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STRIGA MANAGEMENT IN MAIZE PRODUCTION



TRAINING MANUAL ON STRIGA MANAGEMENT AND CONTROL

Preface

This handbook will serve as a guiding tool for extension personnel and other trainers when training farmers on *Striga* (witches weed) management and control in maize and other cereals. It provides knowledge on different practices which ought to improve maize productivity in *Striga* infested areas. This document has been developed by a consortium drawn from the following Institutions: National Crops Resources Research Institute (NaCRRI), Africa 2000 Network (A2N), Nalweyo Seed Company (NASECO) and Ministry of Agriculture Animal Industry and Fisheries with funding from the International Maize and Wheat Improvement Centre (CIMMYT).

NARO 2015
First Edition
Citation:
NARO 2015: Kasozi L.C., Asea G., Sserumaga J.P., Katweere G., Mawanda A., Muwonge A. and Byantwale S. *Striga* management in maize production

Acknowledgement

The producers of this manual thank the Crop Research Program (CRP) of the International Maize and Wheat Improvement Centre (CIMMYT) for providing financial support which enabled development and production of this document through the project titled "Enhancing maize productivity in *Striga*-infested areas in Uganda through Imazapyr treatment and deployment of *Striga*-resistant maize cultivars".











Africa 2000 Network-Uganda
Promoting Community Empowerment For Sustainable Developments.



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LIST OF ACRONYMS

A2N	Africa 2000 Network
CIMMYT	International Maize and Wheat Improvement Centre
DAP	Di-ammonium Phosphate
GLS	Gray leaf Spot
ICIPE	International Centre of Insect Physiology and Ecology
KARI	Kenya Agricultural Research Institute
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MFPED	Ministry of Finance, Planning and Economic Development
MLN	Maize Lethal Necrosis
MSV	Maize Streak Virus
NaCRRI	National Crops Resources Research Institute
NARO	National Agricultural Research Organisation
NASECO	Nalweyo Seed Company
TLB	*Turcicum* Leaf Blight

1.0 Background

Maize (Zea mays L.) is an important crop serving as a major source of carbohydrates as well as providing a reliable source of income to a number of households in Uganda. Currently, maize is among the top export commodities in Uganda; for instance in 2010 it earned the country up to US$30 million from exports, as indicated by the Ministry of Finance, Planning and Economic Development (MFPED). Regarding its dietary contribution, maize is the third most important staple food crop in Uganda providing up to 11% of the country's caloric requirements, compared to 13% and 18%, provided by cassava and bananas, respectively (FAOSTAT, 2010). Additionally, maize is a major ingredient in livestock and poultry feeds and is the most widely adopted crop cultivated in all agro-ecological zones of Uganda, with over 80% of the farming households engaged in its production.

Despite its numerous importance, maize productivity is being constrained by a number of factors including: abiotic factors (environment related) of which low soil nitrogen and drought stresses are the most economically important in Uganda. These factors can be remedied through soil amendment practices such as DAP, Urea and NPK applications during planting and crop growth, and timely field operations. Socio-economic factors which are mainly farmer-related issues like limited knowledge and access to modern maize production technologies, appropriate handling procedures, and linkages to reliable market are other constraints to maize production. Additionally, biotic factors constitute part of the most important category of constraints greatly affecting maize production in Uganda. The major biotic factors include: field pests such as stem borers and termites, and storage pests such as the maize weevil; diseases such as *Turcicum* Leaf Blight (TLB), Gray Leaf Spot (GLS), Maize Lethal Necrosis (MLN), Maize Streak Virus (MSV), common rust, and ear and stalk rots. Weeds also constitute a big component of the biotic factors and they include "non-parasitic" weeds such as coach grass *(Digitaria scalarum)* and *Commelina* spp; and the "parasitic" type particularly *Striga (S. Hermonthica* and *S. asiatica).*

This manual was specifically developed to guide extension staff and farmers on enhancing maize production under *Striga* infested areas. A detailed guide on modern maize production in Uganda is given in the maize production and post harvest handling handbook produced by the Ministry of Agriculture Animal Industry and Fisheries.

2.0 *Striga* problem in maize production: What is Striga?

Striga is an obligate plant parasitic weed infesting the roots of the host plants especially of *Graminae* (grass) family. It survives by siphoning water and nutrients required for its growth from maize and other cereals. Usually, *Striga* seed overwinters in the soil, but the presence of maize root exudates triggers its germination. On germination *Striga* develops haustoria which penetrates and subsequently colonizes the maize root cells. After colonizing the maize plant, *Striga* remains underground where it may spend 4 – 7 weeks before emergence. On emerging it rapidly grows to flowering and seed production, shortly before drying. Each *Striga* plant is capable of producing numerous seeds; for instance *S. Hermonthica* can produce up to 200,000 seeds while *S. asiatica* can produce up to 58,000 seeds. In order to develop a sustainable control strategy, knowledge of *Striga* life cycle is very important as it enables identification of the most critical stage(s) that ought to be targeted by the control measure., The *Striga* life cycle is summarized in Figure 1.

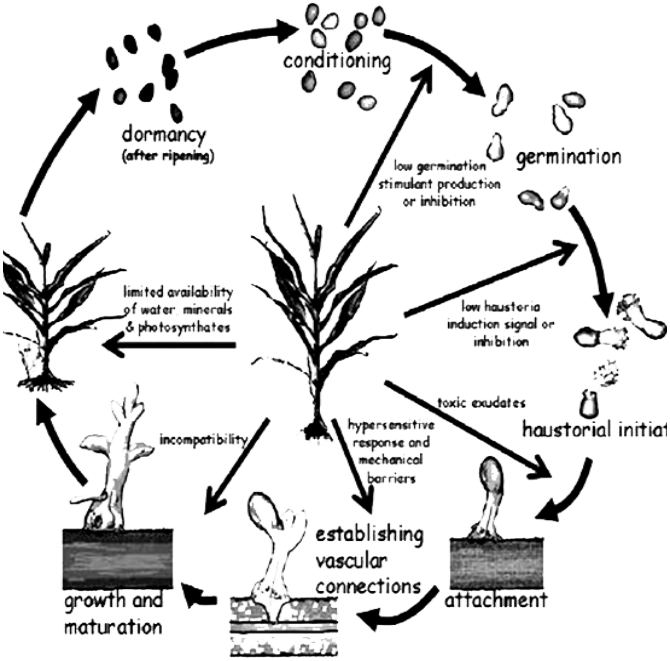


Figure 1: Striga life cycle showing intricate association between the parasite, its hosts, and the environment with specific stages for possible intervention. Source: G. Ejeta, Crop Sci. 47(S3) S216–S227 (2007)

2.1 How to distinguish *Striga* from other weeds?

Striga is characterized by bright-green stems and leaves with small brightly coloured flowers which are usually pink or red depending on the species. It is commonly known as "witchweed" because when it attacks maize or other cereals, the affected plants exhibit a characteristic "witch" appearance resulting from the severe withdraw of photosynthates, minerals and water, in addition to phytotoxin production. Ultimately, stunting, wilting and at times chlorosis may manifest as depicted by pictures in Figure 2. The typical devastating effect of *Striga* is that its occurrence is usually noticed after causing serious damage to maize, before emerging from the soil.



Figure 2: a – Characteristic stunting, b – Wilting/ premature drying, usually caused by Striga attack of the maize crop

3.0 *Striga* prevalence in Uganda: Which areas are mostly affected by Striga?

In Uganda severe *Striga* infestations occur in eastern region covering Bugiri, Iganga, Kaliro, Kamuli, Namutumba, Pallisa, Namaingo, Budaka, Butalejja, Busia, Tororo, Kumi and Bukedea districts; in the north-western region it is Moyo, Arua, Yumbe, Maracha and Nebbi districts. *Striga* affected districts in northern Uganda include Amuru, Kitgum, and Lira; while Kasese and Kamwenge are some of the affected districts in western Uganda. On-farm field observations in eastern Uganda show that yield losses associated to *Striga* infestation are estimated between 20 and 70%; however, under severe infestations farmers may encounter up to 100% yield loss.

3.1 Which *Striga* species are of most economic importance in Uganda?

The most devastating *Striga* species in maize production in Uganda are Striga *Hermonthica* and S. asiatica (Figure 3).



Figure 3: a – Striga hermonthica: this species is endemic in eastern, western, northern and north-western Uganda, while b – Striga asiatica: This species is mainly endemic in northern Uganda

3.2 Other host crops: Which other crops are affected by *Striga* in Uganda?

The crops commonly affected by *Striga* mainly belong to the grass family including: sorghum, rice, millet and sugarcane.

3.3 How *Striga* spreads: Which factors are responsible for spreading *Striga?*

Striga seeds being very small, they are easily carried on different items including shoes, clothes, field tools, livestock, run-offs and/or eroded soils; but the major means of dispersal is through human activities such as field preparation (machinery/tools) and clothing. *Striga* can also be spread through planting contaminated seed.

4.0 *Striga* management and control measures: How to manage Striga in already infested fields and how to control it from spreading to new areas?

Striga intensity in a particular area and its spread to new places can be broadly controlled by three approaches namely:

i. Reducing the amount of seed already in the soil *(Striga* seed bank)
ii. Reducing the amount of new seed added to the soil
iii. Avoiding its introduction into new areas.

4.1.0 Reducing the *Striga* seed bank: What practices can reduce the amount of *Striga* seed from the soil?

In addition to producing lots of seeds, *Striga* seeds can remain viable in the soil for up to 10 – 20 years. Therefore, *Striga* control measures should aim at avoiding addition of new seed while at the same time reducing the seed bank from the infested soils. Several measures can be executed in order to reduce *Striga* seed bank from the soil, they include: planting herbicide-treated (Imazapyr-resistant) maize seed, adoption of push-pull technology, use of *Striga* resistant maize varieties, trap-cropping, and good agricultural practices such as fertilization, crop rotation, intercropping and physical removal of *Striga.* These control measures ought to be popularized among farmers in order to enhance maize productivity in *Striga* infested areas.

4.1.1 Use of herbicide-treated maize seed

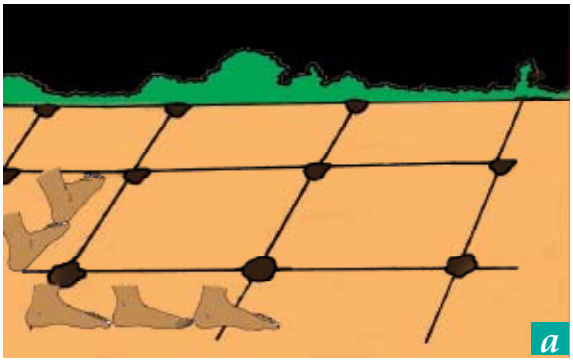
The major group of herbicides used for controlling Striga in maize is called Imidazolinone, Imazapyr being the most popular herbicide under this category. Imazapyr resistance technology in maize has been comprehensively studied by Scientists at the International Maize and Wheat Improvement Centre (CIMMYT), Weizmann Institute of Science, Kenya Agricultural Research Institute (KARI) and BASF the chemical manufacturer.

4.1.1.1 How Imazapyr resistance (IR) maize technology works in the control of *Striga* in maize

The principle of *Striga* control using herbicides lies in the fact that the maize variety has to be resistant to the herbicide, that once the seed is coated with the chemical (Imazapyr), the maize survives, while *Striga* is killed during the initial stages of attachment to the root (before it can damage the host plant). *Striga* seed bank is reduced due to direct action of herbicide on the seeds. A dose of 30 g/ha of Imazapyr is required for effective *Striga* control in maize (30 g of Imazapyr coated on 25 kg of seed). Imazapyr-resistant maize technology is a novel approach based on a natural form of herbicide resistance found in maize, it is widely referred to as IR maize.

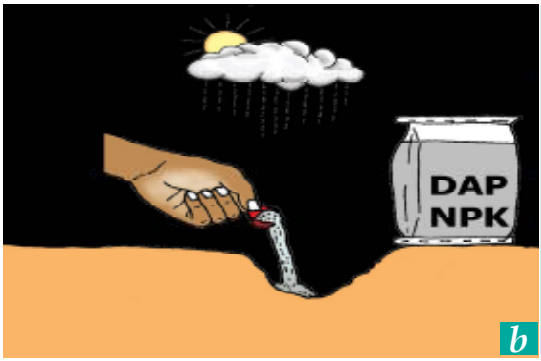
Various maize hybrids including Longe7H have been converted for resistance against Imazapyr. Furthermore, development and evaluation of *Striga* and/or Imazapyr resistant maize germplasm is ongoing at the National Crops Resources Research institute, Namulonge. Several promising IR maize hybrids are being selected for advanced evaluations, with the hope of selecting superior ones for release and ultimately commercial production. Currently, IR maize is being promoted under the trade name of "StrigAway" maize; but it has different local names such as Kayongo-GO in Uganda, Ua Kayongo in Kenya and Komesha Kiduha in Tanzania.

Figure 4 (a – f): Diagrammatic illustrations for planting Imazapyr-treated maize seed (Courtesy diagrams by NASECO)



Prepare a fine field and make planting holes at spacing of 0.75 m x 0.50 m, for planting 2 seeds or 0.75 m x 0.30 m when planting 1 seed per hole.

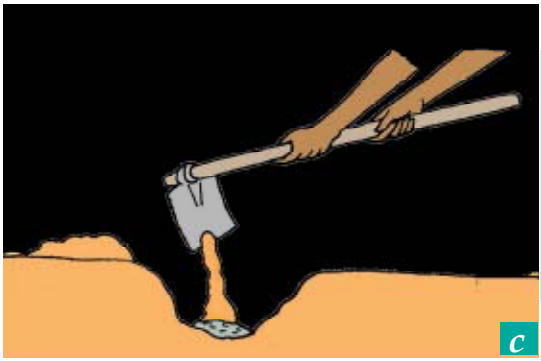
Tip: You can save labor through minimum tillage, use selective pre-emergence herbicide to ensure a weed free field.



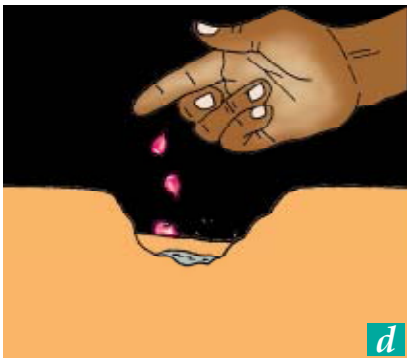
Tip: Put one bottle top (soda bottle) of DAP/NPK per hole and cover it with little soil.

Soils should be moist at planting.

Where possible apply farm yard manure during land preparation.

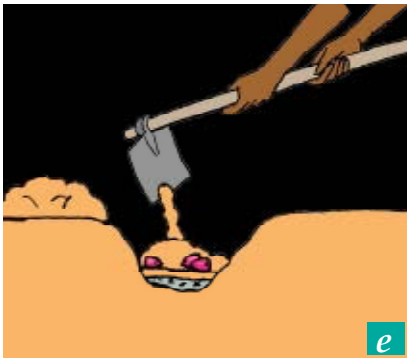


Cover the fertilizer with little soil. This is to ensure the seed and fertilizers do not mix as the seed may be scorched and killed by the fertilizer.



Plant 2 seeds of Imazapyr-treated (Imazapyr Resistant) maize seed (Strigaway®) per hole and cover with soil. Two seeds are used because sometimes Imazapyr treated seeds exhibit lower germination rates than non-treated ones. However, if both seeds germinate, then thin them to 1 plant per hill (for 0.75 m x 0.30 m spacing). Thinning is usually done from 14 to 21 days after germination.

Tip: Do not store seeds after opening the packaging material.



On germination (after 7-14 days) the plants will appear yellowish, a sign that the herbicide has been translocated in the plant system. Do not uproot the yellow plants, as within a few days they will all be green. Top dress with Urea/CAN at 6 leaf stage (21 days after germination). Fertilizers should always be applied between plant rows and covered with soil

Finally cover the seeds with soil



Dispose off the packaging materials in a safe manner. Wash hands with soap and water after planting Imazapyr treated maize seeds (Strigaway).

Do not plant non-Imazapyr resistant (IR) seed before washing hands with soap. Otherwise, the seed may be killed by the herbicide (Imazapyr) in your hands. Similarly, do not plant other seeds in the same holes with Imazapyr treated maize seed.

Ensure a weed free field and remove any remaining *Striga* weed from the crop. *Striga* plants should always be removed before flowering to avoid adding more seeds to the soil (re-infestation).

Advantages of using IR maize technology

- It depletes the *Striga* seed bank in the soil;
- On-farm use of IR maize technology enables farmers to increase harvests from a paltry average of 500 kg/ha to over 1,500 kg/ha.

Disadvantages

- There is no seed recycling. The farmer has to buy IR maize every season;
- It is toxic and therefore the seed should be handled with care to avoid related hazards.

4.1.2 Push-pull technology

The push-pull technology involves intercropping Maize with *Desmodium* in addition to planting napier grass at the borders (Figure 5). This technology has been proven by ICIPE to effectively control *Striga* and stem borers in maize. *Desmodium* produces secondary metabolites in its root exudates that exhibit allelopathic effects on *Striga*. The allelopathic effects exhibited by *Desmodium* provide an effective means of reducing *Striga* seed bank in the soil through suicidal germination. Additional benefits of the push-pull technology are derived from increased availability of nitrogen and soil shading.

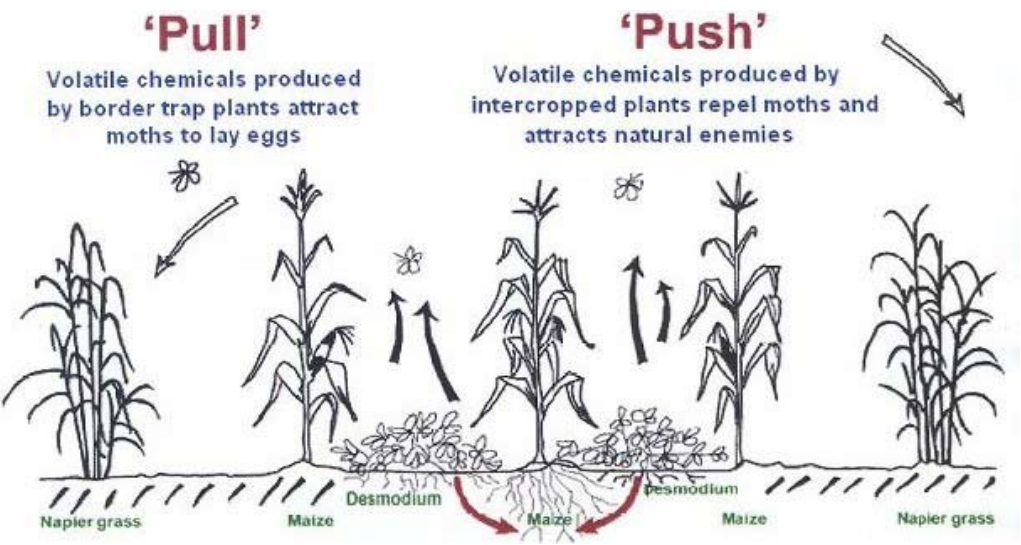


Figure 5: Push-pull technology. Source: ICIPE http://www.push-pull.net/works.shtml

Advantages of push-pull technology

- Reduces ***Striga*** biomass and seed bank from the soil
- Controls stem borers
- Provides livestock feeds
- Improves soil fertility through nitrogen fixation by *Desmodium*

Disadvantages

- The practice is labour intensive
- The technology may not be applicable to the farming system in Uganda where farmers change enterprises seasonally as it requires one to maintain the Desmodium in his/her field for over a period of time, and yet farmers may want to grow other crops in that field depending on the seasons.

4.1.3 Cultural control practices

The cultural control practices are those Striga management procedures that farmers can easily carry out without necessarily applying chemicals. They include practices like crop rotation, trap-cropping, timely planting, use of fertilizers, hand weeding among others.

4.1.3.1 Crop rotation

This involves cultivation of maize on the same piece of land in sequence with other crops especially leguminous crops such as beans, cowpeas, groundnuts, pigeon pea, soybean, lablab, mucuna and bambara nuts, or with trap crops like sunflower. Once legumes or other trap crops are grown in rotation with maize they will induce Striga germination; but since *Striga* is not adapted to their root system it dies shortly after germination. This practice reduces *Striga* seed bank in the soil. A good rotational sequence for maize should include crops that are capable of suppressing growth of a number of other weed species in addition to Striga. Such crops include sweet potatoes and cowpeas, with growth characteristics that smoother weeds.

4.1.3.2 Trap-cropping

Trap cropping involves planting a non-host crop in a *Striga* infested field to induce *Striga* seed germination but the *Striga* plants eventually die due to failure to attach to the non-host plant. This phenomenon is referred to as suicidal germination. This method has been used in sorghum fields by planting rows of *Celosia argentea* between sorghum rows. Similarly, planting silver leaf *Desmodium* (*D. uncinatum)* has worked in maize. Additional non-host crops that can serve as trap crops include cotton, sunflower and linseed. The same principle of trap-cropping may apply for other sets of maize-legume intercrops.

4.1.3.3 Timely Planting

The maize crop usually planted at the beginning of the season exhibits high growth vigour and can establish well before *Striga* sets in. The seed should be acquired and planted at the earliest opportunity so that the maize crop establishes early in the season.

4.1.3.4 Hand weeding

Weeding using a hand-hoe is the most popular method of *Striga* management in maize production especially under subsistence scale. It is often done in combination with hand pulling Striga and other

weeds in proximity with the maize plants.

4.1.3.5 Use of certified seed from reliable sources

Planting must be done with certified seeds free from *Striga* seeds. It is always recommended to use treated seed bought from a recognized agro-input dealer.

4.1.3.6 Soil fertility improvement

Applying commercial fertilizers or adapting other soil fertility amendment practices enhances maize growth vigour, thereby rendering the plants more versatile to withstand *Striga* attack. Furthermore, nitrogenous fertilizers are known to suppress Striga establishment. Thus, application of Di-ammonium phosphate (DAP) and Urea as the common fertilizers recommended for establishing and maintaining a robust maize crop (applied at planting and at 21 – 30 days after germination, respectively) can effectively suppress *Striga* growth. The application rate for both DAP and Urea is 120 Kg/ha.

4.2.0 Reducing the amount of fresh *Striga* seed added to the soil

This may imply that a particular area is already infested by *Striga* but still under low intensity and hence may not be as destructive as when the intensity is high. Therefore, efforts must always be made to avoid adding more *Striga* seed in such areas, but instead reduce it from the soil. This approach entails use of *Striga* resistant maize varieties (yet to be developed) and/or physical removal of *Striga* plants from an area before they flower to produce more seeds. Physical removal can be achieved through timely weeding (hand-pulling and hoeing).

4.2.1 Host plant resistance against *Striga.* How some of the maize varieties can withstand *Striga* attack?

Host plant resistance is the capacity of a particular maize variety to support no or fewer *Striga* plants No commercial maize varieties have been released as *Striga* resistant; however research efforts are

underway to develop such varieties. Other responses exhibited by the maize crop as a result of *Striga* infestation are susceptibility, whereby maize genotypes support a large number of *Striga* plants and show a significant reduction in yield performance. Tolerant genotypes on the other hand, may support as many *Striga* plants as in susceptible genotypes. Under similar field conditions, resistant genotypes yield more grains followed by tolerant genotypes as compared to the susceptible ones.

4.3.0 Avoiding *Striga* introduction into new areas

This is a preventive method that can be achieved through quarantine measures, whereby *Striga* is restricted from spreading from one area to another. It can further be executed through cleaning clothes, tools and equipment used in *Striga* infested fields before working in un-infested fields. Additionally, *Striga*-free seed obtained from reliable sources, should be used when establishing a new maize crop.

4.4.0 Integrated *Striga* management

This approach entails deploying more than one complementary *Striga* control options. It may involve integrating measures aimed at reducing the amount of seed already in the soil with those aimed at avoiding addition of new seed to the soil and/or those aimed at avoiding *Striga* introduction into new areas. It is a more sustainable way of enhancing maize productivity in areas prone to *Striga* infestation.

5.0 Other biotic stresses

5.1 Pests

Other biotic stresses affecting maize production include stem borers, termites, and the maize weevil. Stem borers can be controlled by using resistant maize varieties, or chemical pesticides, especially, bull-dock which is applied in young leaf whorls/funnels 2-3 weeks after crop emergency. Termites can be controlled by applying insecticides (termiticides) in anti-hills surrounding the maize crop or by directly spraying the base of the affected crop (at ground level). However, issues to do with the cost/benefit ratio should be put in mind before applying any chemical. Regarding postharvest pests, the maize weevil *(Sitophilus zeamais* Mostchulsky) is the most important storage insect pest in Uganda causing tremendous losses in quantity and quality of maize under storage. The maize weevil can be controlled to some extent through sanitation and proper grain drying, although chemicals (fumigants) ought to be important on large scale production. Pictures for stem borers and the maize weevil are illustrated in Appendix 1. On the other hand, vertebrate pests such as rodents, birds, wild pigs and monkeys, their control are based on the appropriate technologies in the area.

5.2 Diseases

The major maize diseases include: *Turcicum* leaf blight (*Exserohilum turcicum)*, gray leaf spot (Cercospora zeae-maydis), maize streak virus disease, maize lethal necrosis (MLN) and common rust (*Puccinia sorghi*). Pictorial illustrations of these diseases are given in Appendix 2.

Appendix 1: Major maize pests





a: Maize leaves damaged by stem borers; b: stem borers and their damage on the maize stems (courtesy photos by Dr. M. Otim)





C. Maize cobs attacked by the maize weevil; d. Maize grain attacked by the maize weevil

Appendix 2: Major maize diseases



Turcicum Leaf Blight (TLB)

Spread: Air borne and diseased plant debris

Control:

- Ploughing in or removal of the diseased leaf materials from the soil surface
- Planting resistant varieties crop rotation





Grey leaf spot (GLS)
Spread: Air borne and diseased plant debris
Control:

- Plough under diseased debris to reduce amount of inoculums
- plant resistant varieties
- practice crop rotation

Maize streak virus (MSV)
Spread by leaf hoppers
Control:

- Early planting
- Plant resistant varieties
- Do crop rotation with non host crops



Common rust (Puccinia sorghi)

Disease spread is favoured by humid warm conditions and in severe cases cause death of the leaves

Control

- grow resistant varieties
- control alternate hosts





Maize Lethal Necrosis (MLN)

- Caused by a synergistic infection of two viruses, Sugar Cane Mosaic Virus (SCMV) and Maize Chlorotic Mottle Virus (MCMV).
- Spread by insect vectors, infected seed, mechanical means, e.t.c.

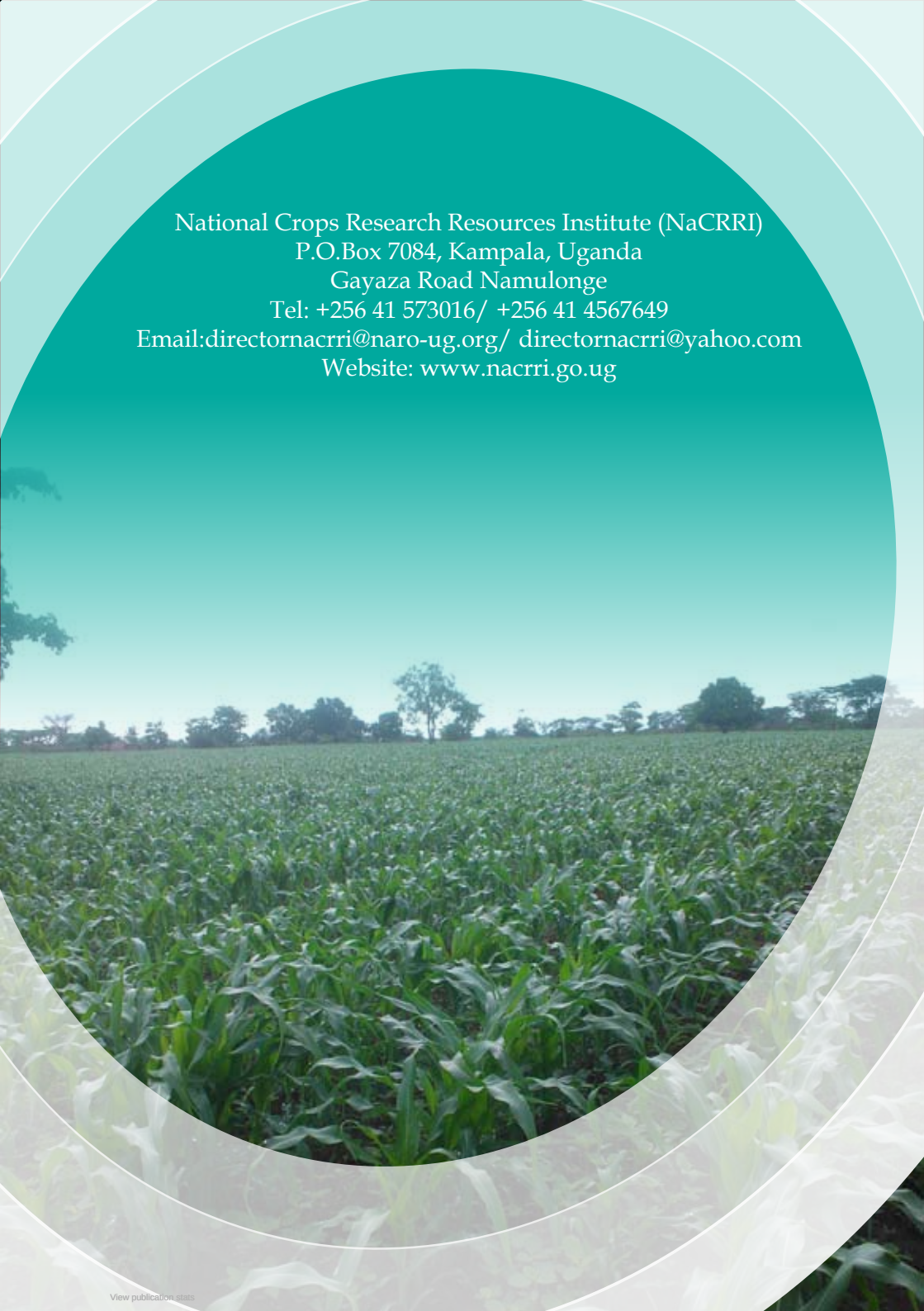




Control

- Plant certified seed
- Keep fields free from weeds, especially grasses
- Scout fields at least once a week to identify diseased plants
- Uproot and burn immediately all plants showing symptoms
- Boost plant growth and vigor by: planting at onset of rains, applying manure, basal and topdressing fertilizers
- Rotate maize with non-cereal crops like beans, sweet potato, sunflower, Irish potato, etc
- Control insect-vectors using appropriate insecticide. Treat seed with Imidacloprid 350 g/L (Gaucho) , followed by insecticide spray with Imidacloprid 100 g/L + β-cyfluthrin 45 g/L (Thunder) at a rate of 0.3 l/ha starting at 1 to 3 weeks after emergence

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