SOYBEAN RESEARCH & DEVELOPMENT IN UGANDA

HIGHLIGHTS
2002 - 2018

Makerere University

CENTRE FOR SOYBEAN IMPROVEMENT AND DEVELOPMENT

Soybean Research and Development in Uganda

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MAKERERE UNIVERSITY

MAAIF - VODP

Soybean Africa

Makerere University Centre for Soybean Improvement and Development

Cover picture:
Front: A farmer in his soybean field; Back: Researcher inspects soybean experimental field

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Research team

From left to right: Phinehas Tukamuhabwa - Soybean Breeder; Paul Kabayi - Senior Technician; Tonny Obua - Soybean Breeder; Mercy Namara - Training Coordinator; George Yiga - Technician

Soybean has been described as a, miracle crop of many uses, gold from the soil, prodigious and crop of the future.

Foreword

I am very pleased to write a foreword for this very inspiring report highlighting 16 years of soybean research at Makerere University, whose result has led to a rapid increase in the number of industries engaged in processing soybean in Uganda and neighboring countries. Traditionally, the kind of results presented here have been dominated by research institutes as opposed to academia. However, the current development prospects and challenges demand that students be directly exposed to the application of science in their day to day experience for enhanced skills acquisition and self-actualization later in life. Through this approach, Makerere University Centre for Soybean Improvement and Development (MAKCSID) has provided a platform for Practical Plant Breeding and Seed Technology within the University environment, paving way for easy access to hands-on experience during training. I want to thank the soybean research team for the innovations brought in the University system. This publication/report provides highlights of the contribution of rust-resistant soybean varieties to the agricultural sector in Uganda. It contains forward-looking research results based on current research findings and forecasts made by the Centre for Soybean Research and Development from 2002 to 2018.

Soybean was first introduced in Uganda way back in 1908. Its production was emphasized to combat malnutrition and to provide soldiers with highly nutritious food during the Second World War. Like most new crops, soybean was not readily accepted by the local people based on claims that it depleted soil fertility, could not be cooked like commonly known legumes, had beany flavor and lacked a readily available market.

The soybean crop was also not given consistent recognition by the National Agricultural Research System (NARS) and suffered decline in production due to a major out break of soybean rust disease in 1996. Makerere University in collaboration with the National Agricultural Research Organization (NARO) and Vegetable Oil Development Project (VODP) of the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) undertook research to control soybean rust disease and to promote and disseminate soybean seed of locally developed superior varieties. It is now very gratifying to note that through efforts of the Centre for Soybean Improvement and Development (MAKCSID), the soybean rust pandemic was brought under control, through breeding and dissemination of superior varieties to the farming communities. The fact that over 93% of these varieties are grown in Uganda is a clear indicator that the Centre has impacted the target end-users with improved technologies.

On behalf of the College of Agricultural and Environmental Sciences (CAES), I greatly appreciate the efforts by the authors, soybean research teams and all partners who contributed to the research and development activities highlighted in this report during the past 16 years.

Wishing you good reading as **“We Build for the Future”**

Prof. Bernard Bashaasha
Principal, College of Agricultural and Environmental Sciences

Acknowledgment

The authors appreciate the donors especially the Vegetable Oil Development Project 2 (VODP 2) of the Ministry of Agriculture Animal Industry and Fisheries (MAAIF), Alliance for Green Revolution in Africa (AGRA) and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM). We thank our partners including the National Agricultural Research Organization (NARO), Integrated Seed Sector Development (ISSD), African Agricultural Technology Foundation (AATF), Local Governments (LGs), Non-Governmental Organizations (NGOs), Community Based Organization (CBOs) and Private Companies for their enormous contribution towards facilitating the research process and seed dissemination. Finally, we thank soybean farmers and farmer groups for their cooperation.

CONTENTS

QUICK FACTS

- Originates from East Asia
- Economically the most important legume in the world
- Naturally rich and cheapest source of protein and oil
- Erect, branching plant with oblong leaves
- Thrives in warm, fertile, well drained, sand loams
- Determinate and indeterminate growth habits
- Capable of biological nitrogen fixation
- Produces about 80 pods with 2-4 seeds
- Matures in 90-120 days in the tropics
- Pods are harvested when dry and threshed by hand

Overview

Early soybean research in Uganda started in the 1930s and resulted in the release of the varieties Kabanyolo 1, Kabanyolo 2 and Congo 72. These varieties served communities in Uganda up to 1996 when Nam 1, Nam 2 and Namsoy 3 were released and commercialized. However, severe soybean rust epidemic experienced in 1996 rendered these varieties obsolete as they were all susceptible.

Soybean research and development efforts in Uganda is led by Makerere University Centre for Soybean Improvement and Development (MAKCSID) in partnership with farmers, research institutes and technology verification centres in the major soybean growing areas. The major breeding objectives are to develop soybean varieties that are: 1) high yielding and maturating in less than 120 days, 2) resistant to diseases and pest with major focus on soybean rust disease and groundnut leaf miners, 3) resistant to lodging and pod shattering, 4) promiscuous in the formation of active nodules with local rhizobia, 5) rich in protein and oil contents, 6) having high pod clearance, and 7) having general end-user acceptance in terms of seed appearance and other traits.

When soybean rust diseases were first observed in Uganda in 1996, two strategies (short and long term) were adopted to mitigate the effects of the soybean rust epidemic. The short-term strategy involved introduction and evaluation of germplasm, while long-term comprised of continuous making of crosses between resistant and elite susceptible soybean lines. This resulted in the release of seven new varieties that include Namsoy 4M, Maksoy 1N, Maksoy 2N, Maksoy 3N, Maksoy 4N, Maksoy 5N and Maksoy 6N.

However, private seed companies have not been keen on the production of certified soybean seed due to its nature of reproduction. The self-pollination nature of soybean makes it possible for farmers to successfully reproduce seed every season, which does not favor profit making in the seed business. Hence, a holistic seed system was adopted by MAKCSID to ensure that farmers access the new soybean varieties. Thus the research team also worked with community-based organisations (CBOs), non-governmental organisations (NGOs) and other stakeholders in the soybean value chain, who were particularly instrumental for 50% of the nationwide dissemination of foundation seed to different stakeholders for multiplication. As a result, the national soybean production area soon increased from 144,000 to 155,000 hectares between 2004 and 2009, with annual production increasing from 158,000 to 181,000 tonnes respectively (UBOS, 2010).

Recent impact studies showed that the new varieties developed by MAKCSID were the most planted and accounted for 93% of the soybean varieties grown by Ugandan farmers (Tukamuhabwa et al., 2016). Currently, Maksoy 1N is the most widely adopted variety by farmers, while Maksoy 3N has the largest quantities of foundation seed disseminated by the centre. The contribution of soybean to smallholder household incomes is estimated at 1,185,600 UGX per hectare per season (Tukamuhabwa and Obua, 2015). The processing capacity for soybean increased from 300 to 600 MT per day- between 2004 and 2011, while the export value of soybean increased by 288% (Ssengendo et al., 2010).

The growth of the soybean sub-sector in Uganda is mainly attributed to the availability of a wide range of improved varieties, government investment in soybean research, and increased private sector investment along the soybean value chain. However, strengthening policies that favour industrial or medium scale enterprises in soybean processing should enhance further national soybean production. Additional support to other components such as mass education and promotion of utilisation of soybean products at the household level is equally important.

Soybean: The Crop

Soybean (*Glycine max* (L) Merill) is the world's most important legume crop because of its high protein (40%) and oil (20%) content. In fact, soybean produces the highest amount of protein per unit area among all crops.

Soybean originated from East Asia and was first domesticated in China in the second century BC (Xu et al., 2002). Soybean is ranked the most important oil crop in the world, providing the cheapest source of protein for both human food and livestock feeds. The protein content of soybean is the highest among legume crops, averaging 40% on a dry matter basis. Soybean protein is balanced with all the essential amino acids, while the seed also contains significant amounts of minerals (notably Fe, Zn, Ca, Mg). Japan, China, and Taiwan have shown the earliest known dishes made from soybean, including tofu, the soybean curd, and tempeh a fermented product.

Due to its nutritional superiority, soybean flour is the only substitute for animal and fish protein. For this reason, soybean-based foods are highly recommended for children under 5 years, expectant mothers and HIV/AIDS patients. Soybean oil is 85% unsaturated, comprising linoleic acid (omega-3 fatty acid) and oleic acid which are known to reduce the risk of heart disease by lowering serum cholesterol by about 33%.

Besides, soybean also contains isoflavones which increase artery and heart health. Impact studies have also shown that regular soy food consumption can reduce the risk of rectal cancer by 80%, mammary tumor by 40% and breast cancer by 50%. Daily consumption of 25 grams of soy protein was recommended as a means to reduce the risk of heart disease by the United States Food and Drug Administration in 1999. Evidence shows that countries whose diets are based on soybeans such as China, Japan, and Korea are known to have longer life expectancy and experience minimum cases of cancers.

Production of soybean stands at 264 million MT worldwide, with United States of America (USA), Brazil and Argentina being the largest producers, where the crop is of strategic national importance for the feed and food sectors (Figure 1). In Africa, Nigeria, South Africa, and Uganda are the largest producers, with annual volumes estimated at 1.5 million metric tonnes (FAO, 2017).

In cropping systems, soybean improves soil properties by fixing nitrogen in the soil. It also breaks the life cycle of pests such as *Striga hermonitheca* when it is planted in rotation with cereals (Plate 1).

With limited land Soybean is also being intecropped with maize at wide spaced rows as illustrated in Plate 2.

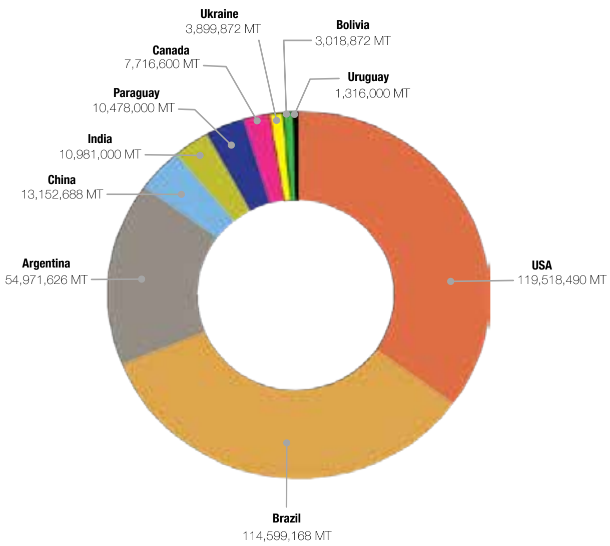

Figure 1: 10 leading global producers of soybean (FAOSTAT, 2017)

Plate 1: Soybean in mixed cropping with cereals disrupts *Striga hermonthica* (Witch weed).

Plate 2: An intercrop of soybean and maize at the recommeded wide spaced rows in northern Uganda.

Uses of soybean

A miracle crop indeed, soybean has many uses to mankind, ranging from human food, livestock feed to industrial products. According to the American Soybean Association, there are 27 whole bean products, 53 soy oil products and 48 products from soybean flour.

Soybean offers several major advantages in sustainable cropping systems that include improvement of soil fertility through addition of nitrogen from the atmosphere, which is a foremost benefit in African farming systems; characterized by exhausted soils due to over cultivation (Graham and Vance, 2003). In principle, soybean can be encouraged as a rotation crop to improve productivity of other crops being grown (Tukamuhabwa and Obua, 2015). The dense canopy of soybean helps to conserve soil water moisture and suppress weeds in the soybean field. The extensive root network of soybean maintains the soil structure and promotes infiltration, which is crucial for absorption of water and nutrients. The soybean crop also disrupts the life cycle of several pests and diseases especially in cereals when grown as an intercrop (Pandey, 1987).

Soybean is also used to make numerous industrial products including; oil, soaps, cosmetics, resins, plastics, ink, crayons, solvents, clothing; human edible products, livestock and fish feeds. Livestock feed prepared from fat-free soybean has higher protein content compared to the whole grain cereals (Figure 2).

In the western world, cultivation of soybean was promoted in the past century to support the feed and food sectors as a rich protein and oil source. Soybean preparations are mostly included as ingredients in different food products, often inadvertently serving as a fortifier, providing high-quality protein and cholesterol-free oil.

In Uganda, the crop is mainly a cash income earner, also used in making high protein foods for human consumption and making animal feeds (Plate 3). However, the various forms in which soybean could be used are yet to be fully exploited. Notably, the inclusion of soybean products into common diets could significantly improve the human nutrition sector.

Plate 3: A signpost at local soybean products outlet in Kampala, Uganda.

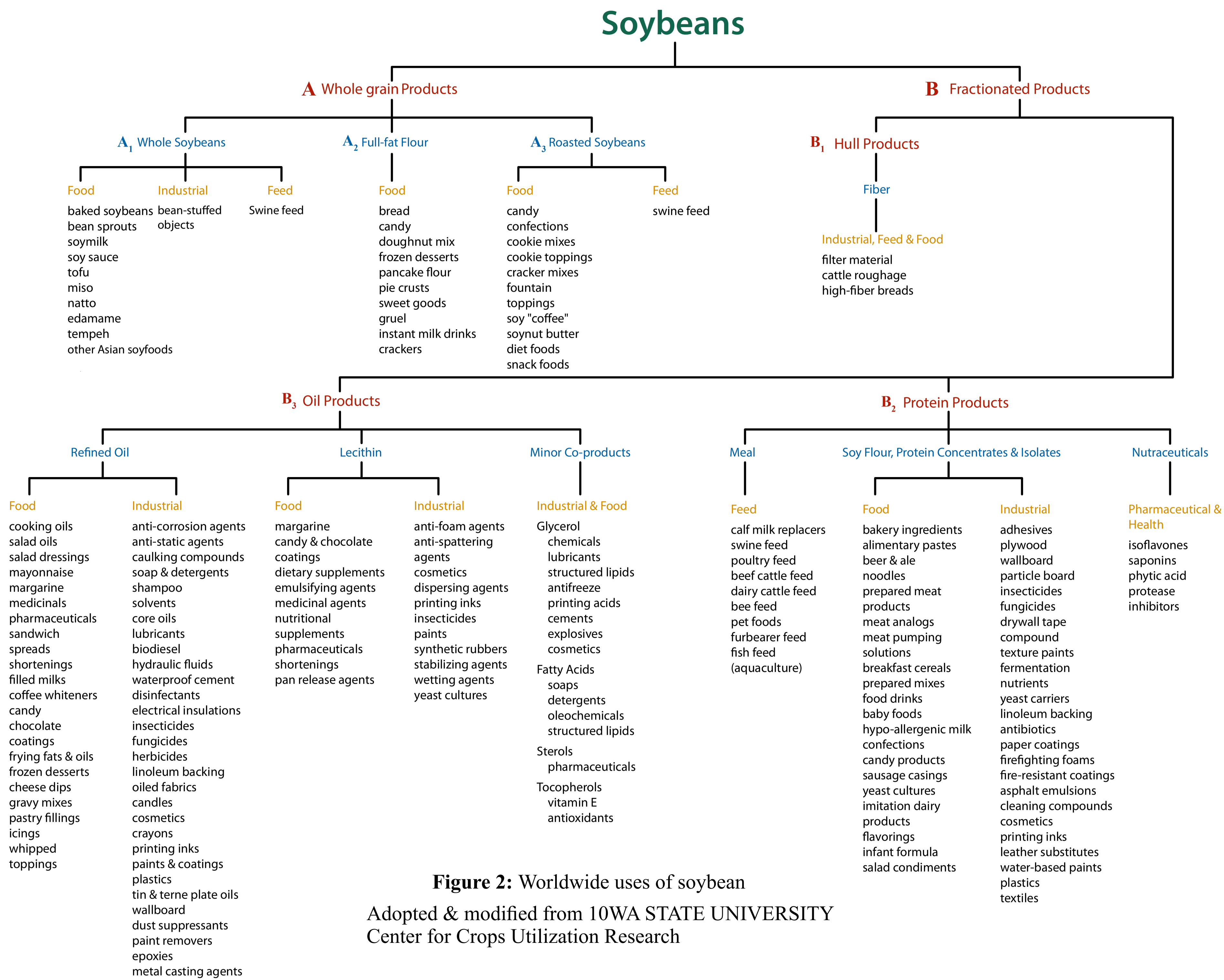

Figure 2: Worldwide uses of soybean

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Center for Crops Utilization Research

Soybean in Uganda

Soybean is believed to have been introduced into Uganda between 1918 and 1945, an era marked by the first and second world wars, to combat protein malnutrition among soldiers of the King's African Rifles (KAR) and kwashiokor among children and due to colonial interest of crop diversification.

Owing to the high nutritious status of soybean, the colonial government made deliberate attempts during the 1940s and 1950s to encourage local production of soybean in order to combat protein malnutrition among soldiers of the King's African Rifles (KAR) and kwashiorkor among children, and in the interest of crop diversification. Despite efforts to promote the use of soybean in the improvement of human nutrition, production continued declining since only a few varieties were available to farmers. This was apparently aggravated by the seldom use of soybean in local diets and reduced enthusiasm among potential growers who opted for competing crops such as coffee and cotton that provided greater returns.

Between 1970-1980, average annual soybean production was less than 50,000 tonnes produced under 5,600 hectares (Tukamuhabwa, 2001). However, in the subsequent years, soybean production gainfully realised fundamental changes in acreage planted. This was partly attributed to the renewed interest by the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) which resulted in both the introduction and development of additional varieties. Furthermore, farmers were motivated by the increased support from the oil seed and livestock feed sectors. This significant boost in production made Uganda the third leading producer of soybean in Africa after Nigeria and South Africa.

Soybean products in Uganda

The products named below are made by over 30 different food processing plants. The major soybean products are soybean meal, soybean oil and several soybean-based food products summarized below: Energy booster (soya, maize and pumpkin seeds), baby soya enkejje (soya, maize, enkejje), baby soya chocolate (maize, soya, carrots, sugar, chocolate, milk solids, vitamins, and minerals), baby soya with banana, baby soya with oats, nutri pumpkin porridge (pumpkin flour, corn flour, soya flour), super soya rice, soy millet, cookies (wheat, soya), queen cakes (wheat, soya), soya milk, soya cup plain, soya cup spiced (vanilla, ginger, cinnamon), soya meat, spicy beef flour soya mince, brown butter, baby porridge (maize, mushroom, soya, carrots), tasty soya protein pieces (soya, maize, spices).

Soybean Research in Uganda

Inception of soybean research in Uganda involved the Ministry of Agriculture and Makerere University as early as 1930s. By 1975 six soybean varieties had been released which include S - 35, Congo 72, Clark 63, Bukalasa 4, No.7 and Kabanyolo 1 (Bashaasha, 1992). However, due to civil strife between 1975 and 1986 almost all of the soybean varieties, and breeding lines were lost. In a bid to restart the soybean breeding program in Uganda, 537 TGX and TGM germpalsm and breeding lines were received from International Institute of Tropical Agriculture (IITA), and 68 cultivars from other parts of the world including the United States of America (Bashasha, 1992). Trials for evaluating soybean breeding lines were conducted at Kawanda, Namulonge, Mubuku and Bukalasa. Varieties such as Nam 1 and Nam 2 are outputs from these efforts. The outbreak of soybean rust epidemic in 1996, which caused yield losses of between 20 to 100%, for the first time in Uganda rendered all these varieties obsolete (Tukamuhabwa et al., 2012).

Following the outbreak of soybean rust, additional soybean germplasm was imported into the country between 1997 and 2004 (Tukamuhabwa and Oloka 2016; Tukamuhabwa et al., 2012). Soybean research resumed at Makerere University in 2002 (Plates 4 and 5). The germplasm was imported from IITA, AVRDC, South Africa and Zimbabwe for screening and breeding for resistance to soybean rust. From this work, two new varieties were released in 2004, namely Namsoy 4M and Maksoy 1N. In 2008 and 2010 additional varieties Maksoy 2N and Maksoy 3N, respectively, were released. Additionally in 2013, two additional varieties Maksoy 4N and Maksoy 5N were released and lastly Maksoy 6N was released in 2017. In 2015, the research program turned into the Centre for Soybean Improvement and Development.

Major production constraints

Soybean is faced with a number of production constraints (i.e. abiotic and biotic) that greatly affect yields. Although pests and diseases should be immediately controlled with recommended agrochemicals once observed in the field, the use of resistant varieties is the most cost-effective and recommended management strategy because it is environmentally safe.

Soybean suffers attacks from several pests and diseases that occur over a wide range of conditions and plant growth stages. Common biotic constraints to soybean production include pests like groundnut leaf miners (webworms), bean leaf beetles, green clover worms and stink bugs. However, lately we have observed bruchids attacking soybean seed during storage. Diseases like soybean rust, bacterial pustule, root rots, mosaic virus, frog eye leaf spot, red leaf blotch, downy mildew, and nematodes among others also affect soybean productivity. Amongst these, soybean rust is the most economically significant constraint. It is very important for growers and extension agents to have an enhanced capacity to detect and identify soybean diseases especially in scenarios where symptoms of several diseases co-exist in the same field. Moreover, accurate identification of pathogen is very difficult if the infected plants are already dead. When this happens, it is advisable to submit samples to a credible plant pathology laboratory. The most important pests and diseases of soybean biotic constraints in Uganda are presented in Plate 6 and 7. Other than pests and diseases, the following factors significantly affect soybean production in Uganda:

- Poor agronomic practices
- Inaccessibility to good seed by farmers
- Lack of functional farmers' groups
- Weeds and acute labour demands
- High incidence of counterfeit seed on the market
- Depleted soil fertility
- Intermittent drought

Plate 4: Mr. Paul Kabayi, senior soybean technician, examining genetic uniformity of an Advanced line at NaCRRI

Plate 5: Mr. George Yiga, soybean technician, identifying successful crosses in the screen house at MUARIK.

Pests and Diseases

(a) Beetle damage

(b) Green cloverworm

Plate 6: Important pests of soybean in Uganda

(e) Soybean rust

(f) Red leaf blotch

(g) Bacterial pustule

(h) Purple stain (cercospora kikuchii)

Plate 7: Important diseases of soybean in Uganda

Soybean rust

Soybean rust caused by the fungus *Phakospora pachyrizi* Sydow is the most limiting factor to soybean production in Uganda and the tropics. Its entry and rapid establishment in sub-Saharan Africa (SSA) have caused major yield losses.

The disease is believed to have originated from Asia thus the name Asian soybean rust (ASR). Soybean rust is the disease of economic importance in Uganda and the tropics. Symptoms of soybean rust include small-water soaked lesions on the underside of leaves, blister-like uredia with a central pore with extruding urediniospores on the lower side of the leaf (Plate 8). Lesions gradually increase in size and later turn from gray to tan, reddish-brown or dark brown and assume a polygonal shape restricted by leaf veins.

The impact of soybean rust is thus linked to the high specialization and the significant genetic variation that exists in the population of this obligate pathogen, which reduces the effectiveness of specific resistance genes deployed against the pathogen.

Management of soybean rust disease

Fungicides have been proven effective in managing soybean rust, however, the additional costs of purchasing and application of fungicides have made chemical control impractical among many farmers in Uganda. However, to provide an optional management strategy, the soybean research team screened seven fungicides against soybean rust disease in Uganda and scored yield loss of up to 52.6%. Interestingly, the resistant control UG5 showed a significant reduction in yield when sprayed with the fungicide, suggesting that it is uneconomical to spray resistant varieties.

Therefore, under resource-limited farming systems, use of rust resistant varieties is the only sustainable management strategy. However, sustainable resistance is difficult to obtain at present, due to the high degree of genetic variability of the pathogen, that causes resistance breakdown in a short period after new resistant varieties are released. Therefore development of soybean varieties with resistance to soybean rust should be a continuous process.

Plate 8: Soybean rust resistant variety. Close-up showing rust symptoms.

Breeding strategies

The general objective of soybean research and development activities in Uganda has been to develop locally adapted resistant varieties and to disseminate seeds of improved varieties to the different seed stakeholders in the soybean value chain.

Breeding for resistance to rust disease

Diseases have hampered growth of the soybean sector in Uganda, however, soybean rust has been the most economically significant. At the onset of the soybean rust epidemic in 1996, all existing local and commercial cultivars showed susceptibility. The fungus spread rapidly to all soybean growing areas in Uganda. For this reason, the quest for rust-resistant varieties has been the prime focus of research in the country in the last 16 years.

Early advanced breeding efforts conducted between 1997 and 2004 deployed short and long term strategies that resulted in the identification of locally adapted resistant varieties. The short term strategy involved the importation and screening of over 200 accessions from the Asian Vegetable Research and Development Centre (AVRDC) and the International Institute of Tropical Agriculture (IITA), South Africa, the USA, and Zimbabwe. Meanwhile, the long term strategy comprised of the hybridization program, which involved development of resistant lines and elite adapted varieties. Table 1 is a summary of some of germplasm that was used in development of rust resistant soybean varieties in Uganda.

The tested accessions showed different levels of soybean rust resistance, with the accessions GC 00138-29 from AVRDC and TGX 1035 10E from IITA showing considerable resistance to the disease (Table 2). However, GC 00138-29 suffered from pod shattering and susceptibility to bacterial pustule (*Xanthomonas campestris* pv. glycines). Similarly, resistance of TGX 1035 10E was not uniform hence it was subjected to mass selection in order to constitute a variety that was early maturing and resistant to soybean rust disease. As a long term strategy, crosses of GC 00138-29 × Nam 2, GC 00138-29 × Duiker and TGX 1035 10E × Duiker (Plate 9) were made resulting in progenies which underwent development along the complete cultivar value chain. Some of the activities in the breeding process include single plant selection (Plate 10), and evaluation trials (onstation and on farm).

In 2004, the varieties Namsoy 4M and Maksoy 1N were released following extensive on-station testing and onfarm evalulations. Although Maksoy 1N and Namsoy 4M provided some relief to farmers, they also exhibited some limitations. The yield potential of Maksoy 1N was low compared to earlier cultivars Nam 1 and Nam 2. Meanwhile, Namsoy 4M was mildly susceptible to pod shattering, particularly during intense heat since it was a direct progeny of the shattering-susceptible GC 00138-29. More than 1000 breeding lines were obtained from other crosses between susceptible and resistant lines to produce better varieties for farmers as well as broaden the genetic base of resistance against rust which is known to challenge single resistance genes due to its high genetic variability.

With further breeding work, other varieties were released, namely Maksoy 2N in 2008, Maksoy 3N in 2010, Maksoy 4N and Maksoy 5N in 2013, and Maksoy 6N in 2017.

Plate 9: Making soybean crosses at a screen house at MUARIK

At present there are 25 lines at advanced level, 60 lines at preliminary level, 1015 breeding lines, 300 single plant rows, 400 segregating populations and 40 F1s. The plant breeding pillar of the centre is envisaged to ensure a sustainability base upon which a continuous process of population development and advancement lead to release and commercialisation of new products (varieties) that will also form a basis on which the pillar of seed systems and other center pillars depend.

Table 1: Germplasm used in breeding for resistance to soybean rust

Genotype	Source	Traits of interest	Negative traits
TGX 1035-10E	IITA, Nigeria	Resistance to rust, pod shattering, early maturity	Short pod clearance
GC 00138-29	AVRDC	Rust resistance	High levels of pod shattering
Duiker	Zimbabwe	Excellent seed quality	Rust susceptibility
Nam 2	Uganda	High yield potential	Rust susceptibility
UG 5	Uganda	Rust resistance	Susceptible to bacterial pustule
Nam 1	Uganda	High yield potential	Rust susceptibility

Table 2: Performance of soybean rust resistant germplasm from AVRDC - evaluated in Uganda

No.	Accession code	Rust scores*			
		R1	R3	R6	Mean
1	G 00073	3	3	3.5	3.2
2	G 02020	1	2	3	2
3	G00033	2	2.5	2.5	2.5
4	UG 5 (Local resistant line)	2	2	3	2.3
5	GC 86048-429-3	2	3	3.5	2.8
6	GC 84058-21-4	1	1	2	1.3
7	GC 86049-35-2-1-1-8-1 N	2	2.5	2.5	2.3
8	GC 84051-32-1	2	2.5	2.5	2.3
9	GC 84040-21	2	2.5	3	2.5
10	GC 86045-23-2	2	3	3	2.7
11	GC 8586	2	2.5	3	2.5
12	G 58	3	3	3	3
13	G 10429	2	2.5	2.5	2.3
14	G 7955	1	2	3	2
15	GC 84040-27-1	2	2.5	3	2.5
16	AGS 183	2	3	3	2.6
17	GC 00138-29	1	1	1.5	1.2
18	GC 60020-8-7-7-18	1	2	2.5	1.8
19	Nam 2 (local check)	3	4	4	3.9

* 1 - no lesion, 2 - few lesions (5%), 3 - medium lesions (25%), 4 - heavy lesion (>50%); R1 - Beginning of bloom, R3 - Beginning of podding, R6 - Full pod filling

Progeny testing

The selection procedure used at Makerere Soybean centre is a modified single seed descent method, where a single pod is used instead of a single seed. Single plant selections are made from F5 generation stage on words depending on the trait of interest.

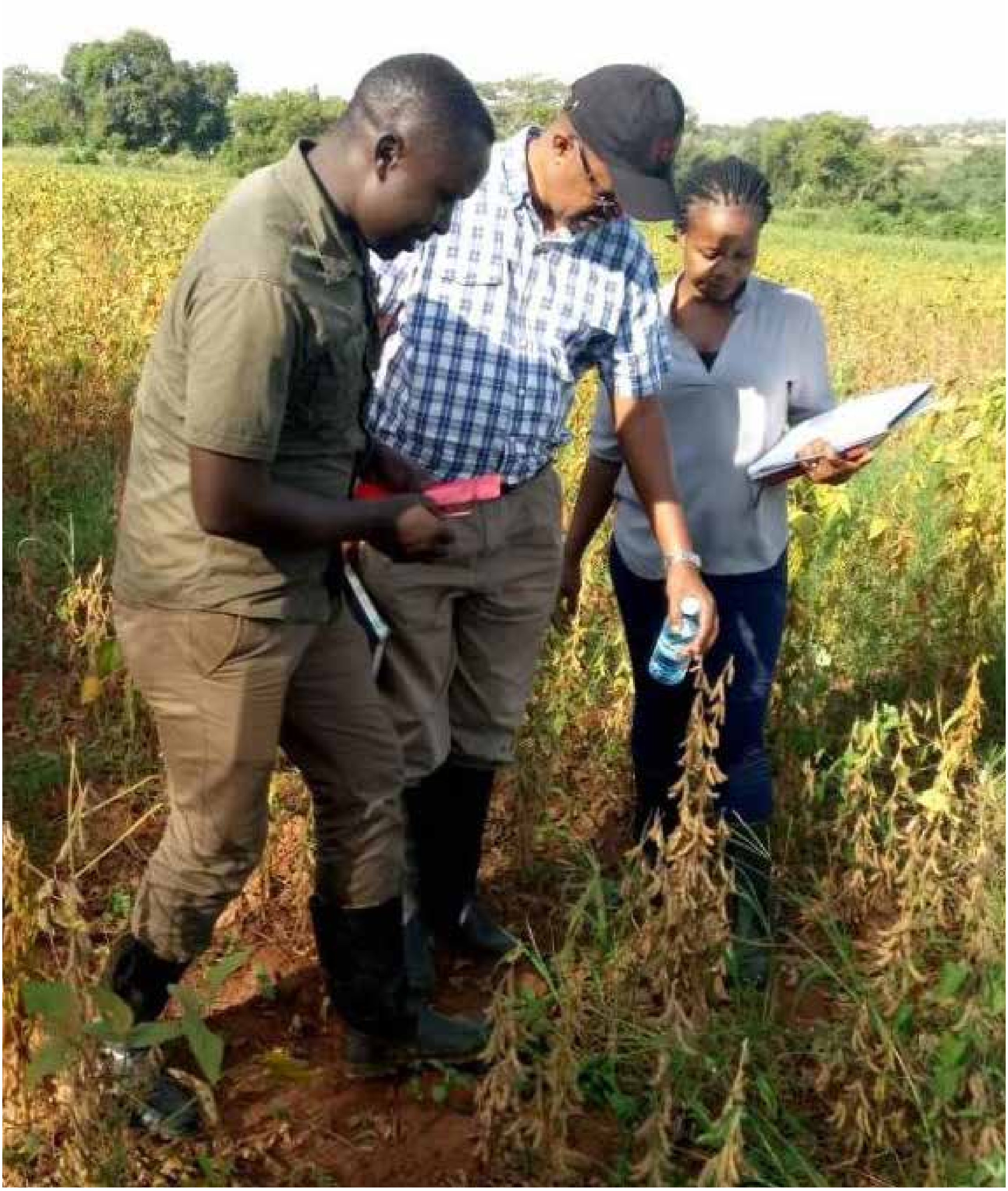

Plate 10: Making single plant selections in progenies at MUARIK

Breeding for pest resistance

The green stink bug *(Nezara viridula)* has been a major pest to soybean production in the country. The pest damages developing pods and significantly affects grain yield. The effects of the stink bug are usually seasonal although the pest is constantly present in many soybean growing areas. In the country, direct efforts to breed for resistance to the stink bug have not been made. Further research needs to be conducted to quantify the effects of the pest as well as devise management strategies. Groundnut leaf miners are now a major challenge to soybean farmers in Uganda. These pests are also seasonal, and incidences have tended to be higher during the second rains of the year in Uganda. Management options have mainly been through the application of insecticides. None of the currently released varieties is resistant to groundnut leaf miners. Recent screening work has identified four genotypes with substantial resistance to the pest which are most severe in Eastern Uganda, during the second growing season.

Breeding for drought tolerance

Drought is undoubtedly a serious production constraint for smallholder farmers in most developing countries who grow soybean under rain fed farming systems. In Uganda, yield variations between seasons and locations have been to a great extent attributed to the amount of moisture available to the plant. Figure 3 shows the effect of drought on yield results obtained from testing sites which were not irrigated in comparison to the Mubuku Irrigation Scheme in Kasese, western Uganda. The mean yield difference range of the irrigated and non irrigated trials was 578 -1450 Kg ha-1, equivalent to 24-61% yield benefit in the irrigated plots. Even though these comparisons require further controls, the yield difference was a clear indicator that adequate moisture is critical for maximizing soybean productivity. Breeding for drought tolerance in soybean is traditionally difficult to achieve due to the crop's high moisture requirement for optimal growth and yield. Hence, effect of drought was inadvertently noted in the other locations compared to Mubuku Irrigation Scheme, whose moisture supply is always adequate because of flood irrigation. A decade of observations suggest the second growing season is better for soybean in Uganda, which may suggest better rainfall distribution for soybean growth. However, ongoing climatic changes can greatly affect rain-fed agriculture, both positively and negatively regardless of traditional cropping seasons in Uganda. This calls for targeted efforts torwards selecting drought tolerant soybean varieties.

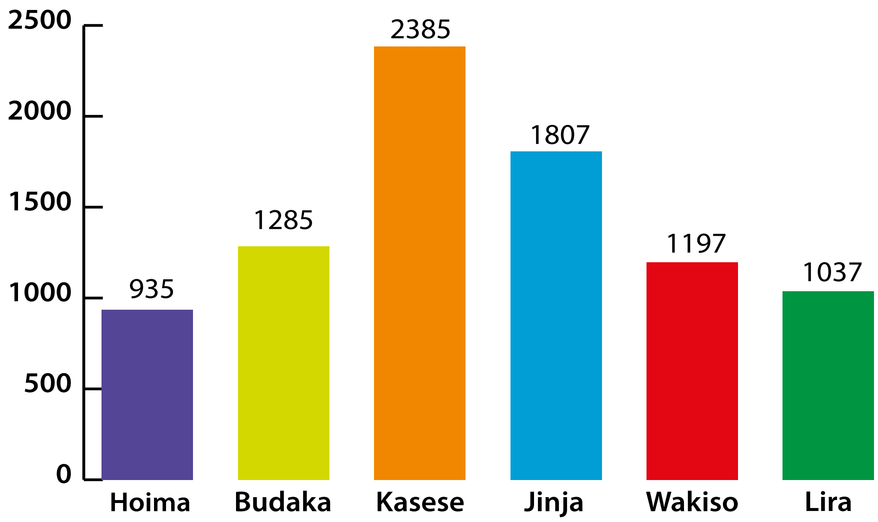

Figure 3: Mean yield (kg) per hectare at six national evaluation locations in 2008A

Variety development strategy

New selections are tested in preliminary yield trials at Namulonge and MUARIK and later at various research stations in advanced yield trials and farmers' fields, where they displayed considerable resistance to ASR and gave acceptable yields under ASR pressure.

Breeding process

On-station trials were conducted at the National Crops Resources Research Institute (NaCRRI) at Namulonge in Wakiso, Makerere University Agricultural Research Institute Kabanyolo (MUARIK) in Wakiso, Nakabango Variety Trial Centre (NVTC) in Jinja, Bulindi Zonal Agricultural Research and Development Institute (BuZARDI) in Hoima, Ngetta Zonal Agricultural Research and Development Institute (NgeZARDI) in Lira, Abi Zonal Agricultural Research and Development Institute (AbiZARDI) in Arua district and District Agricultural Training and Information Centre (DATIC) at Iki-Iki in Budaka and Mubuku irrigation scheme in Kasese (Table 3).

On-farm trials were conducted at more than 14 districts in the country (Figure 4). Few elite lines (less than 5) were considered for trials in farmers' fields. Soybean rust was a major breeding objective for these trials, farmers' major concerns were yields of the test materials that indeed varied by farmer location (Figures 4 and 5). The variety development efforts were supported by various development partners and the Government of Uganda (GoU) in particular, the Vegetable Oil Development Project (VODP) of the Ministry of Agriculture Animal Industries and Fisheries (MAAIF) which have been very instrumental in providing direct financial support to the soybean rust resistance breeding efforts. Other major donors are Alliance for a green revolution in Africa (AGRA) and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM).

After passing variety release tests for distinctness, uniformity, and stability (DUS), the first elite lines with resistance to ASR were formally released in 2004 as Namsoy 4M (NG 10.4) and Maksoy 1N (TGX 1835-10E). The probability of farmers accepting these genotypes is demonstrated in Figures 5 and 6.

Plate 11: Examining soybean breeding lines on farmer's field in Jinja

Table 3: Locations where advanced yield trials were conducted

Location	Position	Location in Uganda	Altitude (m.a.s.l)	Mean annual temperature (o C)	Mean Annual rainfall (mm)
Namulonge	0°32'N/32°37'E	Central	1160	22.6	1400
Nakabango	0°29'N/33°14'E	Eastern	1210	22.8	1400
Iki-Iki	1°06'N/34°00'E	Eastern	1156	24.7	1200
Ngetta	2°17'N/32°56'E	Northern	1103	24.7	1200
Mubuku	0°13'N/30°08'E	Western	1007	27.8	750
Kabanyolo	0°28'N/32°36'E	Central	1180	21.4	1234
Bulindi	1°41'N/31°42'E	Mid West	1122	22.9	1355
Abi	3°04'N/30°56'E	West Nile	1214	22.9	1404

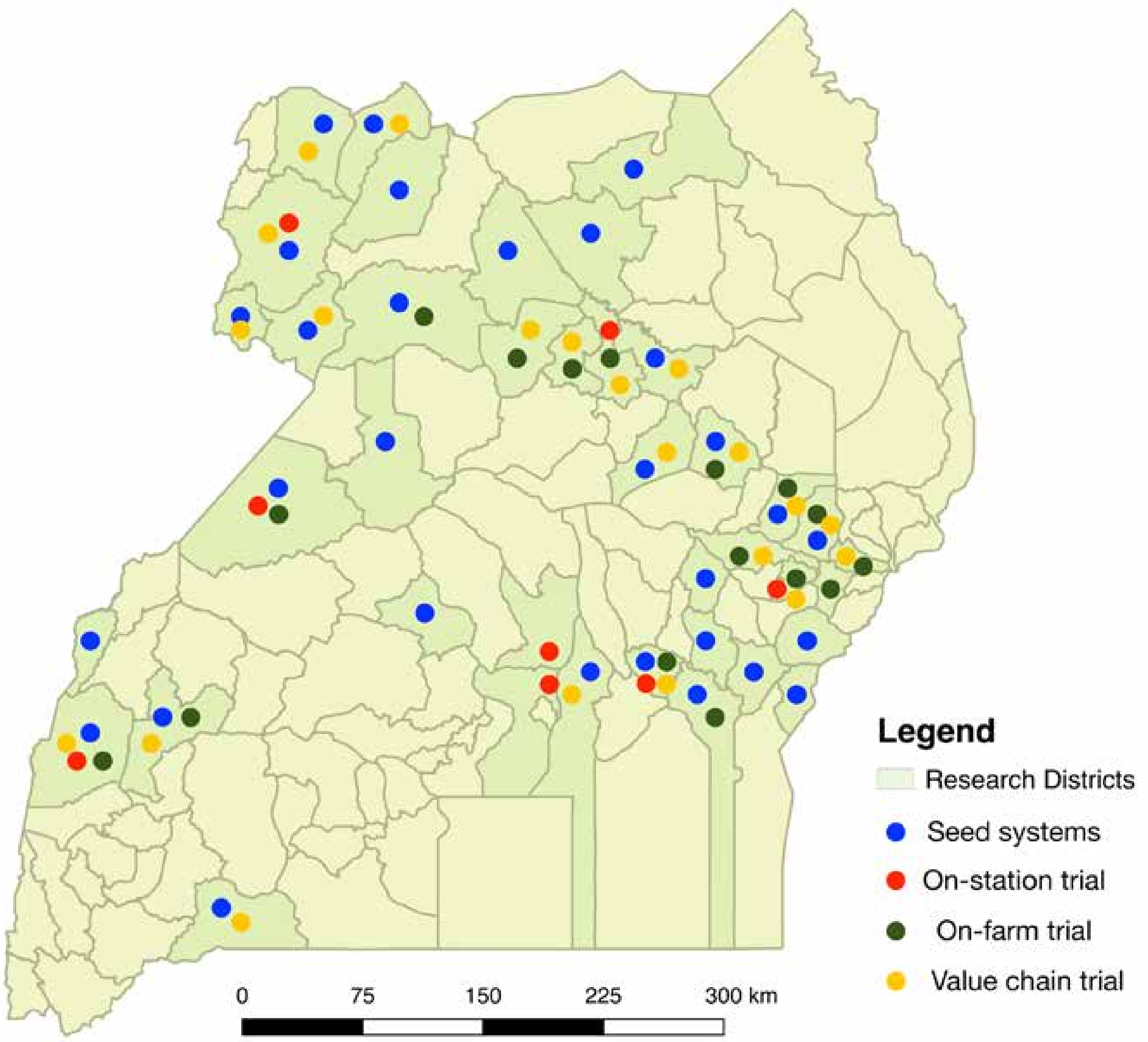

Figure 4: Map of Uganda showing areas of direct contact with soybean research activities.

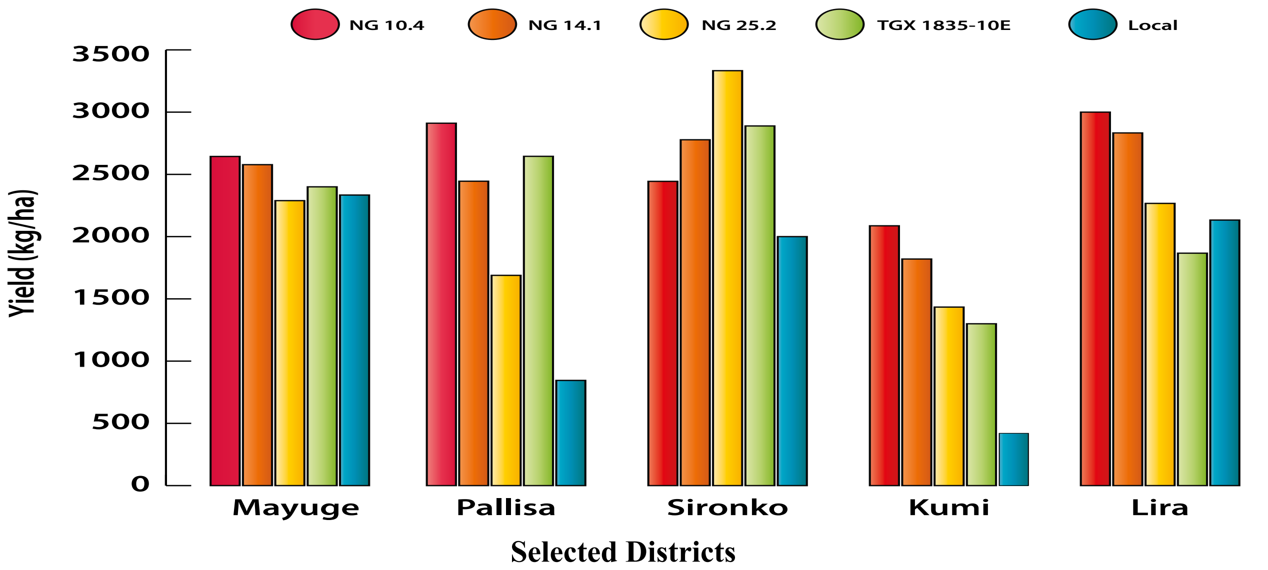

Figure 5: Yield data of elite breeding materials from on-farm trials in five selected districts during 2003 National Soybean Evaluations.

Two new soybean varieties were released in 2004, after national evaluations namely Namsoy 4M (derived from Nam 2 X GC 00138-29) and Maksoy 1N, a selection from TGX 1035 10E. Additional varieties; Maksoy 2N and Maksoy 3N were released in 2008 and 2010 respectively. Thus, soybean acreage steadily increased from 144,000 to 155,000 hectares, while the annual production increased from 158,000 to 181,000 MT between 2004 and 2009 (UBOS, 2010). In 2013, two other varieties Maksoy 4N (BSPS 48A-27) and Maksoy 5N (NG 14.1-24) were released. Maksoy 4N is a line developed from Duiker x GC 00138-29 progenies while Maksoy 5N is derived from a cross of Nam 2 x GC 00138-29 and Maksoy 6N from Nam 2 x GC 00138-29 (Table 4). In 2017, Maksoy 6N was released and its traits are summarized in Appendix 2. Disease scores of the breeding lines and elite genotypes developed by the Centre are presented in Table 5 and Appendix 7. The protein and oil content of these varieties is presented in Table 6, while more detailed description is in Appendix 2. Yield and other agronomic traits of some of the elite lines are presented in Appendices 2 - 8.

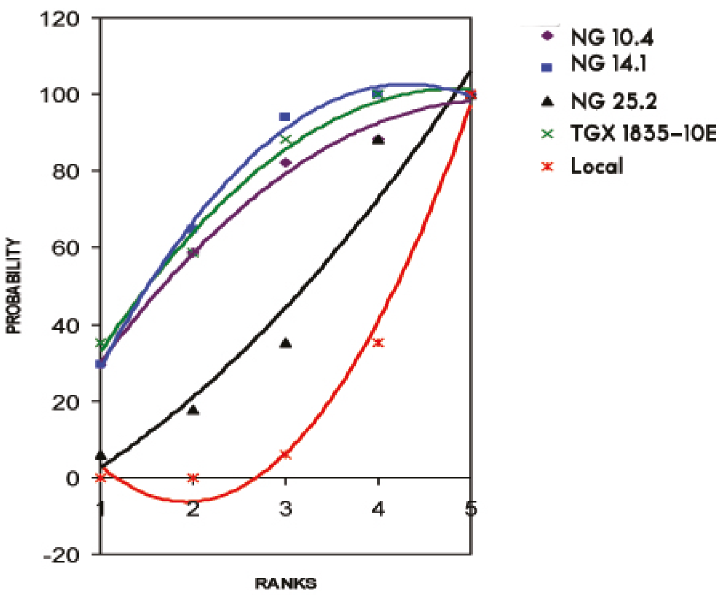

Figure 6: Farmer performance rankings of soybean genotypes on a 1-5 scale (1 = least prefered; 5 = highly prefered) in 2004

Table 4: Released soybean varieties 1990-2017

Cultivar	Pedigree	Released	Current use status
Maksoy 6N	Nam 2 x GC 00138-29	2017	Commercial
Maksoy 5N	Nam 2 x GC 00138-29	2013	Commercial
Maksoy 4N	Duiker x GC 00138-29	2013	Commercial
Maksoy 3N	GC 00138-29 x Duiker	2010	Commercial
Maksoy 2N	Maksoy 1N x Duiker	2008	Commercial, tolerant to ASR
Maksoy 1N	TGX 1835-10E	2004	Commercial
Namsoy 4M	Nam2 x GC00 139-29	2004	Commercial
Namsoy 3	Kabanyolo 1 x Nam 1	1995	Parental line
Nam 2	TGM 79	1992	Parental line
Nam 1	ICAL 131	1990	Parental line
Kabanyolo 1	Mutant of Clark 63	-	Parental line

Table 5: Mean rust scores of 15 soybean genotypes at four locations for seasons 2005B, 2006A and 2006B

	Mean rust score at R6 (0-9 scale)									
	2005B			2006A				2006B		
Genotype	*Nam	Naka	Bul	Nam	Naka	Bul	Nam	Naka	Nget	Bul
MNG 1.37	1.8	3	0.8	1.1	0.5	0	4	8.3	7.8	8.3
MNG 1.38	1.9	3	0.8	0	0.3	0.8	3.3	8.8	8.3	7.6
MNG 1.41	1.5	3	0.8	1.5	0.5	0.5	1.8	6.8	7	6.4
MNG 1.60	1.3	3.3	1.4	0.5	0.5	0.3	1	6.3	6.5	6.3
MNG 1.63	1.8	3	0.8	1.4	0	0.3	0.8	6.3	7.4	7.1
MNG 2.12	1.5	3	1	0	0.3	0.3	2.9	7.5	7.1	7.9
MNG 2.13	2	3.3	1	2	0.3	0.5	5.8	6.8	7.3	6.6
MNG 2.15	1.8	3	0.8	0	0.3	0.5	2.8	7.8	7	7.8
MNG 5.17	1.8	3	0.8	0	0.3	0.3	1.4	6.8	7.3	8.5
MNG 7.13	2	3.8	1	0	0.3	0.3	0	7.9	8.3	9
MNG 8.10	2.1	4.6	1.4	0.5	4.8	0	5.3	7.8	6.4	7.6
MNG 8.25	1.9	3	1.3	0.8	0.6	0.5	1.1	7.4	6.8	8.1
MNG 4.11	1.4	3	1	0	0.5	0	0.8	5.5	5.4	8.3
NAM 1	3	7.9	2	5.4	5.8	0.3	7.4	8.8	7.8	8
MAKSOY 1N	1	3	1	0.8	0.9	1.8	1.5	5.8	6.6	6.4
Mean	1.8	3.5	1.0	0.9	1.0	0.5	2.6	7.2	7.1	7.6
F-prob	**	**	*	**	**	*	**	**	**	**

*Nam = Namulonge, Naka = Nakabango, Bul = Bulindi, Nget = Ngetta. *, ** significant at 5% and 1% respectively.

Germplasm conservation

Germplasm conservation is a core component of any breeding programmes given that wide variation is required in the gene pool for any selections to be made. Hence, countries should develop their own genetic conservation programmes.

National conservation systems are needed so that collections of key germplasm can be maintained for all crops in the country. In the past 16 years, the research collaboration between Makerere University and National Crop Resources Research Institute (NaCRRI) has helped to maintain eight soybean varieties, more than 400 germplasm and more than 1000 breeding lines. The major commercial cultivars and previous cultivars are also being maintained at NaCRRI through seasonal regeneration to ensure availability of breeder seed. Eleven released soybean varieties are being maintained (Table 4).

Conservation has been mainly through field banks and short term storage in seed genebank with regular regeneration. Materials in storage were received from the AVRDC, USA, IITA – Nigeria, Zimbabwe, and farmers' fields in Uganda. The accessions under conservation also include vegetable soybean.

Descriptors for these accessions have been recorded and whenever necessary, specific accessions are used in crossing experiments. Whereas most of these accessions are not locally adapted, they contain important genes such as soybean rust resistance (Rpp1, Rpp2, Rpp3, Rpp4, UG-5, TGX-1835-10E) that have been crucial in breeding programs in the country.

A lot of effort is needed to improve germplasm conservation infrastructure. A seed bank was established at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK) in the 1960s but considerable efforts and resources should be committed to utilizing this facility.

Maintenance and operational resources have to be provided in a manner that will be sustainable such as solar powered storage facilities. Irrigation facilities should also be established at field locations where regeneration activities will be conducted to avoid crop failure.

Germplasm database for researchers

A database has been developed by the Centre for Soybean Improvement and Development for management of various soybean research information to ensure proper storage, retrievals and sharing information among scientists to facilitate germplasm use and exchange. It is a relational database of linked primary and secondary tables developed using the Microsoft Office Access Program. The primary tables have fixed fields for variables and draw a lot of the information from the different secondary tables which are designed to have continuous gap fillings.

Table 6: The protein and oil content of released varieties.

Variety	**Protein Content (%)**	**Oil Content (%)**
Maksoy 1N	41	17
Maksoy 2N	38	20
Maksoy 3N	36	22
Maksoy 4N	38	21
Maksoy 5N	38	19
Maksoy 6N	41	20

Plate 12: Assessment of germplasm received from Zambia during 2018B season

Key data fields in the database include: different types of germplasm (released varieties, introductions, elite stocks, breeding lines and landraces). For each germplasm category, information provided includes sources and origin, pedigree, qualitative information like seed color and size, plant architecture and plant vigor, as well as quantitative information like yield parameters. Other variables are adaptations of the germplasm to different locations and resistance to major constraints such as pests, diseases, and drought. The plans for further improvement and accessibility of the database include gap fillings with the available information. The database will also need to be integrated with a website so that it can be accessed online by many users. However, the rights to full and limited access to this information by different users are under review. There is a need also to test the ease of use of the database by the end-users.

Table 7: Some of soybean germplasm being conserved at MUARIK 2014B

Germplasm	Number
AVRDC	49
USA Germplasm	17
Vegetable soybeans	3
Uganda parents	15
Zimbabwe parents	6
NGDT 8.11 series	24
BSPS 48A series	25
NG 14.1 series	20
NGDT series	44
N II × GC progenies	35
BSPS SPS 48A	34
S-lines	16
Maphosa (F4)	40
Kiryowa	28
Bulindi BLP series	159
F3 Progenies	7
F4 Progenies	24
F5 Progenies	6
BSPS 48A single row selection	14

Soybean seed systems

MAKCSID has in the past 16 years supported various seed dissemination activities to avail new rust-resistant varieties to farmers. Over 300 tons of foundation seed has been supplied to different farmers and groups.

In a drive to promote soybean production in Uganda, the Centre for Soybean Improvement and Development has trained selected farmers' groups in Mukono, Wakiso, Kole, Kamwenge, and Luweero districts in the production of quality seed (Figure 5). Seed multiplication of the varieties Maksoy 1N, Namsoy 4M, Maksoy 2N, and Maksoy 3N, Maksoy 4N and Maksoy 5N have been carried out every season since the time of their respective release. The summary of the Breeder and Foundation seed that has been disseminated via several seed channels to the communities is in Table 8.

For this reason, the research team has involved the interested farmers' groups in the multiplication and dissemination of the newly released soybean varieties. Farmers were targeted in their special interest groups and trained how to produce viable quality soybean seed. They were supplied with these new varieties and each one of them was continuously inspected by researchers in collaboration with partnering Soybean Africa Limited throughout the season.

It is believed that if well conducted, this multiplication will be trickling down the new soybean seed varieties to most remote of farmers through the traditional farmer to farmer seed distribution and local seed businesses (LSBs). It is also planned that some farmers will eventually specialize in soybean seed multiplication as a commercial activity becoming suppliers to the surrounding farming communities.

The research team has worked with various stakeholders to ensure constant supply of the new varieties in the informal seed system (Figure 7). The research team has worked with community-based organizations (CBOs), non-governmental organizations (NGOs) and other stakeholders in the soybean value chain (Appendix 9). In particular, CBOs and NGOs accounted for 50% of nationwide dissemination of foundation seed to other stakeholders for multiplication (Figure 7).

Table 8: Total foundation seed dissemination (Kg) through various channels from 2004 - 2015

Seed dissemination channel	Year and season								
	2004 to 2008	2009 & 2010A	2010B & 2011B	2012	2013	2014	2015A	Total	%
Government	11050	30	300	-	7975	10120	6060	11380	10.1
Seed companies	2300	500	7000	2462	360	4631	2950	9800	8.7
Private sector	3000	880	4370	6250	-	12	12400	8250	7.3
NGOs & CBOs	900	68000	12150	2700	741	4614	755	81050	71.7
Others	1120	390	1050	200	7410	5068	1980	2560	2.3
Total	18370	69800	24870	11612	18511	24445	24145	113040	100

Varieties Maksoy 3N and Maksoy 2N are the most demanded, accounting for 46% and 26% of the breeders and foundation seed disseminated respectively (Figure 8). Maksoy 4N, Maksoy 5N and Maksoy 6N were least demanded because they are the most recent releases and require further promotional activities (Figure 8).

The Centre for Soybean Improvement and Development has produced over 300 tons of soybean foundation seed in the last 14 years for the different varieties (Table 9). Figure 9 illustrates the production and trend of the different varieties produced by the Centre over the years.

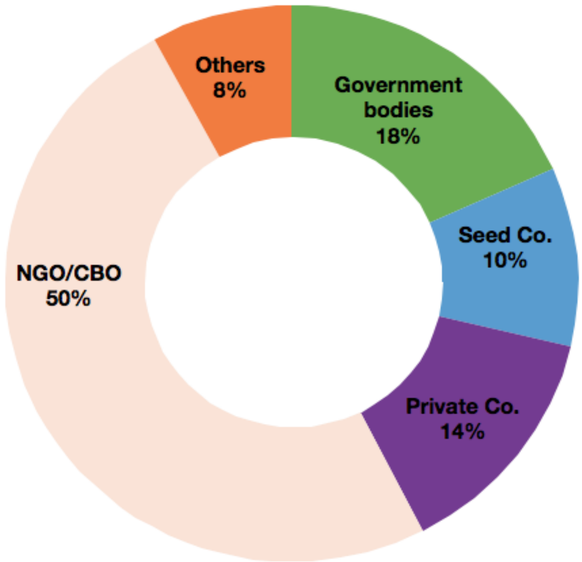

Figure 7: Dissemination of foundation seed by various stakeholders

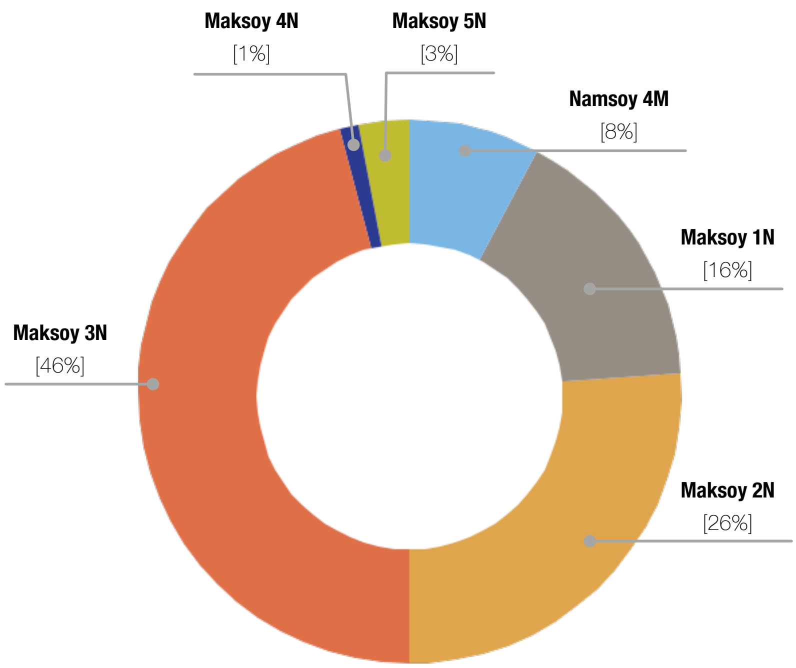

Figure 8: Percentage demand for soybean varieties in 10 years

Soybean Africa Ltd (SAL) is a private company established in Uganda and signed a MOU with with Makerere University through the Centre for Soybean Improvement and Development (MAKCSID), in ensuring accessibility of improved soybean varieties to farmers. Through this collaboration over 300 tons of foundation seed of Maksoy varieties developed by Makerere University have been disseminated, thereby contributing to improved access of soybean foundation seed to the entire soybean value chain in Uganda. Since SAL has a strong capacity in marketing, working with CAES-MAKSCID will have great synergies in ensuring development of more varieties by MAKCID and their dissemination in Uganda and the region for the benefit of farmers as illustrated in Figure 8.

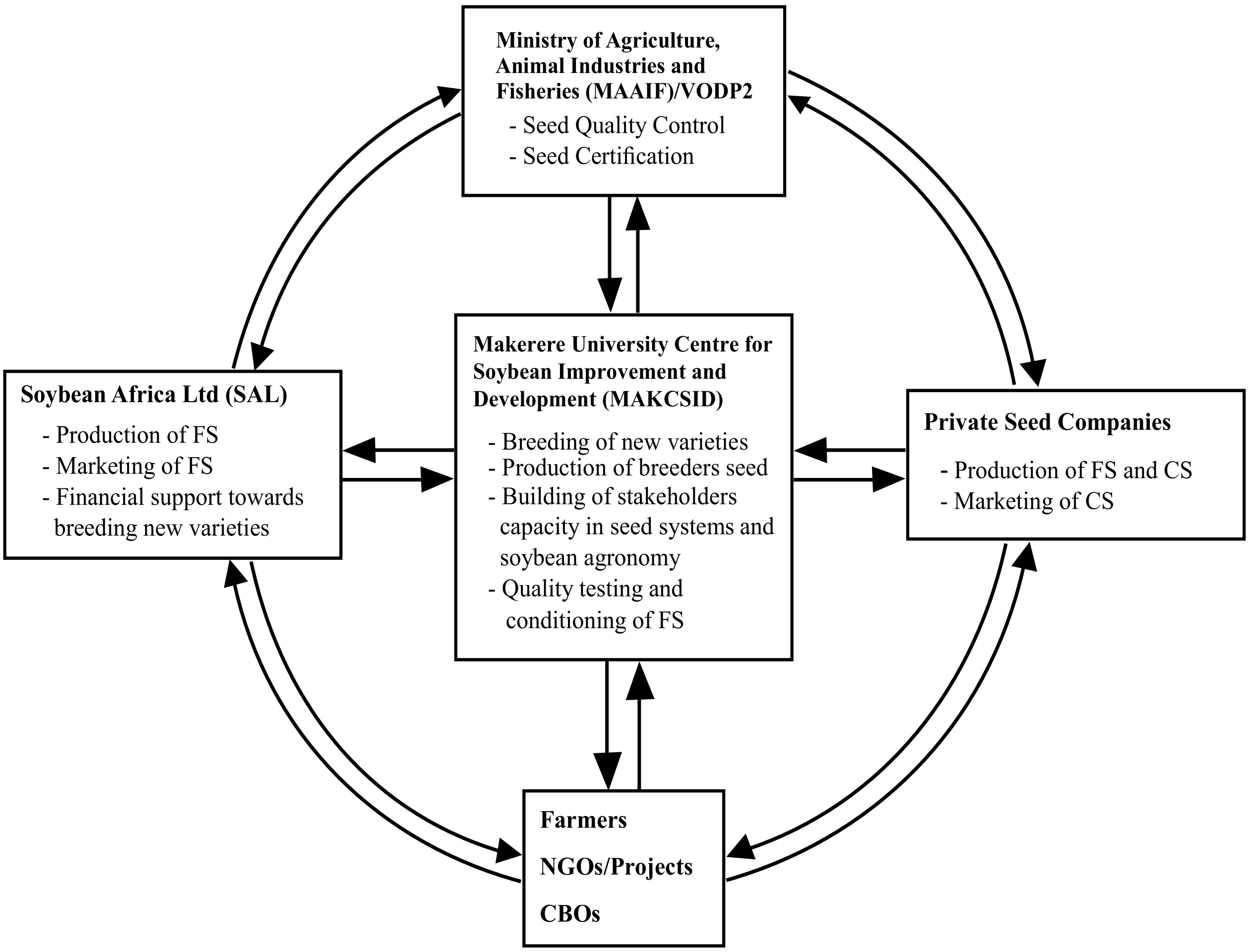

Figure 9: Linkages of centre for soybean improvement and major soybean stakeholders in Uganda

Table 9: Foundation seed distribution to different stakeholders in 2018A

Organization	Variety						Total
	Maksoy 1N	Maksoy 2N	Maksoy 3N	Maksoy 4N	Maksoy 5N	Maksoy 6N	
Alito Joint			220	20	120		360
Farm Stew (U)			450				450
Bedijo LSB			40	20			60
Lango diocese			400				400
Tim Kica Youth Group			106				106
VEDCO			1,600		1,550		3,150
Iowa State University			200				200
Namuyunga LSB			50				50
Devine business associates			600				600
Global food exchange Ltd			4,000				4,000
VODP Mbale			890	200	100		1,190
VODP Arua			1,815	760	300		2,875
Clinton Foundation			1,000				1,000
VODP Lira			2,075	700	200		2,975
Sasakawa			200	200			400
NARGC			2,500	800			3,300
AFSRT					200		200
VODP Gulu		150	1,900	450			2,500
Others			5,631	560	1,358	400	7,949
Seed in store			600	100	4,000		4,700
Total		**150**	**24,277**	**3,810**	**7,828**	**400**	**36,465**

Soybean variety life cycle

Our breeding program released the first 2 varieties in 2004, followed by others in 2008, 2010, 2013 and 2017. We observed that performance and demand for these varieties decline with time. For example, demand for varieties Namsoy 4M, Maksoy 1N and Maksoy 2N have shown steady decline and are now produced in small quantities. This may be attributed to pest and disease resistance break down over time which lead to low productivity of these varieties. In general the varieties pick up exponentially after release and decline after reaching a plateau, as illustrated in Figure 11. The exponential growth for Maksoy 3N, released in 2010 has superceded the rest of the varieties and its popularity with growers is still growing. These results suggest that breeding effort is a continuous process to insure against varieties getting obsolete. The breeding process also aims at development of varieties with different traits so that the growers may have choice (Plate 13).

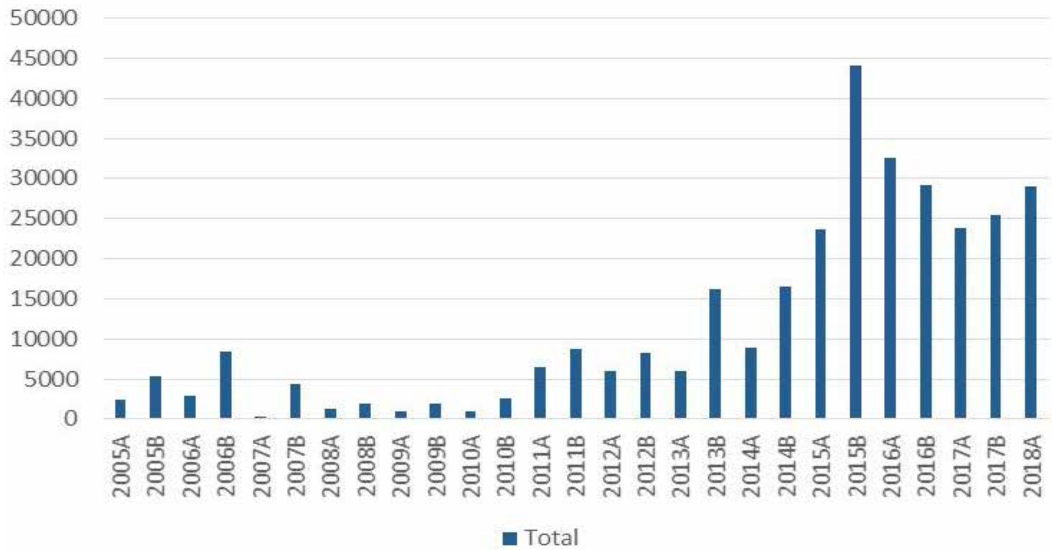

Figure 10: Foundation seed dissemination trend from 2005 - 2018.

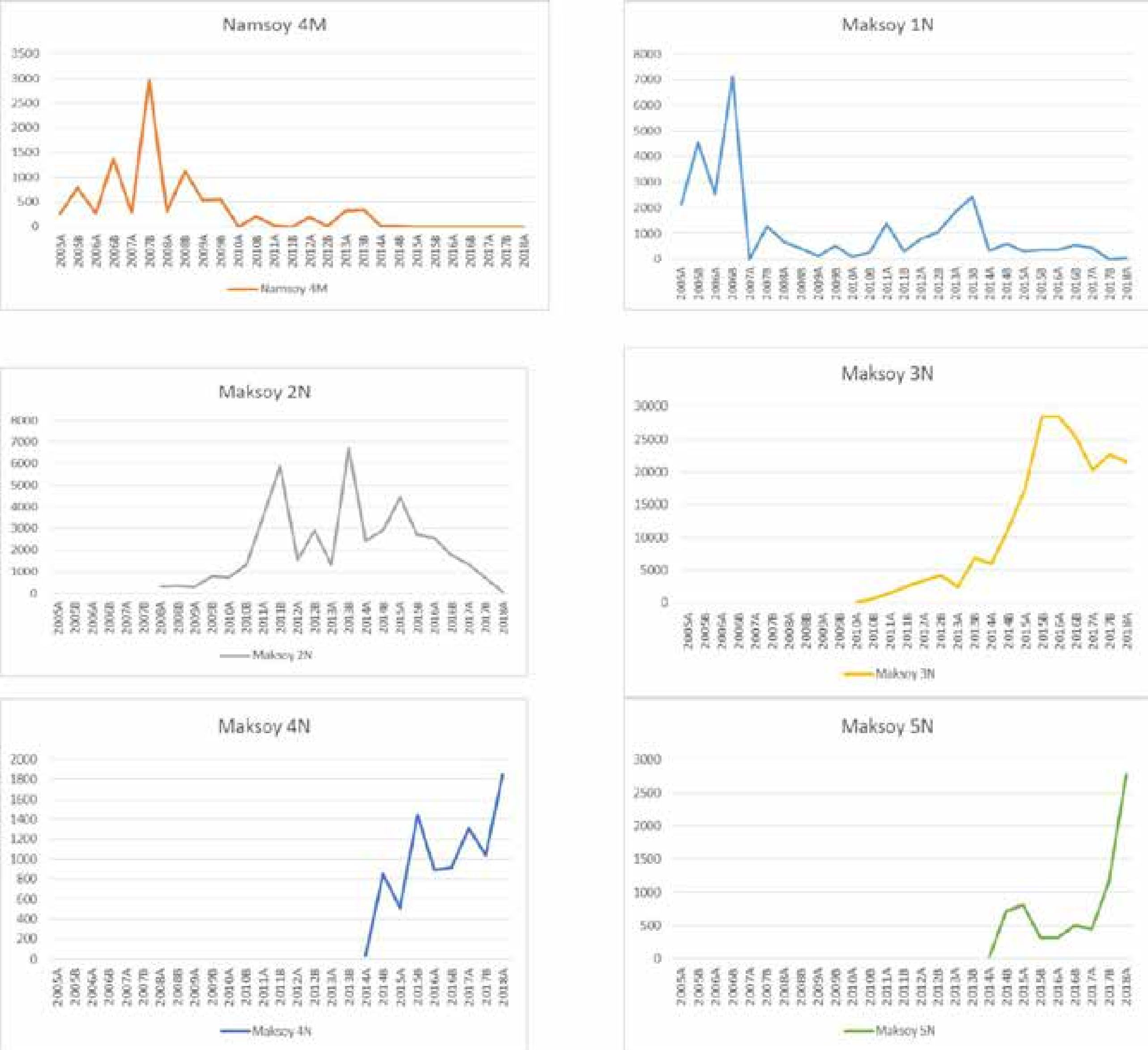

Figure 11: Varieties generally pickup exporientially after release and decline after reaching a plateau.

Plate 13: Breeders seed production of Maksoy 3N (right) and Maksoy 4N (left) at MUARIK, 2015B

Plate 14 (a): MUARIK foundation seed storage facility built with support from VODP2
Plate 14 (b): Seed cleaner build with support from ISSD
Plate 14 (c): Local seed business officals on familiarization visit to the centre.

Plate 15 (a & b): The soybean seed clearner and the minister of Agriculture animal industry and fisheries after commissioning the clearner and the seed storage facility funded by VODP2.

Capacity building

Soybean research and development work in Uganda over the past 17 years has supported various capacity building activities to avail students, farmers and scientists with knowledge and understanding of the crop.

The Makerere University Centre for Soybean Improvement and Development (MAKCSID) at MUARIK has acted as a spring board to train and equip students with hands-on practical skills (Plate 16). In total, 13 graduate students successfully completed their degrees and are currently contributing to national and regional soybean breeding and seed systems. The research of current and past students attached to the centre are summarised in Appendix 1. A list of related publications is presented on page 38 - 40. Efforts to scale up capacity on soybean production have been achieved through training of stakeholders from Zonal Agricultural Research and Development Institutes (ZARDIs), NGOs, seed companies and farmers (Plate 17).

In collaboration with World Vision, the programme has undertaken farmer training in the Districts of Kiboga, Oyam, Kasese, Sheema, Mbale, Soroti Kamuli, Mayuge, Arua, Gulu, Zombo and Adjumani in order to provide farmers with knowledge of soybean production techniques, prospects of local markets for soybeans and identification of products that can be obtained from soybean grain for home use. During such workshops, the participants are also presented with information on soybean cost-benefit analysis and a list of potential buyers whom the farmers could contact after bulking at one location, preferably a group store (e.g Plate 18).

In addition, the centre also conducted a training of trainers' workshops for staff from VEDCO and AFARD, with focus on seed production. It should be noted that most of the training activities are carried out on the farm and farmers' homes during monitoring and evaluation activities.

Plate 16: Undergraduate students being taught how to make crosses in soybean.

Plate 17: Scientists from Tanzania on a soybean familiarization visit at MUARIK

Plate 18: Training of trainers in best practices soybean production in Lira district.

Plate 19: The soybean centre offers an excellent opportunity for PhD and Msc students to do research in the field , screen house and Laboratories.

Plate 20: Building farmers' capacity in best practices in soybean agronomy and post harvest handling through a field day.

Impact indicators

The soybean research and development team has in the past 17 years supported various seed dissemination activities to avail new rust-resistant varieties to farmers.

The Centre for Soybean Improvement and Development has multiplied and disseminated over 300 tonnes of foundation seed to provide basic requirements for seed companies producing certified seed, including other private companies and NGOs. According to the survey by Tukamuhabwa et al. (2016), over 93% of soybean varieties grown in Uganda were developed by Makerere University in collaboration with NARO (Figure 12). These developments triggered enormous interest among farmers to grow soybean as a major cash crop because of the readily available market. The different companies involved in processing soybean offer competition for the commodity resulting in better prices for the farmer.

For instance, soybean price increased from 600 UGX per kilo in 2008 to 1000 UGX per kilo in 2011 and is now 2000 UGX. About 90% of farmers in northern Uganda observed that the demand for soybean is increasing. Further, Ssengendo et al. (2010) observed increase in soybean contribution from US$ 300,000 in 2006 to US$ 1,163,000 in 2009 in terms of export earnings which is equivalent to an increase of 288%. Tukamuhambwa and Obua (2015) estimated the returns from soybean to reach 1,185,600 UGX per hectare per season. However, a wide range of soybean varieties, government investment in soybean research and increasing investments in soybean value chain are major strengths for the soybean subsector in Uganda.

Processing Capacity

The processing capacity for soybean increased from 300 tons in 2009 (Anon, 2010) to over 600 tons in 2011 (SNV, 2011). This dramatic increase was due to the increased private sector investment in the vegetable oil production sector. Particularly, installation of Mt Meru Oil Mill in Lira with processing capacity of 300 MT per day, Mukwano in Lira with 250 MT per day, Guru Nanak Oil Mill in Lira with 15 MT per day, Nile Agro in Jinja with 150 MT per day and Seba Foods in Tororo with an installed capacity of 15 MT per day, which manufactures soy pieces, and unimix for human consumption.

In addition, several processing plants have been established in the last 5 years due to the availability of improved soybean varieties in Uganda for their out-grower program. These include the East African Basic Foods Ltd, Maganjo Grain Millers, Sesaco Ltd, Ugachick, Biyinzika Internatioanl, RECO Industries, Kayebe Sauce Packers and Soy Products International Limited in Northern Uganda and several outlets (Appendix 9). Formula Feeds and others account for over 300 MT per day (Kawuki, 2004). These are relatively heavy investments that were developed upon the assurance offered by the availability of high yielding soybean varieties.

Opportunities for the national economy

While soybean is a major crop in industrialized countries such as USA, Argentina, Brazil, and China, in Uganda, the crop has not been given adequate priority in the past despite its potential in enhancing both nutrition and incomes of Ugandans. Being a tropical country with largely suitable soils, Uganda can produce competitive quantities of soybean to meet the increasing demand for grain as both human food and livestock feed.

Soybean is globally an important crop. It is ranked the sixth most important crop in the world. As an oil crop, soybean has a significant amount of oil and as a grain legume, soybean has the highest amount of dietary protein. Therefore, Uganda cannot manage to ignore the crop and efforts should be made to promote the crop as much as possible. The economies of Argentina and Brazil are greatly supported by soybean. In Argentina, soybean and soy products contributed nearly a third (a USD 20 billion value) of the country's USD 72 billion export value. This was achieved in the past twelve years when the government of Argentina made deliberate decisions to promote the crop as food, industrial and export commodity (Schnepf et al., 2001, Ridley and Devadoss, 2015).

In Brazil, soybean is essential for generation of foreign exchange via exports and is the most valuable product of the country's agriculture. A study conducted by MAPA (2017a), showed that soybean reached a Gross Production Value (GPV) of US$ 35.4 billion, corresponding to 21.7% of Brazil's agricultural farm production. Brazil has seen a tremendous improvement in the Human Development Index (HDI) of those municipalities where soybean is grown compared to those which do not grow soybean.

Soybean, being an easy crop to cultivate, can be expanded to larger areas with the intensification of production systems that could yield up to one million MT, a figure that would guarantee the economy over half a billion dollars' worth of production, without considering the value chain for soybean in the economy.

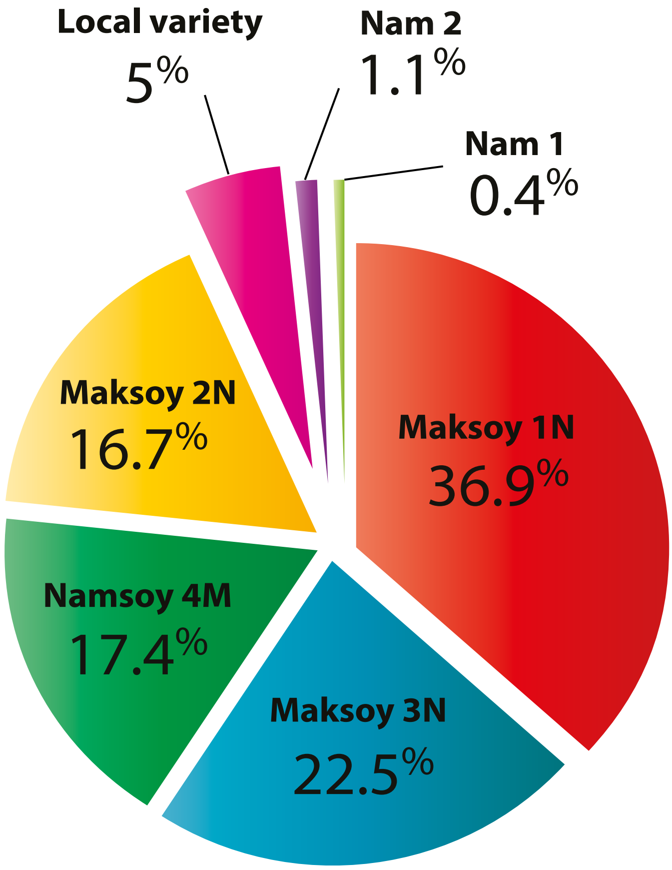

Figure 12: Awareness of soybean varieties in Uganda

Farmers in eastern, northern and western Uganda have shown enthusiasm to grow soybean, mostly as a cash crop, with the major buyers being Kenya, and food and feed processors in the country. Improving agronomic practices, including the use of nutrient amendments and the use of improved disease resistant cultivars will greatly enhance soybean production in the country.

Way Forward

The soybean industry in Uganda could benefit from strengthening of policies that favor industrial or medium scale enterprises that would enhance value addition to the country's produce. The value chain of soybean, once developed, can be a major contributor to the national economy. Policies alone will not grow the sector. Additional support to other components such as mass education, development of high yielding varieties, improved agronomic practices, promotion of soybean consumption among rural and urban vulnerable populations, marketing systems, and processing facilities, will be needed in the country. Such efforts have been made but additional resources and technical support is still needed to make the crop a premium commodity in the Ugandan agricultural landscape and communities.

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Appendices

Appendix 1: List of academic studies ongoing and completed.

Name	Country	Level	Subject	Year
Oloka K Herbert	Ugandan	PhD	Introgression of ghyphosate tolerant genes in Ugandan soybean varieties	Ongoing
Mathe Lukanda	DR Congo	PhD	Diversity and candidate genomic regions of resistance to Coniothyrium glycines, the causal agent of red leaf blotch in soybean	Ongoing
Angele Ibanda	DR Congo	PhD	Inheritance of resistance to groundnut leaf miners in soybean	Ongoing
Mercy Ulemu Msiska	Malawi	PhD	Genetics of resistance to bruchids in soybean	2019
Hailay Mehari Gebremedh	Ethiopia	PhD	Mapping resistance genes to soybean rust (Phakopsora pachyrhizi) in local germplasm	2019
Eric Agoyi Etchikinto	Benin	PhD	Screening soybean genotypes for symbiotic promiscuous association with bradyrhizobium spp.	2017
Tonny Obua	Uganda	PhD	Genetic improvement of soybean oil quality and yield in Uganda	Ongoing
Claver Mukuze	Zimbabwe	MSc	Genetic diversity and GxE interaction of selected advanced generation soybean	Ongoing
Julius Ahangaana	Uganda	MSc	Optimising phosphorus nutrition and yield of improved soybean varieties in Uganda	Ongoing
Mercy Namara	Uganda	MSc	Resistance of soybean germplasm to the groundnut leaf miner(Aproaerema modicella) in Uganda	2015
Albert Tsindi	Zimbabwe	MSc	Evaluation of exotic vegetable soybean (edamame) gemrplasm in Uganda	2015
Godfrey Ssendege	Uganda	MSc	Soybean genetic diversity and reistance to soybean rust disease	2015
Tonny Obua	Uganda	MSc	Soybean rust diversity and adaptation of elite soybean lines to the Ugandan environment	2013
Maphosa Mcebisi	Zimbabwe	PhD	Enhancing genetic resistance to soybean rust disease	2013
Asiimwe Moses	Uganda	MSc	Evaluation of new soybean varieties for market traits and adaptation in Uganda	2012
Oloka Herbert	Uganda	MSc	Tolerance to soybean rust(Phakopsora pachyrhizi) and stability of elite soybean genotypes in Uganda	2008
Buyinza Musa	Uganda	MSc	On-farm seed quality, production and profitability of rust resistant soybean varieties in eastern Uganda	2008
Kiryowa Moses	Uganda	MSc	Inheritance of resistance to soybean rust	2007
Robert Kawuki	Uganda	MSc	Soybean germplasm reaction to rust in Uganda, associated yield loss, and rust control using fungicides	2003

Appendix 2: Description of 7 soybean varieties developed by MAKCSID

Character	Maksoy 1N	Namsoy 4M	Maksoy 2N	Maksoy 3N	Maksoy 4N	Maksoy 5N	Maksoy 6N
Pedigree	TGX 1035-10E	NG 10.1	MNG8.10	BSPS 48A	BSPS 48A-27	NG14.1-24	Nam 2 x GC44.2
Hypocotyl anthocyanin coloration	Dark	Mild	None	None	None	Present	Purple
Days to flowering	43	45	50	50	48	45	48
Growth habit	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate	Semi determinate
Days to physiological maturity	90	100	105	102	103	96	93
Reaction to soybean rust disease	Resistant	Resistant	Tolerant	Tolerant	Resistant	Resistant	Resistant
Pubescence color	Grey	Brown	Grey	Brown	Light brown	Brown	Light brown
Pod color	Cream	Dark brown	Dark	Brown	Light brown	Brown	Light brown
Pod clearance(cm)	7.4	14	12	10	20	14	17
Pod shattering	Very resistant	Moderate resistant	Resistant	Resistant	Resistant	Resistant	Resistant
Leaf color	Dark green	Dark green	Pale green	Dark green	Pale green	Pale green	Light green
Plant height at physiological maturity (cm)	52	89	90	90	88	87	80
Leaf shape	Rhomboid	Rhomboid	Rhomboid	Rhomboid	Rhomboid	Pointed Rhomboid	Elliptic
Leaflet size	Large	Medium	Medium	Medium	Large	Large	Large
Flower color	Light purple	Light purple	Purple	Purple	Purple	Purple	Light purple
Seed size	Medium	Large	Large	Large	Large	Large	Large
Seed shape	Ovoid	Ovoid	Round	Round	Ovoid	Round	Oval
Seed coat color	Cream	Cream	Cream	Cream	Cream	Cream	Cream
Helium color	Light brown	Black	Cream	Light brown	Grey	Dark brown	Black
Number of seeds per pod	3	3	3	3	3	3	3
100 seed weight (g)	15	17	17	17	19	19	19
Protein (%)	41	43	38	36	38	38	40
Oil (%)	17	19	18	23	21	19	20

Appendix 3: Lodging Scores of 25 soybean genotypes that were evaluated in the AYT in 2018B

Genotype	Abi	Bul	Iki	Kab	Mub	Nak	Nam	Nge	Mean
NII × GC 35.3-2	1.0	1.2	1.0	1.2	1.5	1.0	1.2	1.0	1.1
Nam II GC 17.3	1.0	1.0	1.0	1.2	2.2	1.0	1.0	1.0	1.2
NII × 35.3-3	1.0	1.5	1.0	1.2	1.5	1.2	1.0	1.0	1.2
Mak 3N × 1N	1.0	1.2	1.0	1.0	2.0	1.0	1.2	1.2	1.2
NG 14.1 × NII-1	1.0	1.3	1.0	1.2	2.0	1.2	1.0	1.0	1.2
NII × GC 35.3-1	1.0	2.3	1.0	1.2	1.2	1.0	1.0	1.0	1.2
G8586 × UG5	1.0	1.0	1.0	1.2	2.8	1.0	1.0	1.0	1.3
Nam 4M × 2N-2	1.0	1.5	1.0	1.5	1.3	1.2	1.7	1.0	1.3
GC × 2N-1	1.0	1.5	1.2	1.3	2.0	1.0	1.2	1.3	1.3
NDGT 8.11× 3N-1	1.2	1.2	1.3	1.3	2.5	1.0	1.0	1.0	1.3
NII × GC 13.2	1.0	1.3	1.0	1.2	2.7	1.0	1.2	1.2	1.3
BSPS 48A-24-1	1.0	1.8	1.0	1.0	2.3	1.2	1.0	1.3	1.3
Maksoy 3N	1.0	2.0	1.0	1.0	2.7	1.0	1.0	1.0	1.3
2N × GC	1.0	2.7	1.0	1.0	2.2	1.0	1.0	1.3	1.4
NGDT 8.11 × 14.16B	1.0	1.5	1.0	1.5	2.5	1.0	1.2	1.5	1.4
BSPS 48A-28-1	1.2	1.7	1.0	1.3	2.7	1.0	1.2	1.7	1.5
NDGT 8.11 × 3N-2	1.0	1.3	1.0	2.2	3.0	1.0	1.2	1.0	1.5
Bulindi 18.4B	1.0	2.0	1.0	1.3	3.3	1.2	1.2	1.0	1.5
Bulindi 24.1A	1.0	2.0	1.0	1.7	2.5	1.5	1.2	1.2	1.5
BSPS 48A-25-1	1.0	1.8	1.0	1.3	3.5	1.0	1.5	1.3	1.6
NG 14.1 × UG5	1.5	2.0	1.0	1.7	2.2	1.0	2.8	1.0	1.6
Maksoy 4N	1.0	2.3	1.2	1.2	3.7	1.5	1.8	1.2	1.7
BSPS 48A-28	1.0	2.3	1.0	1.5	4.2	1.0	2.2	1.0	1.8
BSPS 48A-27-1	1.0	3.5	1.0	1.2	4.2	1.2	1.0	2.0	1.9
Duiker × 3N-5	1.7	2.7	1.5	2.0	3.5	1.5	2.3	1.8	2.1
Mean	1.1	1.8	1.0	1.3	2.6	1.1	1.3	1.2	1.4
CV%	27	47.2	16.2	24.5	38.8	30.5	40.6	40.1	
l.s.d	0.4689	1.3826	0.2777	0.5344	1.632	0.5517	0.8747	0.7905	

Appendix 4:Nodulation Scores of 25 soybean genotypes that were evaluated in the AYT in 2018B

Genotype	Abi	Bul	Iki	Kab	Mub	Nak	Nam	Nge	Mean
2N × GC	1.2	1.5	1.7	4.2	1.7	2.5	3.2	1.0	2.1
BSPS 48A-24-1	1.0	1.3	1.3	4.3	2.8	2.7	4.0	1.2	2.3
BSPS 48A-25-1	1.0	1.2	1.3	3.7	3.0	3.5	2.7	1.0	2.2
BSPS 48A-27-1	1.0	1.2	1.0	3.2	4.2	2.5	2.7	1.0	2.1
BSPS 48A-28	1.0	1.2	1.3	3.7	2.3	2.5	1.3	1.0	1.8
BSPS 48A-28-1	1.0	1.2	1.2	2.7	3.5	2.8	3.0	1.0	2.0
Bulindi 18.4B	1.0	1.2	1.2	3.8	2.8	2.5	2.5	1.0	2.0
Bulindi 24.1A	1.0	1.3	1.2	1.7	1.7	3.2	2.5	1.0	1.7
Duiker × 3N-5	1.0	1.5	1.0	2.3	2.7	2.3	1.7	1.2	1.7
G8586 × UG5	1.0	1.7	1.2	2.5	1.8	2.0	3.2	1.2	1.8
GC × 2N-1	1.0	1.2	1.2	4.2	2.2	2.0	2.0	1.0	1.8
Mak 3N × 1N	1.0	1.0	1.0	2.2	2.0	1.5	1.3	1.2	1.4
Maksoy 3N	1.0	1.3	1.0	3.3	1.8	2.2	4.2	1.0	2.0
Maksoy 4N	1.0	1.2	1.7	3.0	2.5	2.3	2.7	1.0	1.9
Nam 4M × 2N-2	1.0	1.2	1.0	3.2	1.7	2.3	1.5	1.0	1.6
Nam II GC 17.3	1.2	1.2	1.8	2.7	2.8	2.3	3.0	1.0	2.0
NDGT 8.11 × 3N-2	1.2	1.7	1.3	4.3	2.2	2.5	3.5	1.0	2.2
NDGT 8.11× 3N-1	1.0	1.3	1.3	2.5	2.5	2.5	2.5	1.2	1.9
NG 14.1 × NII-1	1.2	1.2	1.2	2.2	2.7	2.3	2.7	1.0	1.8
NG 14.1 × UG5	1.0	1.2	1.2	2.0	1.7	2.7	2.8	1.0	1.7
NGDT 8.11 × 14.16B	1.0	1.3	1.5	1.8	3.0	2.0	1.7	1.0	1.7
NII × 35.3-3	1.0	1.2	1.5	1.5	2.7	3.2	2.3	1.0	1.8
NII × GC 13.2	1.0	1.2	1.2	3.5	1.7	1.8	1.3	1.0	1.6
NII × GC 35.3-1	1.2	1.2	1.5	2.5	1.5	2.5	3.2	1.0	1.8
NII × GC 35.3-2	1.0	1.2	1.0	3.5	2.8	2.3	2.3	1.0	1.9
Mean	1.0	1.3	1.3	3.0	2.4	2.4	2.5	1.0	1.9
CV%	11.9	24.8	20.6	28.5	49.3	36.9	37.1	11.9	
l.s.d	0.2025	0.5128	0.4278	1.3923	1.945	1.476	1.549	0.2025	

Appendix 5: Soybean Grain Yield (Kg ha^{-1}) of 25 soybean genotypes that were evaluated in the AYT in 2018B

Genotype	Abi	Bul	Iki	Kab	Mub	Nak	Nam	Nge	Mean
BSPS 48A-28	629	2,210	134	645	1,935	1,038	1,443	733	1,096
BSPS 48A-27-1	979	2,012	105	520	2,317	913	1,299	521	1,083
Bulindi 18.4B	669	1,917	110	606	2,136	867	1,670	529	1,063
Maksoy 4N	697	1,835	89	585	1,845	1,120	1,573	621	1,046
NDGT 8.11 × 3N-2	752	1,697	119	488	2,214	946	1,533	564	1,039
Maksoy 3N	1,028	1,900	182	637	1,498	928	1,478	605	1,032
2N × GC	906	1,840	208	654	1,500	936	1,371	734	1,019
Mak 3N × 1N	1,059	1,987	243	637	1,681	927	971	649	1,019
BSPS 48A-25-1	749	1,863	127	530	2,048	807	1,353	652	1,016
NII × GC 35.3-1	1,001	2,172	181	550	1,711	831	1,054	554	1,007
NGDT 8.11 × 14.16B	1,090	1,613	164	563	1,852	736	1,198	774	999
BSPS 48A-24-1	767	1,946	109	622	1,559	1,120	1,251	442	977
GC × 2N-1	1,072	1,761	109	475	2,041	622	1,103	576	970
Nam II GC 17.3	759	1,213	122	569	1,993	710	1,634	728	966
BSPS 48A-28-1	941	1,756	125	524	1,706	670	1,194	640	944
NII × 35.3-3	845	1,764	219	457	1,706	763	1,156	619	941
NG 14.1 × NII-1	937	1,545	223	463	1,633	765	1,388	563	940
Bulindi 24.1A	842	1,653	143	498	1,402	944	1,414	597	937
NDGT 8.11× 3N-1	1,010	1,496	153	426	1,832	541	1,259	493	901
Duiker × 3N-5	973	1,883	144	362	1,278	825	1,073	483	878
NII × GC 35.3-2	852	1,683	164	403	1,609	630	936	748	878
NG 14.1 × UG5	964	1,358	149	436	1,457	712	1,103	705	860
Nam 4M × 2N-2	870	1,593	82	615	1,311	576	1,227	555	854
NII × GC 13.2	488	1,737	111	484	1,513	674	1,108	597	839
G8586 × UG5	647	1,747	166	475	849	862	906	776	804
Mean	861	1,767	147	529	1,705	819	1,268	618	964
CV%	26.2	16.7	35.2	26.1	17.1	29.4	20.4	19.2	
l.s.d	369.9	484.1	85.00	226.8	479.2	394.7	424.0	194.7	

Appendix 6: Grain yield (kg ha-1) of 30 soybean genotypes evaluated in eight locations for six consecutive seasons (2014A – 2016B)

Genotype	Location									Yield advantage	
	Abi	Bulindi	Iki	Kab	Mub	Nak	Nam	Nge	Mean	4N	3N
BSPS 48A-9-2	1,144	1,346	638	936	1,400	1,479	1,509	1,205	1,229	**101**	**141**
Nam II × GC 44.2	903	1,652	749	912	1,411	1,649	976	1,325	1,196	**68**	**108**
Nam II × GC 13.2	892	1,215	649	1,023	1,564	1,536	960	1,316	1,194	**66**	**106**
Nam II × GC 17.3	638	901	828	958	1,528	1,460	1,096	1,187	1,173	**45**	**85**
Nam II × GC 44.3	772	743	771	917	1,483	1,080	1,701	1,039	1,169	**41**	**81**
BSPS 48A-27-1	1,013	1,384	669	1,020	1,372	1,628	892	1,260	1,167	**39**	**79**
BSPS 48A-28	1,316	1,709	778	939	1,389	1,496	843	1,187	1,145	**17**	**57**
BSPS 48A-25	1,180	1,674	810	1,024	1,302	1,487	842	1,166	1,139	**11**	**51**
MAKSOY 4N	858	1,590	735	1,030	1,316	1,453	807	1,289	1,128	**0**	**40**
BSPS 48A-8	596	1,610	761	972	1,524	1,483	865	1,017	1,126	**-2**	**38**
BSPS 48A-3B	999	1,728	657	936	1,359	1,361	1,048	1,143	1,123	**-5**	**35**
BSPS 48A-31	790	1,798	580	895	1,259	1,401	1,336	1,000	1,122	**-6**	**34**
BSPS 48A-26	802	1,393	660	1,002	1,348	1,391	830	1,357	1,116	**-12**	**28**
Nam II × GC 35.3	613	1,465	697	969	1,648	1,294	849	1,074	1,109	**-19**	**21**
Nam II × GC 43.2	783	1,086	729	891	1,572	1,417	819	1,166	1,109	**-19**	**21**
Nam II × GC 4.8	493	1,009	732	1,008	1,312	1,409	944	1,145	1,091	**-37**	**3**
MAKSOY 3N	945	1,797	662	1,062	1,335	1,276	783	1,190	1,088	**-40**	**0**
Mean	824	1,427	702	941	1,360	1,342	906	1,132	1,079		

Appendix 7: Rust Disease Scores (1-5) of the soybean genotypes across the 8 locations in Uganda (2014A – 2016B)

Genotype	Location								Mean
	Abi	Bulindi	Iki Iki	Kaba	Mubu	Naka	Namu	Ngetta	
Nam II × GC 44.2	2.3	2.0	2.4	2.5	2.8	3.3	2.3	2.7	2.6
BSPS 48A-25	1.5	2.0	2.3	3.1	2.6	3.3	2.3	2.3	2.6
Nam II × GC 4.8	2.2	2.0	2.7	2.8	2.6	3.2	2.5	2.3	2.6
BSPS 48A-27-1	1.7	2.7	2.5	2.8	2.8	3.4	2.4	2.4	2.7
BSPS 48A-28	1.5	2.5	2.2	2.8	2.9	3.3	2.5	2.5	2.7
BSPS 48A-26	1.8	2.5	2.6	2.9	2.8	3.2	2.3	2.5	2.7
Nam II × GC 7.2	3.0	2.2	2.4	2.7	2.4	3.4	2.6	2.6	2.7
BSPS 48A-9-2	1.5	2.7	2.2	3.1	2.7	3.3	2.5	2.5	2.7
Nam II × GC 13.2	2.3	2.2	2.4	2.7	2.8	3.2	2.5	2.9	2.7
MAKSOY 4N	1.7	2.0	2.4	3.5	2.6	3.3	2.3	2.4	2.7
BSPS 48A-5	2.6	2.5	2.4	3.0	3.1	3.1	2.5	2.4	2.7
Nam II × GC 32.6	2.2	2.7	2.3	3.1	3.0	3.5	2.4	2.1	2.8
Nam II × GC 43.2	2.5	2.0	2.6	2.6	2.7	3.5	2.6	2.8	2.8
BSPS 48A-31	2.3	2.5	2.6	3.2	3.0	3.2	2.5	2.9	2.9
BSPS 48A-8	2.5	2.5	2.4	3.4	3.0	3.3	2.4	2.6	2.9
Nam II × GC 28.2B	2.3	2.3	2.3	3.1	2.8	3.8	2.8	2.3	2.9
Nam II × GC 30B	2.5	2.7	2.5	3.1	2.8	3.5	2.7	2.5	2.9
MAKSOY 3N	2.2	2.0	2.3	3.2	3.3	3.4	2.8	2.5	2.9
Mean	2.3	2.6	2.6	3.2	3.0	3.5	2.6	2.7	2.8

Appendix 8A: Seed yield (Kg ha^{-1}) of six genotypes tested on farmers' field in different districts

Season	Variety						
	District	NG 1.63	MNG 2.12	MNG 2.15	MNG 7.13	NG 8.10	Local
	Apac	4167	2292	1958	1875	2083	1667
2005A	Mayuge	667	625	1083	1000	1083	1250
	Lira	2604	3125	3542	3125	3542	3750
	Hoima	2083	2500	2292	2708	3125	1667
2005B	Apac	1006	1879	1765	1200	2155	1800
	Mayuge	1088	1900	1980	1897	1509	1050
	Lira	599	400	340	460	850	580
	Hoima	780	834	790	600	880	230
2006A	Apac	1796	1997	1565	1440	1800	1500
	Lira	1657	2300	1967	1700	2493	1020
	Hoima	1112	1584	1110	1409	1603	857
	Mean	1595	1767	1672	1583	1920	1397

Appendix 8B: Mean yield of genotypes across four seasons (2005A, 2005B, 2006A, 2006B)

Genotype	Mean yield (kg/ha)				
	Bulindi	Nakabango	Namulonge	Ngetta	Mean
MNG 1.37	1084	1831	1866	1217	1500
MNG 1.38	889	1827	1738	1000	1364
MNG 1.41	1035	1728	1785	1010	1389
MNG 1.60	1001	1702	1635	1032	1343
MNG 1.63	942	1740	1814	1101	1399
MNG 2.12	1043	1714	1860	1126	1436
MNG 2.13	896	2038	2062	1154	1537
MNG 2.15	966	1663	1892	1120	1410
MNG 5.17	808	1734	1727	1037	1326
MNG 7.13	922	1703	1892	1014	1382
MNG 8.10	1040	1755	1723	1006	1381
MNG 8.25	1033	1907	1869	1135	1486
MNG 4.11	775	1782	1642	929	1282
MAKSOY 1N	822	1560	1582	932	1224
NAM 1	796	1535	1367	1069	1192
Location mean	937	1748	1764	1059	1377
LSD (5%)	178.6	NS	191.6	153.2	117.1
F prob	0.002	0.317	<0.001	0.008	<0.001

Appendix 9: Major soybean seed dissemination channels along the value chain

Organization	Category	Operations
World Vision	**NGO**	**National**
Mayuge Farmers Association	**CBO**	**Eastern Uganda**
VODP	**Government project**	**National**
NAADS	**Government service**	**National**
Victoria Seeds	**Private seed company**	**National**
East Africa Seed Co.	**Private seed company**	**National**
Equator Seeds	**Private seed company**	**National**
Pearl Seeds Co.	**Private seed company**	**National**
Naseco Seeds Co.	**Private seed company**	**National**
FICA Seeds	**Private seed company**	**National**

Organization	Category	Operations
Masindi Seed Co.	Private seed company	National
Mak Seeds Co.	Private seed company	National
Soybean Africa Limited	Private seed company	National
Mt. Meru	Private company	Northern Uganda
Mukwano Group	Private company	Northern Uganda
Formular Feeds	Private company	National
Canmiidiro Group	CBO	Lira
Zirobwe Agaliawamu Agribusiness Enterprise	CBO	Luwero
Aliwol Enterprises	Private company	Kitgum
Omer Farming Co. Ltd	Private company	Northern Uganda
Par Pir Itino	CBO	Lira
Cam Kwok Kin	CBO	Lira
Yele Icom Can Atur	CBO	Lira
Agyeda Women's Guild	CBO	Apac
District Agricultural Office	Local Government	Kaliro, Lira, Apac, Gulu, Soroti, Mbale, Palisa, Kaberamaido, Soroti, Kumi, Sironko
Africa 2000	NGO	Tororo
Pakanyi United Young Farmers Enterprise	NGO	Masindi
Soybean Products International	Private company	National
Juna Magara	NGO	Kamwenge
Bala Women and Youth Farmers Association	NGO	Apac
Pallisa Progressive Farmers Association	NGO	Pallisa
Oilseed Producers and Processors Association	NGO	Lira
Lira Concerned Parents Association	NGO	Lira
Care International	NGO	Lira
International Rescue Committee	NGO	Northern Uganda
Agency for Accelerated Regional Development	NGO	West Nile
Millenium Villages	NGO	Isingiro
Rugendabara Coop. Society	NGO	Kasese

Organization	Category	Operations
Karo One Twins Group	CBO	Isingiro
Federation of Association of Uganda Exporters	NGO	National
CIAT	NGO	Eastern
IITA	NGO	Kiboga
N2 AFRICA	IITA Project	Northern
ISSD	NGO	National
One Acre Fund	NGO	Eastern
Uganda Soybean Initiative	NGO	National
Mirembe Farmers Group	CBO	Central
Awak Farmers Group	CBO	Northern
Intaz (U) Ltd	Private company	Central
Ngetta ZARDI	NARO	Lira
Abi ZARDI	NARO	Arua
Farm Solutions Africa	NGO	Central
ISU-UP	NGO	Central
Akalo Farmers Group	CBO	Alebtong
Palladium/NUTEC	NGO	Northern
Alito Joint	Local seed business	Northern
Bedijo	Local seed business	Northern
Aluga Cooperative	Local seed business	Northern
VEDCO	NGO	National
Clinton Foundation (Rwanda)	NGO	Rwanda
Sasakawa Global 2000	NGO	National
NAGRC & DB	Government programme	National
AFSRT	NGO	Northern
Pinnacle Integrated Resources Farm	Local seed business	Northern
Equipping With Truth Ministries	NGO	Northern

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