



THE KENYA CEREALS ENHANCEMENT PROGRAMME - CLIMATE RESILIENT AGRICULTURAL LIVELIHOODS (KCEP - CRAL) WINDOW

Millet Extension Manual



SUPPORTED BY FUNDS FROM EU
APRIL 2021



European Union



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Disclaimer

The information presented in this manual is for advisory use only. Readers using the manual should verify details that relate to their agro-climatic zones from their area agricultural extension officers.

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We also thank the researchers, farmers and stakeholders who participated in the project for their support in setting up trials, collecting and processing the data and thus generating large amounts of knowledge and information that KCEP-CRAL has packaged and shared through scientific papers, in seminars and in reports among others. The support of technical officers, laboratory personnel, administrative and support staff is also appreciated as it contributed to the success that the project achieved.

FOREWORD

Kenya Agricultural and Livestock Research Organization (KALRO) is one of the key partners in the Kenya Cereals Enhancement Programme - Climate Resilient Agricultural Livelihoods Window (KCEP-CRAL) Programme funded by the European Union (EU) and implemented by the International Fund for Agricultural Development (IFAD). KALRO participation in this programme is based on proven experience and expertise in agricultural research. Within the programme, KALRO handles the research component, conducting on station and on farm trials, develops farmer recommendations together with training materials for extension staff and service providers and conducts the training. The implementation of KCEP-CRAL is in thirteen (13) counties namely Nakuru, Nandi, Trans Nzoia, Kakamega, Bungoma, Kitui, Tharaka-Nithi, Embu, Machakos, Makueni, Taita Taveta, Kwale and Kilifi.

KCEP-CRAL focuses on the three leading rain-fed cereals (maize, sorghum and millet) and associated pulses (beans, green grams, cowpeas and pigeon peas). The programme's overall objective is to contribute to the reduction of rural poverty and food insecurity of smallholder farmers.

Through this manual, the programme will provide a comprehensive guide to extension officers, service providers and lead farmers on how to successfully produce cereals and pulses in Kenya. The manual is a useful training and reference material for extension officers and other stakeholders seeking to enhance the capacity of farmers, increase commercialization for food security and promote gender inclusion and participation along the commodity value chains.

Initial lessons learnt in this project indicate that enhancing the capacity of the extension staff and service providers has improved uptake of new technologies for dry land farming. It has opened up more land for farming through use of conservation agriculture in areas that hitherto were not under agriculture. Besides easing the pressure on previously arable land, farmers in the project areas have been trained to use alternative disease and pest management regimes using Integrated Disease and Pest Management and Push pull technologies for persistent pests of economic importance.

On behalf of KALRO, I am grateful to the European Union for supporting this project through the IFAD and KCEP-CRAL of the Ministry of Agriculture, Livestock, Fisheries and Cooperatives (MoALF&C). I also appreciate the excellent coordination of the whole process by the KCEP-CRAL Secretariat led by Dr Anthony O. Esilaba, MoALF&C and other partners, scientists in participating centres, Knowledge, Information and Outreach Unit team and secretarial staff. It is my hope and desire that in using this manual, the expectations of all stakeholders will be met.

Eliud K. Kireger, (PhD, OGW)
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ABBREVIATIONS AND ACRONYMS

AEZ	Agro-ecological-zones
ASALs	Arid and Semi-Arid Lands
°C	Degrees Celcius
CAN	Calcium ammonium nitrate
FYM	Farmyard manure
ICRISAT	International Crops Researchh Institution for the Semi Arid Tropics
KALRO	Kenya Agricultural and Livestock Research Organization
KCEP	Kenya Cereal Enhancement Programme
KES	Kenya Shillings
KSC	Kenya Seed Company
NPK	Nitrogen, Phosphorus, Potassium
GDP	Kenya's Gross Domestic Product
MoA	Ministry of Agriculture
ppm	parts per million

1 INTRODUCTION

Millets are a group of small seeded cereals grown in semi-arid dry areas. They include pearl millet, finger millet, foxtail millet and proso millet. They have a short growing season, can withstand dry and high-temperature conditions and yet yield well, hence they are important food security crops in semi-arid lands of Kenya. Millets are widely cultivated as human food or as fodder for animals. The grains are similar in nutrient composition to maize but richer in protein and fibre. They fit well in popular local recipes such as *Ugali* and *Uji*. In addition to grain and forage/fodder uses, millet crop residues are used as building material and fire wood for cooking, particularly in dry land areas. In recognition of millets nutrition value and frequent maize crop failures, the Government of Kenya is putting more emphasis on production of millet to mitigate food and nutritional security.

2 ECOLOGICAL REQUIREMENTS

2.1 Altitude

Generally, millets adapt to a wide range of agro-economic zones. In Kenya millet is grown from 0 – 2400 M above sea level (Masl). However, in the arid and semi-arid areas (ASALs) it is grown within 250 – 1500m above sea level.

2.2 Rainfall

Millets are water user efficient crops and grow well in areas of low moisture. They are early maturing and therefore drought escaping. An average annual rainfall of 200-600 mm is sufficient for the production of pearl, proso and foxtail millets, while finger millet requires an annual rainfall of 250-900 mm.

2.3 Soil types

Millets grow in a wide range of soil types provided it is well-drained loamy, even on hilly areas as long as soil erosion control measures are in place. However, it can also grow in shallow soils and in soils with clay, clay-loam and sandy-loam texture. Millets do not tolerate water-logged soils or extreme drought conditions. Root development can be severely restricted in soils having excessively high or low soil moisture levels, and hard pan and compacted layers. It is also grown on medium black soils, deep alluvial loams and on sandy and gravelly soils of poor fertility with low organic matter content, but the yield is low.

2.4 Temperature

Millets are adapted to a wide range of temperatures. They require warm temperatures for germination and development and are sensitive to cold. Optimum soil temperatures for seed germination are between 15°C and 30°C. They can tolerate temperature as low as 10° c, however, very cold temperature hampers growth. Pearl millet is a warm-weather crop and grows best at temperature of 30 - 34°C. Millets are more tolerant to higher temperatures than probably any other major cultivated cereal.

2.5 Varietal selection

In varietal selection, agro-climatic adaptation of the crop and farmer preference, household utilisation and market are key factors of consideration (Table 1 and Figure 1). Millet has a wide range of maturity periods. Some varieties mature in as little as 60 to 80 days (short duration) while others take about 100 days (medium) to mature. Long season varieties can take up to 180 days to mature from planting. Cultivation of short-duration varieties reduces the risk of crop failure.

Table 1: Millet varieties for Kenya

Crop	Variety	Maturity (months)	Grain colour	Yield (90 kg bag)/acre
Pearl millet	KAT/PM-1	2.5 - 3	Grey	8 - 10
	KAT/PM-2	2	Grey	7
	KAT/PM-3	2.5 - 3	Grey	10 - 12
Finger millet	P224	4	Brown	10 - 12
	Gulu E	4	Brown	8
	KAT/FM-1	3	Brown	6 - 8
	LANET FM-1	4	Brown	7 - 10
Proso millet	KAT/PRO-1	2.5	Cream	6 - 8
Fox millet	KAT/FOX-1	4	Cream yellow	8 - 10



a



b



Figure 1: Varieties of Millets (a) Pearl millet, (b) Finger millet, (c) Proso millet and (d) Fox millet

2.5.1 Seed selection and treatment

Seed is a vital input in millet production. Therefore, access and availability of certified, quality seed, either through the authorised formal or informal seed merchants are recommended for optimal production. Farmers can also select and save seeds from the harvest and re-plant them for 3 seasons before buying certified seed once more.

These steps are essential when farmers are selecting their own seed:

- Identify disease and pest free plants in the field
- Select plants with large panicles and preferably in the middle of crop field
- Tag the identified plants
- Harvest them separately before harvesting the rest of the crop
- Sun dry to the recommended moisture content (12%)
- Discard the tip of the panicle to avoid small malformed grains
- Thresh and clean the seed before treatment
- Store seeds in a cool dry environment
- Dress the seed with recommended seed dressing chemical.

2.5.2 Seed germination test

To determine the viability germination of the saved seed:

- i. Select a site near the homestead where there is access to water
- ii. Prepare 1 × 1 m seedbed and make 100 planting holes spaced at 10 cm × 10 cm
- iii. Plant a 100 seed and cover with soil and water adequately for seven days
- iv. Take first germination count after 3 days and the final after seven days
- v. The best temperature for the germination of millet seed is 23 to 32°C. Poor emergence and seedling growth may result, if planted before soil temperatures reach 23°C
- vi. 85% germination count is considered adequate for millet
- vii. Select seeds with good vigour (Figure 2).



Figure 2: Normal seedlings with vigour

2.6 Site selection and land preparation

Dry ploughing is advantageous to kill the weed seeds and hibernating insects and pathogens by exposing them to the heat. Initial ploughing should be carried out at optimum moisture range to get fine seedbed and should be avoided when moisture is in excess.

For pearl millet, proso and foxtail millets, birds are a major threat in all major millet production areas in Kenya and especially where isolated production takes place. In such areas, isolated fields far from homesteads and near birds breeding sites should be avoided.

Timely land preparation facilitates timely planting which ensures higher yield. Millet is a small seeded crop and therefore requires a fine seedbed, for good seed germination and seedling establishment. If a tractor or oxen plough is used to open the field, it is advisable to harrow it once in order to break the large soil boulders as seen (Figure 3). When hand-hoes are used for land preparation, the large soil boulders should be reduced by breaking them to provide a moderately smooth seed bed (Figure 4). Land preparation should ensure that all crop residues, crop volunteers and weeds are completely buried in the soil.

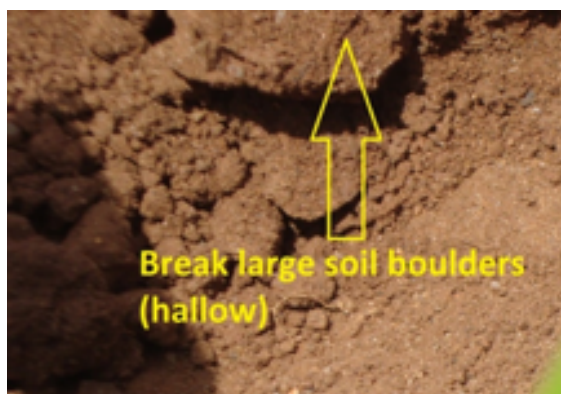


Figure 3: Poor seedbed



Figure 4: Ideal seedbed

2.7 Soil fertility management

Most soils in millet production areas are deficient in essential macronutrients such as nitrogen (N) and phosphorus (P), which are essential for adequate crop growth. To correct these deficiencies, a wide range of organic and inorganic fertilizers are recommended. During planting, it is recommended to apply NPK (20:20:0 or 23:23:0) at a rate of one bag (50 kgs) or DAP (18:46:0) 25 kg/ha per acre. Planting fertilizer is drilled along the planting furrow and thoroughly mixed with soil before seeds are planted. In soils with low fertility and in instances where rainfall continues beyond 30 days after planting, top dress with CAN at a rate of one bag (25 Kgs) per acre when the crop three weeks after germination.

2.7.1 Manure/compost

Manure improves nutrients level in the soil. It also improves the soil structure and increases moisture retention capacity of the soil. Well-decomposed manure (2 tons/Acre) is broadcasted in the field close to the onset of the rains and mixed with the soil during ploughing. In case of low volumes of manure, it can be spread in bands along the planting furrows and mixed with the soil before seeds are placed (Figures 5 and 6).



Figure 5: Manure banded in rows



Figure 6: Mixing manure with soil at planting

2.8 Planting

The full production potential of millets can be achieved through planting before or at the onset of the rains by either drilling in furrows made by oxen plough, tractor or hand hoe/ jembe, or planting in holes dug by a jembe or panga. The recommended planting depth is 5 cm on dry soils, and 2 and/or 4 cm on wet soils. The spacing of planting furrows depends on; the type of millet being used and whether it is a sole or intercrop. For pearl millet sole cropping, 15 cm between seeds and 60 cm between rows is recommended when hand planting is done, however a spacing of 90 cm between row and 20 cm when using ox-plough can be used (Figures 7 and 8). For finger millet, foxtail and Proso millet a spacing 10 cm between seeds and 30 cm between rows is recommended. The seed rate for Pearl millet is 2-3 kg/acre, finger millet is 1.2 kg/acre, proso millet is 1.6 kg/acre and fox tail millet is 1.6 kg/acre.



Figure 7: Furrows made by ox-plough

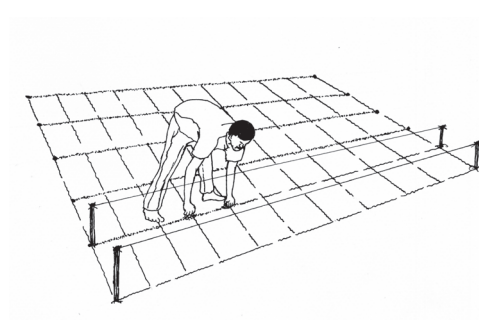


Figure 8: Manual planting

Millet can be intercropped with pulses such as pigeon peas, beans, cowpeas and green grams. The row arrangement for the millet and pulses could be a single alternate where a legume falls between two rows of millet spaced at 90 cm. Two rows of pulses could also be alternated with two rows of millet all spaced at 60 cm apart (Figure 9).



Figure 9: Pearl millet-groundnuts intercrop

2.9 Weeding

The first weeding should be done within 2 weeks after emergence (Figure 10), as the yield components that determine the grain filling capacity are determined within 45 days after emergence. Two weeding sessions in a season are recommended. Chemical weeding can also be done using recommended pre-emergence herbicides.



Figure 10: Weeding and thinning stages

2.10 Thinning

Due to the millets seed size the population is always high at emergence. To reduce competition for nutrients, water and sunlight within the seedlings, thinning must be done to single plant per stand 3 weeks after emergence (at 3-4th leaf stage). Wider spacing on sandy soils allows individual plant to develop more lateral roots and make the plants more resilient to droughts. The general recommendation is that thinning should be done when the soil is moist to ensure minimal disturbance of the roots of the remaining plants for a healthy growth. While thinning the less vigorous, diseased or weak seedlings is recommended. If necessary, thinned healthy seedlings can be used to fill in gaps in places where emergence was poor. Seedlings used for gapping should be used on the same day that they are thinned out, and adequate moisture should be available or provided to facilitate their re-establishment.

2.11 Roguing

Rouging is done at plant maturity to ensure quality seed or grain. This is the removal of plants that are less vigorous (weak), diseased or attached by pests. It also involves the removal of plants that display off type characteristics like being taller, having different flower and grain colour from the majority of other plants.

3 CROP PROTECTION

3.1 Diseases of economic importance in millet production

3.1.1 Downy Mildew/ Green ear disease (*Sclerospora graminola*)

Chlorosis occur at the base of infected leaves, followed by development of spores on the underside of the leaf usually referred to as “half -leaf” symptom (Figure 11). The plant assumes a bunchy and bushy appearance. Severely infected plants are generally stunted and do not produce panicles, floral parts are transformed into leafy structures.



Figure 11: Bunchy and bushy appearance on affected crops

Photo source: American Phytopathological society

Management: Provide good drainage in your soils and avoid planting in water logged areas. Practise crop rotation and proper field hygiene, including rouging out and burning of infected plants and weeding. Apply chemical sprays of mancozeb and cymoxanil based products.

3.1.2 Cercospora Leaf Spot (*Cercospora penniseti*)

Leaves and stems develop grey water-soaked lesions that turn brown upon drying. Lesions are often surrounded by a chlorotic halo that will die and give concentric rings (Figure 12).



Figure 12: Brown and water-soaked lesions

Photo source: American Phytopathological society

Management: Plant resistant varieties and practice crop rotation in the farm.

3.1.3 Ergot of millet (*Claviceps fusiformis*)

It is a disease of millet grain bearing heads. It causes direct grain yield loss by replacing grains with toxic sclerotia making it unfit for consumption.

It produces cream to pink mucilaginous droplets of “honeydew” ooze out of infected florets. Within 10 to 15 days, the droplets dry and harden, and dark brown to black mass develop in

place of seeds on the panicle. The Sclerotia are irregularly shaped, and generally get mixed with the grain during threshing (Figure 13). If grains are processed with sclerotia, they result to mycotoxin contamination leading to ergot disease upon consumption.



Figure 13: Rotting grains

Management: Practise good field sanitation, plant resistant varieties, remove affected panicles, use clean seeds and practice crop rotation with pulses.

3.1.4 Leaf Rust (*Puccinia substriata*)

Distal half of the leaf is infected first. Appears as yellow to white spots on leaves. The fungal bodies spread over both surfaces of the leaves as reddish brown pustules but occur at the upper side of the leaf. Necrotic spots may develop around the pustules and causes premature drying of the leaves (Figure 14).



Figure 14: Reddish brown pustules on both surfaces of the leaves

Management: Practise proper farm hygiene including weeding to remove alternate host that may keep the inoculum. Grow resistant varieties. Spray with Azoxystrobin, tebuconazole or propiconazole based products at recommended rates.

3.1.5 Leaf/ Head blast (*Pyriicularia setariae*)

Young seedlings may get blast in the nursery and the field (Figure 15). The lesions are spindle shaped, early formed spots have yellowish margins and greyish green centre which latter become whitish grey and disintegrate.

The olive grey overgrowth of fungus develops at the centre of the spot. The lesions develop on the blades of adult plants and the spots appear on the blade.



Figure 15: *Spindle shaped lesions and yellowish spot are the initial symptoms*

Photo source: CABI

Management: Practice crop rotation with non-host family crops such as legumes, collect and destroy by burning infected crop residues from the previous season. Spray with Carbendazim, Trifloxystrobin and tebuconazole based products at recommended rates.

3.1.6 Millet Smut (*Moesziomyces penicilliraea*)

The disease affects the inflorescence of the millet plant immediately after the boot stage. The infected floret ovaries are converted into structures called sori which are oval and conical in appearance. The bright green sori project beyond the grain glumes and latter turn brown to black (Figure 16).

Management: Use of resistant varieties to manage the disease, Rotate with beans, cowpea, greengram family for a minimum of 3 seasons. Plough deep at least 2 months before planting. Avoid planting in areas with history of disease. Remove and destroy by burning affected plants. Spray using copper oxychloride (70g/20 Ltr of water) or Propiconazole and cyproconazole based products.



Figure 16: *Infected floret ovaries are converted into sori that are oval and conical appearance*

Photo source: ICRISAT

3.1.7 Damping off (*Pythium*, *Rhizoctonia*, *Fusarium*, *Aspergillus*)

Germinated seedlings die back and leaves have water soaked appearance (Figure 17). At the soil line, seedlings have girdled stems with lesions and cankers, stems are twisted, discoloured also known as “wire stem”.



Figure 17: Wire-stem and wilting of the seedlings from damping off

Source: R. Gregory - Plant diseases library

Management: Plant certified quality seeds, drain the soils well to avoid water logging in the farm. Seed dress with metalaxyl and difenoconazole based products such as “Apron star”. Drench the affected soils using systemic fungicide such as carbendazim and metalaxylmethyl based products. Drench using Mancozeb (Ridomil Gold), hydrochloride (Previcur at 30-50ml/20 Ltr of water) or Carbendazim (Rodazim, Pearl, Sahara, Botran). Observe 4-6 weeks intervals.

3.2 Arthropod Pests

Most arthropod pests can be controlled through a combination of techniques such as use of pesticides, cultural practices, intercropping, use of resistant varieties and biological control. Pesticides are used only after monitoring indicates there is need according to established guidelines. Key insect pests commonly found in millet in Kenya and their management strategies are discussed in the sub-topics that follow.

3.2.1 Shoot fly (*Atherigon asocata*)

The maggots damage seedlings between 5 to 30 days of emergence by cutting the growing point resulting in central leaf drying and formation of a dead heart (Figure 18). The central leaf when pulled out produces a foul smell. The damaged plants produce axillary tillers as a means of recovery and survival.



Figure 18: Dead heart of the whorl leaves caused by shoot fly damage

Photo source: ICRISAT

Management: Practise good crop husbandry in the farm including weeding and clearing of alternate hosts around the farm especially grass family, use high seeding rates during planting to achieve the desired optimum plant population, practice crop rotation and intercropping with sunflower, cotton or legumes. Plant early about 7 to 10 days before the onset of rains to enable the crop escape shoot fly high population densities. Plant with phosphorus and nitrogen fertilizer and avoid animal manure since shoot flies are attracted by manure.

3.2.2 Millet Ear head bugs (*Calocoris angustatus*)

Nymphs and adults suck sap from tender leaves, petioles and grains at milk stage. Heavy infestation results in leaf yellowing and eventually drying (figure 19). This can lead to shedding of leaves, inflorescences, and young grain. Grains shrink and turn black and chaffy. Eggs are blue cigar shaped, nymphs and adults are slender and green.

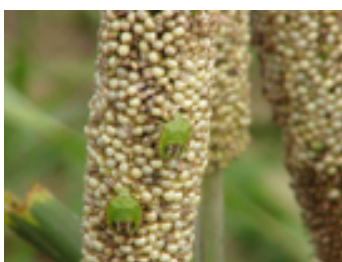


Figure 19: Adults head bugs

Source: University of Georgia extension-Bulletin 1283

Management: Destroy affected parts at the beginning of the infestation. Spray with chlorpyrifos or carbaryl 50 WP base insecticide.

3.2.3 Aphids (*Rhopalosiphum mayidis*)

They are small, long, soft-bodied dark green to bluish-green in colour with two long antennae and live in colonies. Colonies are found on the central whorl or the entire leaf surface (Figure 20). Causes yellowing of the leaves due to excessive sucking, in dry conditions they suck sap from plants until it dies. Aphids release sweet honey dew which allows black sooty mould fungus to grow over it and honey dew is also fed by ants.



Figure 20: Heavy infestation cause leaf yellowing

Photo source: ICRISAT

3.2.4 Root Aphid (*Tetraneura nigriabdominalis*)

They stay above the soil line and are not easily seen. They are slightly smaller than the stem and leaf aphids, they have shorter legs and antennae (Figure 21). They are identified by white waxy material secreted. Damage caused by the root aphids results in wilting and drying of the plants in patches. Black ants can be used as an indicator of the presence of the root aphids.



Figure 20: Heavy infestation cause leaf yellowing

Photo source: ICRISAT

Management: Keep the field clean from alternate hosts such as milkweed. Observe correct planting space to avoid high plant density. Maintain flowering hedge of *Lantana camara* around the farm to enhance conservation of natural enemies. Spray with biopesticides such as Neem based product “Achook”. Seed dress with Thiamethoxam (Cruiser), Imidacloprid (Gaucho) based products. Spray with Acetamiprid, Lambda cyhalothrin Pentagon and deltamethrin Apm, all at a rate of 10-15 20ml /L of water to control aphids.

3.2.5 Millet stem borer (*Coniesta ignefusalis*)

Stem borers are a major pest of millet though not reported as a pest in East African region. The caterpillars of this moth tunnel into the stems causing them to fall over (lodging), ‘dead hearts’ and poor grain development (Figure 22).



Figure 20: Heavy infestation cause leaf yellowing

Management: Use resistant varieties if locally available. Plant early, with the first rains. Intercrop millet with crops such as, cowpeas, beans and pigeon peas.

Destroy crop residues after harvest. Use ‘push-pull’ method against stem borers by intercropping cowpea or dolichos with millet to act as a repellent that ‘pushes’ the pest away from the millet. Around the border of the field, plant a trap crop such as *Brachiaria* or Sudan grass to attract or ‘pull’ the stem borer moths away from the millet.

3.3 Bird control

Various methods are used to control millet grain damage by birds. Chase away birds from damaging millet. Use scare crows or sound bells.



Serinus reichenowi *Plocepasser mahali* *Amadina fasciata* *Quelea quelea* *Streptopelia capicola*

Figure 23: Common bird species that attack millets

In some cases, millets may be harvested early, followed by sun drying for 2-3 weeks to save crop from damage by birds, and the possibility of Aflatoxin contamination (Figure 24).



Figure 24: Drying and winnowing processes

Source: Mutisya, KALRO

3.4 Major Weeds Affecting Millet

3.4.1 Couch grass or Bermuda grass (*Cynodon dactylon*)

It is a spreading perennial grass with vigorous mat-forming stolons. It reproduces and spreads by rhizomes but it is also propagated by seed. Couch grass and other species of *Cynodon* are common in East Africa and are troublesome as a weed of arable land and perennial crops (Figure 25).

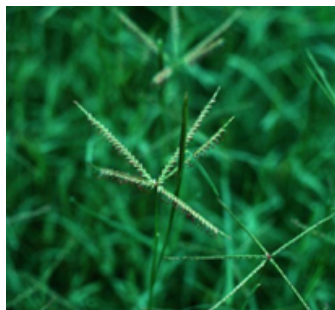


Figure 25: Couch grass infestation in soybean

Source: Charles T. Bryson, USDA

3.4.2 Purple witchweed (*Striga* spp)

The weeds grow on roots of millet and obtain nutrients from the host plant (Figure 26). A single weed plant produces many thousands of tiny seeds that survive in the soil for a long period. The problem is more serious in areas with low soil fertility and rainfall.



Figure 25: Couch grass infestation in soybean

Source: Charles T. Bryson, USDA

Management: Plough or harrow deeply during dry season to ensure the weeds are buried deep. Germination is halted or delayed and rhizomes are exposed to direct sunlight. Practise hand weeding to remove weeds before flowering. Rotate millet with trap crops such as sunflower, pulses and cotton that stimulate the germination of striga seeds, but inhibits post-germination growth of the weed. Intercrop millet with legumes such as green grams. Rotate millet with broad-leaved crop to smother the weeds. Apply selective herbicide 7-10 days after planting such as Satunil 60 EC, Garil EC, Sanaphen DSL (2, 4-D Dimethyl 1-2 days after application). Perennial weeds can be controlled using systemic glyphosate-based products such as Round-up, glycel, weedal 480SL Touchdown forte 500 SL, Erase 480 SL before planting millet.

4 HARVESTING AND POST HARVEST MANAGEMENT

4.1 Harvesting

Millet grains should be harvested as soon as they are physiologically mature. Late harvesting may lead to lodging leading to losses and grain deterioration due to rapid changes in temperature and humidity. In hand harvesting the panicle is cut from the standing stalk at about 16-20% moisture content and the stalks are used as animal feed. The panicles should be kept off the soil on raised platforms, mats, or trays while drying for threshing.

Millet can be threshed by beating the panicles with sticks or using manual or mechanised threshers. After the grain has been threshed, it must be dried again to a moisture content of 13% or less. The threshed grain should be dried on plastic tarpaulins, mats, plastic sheets or wire mesh trays raised on a platform. Spread the grain thinly on the drying surface to allow air to pass through it and turn the grain regularly to avoid overheating. Protect the grain from rain, insects, animals and dirt.

The dryness of the grain can be tested before threshing using:

- Teeth (the grains are brittle when bitten) or pinching with the fingers (Figure 26).
- Salt testing: Dry salt is put into a dry glass bottle and the grain added then shaken. After some minutes if the salt sticks to the sides of the bottle, then the grain moisture content is above 15% but if salt does not stick then the grain has the correct moisture content (Table 4)
- Moisture metre (Figure 27)

The dryness of the grain can be tested before threshing using teeth (the grains are brittle when bitten) or pinching with the fingers (Figure 26).

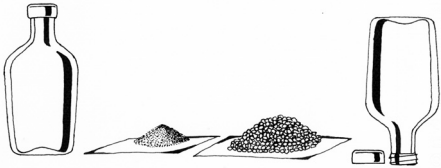




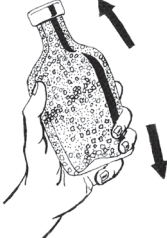
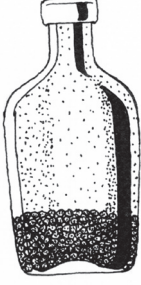
Figure 26: Checking when the grains are dry for threshing, using teeth or pinching with fingers

A more objective approach is to use the ‘salt method’ (Table 2). Dry salt will absorb moisture from grain. This principle can be used to help determine whether a grain sample has moisture content of above or below 15%.

The salt must first be dried by spreading it out on some plastic sheeting in the hot sun and leaving it for at least 3 - 4 hours until it is hard. It should be turned at intervals during this time. It can also be dried in an oven. The dry salt should be placed in a sealed container until it is ready for use.

Table 2: The ‘salt method’ of checking grain moisture

	<p>Materials required:</p> <ul style="list-style-type: none"> - A clean dry glass bottle of about 750 ml capacity, with a cap that makes it airtight - Some common salt - 250-350 g of the grain to be tested
	<ul style="list-style-type: none"> - Take one sample (a handful is enough) from the middle of each bag of sorghum grain. It is best to remove a sample using a special instrument called a sampling spear
	<ul style="list-style-type: none"> - Make sure that the jar you are using is clean and completely dry - Fill one third of the dry bottle with the grain sample (250-300g) - Add the salt in the jar (enough salt to fill up a quarter of the jar) - Close the bottle tightly with its cap

	<ul style="list-style-type: none"> - Shake the bottle vigorously for 1 minute to mix the salt and grain - Allow the grain to settle for about 15 minutes
	<ul style="list-style-type: none"> - If after 15 minutes the salt sticks to the side of the bottle then the moisture content of the grain is above about 15% and so is not safe for storage - If the salt does not stick to the bottle then the moisture content is below 15% and so is safe for storage

Moisture meters are electronic and operate on dry cells or electricity to check for moisture (Figure 27). The meters are quick, portable, simple to use and fairly accurate. The meters are expensive for smallholder farmers, and would normally be used at warehouses and by farmers' groups that handle a lot of grain. However, extension staff have been provided with the meters to help farmers determine if safe moisture content ($\leq 13\%$) is achieved before storage. A sample size of about 150 grams of the grains is scooped with a hand and poured into the moisture meter then closed. The device is given a few seconds to do the detection of moisture and temperature. The digital electronic machines will display the readings on the screen once the detection is over. The recommended grain moisture should be 13% or below.



Figure 27: Dickey-John multi-grain tester to detect moisture content in grains
(Source: www.ruralking.com)

Dry grains are winnowed and sorted to remove chaff, dust, foreign matter such as stones, broken, shrivelled, mouldy, insect damaged, rotten, discoloured or faded grains and any remaining plant parts, leaves and stalks to improve the quality (Figure 28).



Figure 28: Millet winnowing

4.2 Storage

Millet grain should be sun-dried to the recommended moisture content of 12-13 % and dusted with actellic gold. The grain is then kept in either metal or plastic containers. If 90 kg sisal bags are used, they should be kept in a cool, dry and well-ventilated place. If grain is kept for more than 90 days especially in hot areas, a second dusting is recommended after 3 months.

4.3 Processing and Utilization

Millet is a high-energy, nutritious cereal (Table 3). It is particularly recommended for children, lactating mothers, convalescents and the elderly. Some of the healthy benefits of millet includes; prevention of certain types of cancer, help control diabetes, offer a dietary option for people with Celiac disease, improve digestive health, build strong bones, promote red blood cell development, and boost energy and fuel production. Pearl millet is traditionally used for making a variety of foods including thin porridge, “Ugali” and local brew.

Table 3: Nutritional value of Pearl millet

Basic components	Amount
Proteins	22g
Ash	6.5g
Calories	
Total calories	756
Calories from carbohydrates	600
Calories from fats	71
Calories from Proteins	85.3
Carbohydrates	
Total carbohydrates	146
Dietary fibre	17g
Fats and Fatty Acids	
Total fats	8.4g
Saturated Fat	1.4g
Monounsaturated Fat	1.5g
Polyunsaturated Fat	4.3g
Omega-3 Fatty Acids	236mg
Omega-6 Fatty Acids	4g
Vitamins	
Vitamin E	100mcg
Vitamin K	1.8 mcg
Thiamin	842 mcg
Riboflavin	580 mcg
Niacin	9.4 mg
Vitamin B6	768 mcg
Folate	170 mcg
Pantothenic Acid	1.7 mg
Minerals	
Calcium	16 mg
Iron	6 mg
Magnesium	228 mg
Phosphorus	570 mg
Potassium	390 mg
Sodium	10 mg
Zinc	3.4 mg
Copper	1.5 mg
Manganese	3.3 mg
Selenium	5.4 mcg

4.4 Storage Diseases, Symptoms and Control Strategies

Fusarium and aspergillus remain a key challenge to storage of millet. To curb these infections, optimal moisture content should be observed during drying. Moisture content of 13% is usually recommended before storage.

5 TAKE HOME MESSAGES

The main points to remember in millet production and crop protection are:

1. Plant clean certified seeds to prevent seed-borne diseases
2. Ensure timely land preparation and timely planting to take advantage of rain and control diseases
3. Accurate and timely disease identification is critical to undertake correct management decisions in urgent cases
4. Use disease free planting materials from reliable dealers
5. Uproot and destroy severely infected plants by burning
6. Maintain a weed free field to reduce competition and alternative hosts for diseases
7. Scout your fields regularly to identify problems before they get out of control
8. Prevent and control of pest and diseases in all stages to minimize loss (quantity and quality)
9. Only use pesticides if the physical and cultural control methods are not working

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4. Pigeon Pea Extension Manual
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