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Grass-Rows Technology:

Using Native Grasses to Increase Yield of Maize, Sorghum and Millet

A Step-by-Step Guide for Farmers

J. Pittchar, E. Kidiavai, Z. R. Khan and R. S. Copeland

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J. Pittchar, E. Kidiavai, Z. R. Khan and R. S. Copeland
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P. O. Box 30772-00100 Nairobi, Kenya

Funded by the Global Environmental Facility/ United Nations Environment Programme

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A Primer on Planting and Managing Push-Pull Fields for Stemborer and Striga Control in Maize

A Step-by-Step Guide for Farmers

Grass-Rows Technology: Using Native Grasses to Increase Yield of Maize, Sorghum and Millet

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ISBN: 92 9064 178 9

ICIPE Science Press
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Nairobi, Kenya
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Acknowledgements

Financial support for the production of this manual was provided by the Global Environmental Facility/United Nations Environment Programme through project GFL/2711-01-4345; "Conservation of Gramineae and Associated Arthropods for Sustainable Agricultural Development in Africa".

We are grateful to the various project and technical staff at ICIPE for providing logistical support, specimens and information. Mr Silas Ouko, ICIPE research technician, particularly deserves commendation for his commitment and support. We also thank the farmers of Busia, Machakos and Suba districts of Kenya for their co-operation and for providing access to their farm lands.

D. Opiyo, Technical Assistant, ICIPE Habitat Management Programme, posed for the cover photo and figures 21 and 23.

Contents

List of illustrations vi

Foreword viii

The Role of Grasses 1

The Stemborer Problem 3

Control of Stemborers Using Grass-Rows Technology 9

How to Establish a Grass-Rows Plot 13

Step 1. Land Preparation 13

Step 2. Preparing Material for Planting 14

Step 3. Planting *Panicum maximum,* Napier grass and *Hyparrhenia rufa* Around a Plot 17

Step 4. Planting Maize, Sorghum and Millet with the Grass-Rows Technology 20

Step 5. Weeding 22

Step 6. Management of the Planted Grasses 22

Step 7. Harvesting the Maize/Sorghum/Millet Crop 24

Planting Grasses and Crops During the Second and Subsequent Seasons 25

Step 1. Land Preparation 25

Step 2. Planting the Second Crop Using the Grass-Rows Technology 25

Step 3. Care and Management of Grasses 25

Things Not To Do 27

Frequently Asked Questions 28

Glossary 30

List of Illustrations

Figure 1. Wild grass: Napier grass *(Pennisetum purpureum)* 1

Figure 2. Wild grass: *Panicum maximum* 2

Figure 3. Adult stemborer moths:
(A) *Busseola fusca,*
(B) *Chilo partellus* and
(C) *Sesamia calamistis* 3

Figure 4. *Sesamia calamistis* eggs, *Chilo partellus* eggs and larva on maize 4

Figure 5. *Busseola fusca* eggs on maize 5

Figure 6. Maize plant leaf damaged by stemborer larvae 5

Figure 7. *Chilo partellus* and *Busseola fusca* larvae 6

Figure 8. Life cycle of *Busseola fusca* 6

Figure 9. Deadheart caused by stemborer larvae 7

Figure 10. *Sesamia calamistis* larva feeding inside a damaged maize stem 8

Figure 11. *Busseola fusca* pupa inside a maize stem 8

Figure 12. Rows of Napier grass planted around a maize field 9

Figure 13. Stemborer predators: Lacewing and mantid larvae eating *Chilo partellus* caterpillars 10

Figure 14. Stemborer predators: Earwig, spider and the staphylinid beetle, *Paederus* sp. 10

Figure 15. Stemborer larvae are trapped by a sticky substance produced from Napier grass 11

Figure 16. Measuring a grass-rows plot 13

Figure 17. Layout of a grass-rows plot 14

Figure 18. Uprooted *Panicum maximum* and Napier grass plants 15

Figure 19. Preparing soil in a polythene bag for planting grass 16

Figure 20. Planting grass splits in a polythene bag 17

Figure 21. Digging holes for planting grass root splits or canes 18

Figure 22. Napier grass canes 19

Figure 23. Planting Napier grass canes 20

Figure 24. Maize field surrounded by rows of Napier grass 21

Figure 25. Harvesting Napier grass 23

Figure 26. Mature *Panicum maximum* grass around maize plants 24

Figure 27. Maintained grass-rows plot, just planted with millet 26

Figure 28. Sorghum field surrounded by *Panicum maximum* 26

Foreword

Many types of wild grasses grow in Africa. Utilising some of these wild native grasses to drive off insect pests from cultivated cereal grasses can improve farmers' livelihoods. Native grasses are being used in Ethiopia, Kenya and Mali for stemborer control in maize, sorghum and millet in what is being referred to as the 'grass-rows technology'. The International Centre of Insect Physiology and Ecology (ICIPE) and the International Plant Genetic Resources Institute (IPGRI), have developed this technology to prevent attack on these important cultivated cereal grasses.

This manual, developed under the regional project 'Conservation of Gramineae and Associated Arthropods for Sustainable Agricultural Development in Africa', has been compiled to guide African farmers and frontline extension staff on how to establish and manage grass-rows plots. It is expected that the information contained in this manual will enhance adoption of this technology and increase the production of cultivated grasses like maize, sorghum and millet in Africa due to the low pest damage. Some other benefits to small-scale resource-poor farmers in Africa include improved livestock production from the excellent feed produced from the native wild grasses, and the production of handicrafts made from them, as well as the increased availability of material for building houses.

ICIPE is coordinating this project with co-financing support from the Global Environmental Facility (GEF) and implementation support from the United Nations Environment Programme (UNEP). ICIPE and the authors of this manual thank these organisations for their support for the production of this manual and for funding this research.

Prof. Christian Borgemeister
Director General
International Centre of Insect Physiology and Ecology

The Role of Grasses

Grasses, known scientifically as the Gramineae or Poaceae, include the most important species of plants for humankind. More than half of the world's food comes from just three grass species: rice, maize and wheat. But this is only part of the story. Grasses have many other uses. In the Sahel region, wild grasses traditionally provide an important source of food for people. Grasses also provide forage for livestock that are grazers, particularly cattle and sheep.

Many types of useful insects that are essential to the environment and agriculture live on wild and cultivated grasses. These include insects that pollinate plants, recycle organic material or are natural enemies of insect pests.

Wild grasses (Figures 1 and 2), many of which grow naturally in Africa, also provide genetic material that may be used by scientists to improve cultivated grass varieties.

Figure 1. Wild grass: Napier grass *(Pennisetum purpureum)*

In East Africa, grassland habitats support a wide diversity of mammals and are an essential resource for the wildlife that attracts so many tourist dollars. Traditionally, grasses are used on farms as fodder, for thatching roofs, for weaving baskets and for making household items like brooms. Some grass varieties have also been used for human and livestock medicine and in cultural ceremonies.

Grasses offer food and shelter for bird species that eat the larvae of pest insects.

However, because of increased human pressure on the environment and destruction of grassland habitats, valuable grass species are disappearing, and with them the useful insects they harbour. Efforts to conserve native grass species will benefit farming communities and help to preserve our environment.

Figure 2. Wild grass: *Panicum maximum*

The Stemborer Problem

Stemborers are the most destructive insect pests of maize in Africa, and they also attack other cereal crops such as sorghum and millet. Stemborers also attack sugarcane. In eastern Africa, three species of stemborers cause most of the damage to cereal crops: *Busseola fusca, Chilo partellus* and *Sesamia calamistis* (Figure 3).

Researchers in Africa have found that between 20 and 40% of maize yield may be lost each season to stemborer infestation.

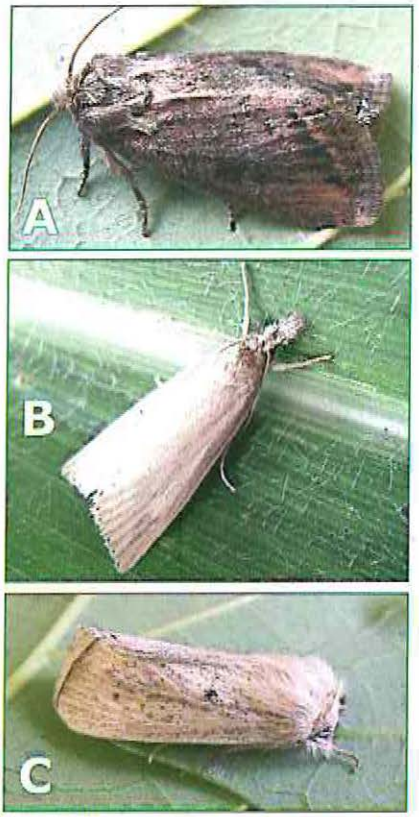

Figure 3. Adult stemborer moths: (A) *Busseola fusca*, (B) *Chilo partellus* and (C) *Sesamia calamistis*

How Stemborers Damage Maize

Because they are normally inactive during daytime, adult stemborer moths are seldom seen in a farmer's field. They become active after sunset. Females lay their eggs on maize plants during the night. *Sesamia calamistis* lays its eggs between the stem and leaf sheath while *Chilo partellus* lays its eggs on the leaf surface (Figure 4).

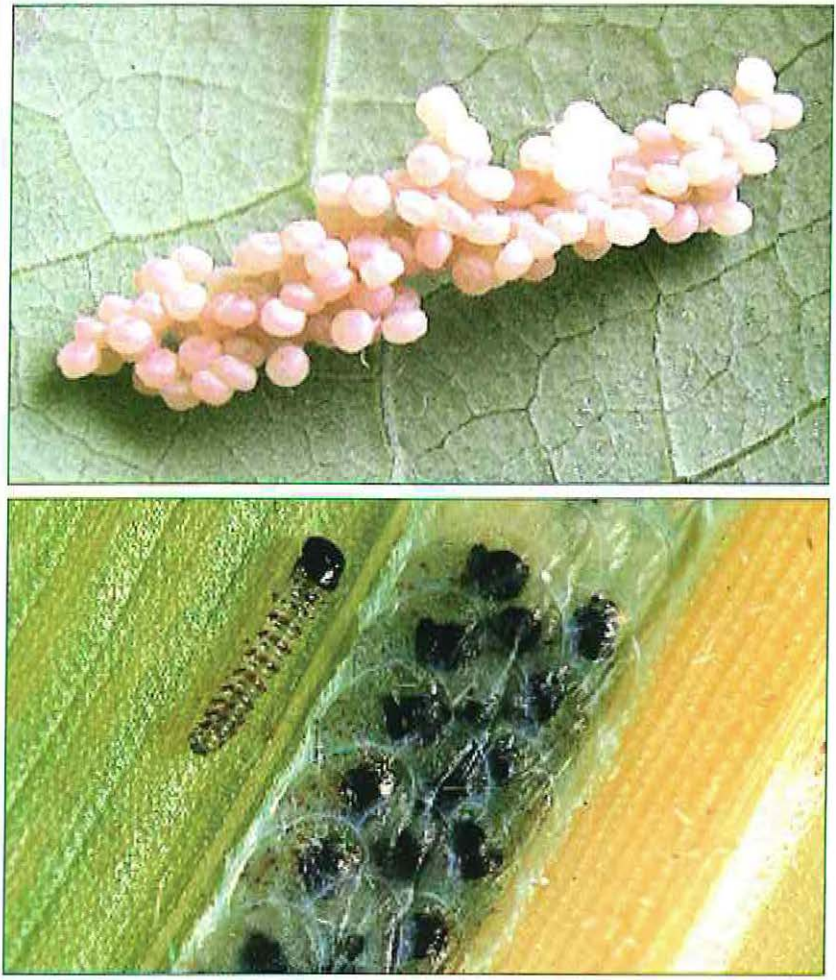

Figure 4. *Sesamia calamistis* eggs (top). *Chilo partellus* eggs and newly hatched larva on maize (bottom)

Figure 5. *Busseola fusca* eggs on maize: leaf sheath opened to reveal eggs

Busseola fusca lays it eggs (Figure 5) beneath the leaf sheath, like *Sesamia*. After hatching, larvae (caterpillars) feed on young leaves (Figure 6) for five to seven days and then enter inside the maize stem.

Figure 6. Maize plant leaf damaged by stemborer larvae

Figure 7. *Chilo partellus* (left) and *Busseola fusca* (right) larvae

After the larvae (Figures 7 and 8) bore into the maize stems, they feed and grow for 2 to 3 weeks. Damage is caused by the worm-like larvae (see also Figure 10).

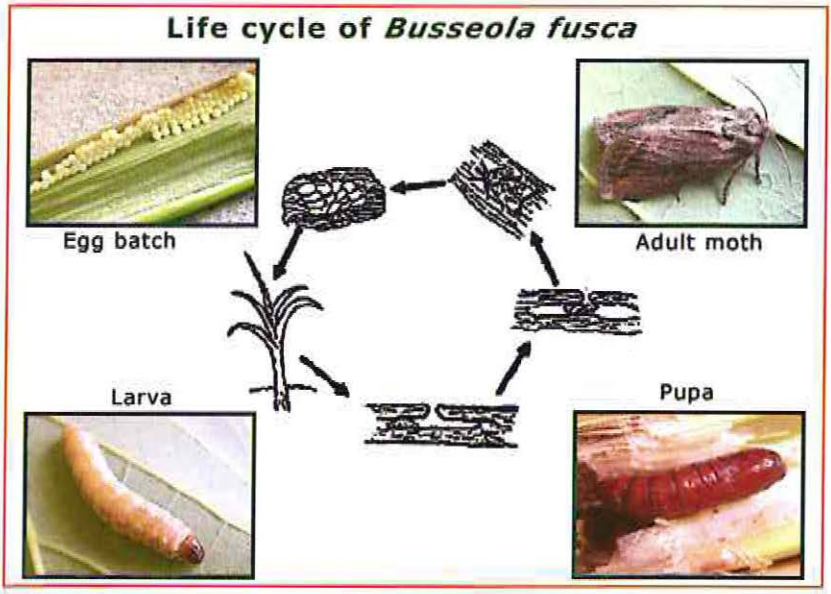

Figure 8. Life cycle of *Busseola fusca*

During the early stage of crop growth, larvae may destroy the growing points of the maize plant, resulting in 'deadheart' (Figure 9).

Figure 9. Deadheart caused by stemborer larvae feeding inside maize plants

At a later stage of growth, the larvae make extensive tunnels inside the stem. This weakens the stalk so that it breaks and 'lodges' (falls over). Damage caused by stemborers may be

Figure 10. *Sesamia calamistis* larva feeding inside a damaged maize stem

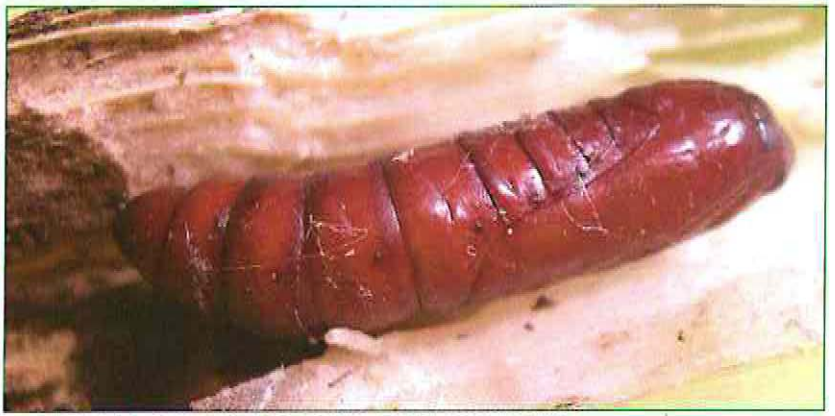

Figure 11. *Busseola fusca* pupa inside a maize stem

as much as 2 to 4 bags of maize out of every 10 that could have been harvested.

When the larvae are fully grown, they pupate and remain inside the maize stem (Figure 11).

After 7 to 14 days, the adults emerge from the pupae and come out of the stem. They mate and lay eggs on the maize plants again and continue damaging the crop.

Control of Stemborers Using Grass-Rows Technology

What is the Grass-Rows Technology?

Grass-rows technology has been developed by the International Centre of Insect Physiology and Ecology (ICIPE) and collaborating partners to promote the practical use of locally available wild grasses and the insect species that live on them, for pest control. In the technology, fields of maize, millet or sorghum are surrounded by three or four rows of one type of wild grass (either *Panicum maximum*, *Hyparrhenia rufa* or *Pennisetum purpureum*—Napier grass) which attract stemborers and prevent them from entering crop fields (Figure 12).

Figure 12. Rows of Napier grass planted around a maize field

The stemborers appear to find some wild grasses surrounding the crop more attractive than the maize itself and may lay their eggs on the grass. Natural enemies of the stemborers—like spiders, mites, ants and other insects—are present on the wild grass and attack and destroy the stemborers (Figures 13 and 14).

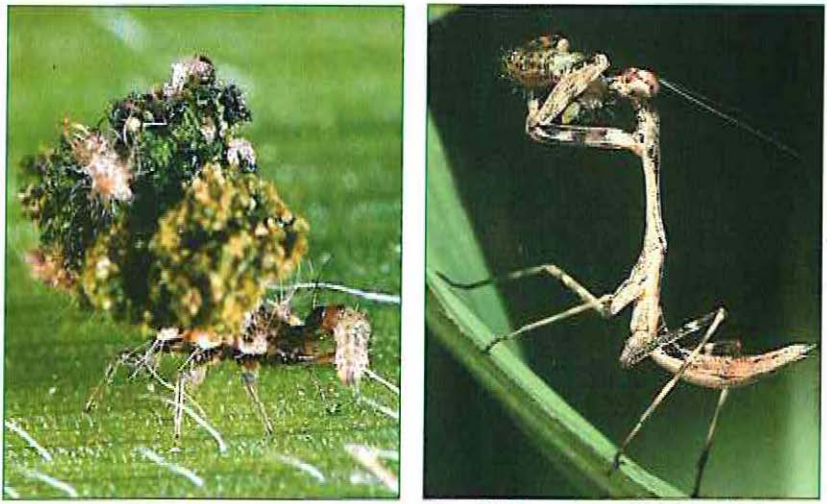

Figure 13. Stemborer predators: Lacewing (left) and mantid (right) larvae eating *Chilo partellus* caterpillars

Figure 14. Stemborer predators: Earwig, spider and the staphylinid beetle, *Paederus* sp.

The grasses that are planted around the crop fields may act as trap plants. For example, stemborer larvae have difficulty developing on some varieties of Napier grass. When the eggs hatch and the small larvae bore into the Napier grass stems, the plant produces a sticky substance like glue which traps them, and they die (Figure 15).

Figure 15. Stemborer larvae are trapped by a sticky substance produced from Napier grass

So, fewer stemborer larvae survive and the maize, millet or sorghum crop benefits because of the grass-rows technology.

And grass rows may act as a wind break to reduce evaporation within a plot, preventing crops from drying out.

Benefits of the 'Grass-rows' Technology

Planting grass rows around maize, sorghum or millet fields has been found to be beneficial to farmers. When a farmer adopts the grass-rows technology and correctly plants his/her crops surrounded by grass, the farmer may:

- Reduce the level of crop infestation and destruction by stemborers.
- Increase maize yield by 20–40%.
- Increase the supply of cattle feed by harvesting *Panicum maximum*, *Hyparrhenia rufa* or *Pennisetum purpureum* (Napier grass).
- Increase the supply of grass for thatching roofs, or for making other structures, e.g. shelters and bathroom walls.
- Conserve grass species that are useful for weaving baskets and making brooms.
- Reduce soil erosion because the grasses are 'soil binders' that hold soil particles and prevent loss of top soil.
- Increase soil fertility by using the grass as 'green' manure to increase soil nitrogen and biomass.
- Help retain soil moisture by using the harvested grass for mulching.
- Make more money and have better nutrition from increased milk production and sales. Farmers have found that feeding cattle with *Panicum maximum* or *Pennisetum purpureum* (Napier grass) increases milk production.
- Provide sources of pollen for honey farming.

How to Establish a Grass-Rows Plot

Step 1. Land Preparation

- Clear your land during the dry season.
- Before the onset of rains, plough and harrow your land until the soil has no large lumps.
- Measure out your grass row plot to a maximum size of 30 by 30 metres (Figures 16 and 17).

Figure 16. Measuring a grass-rows plot

- If you wish to lay out a grass-rows plot on land that is larger than 30 by 30 m, then measure out these pieces of land into plots of maximum 30 by 30 m size. If your

land is less than 30 by 30 m you may still use the grass-rows technology, but do not plant in plots less than 10 by 10 m as the grass may have a shading effect on your crops.

Figure 17. Layout of a grass-rows plot

- If your land is on a steep slope make terraces and plant grass along the terraces, and measure plots that are convenient in relation to your landscape, but measuring between 10 by 10 m and 30 by 30 m.

- If your land is not square-shaped, you may still measure out various sizes of plots ranging from 10 by 10 m to 30 by 30 m.

Step 2. Preparing Material for Planting

Ensure that you have all the needed planting material:

- Maize, sorghum or millet seed. Ensure your seed is good seed, preferably certified seed. You may use your own preserved seed if you are sure of its suitability.

- Plant one type of grass; either *Panicum maximum*, *Pennisetum purpureum* (Napier grass) or *Hyparrhenia rufa*.

Preparation of the Grasses

Preparing grass splits of *Panicum maximum*, *Pennisetum purpureum* (Napier grass) and *Hyparrhenia rufa*

Panicum maximum, Napier grass (Figure 18) and *Hyparrhenia rufa* are perennial wild grasses that may be found easily. First ensure that you identify the grass species correctly. (Please see the glossary at the end of this manual for the local names of these grasses.)

Figure 18. Uprooted *Panicum maximum* (left) and Napier grass (right) plants

Note: It is advisable to prepare the grass seedlings a short distance away from the plot on which you intend to plant maize, sorghum or millet because the grass is perennial and may grow in an uncontrolled manner on the actual crop field.

- Grass seedlings are first established in small polythene bags (4 x 6 cm). Mix ordinary loam soil with farmyard manure or dry cow dung in the proportion of 3 parts of soil to 1 part manure, and fill the polythene bags with the mixture (Figure 19).
- Use a small stick to make holes in the soil mixture contained in the polythene bags. Insert two splits of grass seedling in each hole (Figure 20).
- Water the grass regularly, as often as required, using a watering can.
- Weed the grass seedlings by hand. Pluck out any weeds that may grow in the bags.
- After 2–3 weeks, the grass splits will have established and formed tillers.
- Transplant the grass seedlings around your maize, sorghum or millet field.

Figure 19. Preparing soil in a polythene bag for planting grass

Figure 20. Planting grass splits in a polythene bag

A note regarding Napier grass

You may get Napier grass from Kenya Agricultural Research Institute (KARI) centres, Ministry of Agriculture, Ministry of Livestock and Fisheries Development or other farmers. Napier grass root splits should be obtained from plots that are not infected with Napier grass diseases. Diseased Napier grass plants are yellowish, stunted plants with short internodes. The leaves are very narrow.

Step 3. Planting *Panicum maximum,* Napier grass and *Hyparrhenia rufa* around a plot

Note: In the first year it is important to establish the grass barrier around the crop field ***before*** the planting season starts so that the grass establishes and grows to a sufficient height above the maize, sorghum or millet plants. Before the onset of rains you may need to water the grass until it is well established. Protect the grass from grazing livestock.

Figure 21. Digging holes for planting grass root splits or canes

- Plan your field first as described in **Step 1** (Figures 16 and 17). Make neat rows of small trenches (Figure 21).
- Remove the polythene bags from around the grass seedlings. Transplant the grass seedlings, together with the soil from the polythene bags, in the rows around the maize/sorghum/millet plot as shown in Figures 12 and 17.
- Plant ***at least three rows*** of *Panicum maximum*, Napier grass or *Hyparrhenia rufa* all round the maize/sorghum/

millet plot. The spacing for *Panicum maximum* should be 75 cm between rows and 40 cm between the grass plants within a row. The spacing for *Hyparrhenia rufa* should be 50 cm between rows and 30 cm between the grass plants within a row. The spacing for Napier grass should be 75 cm between rows and 60 cm between plants within a row.

- If available, apply two handfuls of well-decomposed farmyard manure in each hole before planting the grass. You may still plant grass without manure if it is not available.

- If you are planting Napier grass splits, separate single grass splits by hand and plant them directly in the holes.

- You can also choose to plant Napier grass canes (Figure 22) cut from mature Napier grass plants. Use the same spacing as that suggested for Napier grass root splits.

- When planting Napier grass canes, place a three-node cane into the ground and cover the cane with soil, ensuring that two of the nodes are covered in the soil (Figure 23).

Figure 22. Napier grass canes

Figure 23. Planting Napier grass canes

Step 4. Planting Maize, Sorghum and Millet with the Grass-Rows Technology

- Plant your maize, sorghum or millet in the field already surrounded by ***Panicum maximum, Hyparrhenia rufa*** or **Napier grass.**
- Ensure that the first row of maize, sorghum or millet is 1 (one) metre away from the inner row of the grass (Figure 24).

Figure 24. Maize field surrounded by rows of Napier grass, with 1 metre space between the maize and the grass

- The recommended spacing for maize is 75 cm between rows and 30 cm between hills in a row. If available, apply two to three handfuls of well-decomposed farmyard manure. (If you normally use commercial fertilisers, apply one teaspoonful of triple superphosphate or two teaspoonfuls of single superphosphate per hole.)

- In the case of maize, plant two maize seeds per hole and then thin to one plant per hill after the first weeding.

- The recommended spacing for planting sorghum is 60 cm between rows and 30 cm between hills in a row. Thin the plants at the first weeding. (Check the recommended plant population with your seed stockist or with the extension officer.)

- Millet should be planted in continuous lines using the drilling method. At the first weeding, thin the plants to the recommended population for your seed variety. (Check with your seed stockist or with the extension officer.)

Step 5. Weeding

1st Weeding

- Early weeding is very important for the successful establishment of a grass-rows plot.
- The first weeding should be carried out when the maize, sorghum or millet is three weeks old (Figure 24).
- During weeding, thin the maize to one plant per hill, and the sorghum or millet to the recommended plant population.
- The grass rows should also be weeded at this time.

2nd Weeding

- The second weeding should be done when the crop is 5 weeks old.
- If you normally use commercial fertiliser, top-dress the maize with CAN fertiliser at a rate of one teaspoon per plant.
- Grass rows should be weeded again at this time.

Step 6. Management of the Planted Grasses

- The ***Panicum maximum, Hyparrhenia rufa,*** or **Napier grass** barrier should always be maintained at 1–1.5 metres high all round your crop field at all times during the growing season. This will ensure that there is always a barrier to trap the stemborers.

- You may start harvesting Napier grass when it is 3 months old or 1–1.5 metres high (Figure 25). ***Panicum maximum*** or ***Hyparrhenia rufa*** may be harvested when they are at least 1 metre high (Figure 26).

- Start with the innermost row nearest the maize, sorghum or millet plants and harvest this row round the field first. When you harvest grass leave a stem height of 4 inches (10 cm) from the ground at harvesting to encourage it to re-grow quickly (Figure 25).

Figure 25. Harvesting Napier grass

- The grass is useful for feeding your livestock.

- After the first forage has been harvested from the innermost row, you may start harvesting the second row. This gives time for the inner row to grow again.

- The third row should be harvested only when the inner row is again 1–1.5 m high. This will again ensure that

there is always grass of approximately 1–1.5 m high to trap the stemborers.

- The inner row may be harvested again when it reaches 1–1.5 m high, which normally means a period of 6–8 weeks between cuts.

Figure 26. Mature *Panicum maximum* grass around maize plants

Step 7. Harvesting the Maize/Sorghum/Millet Crop

- Harvest the maize, millet or sorghum once it attains maturity.
- In harvesting sorghum, some varieties are taller and need to be cut down before cutting off the panicles (heads). The shorter sorghum varieties and millet plants may be harvested without slashing them. Harvest and thresh the grain as you would normally do.
- Maize, sorghum or millet stover (stalks) left over after crop harvest may be used as livestock feed, particularly during the dry season. Always store the maize stover in a dry place to minimise spoilage.

Planting Grasses and Crops During the Second and Subsequent Seasons

Step 1. Land Preparation

- Do not plough through or uproot the grasses. Continue cutting and utilising the grasses, starting with the inner row as before and weeding the cut grass lines.
- If available, apply farmyard manure or, if you use commercial fertiliser apply CAN fertiliser after cutting and weeding.
- Clear the land of maize, sorghum or millet stover and feed it to livestock.

Step 2. Planting the Second Crop Using the Grass-Rows Technology

Plant maize, sorghum or millet as you did before. Follow the same schedule for weeding grass rows and crops.

Step 3. Care and Management of Grasses

- ***Panicum maximum, Hyparrhenia rufa*** and **Napier grass** are all perennial grasses. That means you do not need to completely remove and replant the grass every year or season. Maintain and protect the grass rows in the position you planted them and continue planting your maize, sorghum or millet crop in the field surrounded by the grass you planted previously (Figures 27 and 28).
- Do not let farm animals graze on the grass rows because this will create gaps in the grass barrier. Instead, harvest the grass as described in Step 6, pages 22–24, and feed your livestock away from the field.
- If some gaps appear in the rows, replant the gaps with the same grass variety.
- Protect the grass from fire.
- Continue harvesting the grass for your livestock 6–8 weeks after the onset of rains.

- Start cutting the inner row, followed by the middle row, then the outer row.
- Always maintain a one-meter high row of the grass surrounding the tender plants (maize, sorghum or millet) and be sure to give time for the previously cut row to grow before cutting the next.

Caution: Leaving your field without a grass border or row of at least one metre high may encourage stemborers to attack your crops.

Figure 27. Maintained grass-rows plot, just planted with millet

Figure 28. Sorghum field surrounded by *Panicum maximum*

Things Not To Do

1. Do not transplant the ***Panicum maximum*** or ***Hyparrhenia rufa*** grass seedlings with the polythene bags they were planted in. First remove the polythene bags from around the grass seedlings before transplanting the grasses.

2. Do not plant the grass inside the maize, sorghum or millet field. Do not establish your seedling nursery in the middle of the crop field because it may grow without control in the maize, sorghum or millet.

3. Do not cut all the three rows of grass at the same time. Always cut one row around your crop field at a time.

4. Do not allow Napier grass to overgrow because it may not be effective in controlling stemborers and may become too hard and coarse for cattle to feed on.

5. Do not graze livestock on the grass rows because this may destroy the grass or create gaps in the grass barrier.

Frequently Asked Questions

Q1. Can I plant grasses at the same time of planting maize/ sorghum/millet?

Answer:
It is better to plant the grasses first. However, in some places rains are scarce and, if not watered, grasses may dry up before the onset of rain. In these areas, grasses may be planted at the same time as the crops. In wetter areas, it is preferable to plant the grass earlier and irrigate it, so that it grows earlier than your crop.

Q2. Should I plant (establish) grass rows every season?

Answer:
No. Since the grasses are perennial, they re-grow after cutting them. You must, however, maintain the grass rows and replant where gaps emerge.

Q3. Can I plant grasses even if I do not own livestock?

Answer:
Yes. Apart from providing fodder the grasses have other domestic uses, such as thatching roofs, weaving baskets, making brooms. The grasses may also be used as 'green' manure, for mulching, for controlling soil erosion and so on. The grasses may also be sold for cash to other farmers. ***Remember*** that the main reason for planting grasses is ***to protect your crop from stemborers.***

Q4. Can I graze my cattle directly in the grass-rows plot after harvesting?

Answer:
No. Direct grazing on the plot damages the grass rows and grass may not regenerate well in time for the next cropping season.

Q5. Apart from the splits, can I plant the grass seeds?

Answer:
Germination of grass is usually difficult, especially when the grass is fresh. Grass seeds may take long to establish. You also need to ensure you have the right grass seeds.

If you mistakenly plant the wrong grass variety and it establishes, it may be very difficult to remove it and establish the right variety.

Q6. Can I plant any other grasses apart from *Panicum maximum*, *Hyparrhenia rufa* or Napier grass ?

Answer:
Yes, especially if they are tall grasses, like Sudan grass, or molasses grass *(Melinis minutiflora)*. However, you need to be careful in selecting the grass species to plant. Although many grass species may work, most have not been well tested. Some may become weeds and difficult to control. *Panicum maximum*, *Hyparrhenia rufa* and Napier grass *(Pennisetum purpureum)* have been tried on farms and generally found to increase the yield of the cereal crop.

Q7. How effective is the grass-rows technology against stemborers?

Answer:
Surrounding your crop field with grass-rows has been shown to increase the size of the maize harvest and that of other cereal crops. It is a natural method that saves you money (that you might have used to buy insecticides), does not 'poison' your environment and maintains the balance of your ecological system.

Q8. Can I intercrop maize with beans or pigeon peas in plots surrounded by grass?

Answer:
Yes, you may plant beans or pigeon peas in between rows of maize. You need to be careful to observe the correct plant spacing.

Q9. Can the grass-rows technology work in all parts of Kenya or Africa?

Answer:
Yes. You need to find out from your agricultural extension staff which grass varieties thrive best in your local ecological system.

Glossary

CAN: Calcium ammonium nitrate. A synthetic nitrogen-fixing fertiliser.

certified seed: Pure seed; seed without any contamination.

dairy cow: Cow raised for production of milk.

deadheart: Destruction of the growing point of maize or sorghum.

funnel (whorl): Young leaves that are still rolled and not yet open.

fodder: Plant part used to feed livestock.

grass/root split: A young, tender tiller of grass.

harrow: Repeat of ploughing to break the soil into smaller particles.

***Hyparrhenia rufa*:** A perennial grass with robust clustered stems that grow to 30–250 cm high; leaf blades grow to 30–60 cm long and 2–8 mm wide. The grass is known locally as 'amakale' in Luhya, 'oboro' in Luo and 'efoto' in Teso. It is common in open bushed and wooded grassland in Turkana, Western, Rift Valley, Central and coastal regions of Kenya. It is used for grazing when young, but becomes coarse when it matures. It is traditionally used for thatching and for general purpose straw.

KARI: Kenya Agricultural Research Institute

larva (pl. larvae): Young worm-like stage of stemborer that has hatched from the egg and feeds on the maize/sorghum/millet leaves and stems. This is the destructive stage of stemborers.

leaf sheath: The lower part of the leaf that 'grasps' the stem of the plant.

Napier grass: Known scientifically as *Pennisetum purpureum*, it is called 'olusi' or 'amakada' in

	Luhya, 'ogada' or 'osiaga' in Luo, 'kitothia' in Kamba and 'thara' in Kikuyu. It is a robust, tall perennial grass that grows up to 6 m or more in height, often forming bamboo-like clumps. Its leaf blades grow up to 120 cm long and 5 cm wide. It is found mainly on river banks, valley bottoms and forest margins mostly on rich soils in Western, Central and Coastal regions of Kenya. It is widely cultivated for fodder and is also used to control soil erosion.
Panicum maximum:	Commonly known as Guinea grass, it is a drought-tolerant perennial grass found throughout Kenya, but is common in open grasslands and along riverbanks. The grass is known as 'mbwea' in Kamba, 'amasanyi' in Luhya, 'eturo' in Teso, and 'odunyno' or 'saka' in Luo. The grass grows in clustered erect stems up to 75–200 cm high; leaf blades are linear, flat, mostly 6–40 cm long and 1.2–3.5 cm wide. Its flowering head is a heavily branched panicle, with the lowest branches arranged in a whorl or a circle. It is excellent livestock feed.
plough(ing):	Breaking of the soil by use of hoe, ox-drawn plough or tractor plough.
polythene bag:	Bags used to plant young grass seedlings.
pupa (pl. pupae):	Stage between larva and adult moth. Usually a dormant stage.
terraces:	Structures made on steep slopes to control soil erosion. Stones and/or plants are usually used to make terraces.
thatching:	Final covering of house roofs.
soil erosion:	Removal of rich top soil by runoff water or wind.
watering can:	Container used to sprinkle water on plants in a gentle way.
weeding:	Removal of unwanted plants (weeds) from the crop field.

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Figure 25

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ISBN: 92 9064 178 9