigeon Pea	Chick-pea
7	Formal	9	0	1	0	1	0	0	1
	Informal	14	14	11	1	1	1	4	11
	Intermediary	0	1	0	0	0	0	0	1
	Own	4	1	1	0	0	0	0	2
8	Formal	13	2	0	0	0	0	0	1
	Informal	17	17	17	3	3	0	6	16
	Intermediary	0	0	0	0	0	0	0	0
	Own	3	7	1	1	2	0	2	1
9	Formal	8	0	0	2	2	0	0	0
	Informal	18	20	13	2	4	0	8	16
	Intermediary	0	0	0	0	0	0	0	0
	Own	2	3	4	0	1	0	0	1
10 (largest)	Formal	7	2	0	0	1	0	1	3
	Informal	5	17	13	3	7	2	4	14
	Intermediary	4	0	0	0	0	0	0	1
	Own	0	3	0	0	0	0	1	0

Figures A4.1 Source of last seed replenishment by agriculture land ownership, all crops



Figures A4.2 Source of last seed replenishment by agriculture land ownership, rice

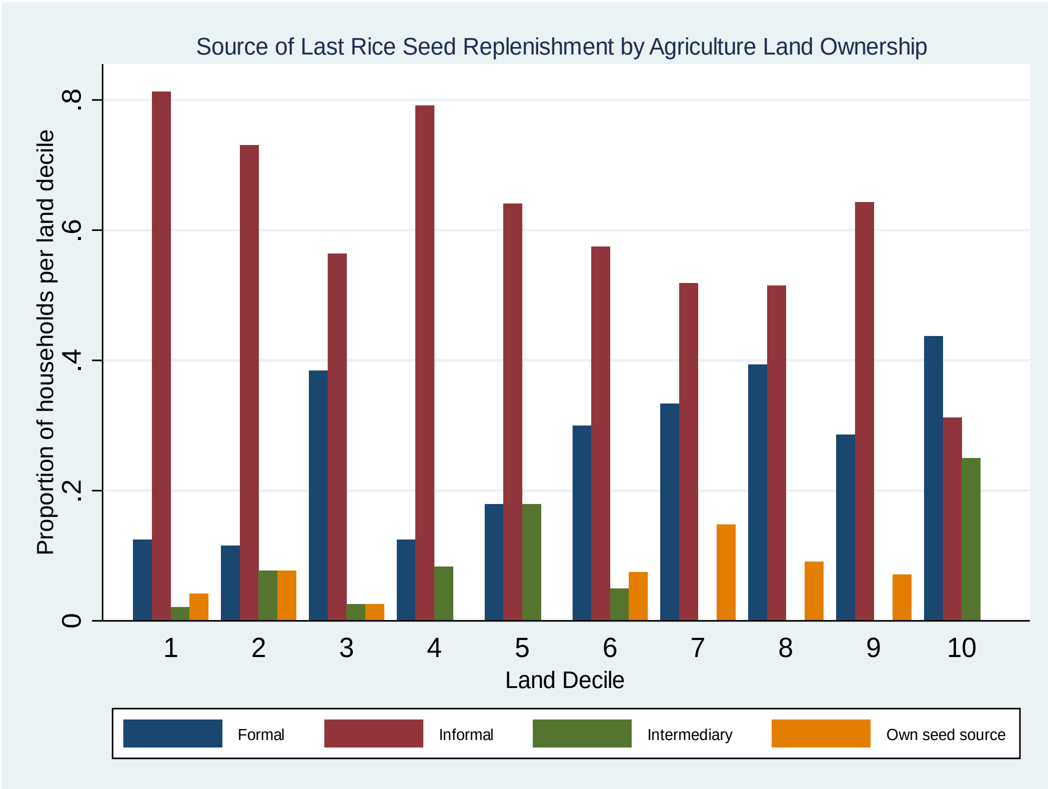


Figure A4.3 Source of last seed replenishment by agriculture land ownership, sesame

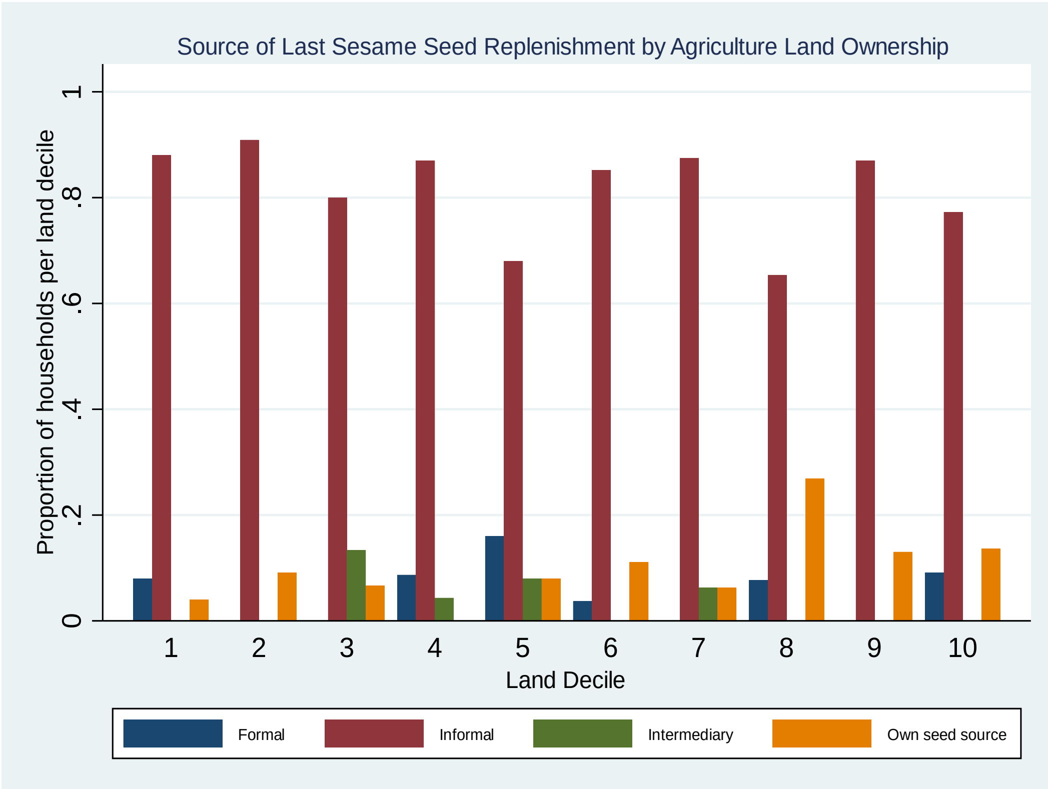


Figure A4.4 Source of last seed replenishment by agriculture land ownership, groundnut

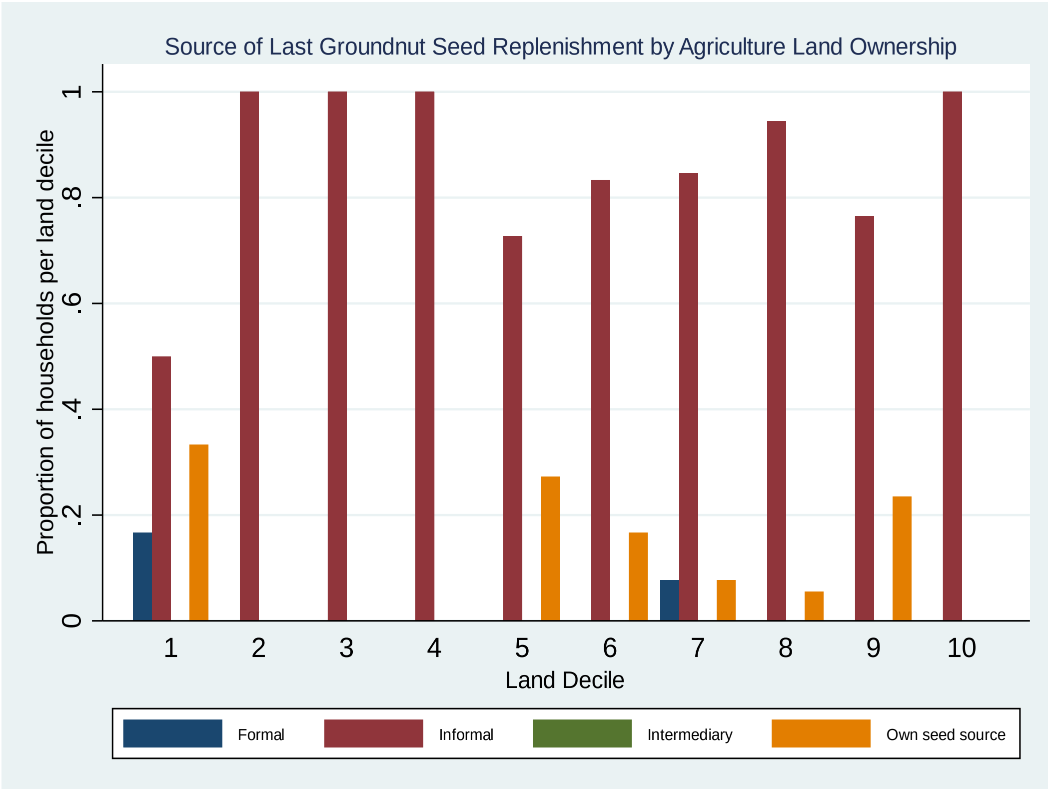


Figure A4.5. Source of last seed replenishment by agriculture land ownership, sunflower

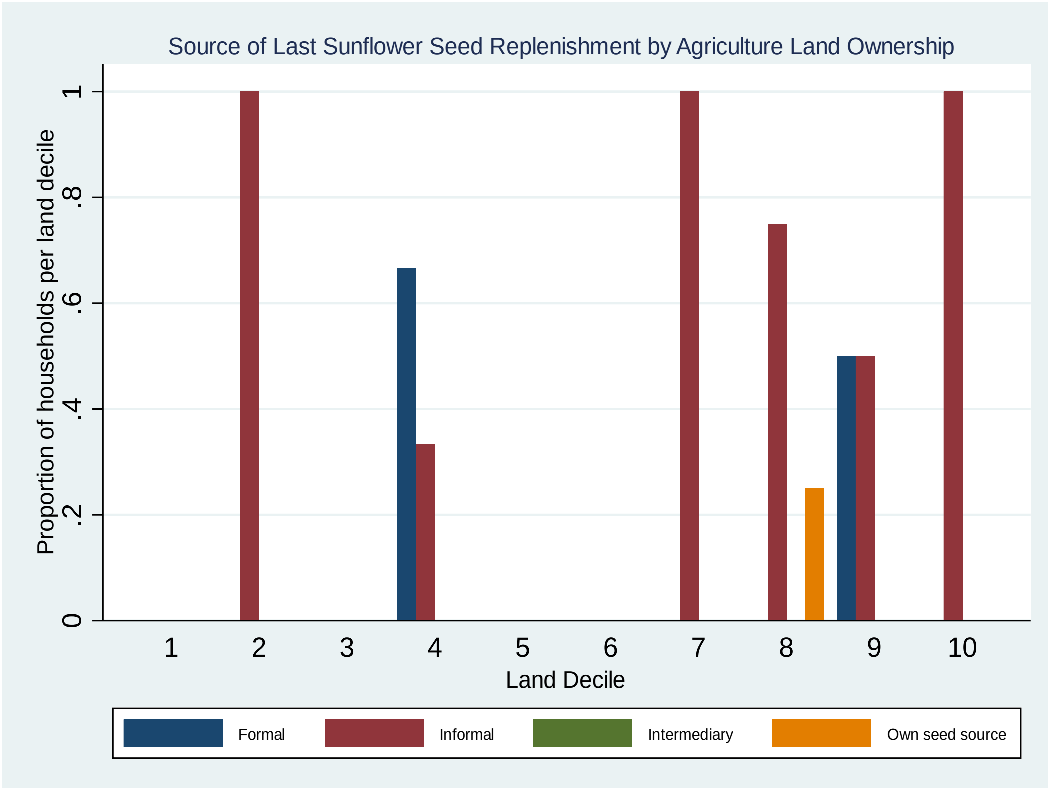


Figure A4.6 Source of last seed replenishment by agriculture land ownership, green gram

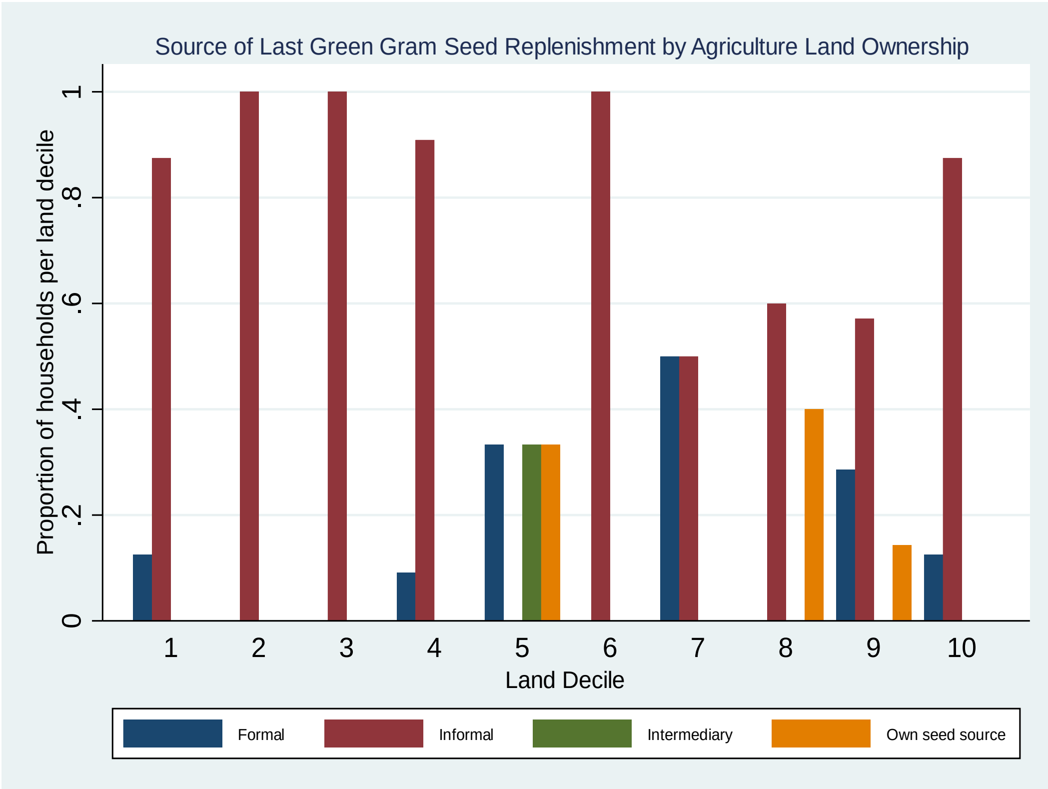


Figure A4.7 Source of last seed replenishment by agriculture land ownership, black gram

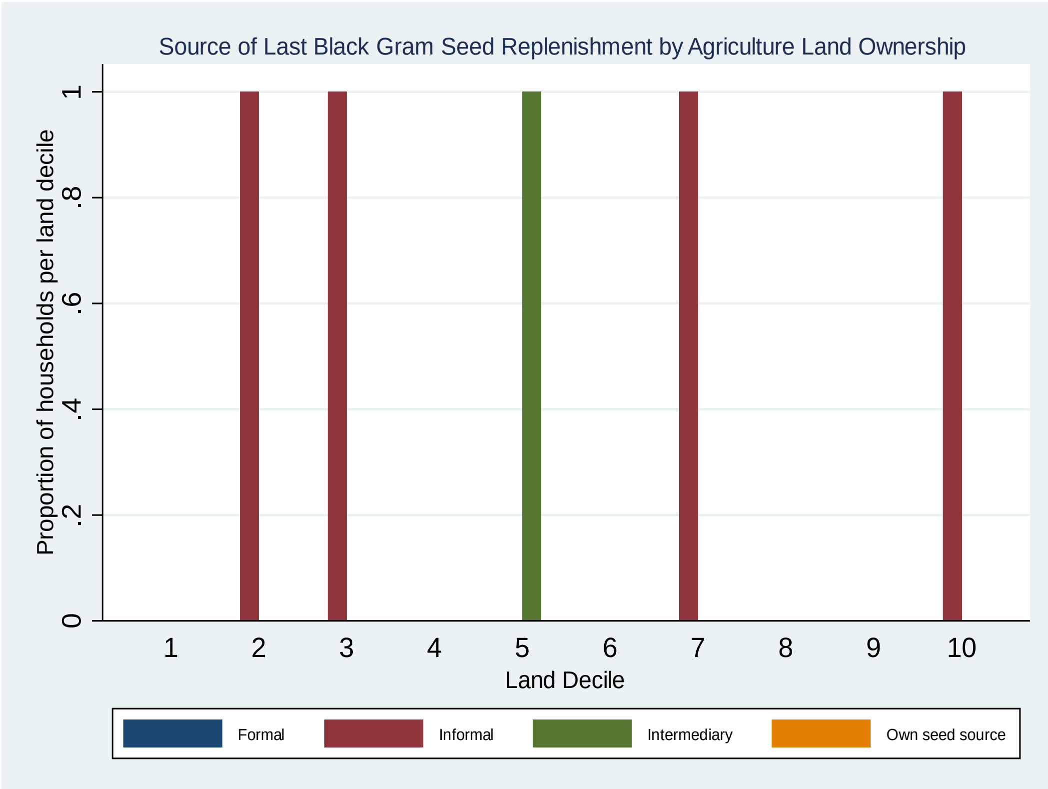


Figure A4.8 Source of last seed replenishment by agriculture land ownership, chickpea

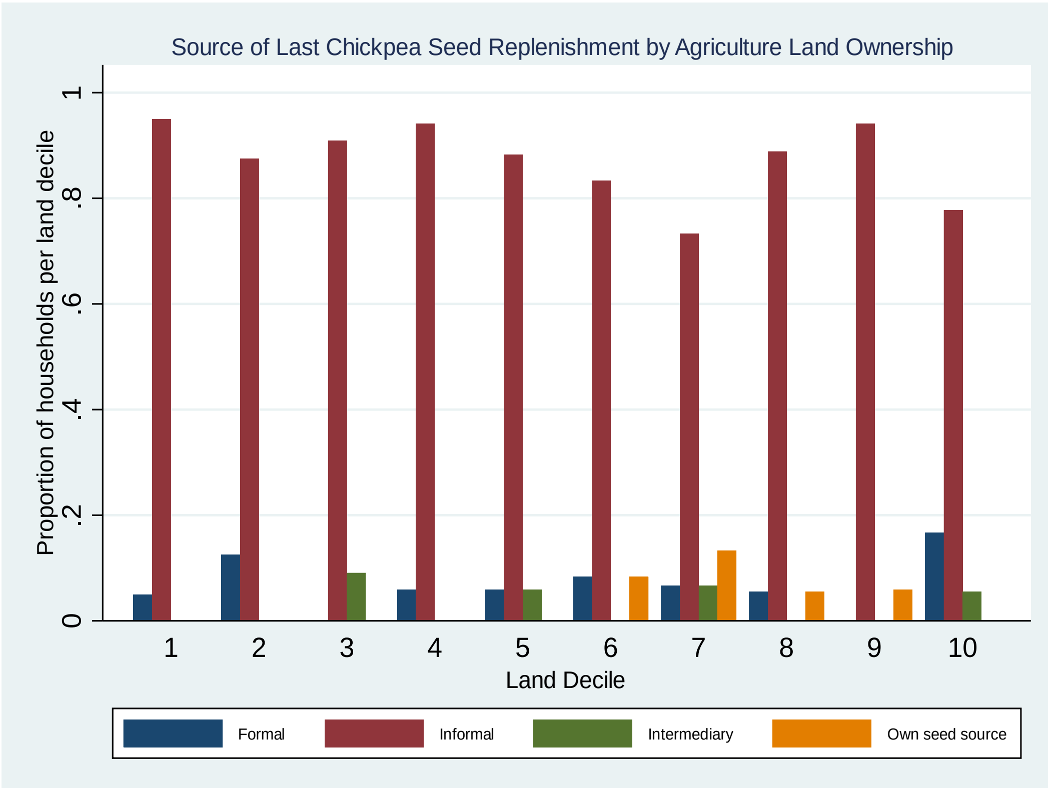


Figure A4.9 Average seed price by agriculture land ownership, rice

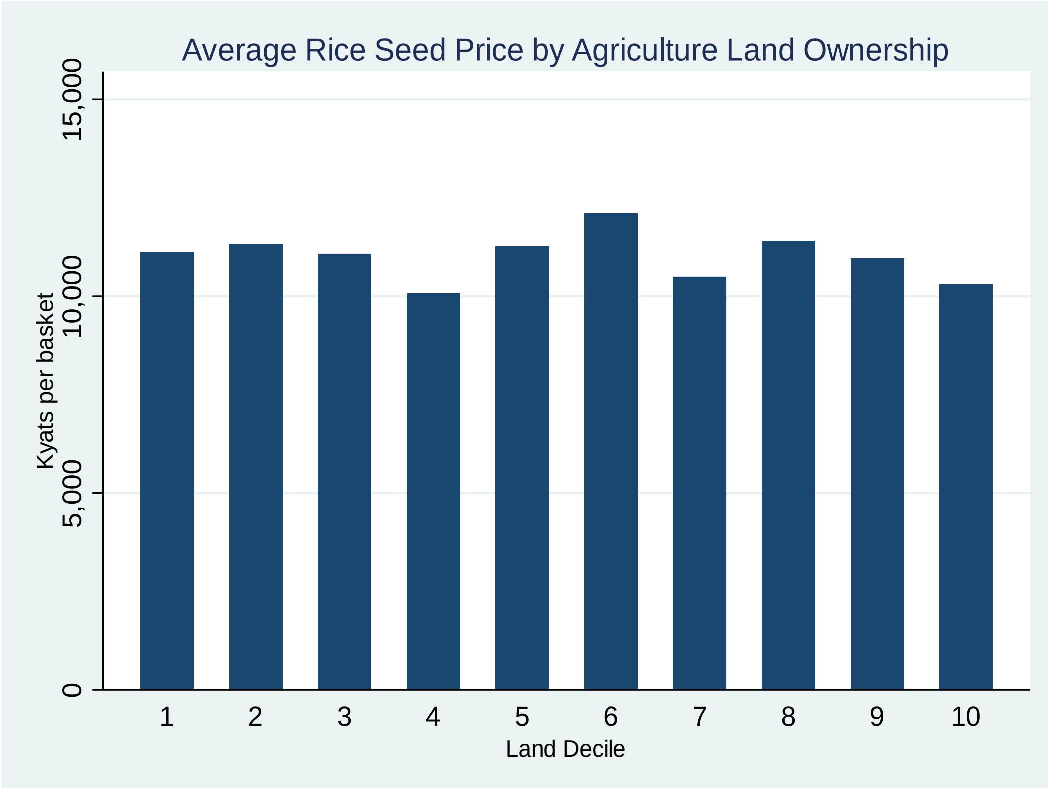


Figure A4.10 Average seed price by agriculture land ownership, sesame

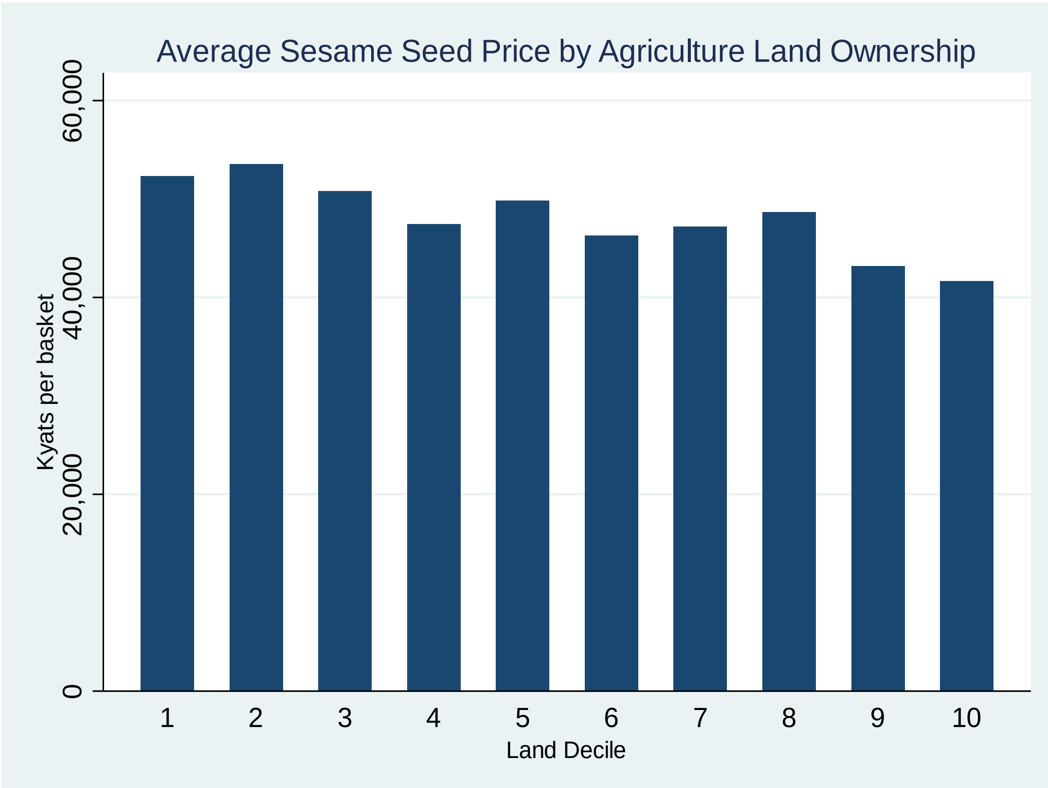


Figure A4.11 Average seed price by agriculture land ownership, groundnut

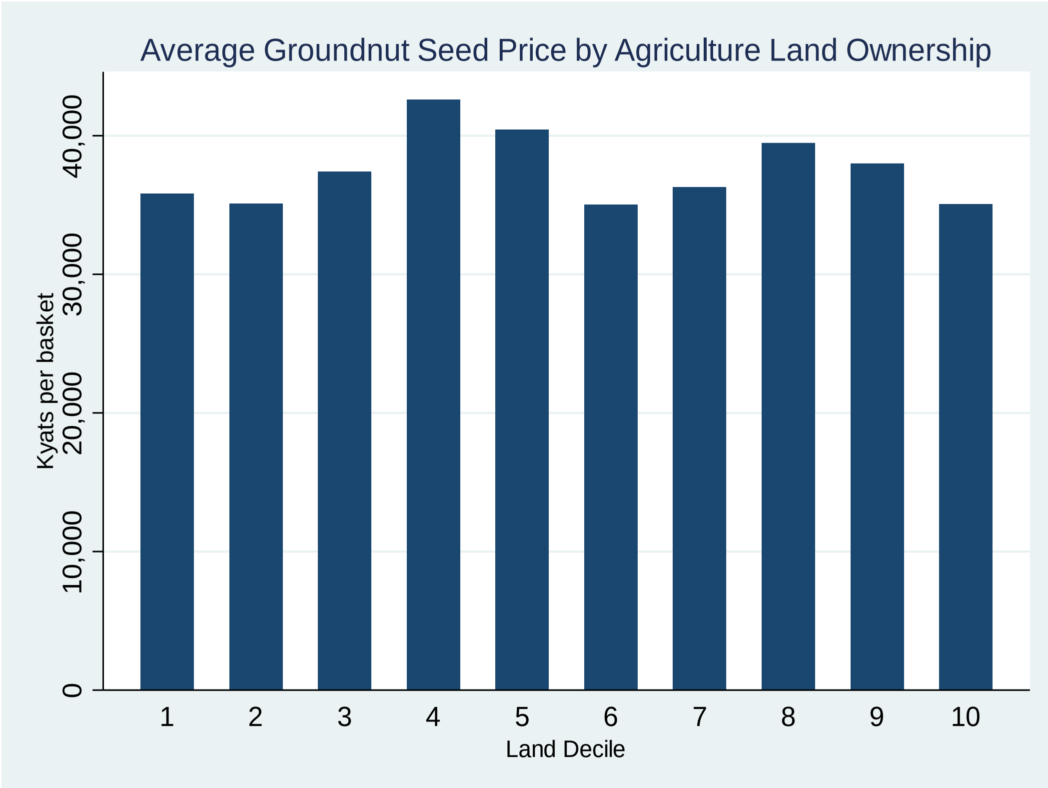


Figure A4.12 Average seed price by agriculture land ownership, sunflower

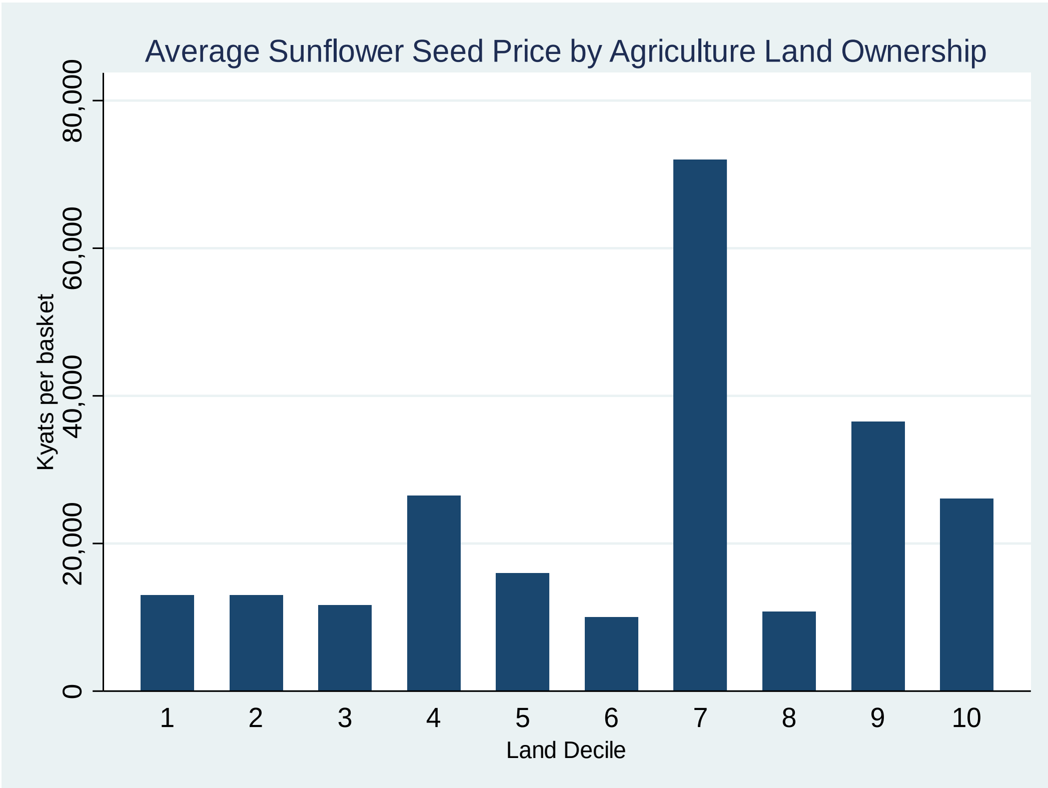


Figure A4.13 Average seed price by agriculture land ownership, green gram

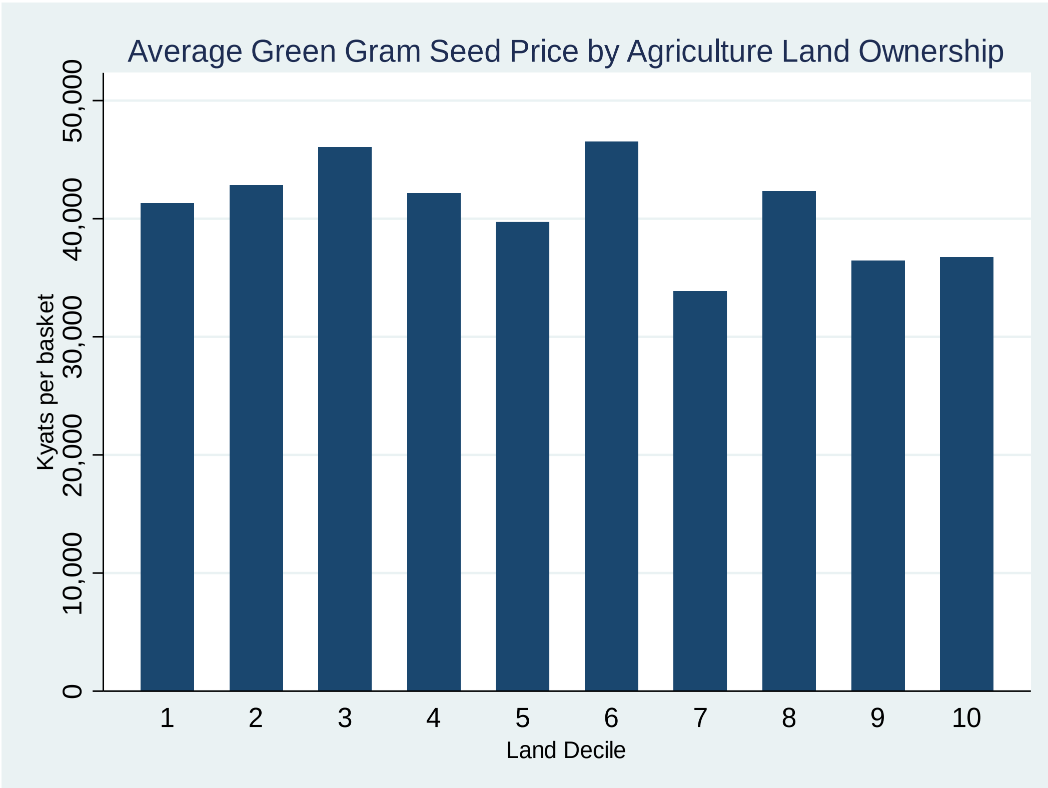


Figure A4.14 Average seed price by agriculture land ownership, black gram

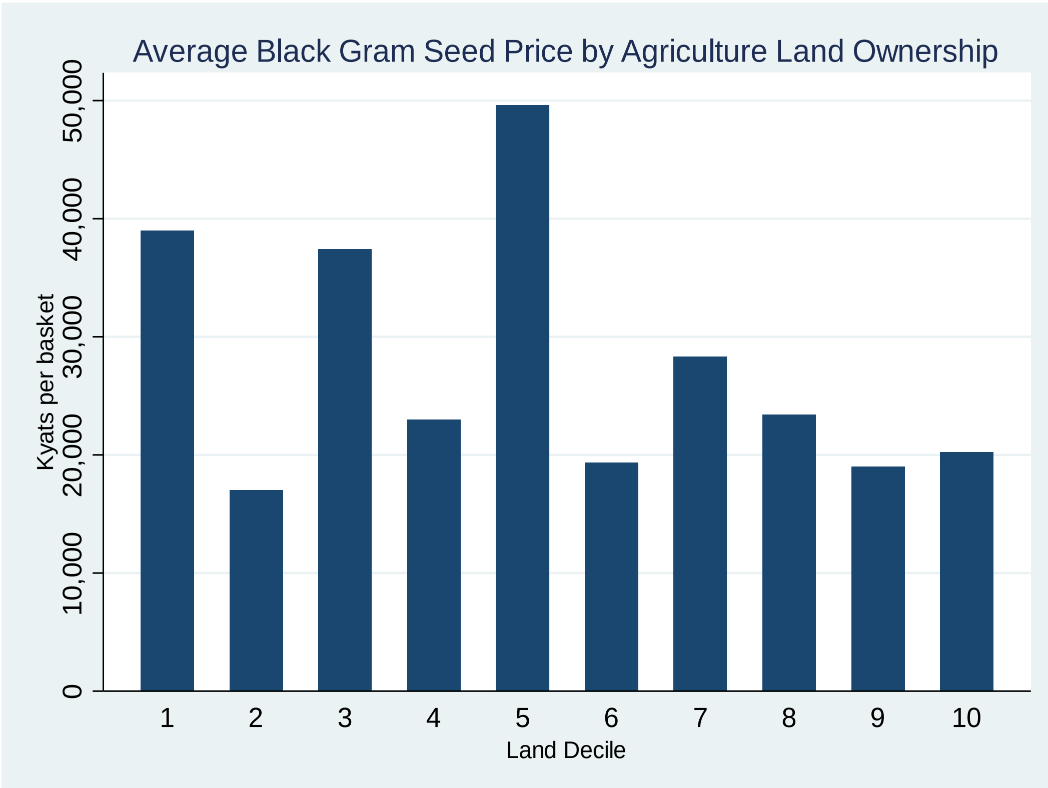


Figure A4.15 Average seed price by agriculture land ownership, pigeon pea

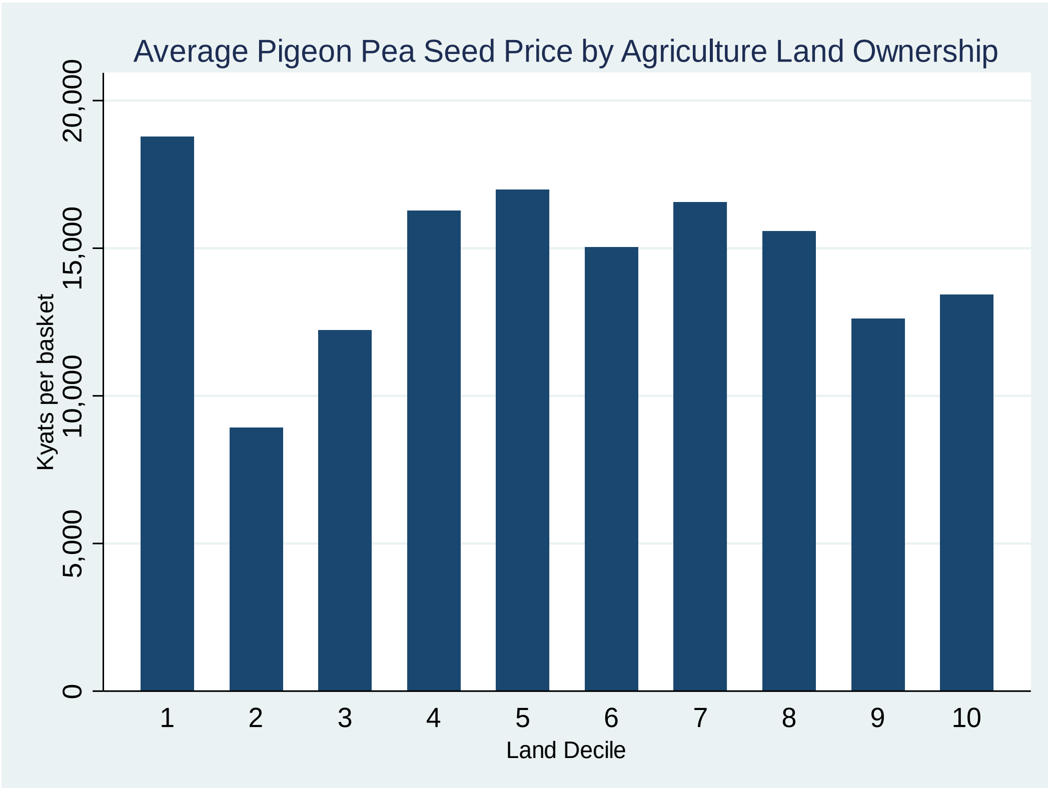


Figure A4.16 Average seed price by agriculture land ownership, chickpea