

**Kenya Wheat Production  
Handbook  
2016**

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**Kenya Agricultural and Livestock Research Organization, KALRO  
Secretariat**

**PO Box 57811-00200**

**Nairobi, KENYA**

**Email:** [directorgeneral@kalro.org](mailto:directorgeneral@kalro.org)

**Tel No(s):** +0709104000-60

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# FOREWORD

Wheat is the second most important cereal in Kenya after maize and contributes substantially to food security, poverty reduction and employment creation. The national demand for wheat and wheat products is on the increase, partly due to the high population growth, increased urbanization, and related changing trends in food consumption patterns. However, the local wheat production has not been able to meet this demand leading to importation of large quantities to plug the gap between supply and demand. This gap is as a result of challenges and constraints faced by farmers and other players along the wheat value chain that include diseases, pests, inadequate seed systems, poor soil and water management practices, low levels of knowledge and information on new and improved varieties, as well as physical and institutional bottlenecks in the marketing chain.

The Kenya Agricultural and Livestock Research Organization (KALRO), Food Crops Research Centre, Njoro has the national mandate to generate technologies, knowledge and innovations that address farmers' constraints to wheat production. As result, KALRO Njoro, through the support of the government and other development partners has developed technologies that can move wheat production from subsistence to commercialization.

The crop protection recommendations in this book were influenced more by the market dynamics, farmers' feedback, and to a lesser extent by field performance trials. This necessitated the use of trade names of chemicals rather than the active ingredients in order to enable farmers to recognize the chemicals in the market. The omission of some trade names from our associated chemical companies is not by design; the list provided is not exhaustive but a guide.

The purpose of compiling this information is to positively influence the production of wheat in Kenya by providing a compact reference of vital information for farmers and other stakeholders in the wheat value chain and to disseminate the outcomes of research. It is also an effort to share evidence of government and donor investments in wheat research and to impact livelihoods on a wider scale beyond where the trials were undertaken.

I would like to recognize the contributions made by the farmers we interacted with during technology development as well as the chemical companies for their input in the testing process of their products.

We are certain that the technologies outlined in this handbook will enable the wheat farming community and related agro-based industry in Kenya realize positive impacts.



**Felister W. Makini, PhD, OGW**  
**Deputy Director-General, Crops**

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## **Edited by**

Johnson Kamwaga (KALRO, Njoro)

Godwin Macharia (KALRO, Njoro)

Lesley Boyd (NIAB, Agri-Transfer Project Leader)

Tinashe Chiurugwi (NIAB)

Ian Midgley (NIAB)

Claudia Canales (MCSC/CMEDT)

Max Marcheselli (MCSC/CMEDT)

Immaculate Maina (Centre Director, KALRO Njoro)

# Wheat Variety Development

**Macharia G., Otukho B., Ndung'u J.**

### Background

The Kenya Agricultural and Livestock Research Organization has developed bread wheat varieties (hereafter wheat varieties) for various stresses and quality in a period spanning over 85 years. During this period, 180 wheat varieties have been released to farmers for use. The goal has been to contribute to enhanced food security as well as economic development at the farm, community, and national levels. Through strategic partnerships, the goal of the wheat breeding programme extends to regional and global frontiers.

Overtime, the breeding objectives that guide the long term research agenda included high and stable yields, tolerance to biotic and abiotic stresses, such as drought, acid soils, pre-harvest sprouting, diseases (especially stem and yellow rusts) and insect pests. The quality aspects considered were protein content, grain density and flour and baking qualities. The varieties obtained with each of these qualities are available for growth in various agro climatic zones of the country. Some notable varieties with special attributes that farmers look for are discussed under the sub topics that follow.

### High Yields

Among the high yielding wheat varieties that are products of this long term research are Kenya Wren and Kenya Korongo with a yield potential of 8.5 tons/ha. Robin variety with a yield potential of 8.1 tons/ha, Kenya Hawk12 and Njoro BW2 varieties both with 8 tons/ha yield potential. Other wheat varieties such as Kenya Tai, Kenya Sunbird, Eagle10, Kenya Kingbird, Kwale and Duma have average potential ranging from 6 to 7.5 tons/ha.

## Abiotic Stresses

As pointed out earlier, wheat research has produced varieties that are able to withstand abiotic stresses that occur in the country's wheat growing areas. Kenya Wren and Njoro BW2 varieties are tolerant to acidic soils that are prevalent in some wheat zones. Others such as Kenya Hawk12 and Njoro BW2 can withstand lodging and pre-harvest sprouting.

Different varieties have variable maturity periods and moisture requirements. The consequence is that farmers in each wheat growing zones of the country can broadly choose the wheat varieties most suited to their moisture levels based on the earliness of the varieties or tolerance to drought. Variety Robin is widely adapted to many zones because it is moderately early in maturing while variety Duma is predominantly grown in drier areas because it is drought tolerant. Eagle10 and Kenya Kingbird varieties are basically early maturing and thus are suitable candidate varieties for wheat growing zones with short rainy seasons or as second crops.

## Disease Resistance

Although disease resistance or tolerance remain a driving goal of the KALRO Wheat Research programme, it is still a big challenge for the varieties already released. However, some of the varieties have resistance to common wheat diseases in the country and region. Kenya Wren, Kenya Tai, Kenya Sunbird, Kenya Wren, Eagle10 and Kenya Kingbird varieties are moderately resistant to stem rust depending on season and location of cultivation. The Kenya Kingbird variety has been identified to possess excellent resistance to both stem rust and yellow rust and is therefore a popular parental line in breeding for rust diseases. Because of the recent emergence of new stem rust races e.g. Ug99 and related races, an integrated disease management programme that also includes appropriate cultural and chemical interventions (chapter 4) is highly recommended, so as to reap the full potential of the varieties.

## Baking Quality

The quality of wheat is determined by the baking quality of the flour it produces. Wheat breeding in the country has resulted in wheat varieties that have varying flour and baking qualities. Farmers may need to consider these parameters as they decide on the varieties of wheat to commercially produce because this determines the market of their end product. Duma, Kwale, Kenya Wren, Kenya Kingbird, Kenya Hawk12, Kenya



Sunbird and Robin are good for both industrial and home baking, making these varieties vital candidates for choice by farmers whose main market is the flour millers. The Kenya Korongo variety is outstanding for baking and confectionery qualities giving it a special place for niche farmers who may want to grow for the high end market for a premium price.

Suffice to say, most Kenyan wheats have good milling qualities (in group II and III) but farmers are advised to pay attention to wheats baking qualities the millers prefer if they have to produce for the market.

Table 1 provides details of the various wheat varieties developed and released by KALRO and currently in commercial wheat production.

**Table 1: List of some of the commercially popular varieties showing their estimated average yield, best suited altitude, rust resistance, protein content, grain density, colour, market wheat grain grouping and year of release.**

Commercial name	Altitude (masl)	Yield potential (tons/Ha)	Wheat group*	Maturity period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Kenya Wren</b>	1800-2400 (Njoro, Timau, Mau-Narok, Moio)	8.5	3	120-130	14	Over 78	2012	<ul style="list-style-type: none"> <li>Moderate resistance to yellow and stem rust</li> <li>Tolerant to acidic soils</li> <li>Large red hard grain</li> <li>Good for industrial and home baking</li> <li>Excellent flour conversion</li> </ul>	50kg/acre	May grow tall under high Nitrogen application  Two or more fungicide applications needed depending on seasonal rust disease pressure

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturation period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Robin</b>	1800-2700 (Njoro, Timau Mau-Narok, Molo, Narok, El-doret)	8.1	3	110-120	14.5	Over 78	2009	<ul style="list-style-type: none"> <li>• Widely adapted and relatively early maturing</li> <li>• Large red hard grain</li> <li>• Good milling and baking qualities</li> </ul>	50kg/acre	Two and often several fungicide applications needed due to its high susceptibility to stem rust and Fusarium Head Blight especially under minimum tillage

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturity period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Kenya Tai</b>	1800-2100  (Njoro, Ti-mau, Mau Narok, Narok, Molo, Eldoret)	6.5	3	100-110	14	Over 78	2012	<ul style="list-style-type: none"> <li>Moderately resistant to stem rust</li> <li>Red hard grain</li> <li>Heavy biomass hence An excellent source of straw for livestock feed</li> </ul>	50kg/acre	One or more fungicide applications needed depending on seasonal rust disease pressure

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturity period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Kenya Sunbird</b>	1800-2100  (Njoro, Ti-mau, Mau Narok, Narok, Molo, Eldoret)	6.5	2	100-110	12.5	Over 78	2012	<ul style="list-style-type: none"> <li>• Moderately resistant to stem rust</li> <li>• Heavy biomass hence an excellent source of straw for livestock feed</li> <li>• Good for industrial and home baking</li> </ul>	50kg/acre	May succumb to yellow rust under high pressure.  One or more fungicide applications needed depending on seasonal rust disease pressure

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturation period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Eagle10</b>	1800-2100 (Njoro, Rongai, Lower Narok, Kinamba, Naivasha)	6.5	3	100-110	14.5	Over 78	2010	<ul style="list-style-type: none"> <li>• Resistant to stem rust</li> <li>• Early maturing</li> <li>• Good for industrial and home baking</li> </ul>	50kg/acre	Suitable for short rain and drought prone areas. A good choice for a second crop.  One or more fungicide applications needed depending on seasonal rust disease pressure

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturity period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Kenya Korongo</b>	2100-2400 (Njoro, Timau, Mau-Mau, Narok, upper Narok, Molo, Eldoret)	8.5	2	120-130	12.5	Over 78	2012	<ul style="list-style-type: none"> <li>• White hard grain</li> <li>• Very high flour conversion</li> <li>• Excellent baking and confectionery qualities.</li> </ul>	50kg/acre	White grain makes it very good for home baking (Chapatti)  Two or more fungicide applications needed depending on seasonal rust disease pressure

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturation period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Kenya Kingbird</b>	1800-2400 (Njoro, Ti-mau, Mau Narok, Lower Narok, Kinamba, Molo)	6.0	2	90-110	12.5	Over 78	2012	<ul style="list-style-type: none"> <li>• High resistance to both stem rust and yellow rust</li> <li>• Early maturing</li> <li>• Good for industrial and home baking</li> </ul>	55kg/acre	A popular parent line in breeding especially for rust diseases



Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturity period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Kenya Hawk12</b>	2100-2400 (Njoro, Timau, Mau Narok, upper Narok, Molo, Eldoret)	8.0	3	120-130	13.5	Over 78	2012	<ul style="list-style-type: none"> <li>• Red hard grain</li> <li>• Lodging and pre-harvest sprouting tolerant</li> <li>• Good for industrial and home baking</li> </ul>	50kg/acre	A good choice for areas that receive rain during harvesting e.g. Mau Narok and Timau  Two or more fungicide applications needed depending on seasonal rust disease pressure

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group*	Maturity period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Njoro BW2</b>	2100-2400  (Njoro, Ti-mau, Mau Narok, upper Narok, Molo, Eldoret)	8.0	2	140-160	14.5	Over 78	2002	<ul style="list-style-type: none"> <li>• High yielding red hard wheat</li> <li>• Tolerant to acid soils, lodging and pre-harvest sprouting</li> <li>• Excellent baking qualities</li> </ul>	45-50kg/acre	A good variety especially under acidic soils prevalent in Uasin Gishu and Molo

Commercial name	Altitude (masl)	Yield potential (tons/ Ha)	Wheat group *	Maturity period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Kwale</b>	2100-2400 (Njoro, Ti-mau, Mau Narok, upper Narok, Molo, Eldoret)	7.5	3	140-160	14	Over 78	1987	<ul style="list-style-type: none"> <li>• Red hard wheat</li> <li>• High biomass</li> <li>• Highly responsive to nitrogen application</li> <li>• Good baking qualities.</li> </ul>	50kg/acre	Also popular for its high test weight. Spraying against stem rust might be required especially under high disease pressure.

Commercial name	Altitude (masl)	Yield potential (tons/Ha)	Wheat group *	Maturation period (days)	Protein content (%)	Hectolitre (kg/hl)	Year of release	Special attributes	Seed rate	Other remarks
<b>Duma</b>	1800-2100 (Njoro, Rongai, Lower Narok, Nainavasha)	6.0	2	100-110	14.5	Over 78	1993	<ul style="list-style-type: none"> <li>• White hard grain</li> <li>• Early maturing</li> <li>• Drought tolerant</li> <li>• Excellent baking quality</li> </ul>	50kg/acre	Susceptible to stem rust under high pressure.  Several spraying might be needed to control stem rust. However, earlier maturity often helps escape disease

\* For Wheat group identity see page 70

Note: *Breeders, basic, and certified seed of above varieties is available through the KALRO Seed Unit-Njoro*

# The Production and Maintenance of Quality Seed Wheat

**Macharia G., Rukwaro G.**

Seed is a primary input in crop production. For seed to play a catalytic role in crop production, it should be accessed by farmers in good quality and quantity. Good quality seed can be defined as seed of an adaptive variety with high varietal species and physical purity, high germination and vigour. The seed should be free from seed-borne pests and diseases and clean, treated and clearly labelled.

The availability, access to and use of quality seed of adaptable wheat varieties are important considerations in increasing wheat production and productivity. Seed quality comprises of many aspects, but four key attributes may be identified:

1. Genetic quality, which is the inherent genetic make-up of the variety contained in the seed, which provides potential for higher yield, better grain quality and better tolerance to abiotic and biotic stresses.
2. Physiological quality, which is the viability, germination and subsequent seedling emergence in the field.
3. Physical quality, which includes freedom from impurity (that is freedom from other crops as well as common and particularly harmful and parasitic weed seeds); seed size; seed weight; and seed lot uniformity.
4. Health quality, which includes the absence of infection or infestation with seed borne diseases and pests.

### **Seed maintenance and multiplication**

The purpose of seed maintenance is to produce new lots of breeder seed with the same genetic composition. It is the task of breeder to maintain the variety once it has been released. For wheat, plants representing the variety are grown in ear-rows and carefully observed. Plants from

selected rows are harvested and grown in small plots; row-plots. Breeder seed is produced from plots with the best wheat crop and highest crop purity. The initial small amount of breeder seed is initially multiplied to produce basic seed which is further multiplied to large quantities of certified seed or commercial seed to satisfy farmers' requirements.

## Steps in Production of Quality Seed

### 1. Selection of adapted varieties

The variety is selected from a list of recommended varieties. Apart from its adaptation, the variety should have high yield potential, tolerance to abiotic and biotic stresses and have good marketability and consumers preferences.

### 2. Selection of seed source

After selecting the variety, the seed for planting should be chosen from a good source. Good quality seed comes from a known source such as from the plant breeder at the agricultural research centre who provide Breeder seed. This class and subsequent classes of seed assures high varietal purity and germinability.

### 3. Selection of production field

The amount of Breeder seed normally used for seed production is of small quantity and hence has to be "increased" in large production fields to achieve the large amounts of "certified" seed that is required by farmers for commercial wheat production. Fields selected to ensure high quality seed production should have the right previous cropping history known to avoid genetic, mechanical and pathological contamination in seed production. Land selected for seed production should be free from varieties of the same crop species for at least one year prior to planting. In wheat seed production, other cereal crops such as oats, barley or rye should be avoided since it will be very difficult to purify by rouging if contaminated with these cereals. The field for seed production should also be free of harmful weeds and seed/soil borne diseases.

### 4. Land and seedbed preparation

Proper and timely tillage preparations are necessary to improve the soil moisture conservation and physical properties. It also reduces weed and volunteer plant population, reduces disease and pest inocula; and enhances germination, emergence and establishment.

## **5. Sowing date, sowing rate and method**

The time of sowing depends on the variety and area of adaptation. A seed crop must be planted at its recommended time. Late planting is not recommended. The optimum seed rates may vary with crop, variety, location and method of planting. The recommended seed rate should be used when a crop is sown at normal time to achieve the right plant population for adequate competition with weeds and for better yields.

## **6. Weed control**

In seed production, contamination of the seed crop with other crops or weed seeds of similar physical characteristics must be reduced to the minimum.

## **7. Harvesting and Transporting seed**

It is critical that harvesting is done when the crop is dry enough and to avoid rainy days. Harvesting machinery should be thoroughly cleaned and checked for any potential contaminants. Moreover, harvested material should be placed in appropriate clean bags, labelled accordingly and immediately transported to the processing yard to avoid deterioration. Transporting seed should ideally be done in water-proof but well aerated containers, and preferably seed for each variety transported separately to minimize unnecessary mixing.

## **8. Seed processing**

Seed requires processing; the seed is dried, cleaned, graded, sized, treated with pesticides and finally packaged (see figure 1). Seed processing is the most capital intensive because it involves the use of various sophisticated equipment and often expensive seed dressing chemicals.

## **Seed quality control**

The Kenya Plant Health Inspectorate Services (KEPHIS) inspects the seed crop at most stages to ensure high quality seed. Seed quality parameters includes purity, germination, health, weed seed content, moisture content, and characteristics.

## **Seed certification**

Seed certification ensures that the seed sold to farmers conforms to the indicated variety. It should also be sufficiently pure, of good germination capacity and disease free.

Seed certification involves the following steps:

*Field inspections* - to verify seed source, varietal identity, previous cropping, isolation distance, impurities and diseases. It is done by an inspector from KEPHIS during the various stages of growth of the crop.

*Seed inspection* - done at the processing plant and in the seed store. Seed samples are taken and tested at the seed testing laboratory.

*Pre-control and post control plots* - these are carried out by the seed certification agency (KEPHIS) on its farm to allow further verification of varietal identity, varietal purity, and absence of seed borne diseases. Pre-control plots are grown in the same season as the seed crop and results are used for certification. Post-control plots are grown from seed that is already certified and function as checks on the effectiveness of field inspection.



*Fig. 1: Processed seed wheat ready for sale*



# Wheat Crop Management

**Kamwaga J., Ooro P., Lang'at P., Amadi D., Mbanda G.**

### Land Preparation

Wheat production in Kenya is mainly rain fed. Therefore timing of operations is very critical for a successful harvest. Wheat is widely grown in the highland areas such as Timau, Uasin Gishu, Mau Narok and Nakuru where the cooler temperatures allow for longer periods of starch accumulation leading to high yields. However, production has moved to more fragile marginal environments such as lower Narok and Mweiga among others where moisture and soil conservation become critical for a sustainable cropping system. In most of these areas the crop is likely to experience moisture stress at some stage and hence the need to conserve as much moisture as possible before and after planting. Recommended tillage operations aim to kill weeds, increase soil aeration, improve water infiltration and generally provide a suitable environment for seedling development and emergence. The tillage system adopted will depend on many factors including soil type, soil condition, elevation and weed situation among others.

### Seedbed Preparation on old or stubble land

Land preparation for stubble land should begin 1-2 months after harvesting. Early land preparation not only improves moisture conservation, but also controls weeds better. To maximize on moisture conservation, farmers should keep their fields relatively weed free to reduce water loss through evapotranspiration. This can be achieved by use of total weed killers such as glyphosate and paraquat that have become relatively more affordable in recent times. Shallow cultivation using a light harrow will encourage weed growth after which the non-selective herbicides are used to control the weeds.

On old land, use of conservation agriculture techniques are encouraged since they enhance both soil and water conservation. In this regard the use of the chisel plough has been proved superior to that of the disc plough in terms of soil and water conservation and even in the cost of operation. One major advantage of the chisel plough is that it loosens the

soil while leaving most of crop residues on the surface. This improves water infiltration and retention thus improving yields, even when precipitation is low. Other minimum tillage systems have advantages over conventional tillage systems due to their lower costs. Currently, conservation tillage systems such as no-till are becoming popular due to concerns over environmental degradation. This is made possible by availability of zero-till planters that are able to seed on undisturbed soil surfaces. Also, recommended herbicide combinations that kill weeds before planting are now more affordable and effective. One harrow operation may be necessary prior to planting.

The use of the conventional tillage system involving the use of a disc plough and disc harrow is still common with small scale farmers despite its major disadvantages. This is mainly due to lack of specialized implements such as the chisel plough. In its most widely used form, the system involves one disc ploughing as the primary operation and two disc harrows (see figure 2), before planting. Continuous use of this system leads to soil compaction, poor soil structure, low soil water infiltration and poor weed control. Regardless of the system used, a fine seed bed should be the ultimate aim to ensure proper placement of the seed in the soil.



*Fig. 2: Disc harrowing*

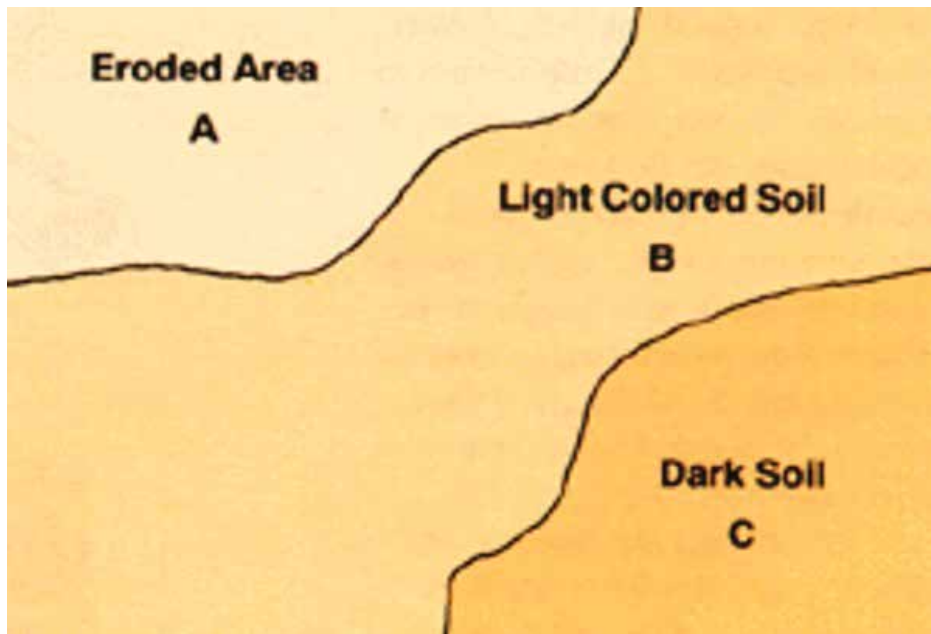
## **Seedbed preparation on new or virgin Land**

On virgin land, ploughing should start 4-6 months before expected time of planting. In most cases, it is necessary to use either a disc or mouldboard plough as the primary tillage operation. This may be followed by two harrows before planting. Farmers have adapted this system to include the use of non-selective herbicides to kill vegetation before the ploughing operation and this results in better weed control and higher yields.

On lighter soils, the chisel plough can effectively be used as the primary operation. Farmers should then keep their land relatively weed free to increase moisture conservation. This is achieved through use of non-selective weed killers that suppress weeds between the initial primary operation and the final operation prior to planting. The final operation before planting is more commonly disc harrowing. Early seedbed preparation conserves more soil moisture and is recommended for marginal areas with low and erratic rainfall.

## **Soil Sampling**

Before using a fertilizer, the farmer should have the soil tested to determine its fertility status. The soil test results form the basis of the fertilizer recommendations. The soil test results are as good as the soil sampling itself. Soil sampling should be done before land preparation. Sampling is done randomly and should be representative of the farm. The example in figure 3 shows a farm with three distinct soil types. In order to get a representative sample of soil from the farm, soil samples should be taken separately for each soil type. Analysis will also be done separately for each soil type. Take five sub-samples per acre. Bulk the samples and send them to a soil analysis laboratory where the nutrient status of the soil will be assessed.



*Fig. 3: Land with three distinct soil types*

Fertilizer recommendations are based on the nutrient status of the soil. For more assistance in soil sampling and testing, farmers are advised to contact the nearest KALRO centre or agriculture extension office. See Appendix 3 for more information.

## **Fertilizer and Fertilization**

### **Nitrogen and phosphate requirements**

Most soils in Kenya are classified as nitrogen (N) and phosphorous (P) deficient. Phosphorous is very critical in wheat production, more so because it does not freely move in soil. Applied phosphorous is also highly fixed by other soil components making it unavailable to plants. Because of its inability to move freely, phosphorous is normally applied with the seed at planting. Nitrogen on the other hand, freely moves in soil and when applied as a top dressing, it is easily taken up by the crop. Some of the nitrogen may be leached to lower levels of the soil below plant root depth. Wheat responds well to the use of fertilizers containing these two nutrients.

Application of fertilizers in optimum quantities is essential in boosting yields. These nutrients are needed in relatively large quantities by plants, and fertilizers containing the two nutrients are available on the market. However, soil reaction, soil organic matter content, and concentration of other mineral elements, cultural operations, soil moisture, fertilizer schedule and cropping pattern influence the availability to and response of wheat to these nutrients. As pointed out earlier, farmers are advised to have their soils analysed to obtain the right recommendations as to the type and amount of fertilizer to be used.

With continuous use of land for crop production other nutrients such as potassium (K) which were earlier deemed sufficient in Kenyan soils may become limiting and soils developed from volcanic rock in the Rift Valley have already been identified as deficient or having marginal levels of potassium. Previous land use is utilized as a guide on the use of nitrogen and phosphate fertilizer for wheat (Table 2).

**Table 2: Fertilizer recommendation for wheat**

Land category	Fertilizer type	Recommended rate (kg/ha)	Nutrient kg/ha	
			N	P <sub>2</sub> O <sub>5</sub>
New land	11:52:0		14	68
	(N:P:K)			
2 <sup>nd</sup> year crop	DAP	130	23	60
3 <sup>rd</sup> year crop	DAP	109	19	50
4 <sup>th</sup> year crop	DAP	87	16	40
Over 4 years	20:20:0	200	40	40
	(N:P:K)			

Legend: N- nitrogen, P- phosphorous, K- potassium, DAP - Diammonium phosphate.

Where specific fertilizer recommendations are not available, Diammonium phosphate (DAP) is widely used at the rate of 130 kg/ha. In most cases this has proved adequate but if the crop emergence and establishment is good, top dressing with urea at 75 kg/ha at tillering stage is beneficial and improves yield and quality. Other formulations of fertilizers are available on the market and farmers should seek advice from extension or research officers on their use.

Traditionally, wheat is sown using a seed drill as seen in figure 4. In

small-scale farms, wheat can be sown successfully by broadcasting the seed and fertilizer and covering with a light harrow as a final operation. Higher seed and fertilizer rates are required for a good crop stand (1.5 bags of 50kg of certified seed and 1.5 bags of 50kg DAP per acre).



*Fig. 4: A Seed drill*

### **Seed rate and seeding**

The seed rate used should aim to have the ideal plant population per unit area of land. Low seed rate results in a poor crop stand which may lead to more weed competition and subsequent lower yields. Higher seed rates may lead to lodging, more competition between plants leading to shrivelled grain and overall higher seed costs. Recommended seed rate is based on 100% germination and tillering ability of the varieties.

If germination is lower, based on seed germination test, the seed rate should be adjusted upwards. Generally, a seed rate of 125 kg per hectare is recommended for most varieties although adjustments could be made depending on germination rate, the condition of the seedbed and the tillering ability of the variety.

To guarantee an ideal plant population on the farm, the farmer should calibrate the seed drill so that it delivers seed and fertilizer at the correct

rates. Seeding depth is another important determinant of plant population. Seeding should be to a depth of 2-3 cm into moist soil. Deeper seeding may result in poor seedling emergence with the seedling failing to reach the surface while shallow seeding may also lead to lower crop stands, especially if planting is done in dry conditions.

The time of seeding is most dependent on rain patterns of the wheat growing areas. In areas where there is a distinct bimodal rainfall, such as Timau, farmers can plant two crops in a year in the months of March and October. Though the time of seeding varies for different wheat areas, it is important that wheat is planted into moist and not wet soil because poor aeration may reduce germination and emergence. Dry planting of wheat is also discouraged because there may be enough moisture to germinate the seed but if there is a dry spell thereafter, the seedlings will die. Another important factor is to programme the planting so that the crop matures during dry weather to avoid losses associated with harvesting in wet weather. Tentative planting dates for different wheat growing areas are shown in table 3. It is important to point out changing weather patterns may determine the actual planting dates.

**Table 3: Tentative planting dates for some wheat growing areas**

<b>County</b>	<b>Location</b>	<b>Planting time</b>
<b>Nakuru</b>	Njoro	April-May
	Mau Narok	June-August
	Molo	June-July
	Bahati	April-May
<b>Narok</b>	Lower Narok	February-March
	Upper Narok	June-August
<b>Uasin Gishu</b>	Moiben	April-May
<b>Meru</b>	Timau	February-March-
		1st Season
		September-October-
		2nd Season

## Weed Control

Weeds are plants, which grow where they are unwanted. They are often prolific and persistent, interfere with agricultural operations, increase labour costs and reduce crop yields. For successful control of weeds one has to consider the following:

1. Life cycle of the weeds
  - To control annual weeds and check their seed formation one needs to identify the weeds and to know their life cycles.
  - Preventing seed formation may also control biennials.
  - To control perennial weeds, spread or re-infestation should be checked and existing stand of established weeds must be eradicated.
2. Knowledge regarding the nature of the weed should be applied during control, e.g. while selecting a weed control method, one has to consider the number of viable seeds produced, adaptation, and mode of seed dispersal and dormancy of the seeds.

In order to reduce the risk of Brome grass and Rye grass in high altitude areas, as well as Setaria in medium altitudes, the following methods of weed control are recommended:

- Use clean seeds.
- Make sure all the weed seeds are removed from the seed.
- Avoid feeding livestock with fodder containing viable weed seeds.
- Avoid allowing cattle to move from weed-infested areas to clean or cultivated areas.

Clean all farm implements and machines properly after use on areas infested with noxious weeds and before using in clean areas.

## Chemical Control Methods

A suitable herbicide can only be chosen if the weeds are correctly identified, see table 4 and figure 6. Farmers should identify the weeds predominant in their farms so that they buy the right herbicide to control the weeds.

- Pre-emergent herbicides: these are applied before or at planting before crop emergence.
- Post-emergent herbicides: should be applied at 4-6 leaf stages of wheat. Some of these kill the weeds, while others check their growth and reduce the number of weeds to a



minimum so that they do not affect crop yields.

Herbicides are classified as:

- Non-selective: these will kill all plants.
- Selective: Some will kill broad leaf weeds only and some grass weeds only. However there are some that will control both grass and broad leaf weeds but leave the crop unaffected (Table 5). The choice of the herbicide and rate will be based on the weeds and the stages of growth of the crop and the weed. The farmer should read the application guidelines of any herbicide carefully to avoid injury to self or crop.

**Table 4: Some common weeds found in wheat fields in Kenya**

<b>English Name</b>	<b>Scientific Name</b>
Black bindweed	<i>Polygonum convolvulus</i>
Blackjack	<i>Bidens pilosa</i>
Chinese lantern	<i>Nicandra physalodes</i>
Cleavers	<i>Galium spurium</i>
Devils Thorn	<i>Datura sp.</i>
Double thorn	<i>Oxygonum sinuatum</i>
Gallant soldier	<i>Galinsonga parviflora</i>
Knotweed	<i>Polygonum aviculare</i>
Chickweed	<i>Chenopodium album</i>
Shepherd's purse	<i>Capsela bursa pastoris</i>
Wild gooseberry	<i>Physalis ixorcarpa</i>
Mallow	<i>Malva verticilatta</i>

Mexican marigold

*Tagetes minuta*

Black nightshade

*Solanum nigrum*

Pigweed

*Amaranthus hybridus*

Mustards

*Brassica napus.*, *B. Campestris*,  
*Raphanus raphanistrum*

Brome grass

*Bromus sterilis*

Setaria

*Setaria Verticillatta*, *Setaria pumila*

Wild oats

*Avena fatua*

Wild finger millet

*Eleusine indica*

---



(a) *Cleavers*



(d) *Amaranthus*



*(b) Chickweed*



*(e) Brome grass*



*(c) Double thorn*



*(f) Rye grass*



*(g) Wild oats*

*Fig.6: Some of the common weeds on wheat farms*

**Table 5: Some of the commonly used herbicides for control of broad leaf and grass weeds in wheat production**

<b>Herbicide trade name</b>	<b>Uses</b>
Ariane	For the control of broad leaved weeds in cereals.
Axial 045 EC	Post-emergent herbicide for the control of annual grasses in wheat & barley.
Badge EC	Post-emergence herbicide for the control of broad-leaved weeds in wheat.
Buctril MC	Post-emergence herbicide for the control of broad-leaved weeds in wheat.
Cobra 75WG	Pre and post emergence herbicide for the control of broad-leaved weeds & some grasses in wheat.
Fagilia SL	A non-selective post emergence herbicide for the control of annual and perennial weeds in pastures, zero- minimum tillage.
Glyphogan 360 SL	A non-selective post emergence herbicide for the control of broad leaf weeds and grasses.
Kausha 480 SL	A post emergence, non-selective herbicide for the control of grasses and broad leaved weeds in non-cropped areas.
Touchdown FORTE 500 SL	A non-selective post emergence herbicide for the control of annual perennial grasses and broadleaf weeds, used in no-tillage production in wheat.
Herbikill	A non-selective post emergence herbicide to control annual and perennial weeds in conservation tillage systems.
Hussar Evolution	A selective post emergence herbicide for the control of grasses and broad leaf weeds in wheat.
Hussar WG	A selective post-emergence herbicide for the control of annual grasses and broadleaf weeds in barley and wheat.

Herbicide trade name	Uses
Image	Herbicide for the control of broad leaved weeds in wheat and barley.
Kiboko Super	A selective post-emergence herbicide for the control of annual grass weeds in wheat.
Murphamine	A pre-emergence & post emergence herbicide for the control of annual & perennial broad leaved weeds in maize.
Topik	Herbicide for control of annual grasses, like <i>Setaria sp</i> , <i>Avena sp</i> , Eleusine and rye grass in wheat.
Ralon super	Very effective on grass weeds especially <i>setaria sp</i> .
Traxos	For the control of broad leaf weeds in wheat.
Pallas	Targets annual grass weeds specifically <i>Setaria pumila</i> , <i>Lolium temulentum</i> , and <i>Bromus pectinatus</i> .

Note:

- (i) Always read the labels for safe use of pest control products.
- (ii) That the list above is not exhaustive and only serves as a guide.
- (iii) Proper application in terms of dose, spray volume and timing is emphasized as per the label.

## Special Problems

### (a) Acid soils

Large areas of Kenyan wheat growing areas have acidic soils, with pH of less than 5.0. In Kenya, these soils are found in Molo, Olenguruone, Elgeyo border, Kaptagat and Moiben. Nutrient availability, especially for phosphorous, is highly reduced in these soils. In such areas, farmers are advised to plant acid-tolerant cultivars such as Njoro BW2 and apply agricultural lime at the rate of 5 t/ha after every 5 years or 1 t/ha every year for 5 years. In addition, farmers should avoid burning of wheat remains (stubble) after harvest in order to increase soil organic matter and to reduce soil acidity.

## (b) Copper deficiency in wheat

Copper deficiency is a serious problem in some wheat growing areas of Kenya, see figure 5. Although it is required in small quantities, its deficiency disrupts the reproductive stage of wheat leading to poor seed set and subsequently low yields. Signs of copper deficiency are seen as young leaves turn pale, and finally die after forming whip like tips. The ears of the wheat become yellow while heads become sterile developing few or no grains at all.

Copper deficiencies are more widespread from soils developed from volcanic ash. In Nakuru, areas affected are: Njoro, Rongai, Menengai and Mau Narok. The whole of Narok County is classified as copper deficient. As a remedy, all wheat seed must be dressed with copper oxochloride at the rate 1kg per 100 kg of seed. In addition, a foliar spray of copper oxochloride at 1kg/ha should be applied at the time of herbicide application. It should be noted that some herbicides may not be tank- mixed with copper-containing chemicals. Copper, complexed with organic compounds (chelates) such as Cop-trace is now available on the market and these are used to correct the deficiency.



*Fig. 5: Wheat showing copper deficiency symptoms, note the yellowing spike*

# Wheat Diseases, Symptoms and Control Measures

**Wanyera R., Wanga H.**

Wheat diseases represent a major constraint in almost all wheat growing environments. The most challenging diseases include stem rust, yellow rust and leaf rust. These and other important diseases are described in this section to enable farmers to identify them and use available controls.

### Stem Rust

Stem rust is also known as black stem. It infects leaves, stems, leaf sheaths, glumes (see figure 7 and 8).

### Symptoms

Long red-brown blister-like pustules that tear the upper surface of leaves giving the plant a tattered (torn) appearance. The pustules are longer and larger than those of leaf rust and are also seen on the lower leaf surface.



*Fig. 7: Stem rust on leaves and stems*



*Fig. 8: Stem rust on the heads*

### Yellow Rust

Yellow rust is also known as stripe rust. It infects leaves and ears (see figure 9).

### Symptoms

Yellow rust spores are orange-yellow in colour. They first appear small



and circular and develop into yellow parallel stripes on the upper leaf surface and as yellow powder inside the glumes.



*Fig.9: Yellow rust on leaves*

### **Leaf Rust**

Leaf rust is also known as brown rust. It infects leaves only (see figure 10).

### **Symptoms**

Leaf rust spores are orange-brown in colour. They appear as circular or oval in shape and are mainly scattered on the upper surface of the leaves. The spores are smaller and rounder than those of stem rust and only appear on the upper leaf surface.



*Fig. 10: Leaf rust on wheat*

### **General information for all the three forms of rust**

- All the three rusts are mainly wind-borne. They are not seed or soil-borne, so rotation in the Kenyan situation is not a viable control mechanism.
- Avoid planting very susceptible wheat varieties.
- Use resistant varieties wherever possible (see Table 1 on varieties).
- Remove or destroy volunteer wheat plants that will harbour the rusts.
- Monitor the crop for signs of infection from 60 days or two months after planting.
- Apply foliar fungicides when you see the first signs of any of the rusts, as shown in Table 6.
- Early fungicide application/protection is important when you plant susceptible wheat varieties. Apply at tillering and flowering growth stages, particularly for stem rust.

## Septoria leaf and glume blotch

*Septoria* leaf and glume blotch, also known as *Septoria* diseases, attack the leaves and heads.

### Symptoms

Brown necrotic lesions with black specks (bearing spores) on the leaves (Figure 11 (a)) and heads (Figure 11 (b)). Severe infection of leaf blotch or glume blotch may result in light shrivelled kernels.



Fig.11a: *Septoria* on leaves



Fig.11b: *Septoria* on heads

### Control

- Plant disease free seed.
- Crop rotation with crops like canola and beans.
- Foliar fungicides recommended for control of rust diseases can also prevent infection if applied early.

## Fusarium Head Blight (FHB)

*Fusarium* head blight is also known as scab. It survives in the soil and on wheat stubble as well as on remains of other grass hosts such as maize.

### Symptoms

Symptoms are confined to the head, grain and sometimes on the peduncle (neck), see figure 12.

Bleaching (whitening) of one or more spikelets or whole immature wheat heads. The white heads are sterile or contain shrivelled and or discoloured seeds. White or pink growth is sometimes seen on the bleached heads/spikelets.



*Fig.12: Fusarium head blight*

### **Control**

- Plant resistant varieties.
- Crop rotation, e.g. Canola between wheat crops.
- Apply a foliar fungicide (Prosaro 250 EC) early to prevent infection at flowering.

### **Take All**

Take all is a soil-borne disease. It infects roots, crown and basal part of the stem (see figure 13).

### **Symptoms**

Reduced tillering and slight stunting of the plants. Infected plants are in patches, bleached (white) heads, ripen prematurely, die before seed set and can be easily pulled from the soil.



*Fig.13: Wheat roots affected by Take all*

### **Control**

- Crop rotation with, e.g. Canola between wheat crops.

### **Loose smut**

Loose smut is a seed-borne disease.

## Symptoms

Easily recognised at heading growth stage by appearance of dusty black heads (black spores) in place of grain (see figure 14).



*Fig.14: Loose smut on wheat*

## Control

- Use certified seed.
- Treat seed with recommended seed treatment fungicides such as Vitavax 200FF, Anchor 200FF, Dividend 030 FS.

## Barley Yellow Dwarf Virus (BYDV)

Barley yellow dwarf is a virus disease and infects many plant species including barley, maize and other grasses.

## Symptoms

Dwarfing and yellow colouring of the leaves from the tip. Infected plants are also associated with upright and stiff leaves (see figure 15).



*Fig.15: Barley yellow dwarf virus on wheat*

### **Control**

- Control aphids that introduce the virus into the plants, (see common wheat pests described in chapter 5).
- Treat seed with recommended insecticides such as Gaucho.

### **Some useful tips to remember when applying fungicides and pesticides**

- Adherence to label instructions insures safe use; Follow instructions as outlined on the label.
- Do not stir by putting your hand into the mixture. Use sticks to stir pesticides since some can be absorbed into the body through the skin.
- Apply pesticides at the right time.
- Control the pest, not everything that moves.

**Table 6: Some of the foliar fungicides recommended for control of wheat rusts**

<b>Common name</b>	<b>Chemical name</b>	<b>Recommended rate/ha</b>	<b>Water volume/ha</b>
Nativo 300SC	trifloxystrobin 100g/l+ tebuconazole 200g/l	1.0 L	200L
Prosaro 250EC*	prothioconazole 125g/l + tebuconazole 125g/l	1.0 L	200L
AmistarXtra 280SC	azoxystrobin+cyproconazole	1.0 L	200L
Silvacur 375 EC	tebuconazole/tridimenol	1.0 L	200L
Orius 25EW	tebuconazole	1.0 L	200L
Folicur 250 WP	tebuconazole	1.0 L	200L
Fezan250 EW	tebuconazole 200g/l	1.0 L	200L
Acanto Plus	picoxystrobin 200g/l + cyproconazole 80g/l	1.0 L	200L
Twiga Epox	epoxiconazole 250g/l	1.0 L	200L
Abacus SE	epoxiconazole 62.5g/l + pyraclostrobin 62.5g/l	1.0 L	200L
Osiris EC	metconazole 27.5 g/l + epoxiconazole 37.5 g/l+200g/l picoxystrobin + 80g/l cyproconazole	1.0 L	200L

\* Can control FHB when sprayed at flowering

## CHAPTER 5

### Wheat Pests and their Control

**Macharia M., Njuguna M., Ngogho G., Koros I.**

Insects can be a major cause of yield losses to wheat growers as a result of direct feeding or as carriers of diseases. Not all pests are equally injurious and the decision to control should be made individually for each pest species. The correct identification of pests is important in order to ensure that appropriate control strategies are chosen and applied on time. The information provided in this section will assist the farmer to correctly identify the wheat pests and therefore choose the appropriate controls.

#### **Termites** (*Macrotermes spp*)

Termites are creamy-coloured, soft-bodied tiny insects resembling white ants, about 4 mm long (Figure 16). Adult workers are pale brown in colour and have a straight abdomen and straight antennae. More often, they are found underground or in self-built galleries made of mud.



*Fig. 16: Termites*



Damage is caused by workers on roots and underground portion of stems resulting in drying up of the infested plants. Presence of stems with galleries packed with soil or tunnels made of thin sheets of soil on the surface or plant stems are indications of termite activity.

### Signs of Termite attack

Termites are problematic in marginal areas and wheat may be attacked any time after planting with increased losses occurring during dry spells or when plants are under stress (e.g. lack of moisture) and at the end of the season. In young wheat plants, the first sign of attack is wilting during the day followed shortly by death. If the plant is dug up, tunnels in the roots/stems containing termites are evident. Damaged plants dry up completely and are easily pulled out. Plants damaged at later stages give rise to 'white heads'.

## Recommended Management Practices

### Cultural control

- Plough the field to destroy termite nests.
- Sow at higher seed rate to compensate for yield losses to termites.
- Adopt practices that promote healthy plant growth (e.g. applying proper fertilizers) to minimise termite damage.

### Chemical control

- Termidor SC (Fipronil) at 6ml/l of water.
- Actara 25WG (Thiamethoxam) at 6 ml/ kg of seed.
- Dagnet FT (Permethrin) at 0.8l/ha.
- Dursban 40EC (Chlorpyrifos) at 3l/ha.
- Endosulfan 35EC at 2.5l/ha.
- Deltamethrin 2.8EC at 400ml/ha.

### Cutworms (*Agrotis spp*)

Caterpillars are greasy-looking and may be greyish or greenish-brown in colour. The caterpillars bend characteristically in an O-shape when disturbed, see figure 17. They hide during the day under the soil and emerge at night when they cause damage by cutting young plant stems at the base and feed on its foliage. Caterpillars cut the stems of young seedlings near ground level causing the plants to collapse and wilt.



*Fig. 17: Cutworms with its characteristic O-shape and in movement*

### Signs of Attack

Cutworm's damage may be suspected when gaps appear along the rows of young wheat plants. Their damage shows up as bare areas or patches in a wheat field. Germinating seeds and young seedlings are damaged or eaten at ground level. Examining soil around base of cut plants will often reveal the cutworm caterpillar.

### Recommended Management Practices

#### Cultural control

- Early ploughing to expose cutworms to predators.
- Ensure fallow fields are kept weed free.

#### Chemical control

- Endosulfan 35% at 1.0l/ha.
- Alphacypermethrin 10%EC at 0.2l/ha.
- Cypermethrin at 1.0 l/ha.
- Keshet 2.5EC (Deltamethrin) at 0.5 l/ha.
- Duduthrin (Lambda-cyhalothrin) at 0.3l/ha.
- Alfix 100EC (Alphacypethrin) at 0.25l/ha.
- Dichlorvos 76%EC at 0.35 l/ha.

### Rose Grain Aphid (*Metopolophium dirhodum*)

Cereal aphids are large (1.5-3 mm long) and light to yellowish green in colour with a dark green stripe on the back as shown in figure 18. They readily drop from the plant when disturbed.



*Fig. 18: Rose Grain Aphids on the underside of a wheat leaf*

Aphids feed on the underside of lowest green leaves and as the leaves becomes older, the aphids move up the plant, to attack higher leaves, feeding eventually on the flag leaf. Feeding damage occurs on leaves and stems in tillering and during later stages of crop growth.

### **Signs of Attack**

Early yellowing of upper leaves and flag leaves occurs under heavy infestation and causes the crop to turn yellow, be stunted and reduces plant vigour and results in yield loss (see figure 19). There is also presence of honey dew, which gives the plant a bright greasy look and black sooty mould appearing on the honey dew. Aphids are good vectors of the barley yellow dwarf virus (BYDV), which they spread even when in low populations.



*Fig. 19: Heavily infested wheat leaves turn yellow*

## Recommended Management Practises

### Chemical control

#### *Seed dressing insecticides*

- Gaucho 350FS (Imidacloprid) at 200ml/100kg seed.
- Cruiser 350FS (Thiamethoxam) at 150ml/ 90kg seed.
- Redigo Deter 350FS (Clothianidin + prothioconazole) at 200 ml/100 kg seed.
- Celest Top 312FS (Thiamethoxam + fludioxonil + difenoconazole at 150 ml/100 kg seed.

#### *Foliar applied insecticides*

- Karate Zeon (Lambda- cyhalothrin) at 150 ml/ha.
- Bulldock star 262.5EC (Betacyfluthrin + Chlorpyrifos) at 0.5l/ ha.
- Thunder OD 145 (Imidacloprid + Betacyfluthrin) at 0.3l/ha.
- Keshet 2.5EC (Deltamethrin) at 0.4 l/ha.
- Twigathoate 40EC (Dimethoate) at 1l/ha.
- Nurelle D 50/505 EC (Cypermethrin + Chlorpyrifos) at 0.5l/ha.
- Alphadime (Alpha-cypermethrin + Dimethoate) at 0.5l/ha.
- Cyclone 505EC (Cypermethrin + Chlorpyrifos) at 0.5l/ha.
- Pirimor 50WG (Pirimicarb) at 0.75kg/ha.

### Russian Wheat Aphid (*Diuraphis noxia*)

The Russian Wheat Aphid is a small (about 2 mm), elongated, spindle shaped, pale yellow-green to grey-green aphid with extremely short antennae and a ‘double tail’. Its body may be dusty with a white wax powder and non-prominent cornicles or ‘tail pipes’ (see figure 20).



*Fig.20: The Russian Wheat Aphid*

### Signs of Russian Wheat Aphid

Aphids feeding cause leaves to tightly curl around the colonies. Under warm and dry conditions and with stressed crops, the pest causes very severe damage by stunting or killing wheat plants.

Plants develop white, purple or yellowish leaf streaks, tightly rolled leaves and trapped heads (i.e. ‘fishhook’ ears), see figure 21.



*(a) Plant with streaks and rolled leaves (b) Plant with “fishhook” ears*

*Fig. 21: Damage caused by the Russian Aphids*

### Recommended Management Practices

#### Cultural control

- Early planting.

- Early destruction of volunteer wheat and barley and grasses.
- Proper fertilization to avoid stressed crops.
- Use recommended high seed rates.

## Chemical control

### *Seed dressing insecticides*

- Gaucho 350FS (Imidacloprid) at 200ml/100kg seed.
- Cruiser 350FS (Thiamethoxam) at 150ml/90kg seed.
- Clothianidin + prothioconazole (Redigo Deter 300FS) at 200 ml/100 kg seed.
- Celest Top 312FS (Thiamethoxam + fludioxonil + difenoconazole) at 150 ml/100 kg seed.

### *Foliar applied insecticides*

- Pirimor 50WG (Pirimicarb) at 0.75kg/ha.
- Bulldock star 262.5EC (Betacyfluthrin + Chlorpyrifos) at 0.5l/ha.
- Thunder OD 145 (Imidacloprid + Betacyfluthrin) at 0.3l/ha.
- Nurelle D 50/500EC (Cypermethrin + Chlorpyrifos) at 0.5l/ha.
- Alphadime (Alpha-cypermethrin + Dimethoate) at 0.75l/ha.
- Twiga ace 20SL (Acetamiprid) at 0.25l/ha.
- Cyclone 505EC (Cypermethrin + Chlorpyrifos) at 0.5l/ha.

## African armyworm (*Spodoptera exempta*)

Young African armyworm caterpillars are green and as they mature, they become blackish and acquire their characteristic stripes as shown in figure 22. When fully grown caterpillars are grey black to velvety-black. Mature caterpillars have a black stripe running along the centre of the back, and on each side of this a paler stripe of broken lines. They do not have hairs on the body.



*Fig. 22: Armyworms infestation wheat leaves wheat seedlings*

Older caterpillars drop to the ground if disturbed. On bare ground, caterpillars crowd together, often moving in the same direction, hence the name “Armyworm”.

### **Signs of African Armyworm Attack**

The main indicators of attack are damaged wheat plants which are partly stripped of their leaves. Young caterpillars scrape out only the green leaf surface creating a window effect and damaged leaves assume a scorched appearance. Severe infestations of the swarming phases of the armyworm result in total defoliation or total destruction of plants to ground level. Older caterpillars feed on the leaves starting from the margin only leaving the midrib.

### **Recommended Management Practices**

The African armyworm management and control is centrally co-ordinated by Crop Protection Directorate, Ministry of Agriculture, Livestock and Fisheries, due to its economic significance. Farmers are encouraged to report any sightings of armyworm to their local Ministry of Agriculture extension officer.

### **Chemical control**

- Endosulfan 35% EC at 1.0l/ ha.
- Malathion 50% EC at 1.0l/ ha.
- Fenitrothion 50% EC at 1.0l/ha.
- Cypermethrin at 150ml/ha.
- Permethrin at 150ml/ha.
- Deltamethrin (Keshet 2.5EC) at 0.5l/ha.

- Lambda-cyhalothrin (Duduthrin) at 0.5l/ha.
- Alphacypermethrin (Alfix 100 EC) at 200ml/ha.

### African Bollworm (*Helicoverpa armigera*)

Young caterpillars of the African Bollworm are pale green after hatching and change colour as they grow. The colour varies from green to brownish, with dark and light stripes alternately running along the body. The head and legs are brownish. A fully grown bollworm is about 40 mm (see figure 23).



Fig. 23: The African Bollworm

### Signs of African Bollworm Attack

Caterpillars can be seen feeding on ear heads where they eat out the developing grains at the milky stage (one caterpillar/ear). Their excrements (faecal pellets) of the feeding caterpillars are evident at the base of damaged plants. The African Bollworm caterpillars have a habit of moving from one ear to another and damage more than they actually consume. Caterpillars are aggressive when touched.

### Recommended Management Practices

#### Chemical control

Very often, a short-lived chemical is necessary as the wheat ears are attacked shortly before harvest.

- Cypermethrin at 150ml/ha.
- Deltamethrin at 260ml/ha.
- Permethrin at 150ml/ha.
- Endosulfan at 2.0l/ha.
- Keshet 2.5EC (Deltamethrin) at 0.5l/ha.
- Duduthrin (Lambda- cyhalothrin) at 1.0l/ha.
- Polytrin P 440EC (Profenofa 'Q' + Cypermethrin) at 1.0l/ha.



- Nurelle D 50/500EC) (Cypermethrin + Chlorpyrifos at 0.5l/ha.
- Alphasime (Alpha-cypermethrin + Dimethoate) at 0.5l/ ha.
- Cyclone 505 EC (Cypermethrin + Chlorpyrifos) at 1.5l/ ha.

## Rodents (Field Rats)

### (i) Multi-mammate *shamba rat* (*Mastomys spp.*)

The body colour of this rat is grey-brownish with a white belly with soft fur. Its tail is the same length as the rest of the body (see figure 24 (a)). The rat is active especially at night.

### (ii) African grass rat (*Arvicanthis spp.*)

The body colour of the African grass rat is grey with white speckles with a pale belly with rough fur. Its tail is shorter than the rest of the body (see figure 24 (b)). It is active including during day.



a) *Shamba rat*



b) *African grass rat*

Fig. 24: Common Rodents on wheat fields

## Rodents Attack

Wheat is attacked at germination where rats retrieve sown seeds. Damage starts at early booting and continues through the mature grains and also damage to mature wheat crops before harvest. The damage can be recognized by visual observation of patches of “whiteheads” in a wheat field and presence of completely severed stems and cut short lengths of stems on the ground between the rows; and through the presence of runways, burrows and nest sites (see figure 25).



*Fig. 25: Wheat straw damage by rats*

## Recommended Management Practices

### Cultural control

- Disturb and destroy habitat (burrows) of the rodents by practicing clean cultivation.
- Physical measures –trapping using kill and live-traps.
- Early harvesting and efficient harvesting of wheat in order to reduce available food resources for rodents.
- Environmental manipulation, by ploughing and grazing after harvest, lead to decrease in shelter and food sources available for rodents.
- Improving storage structures by rat proofing.
- Minimize the alternate food sources and secured habitation by removing the weeds and crop residues in/around the wheat fields.

### Chemical control

Use recommended rodenticides preferably as ready-made baits:

- Miratex, Lanrat (Bromadiolone 0.005%).
- Baraki (Difethialone 0.025%).
- Storm (Flocoumafen 0.005%).
- Zinc phosphide 2.0%.

### Red-billed Quelea (*Quelea quelea*)

The Red-billed Quelea bird is small sparrow-like bird (11-13 cm long) with a weight of 15-20g. The birds move in large flocks of thousands of birds. Males have a colourful plumage and red bill surrounded by a black face during breeding while the female has a yellow bill during breeding and red during non-breeding season (see figure 26). During non-breeding season, both male and females have beige and cream coloration.



(a) Male in breeding plumage



(b) Female in breeding plumage



(c) Non-breeding plumage

*Fig. 26: The different plumages seen on the Red-billed Quelea bird*

### Signs of Quelea Attack

The Red-billed Quelea bird is a major sociable migrant pest that can devastate wheat fields. Birds damage the crop after the dough stage by eating the grain directly from the spikes and by causing ears to shatter completely resulting in grains that fall to the ground and also by flattening the crop. Quelea damage is recognized by presence of wheat plants showing “whiteheads” where the grain has been eaten by the birds, broken seeds left on the heads and husks of grains left on the ground as seen in figure 27. Early and late wheat crop is more liable to damage by birds.



*Fig. 27: Quelea damage on wheat*

### **Cultural control**

- Manual bird scaring, scarecrows and noise making devises.
- Cutting trees harbouring roosts and colonies.
- Good weed management (weeds attract birds, resulting in greater bird damage) and early harvesting.
- Using reflective ribbons that scare birds from the field.
- Blowing up the nest colonies and roosts with fire bombs and dynamite.

### **Chemical control**

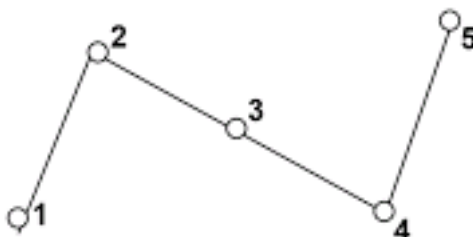
Spraying avicides e.g Fenthion 60%EC to kill the birds wherever they have roosted.

Due to its economic significance, management and control is centrally co-ordinated by Crop Protection Directorate, Ministry of Agriculture, Livestock and Fisheries. Farmers should report any sightings of Quelea birds and their roosting sites to their local Ministry of Agriculture extension officer.

## Monitoring Insect Pests in Wheat Crops

**Macharia M., Njuguna M., Ngotho G.**

Monitoring the insect pests' abundance, correct identification and pest damage symptoms are important to wheat growers. These help in strategy planning and for taking timely pre-emptive measures to avoid pest epidemics. The purpose is to minimize insecticide use and control costs by avoiding unnecessary treatment applications and by timing required treatments properly. Yields can be improved if wheat growers take time to inspect their fields during the growing season for insect pests. Surveillance on pest occurrence in wheat fields should commence at weekly intervals soon after crop establishment. Scouting should begin at early tillering and continue through heading and grain ripening. In each field, select five spots randomly using a ziz-zag or "Z" sampling pattern as shown in figure 28.



*Fig.28: "Z" Sampling plan to be used in a wheat field*

Select five random plants at each spot for recording counts of insects. For most pests, it is important to walk a few rows into the field before sampling the first plant to avoid edge effects. All insects are not pests. One should know the insects which are beneficial. Lady bird beetles, hoverflies, lacewings, spiders, dragonflies and praying mantis feed on other insects. Using insecticides indiscriminately can cause harm to beneficial insects too. Monitor and consider beneficial insects (see figure 29) when making control decisions. After treatment application, continue monitoring to assess pest populations and their control.







 <p>Ladybird beetle</p>	 <p>Hoverfly</p>
 <p>Lacewing</p>	 <p>Spider</p>
 <p>Dragonflies</p>	 <p>Praying mantis</p>

Fig. 29: Beneficial insects (insect friends) which feed on insect pests

## Scouting for Pests

### 1. Cereal aphids

Scouting for aphids is usually done by visually inspecting wheat plants in the field. Select 25 plants randomly and carefully examine them for the presence of aphids. Shake the plants over a piece of white paper, count and record the number of aphids per plant. Damage is expressed as percentage damaged tillers. Consult your local Agricultural Officer for advice and take the appropriate decision regarding management practices. Early detection is important since aphids can multiply rapidly, thus the crop should be scouted regularly. Treatments should only be considered if aphid numbers are increasing and weather conditions (drought) favours rapid multiplication of the cereal aphids.

In case of Russian wheat aphids (RWA), field scouting based on damage symptoms (purple, yellowish to white streaks on stems and leaves and severe leaf rolling), coupled with affirmation

that live aphids are present is an accurate means of determining infestation. Fields should be closely monitored for RWA from emergence through soft dough stage.

## **2. Cutworms**

Regular monitoring of the pests involves close observation of the crop. The best time to monitor is late afternoons and evenings when larvae come out to feed. During the day, scratch away soil around damaged plants to find larvae sheltering in the soil, they bend in an O-shape when disturbed.

## **3. Armyworm**

(i) In each field, using a standard sweep net, select five spots randomly and sweep five strokes each spot, count and record the larvae. Presence of swarming grey black to velvety-black-coloured caterpillars with a black stripe running along the back is an indication of armyworm infestation. Sweep sampling is useful early in an infestation when larvae are small. Pay special attention to wheat fields in which birds are active.

(ii) Pheromone traps are currently being used by officers from Crop Protection Directorate, Ministry of Agriculture, Livestock and Fisheries to enable early detection of the pest as part of the early warning system. Change of lures is made at regular intervals and during each week of surveillance, the number of moths per trap is counted and recorded. The information about potential outbreaks is then passed to Sub-County/County Agriculture Extension offices for actual confirmation in wheat fields for detection of early infestation of the pest.

## **4. African Bollworm**

As the bollworm feeds on ear heads, percent number of infested plants as well as number of caterpillars per tiller should be counted. Take the appropriate decision regarding management practices.

## **5. Rodents**

Through regular surveillance it is much easier to notice the presence of rodents, and the earlier the presence of rodents is observed, the cheaper and simpler any rodent management action

will be. Therefore losses will remain negligible. Growers are advised to check for signs of the presence of rodents through crop damage by cut stems and burrows.

## **6. Birds**

Monitoring and surveillance relies on scouting, aerial surveys and reports by affected farmers. Monitoring bird numbers enables the species involved and its behaviour to be determined and predict the amount of damage they will cause and assessment of techniques available to protect the crops from bird damage by Crop Protection Directorate, Ministry of Agriculture, Livestock and Fisheries. The Officers from the Crop Protection Directorate monitor the movement of the red billed quelea birds and their roosting sites on a regular basis and apply control measures whenever the pest poses a threat to wheat production.

### **Institutional and Government Support**

Wheat growers are advised to seek advisory help in pest identification and control strategies from the nearest County Agricultural Extension Office or Kenya Agricultural and Livestock Research Organization centres. In case of detection of armyworm outbreaks and red-billed Quelea infestation, please alert the nearest Sub County/County Agricultural Extension Office which will inform the Crop Protection Directorate, Ministry of Agriculture, Livestock and Fisheries. Armyworm and Quelea birds control programmes by aerial spraying is done by Crop Protection Directorate personnel.



### Post-Harvest Wheat Management

**Macharia M., Nyakwara Z., Njuguna M., Ngotho G.**

#### Harvesting

Wheat grains must be dry before they can be harvested which should be done without delay when the crop reaches maturity, i.e. when the whole plant turns a golden brown colour and grain cannot be dented with the fingernail or grain can break into pieces on biting. Harvest should begin as soon as is practical after maturity, but this depends on the farmer's harvest method. When the crop is ready for harvesting, the small scale farmers use sickles or sharp knives to cut off the wheat heads. The harvested heads are placed in bags for storage and threshing later. The bag-fulls of wheat ears are threshed by beating with sticks, the grain dried and winnowed. Small scale farmers can also cut down the stalks just about 30cm above the ground level (see figure 30), and tie them into bundles with a sisal twine



*Fig. 30: Harvesting wheat with a sickle*

Tie the lower end and the middle of the bundles, binding the stalks together. Make sure all the grain heads are pointing in the same direction, before binding them with the twine. The cut stalks can then be threshed by beating with sticks on a canvas (see figure 31).



*Fig. 31: Threshing harvested wheat by beating with sticks*

The grain falls off the ears, and the stalks are discarded, and the grains are winnowed.

Large scale farmers use machines; mainly combine harvesters. Harvesting should commence at 16%(or lower) grain moisture content. The grain moisture meter can be used to determine the grain moisture content of the grains, otherwise farmers should contact their local Ministry of Agriculture extension officer for help with determining grain moisture. When the crop is ready for harvesting, farmers use combine harvesters adjusted according to the operator's manual to minimize harvest losses. Schedule weedy fields last because yield and quality of harvested grains is likely to be poorer. Damaged grain and foreign material (un-threshed ears, weeds, grass, gravel, etc.) reduce profits when wheat is marketed and make grain more difficult to store. In addition, damaged and broken

grain is more susceptible to damage by storage moulds and storage insect pests. Over-drying of the wheat crop after maturity in the field, results in shattering of grains. The grains should then be dried to have their moisture content of between 12 -13%, which is ideal for storage. Many farmers usually plan on selling wheat directly from the field; hence much wheat is allowed to dry naturally in the field.

### **Post-harvest Handling**

The combine harvesters simultaneously carry out the operations of harvesting, threshing and winnowing. The winnowing process separates and cleans the grains from the chaff, un-threshed ears, and small bits of straw, weeds and grass. In case of hand harvested and threshed wheat, winnowing can be done by the use of shaking screens or tossing the grain into the wind by pouring the harvested wheat grains from one container to another in a stiff breeze so that the wind blows away the lighter chaff while the heavier grain falls back for recovery. It is usually supplemented by manual removal of stones, clods, noxious weed seeds and other heavy trash such as un-threshed ears and short straws. In all situations, grain must be harvested in a timely manner before shattering, or bird damage to minimize pre-harvest losses, and after the grains are dry enough for storage.

When grain is stored on-farm (particularly for seed wheat and for commercial wheat stored while waiting for domestic prices to improve), wheat growers must remember that quality never improves during storage. Growers must monitor stored wheat on a regular basis until the grain is sold or planted. Mitigating measures to reduce post-harvest losses include timely harvesting, timely application of dusting pesticides and scouting during storage for temperature, moisture, insects and moulds.

### **Storage**

Grains must be stored under cool dry conditions after harvest in order to avoid damage by pests, moisture and fluctuating temperatures. Moisture build up is the first step in quality deterioration. Some farmers sell their wheat directly after harvest, while some prefer to store the wheat on their farms for sometime while monitoring the market prices.

### **Protecting the grain**

When wheat is harvested in the field, it is not entirely free from pest infestation. Grain is also infested during transportation, processing and

storage. Insect pests destroy the grains and contaminate the rest with undesirable odours and flavours. If infestation is severe, grains give out an unpleasant smell. The capacity of wheat to germinate is lowered as a result of destructive activities of the stored grain pests, forcing farmers to use high seed rates when planting wheat to compensate.

The most important storage pests include weevils, the larger and lesser grain borers, the grain moth, red flour beetles and rodents as shown in table 8.

**Table 8: Identification of important storage pests of wheat**

Pest	Identification	Signs of infestation	Damage
Rice weevil <i>(Sitophilus oryzae)</i>	<ul style="list-style-type: none"> <li>Adults are dark brown with four reddish patches on wings.</li> <li>Larvae are white; legless that develop inside the seed.</li> <li>Adults are about 3 mm.</li> </ul>	<ul style="list-style-type: none"> <li>Grains with round holes formed by exiting adult weevils.</li> <li>Increased moisture levels of the grains and heating on the surface.</li> </ul>	<ul style="list-style-type: none"> <li>Adult weevils feed on whole seeds.</li> <li>Larvae develop inside seeds.</li> <li>Feeding contributes to heating of grains.</li> </ul>



Pest	Identification	Signs of infestation	Damage
Larger grain borer <i>(Prostephanus truncatus)</i>	<ul style="list-style-type: none"> <li>• Adults are black or brown and cylindrical in shape, heads face down.</li> <li>• Adults are about 3- 4 mm.</li> <li>• Larvae are grub-like with poorly formed legs.</li> </ul>	<ul style="list-style-type: none"> <li>• Extensive tunnelling of storage structures.</li> <li>• Readily visible holes are bored on seeds.</li> <li>• Large amounts of flour are produced.</li> </ul>	<ul style="list-style-type: none"> <li>• Adults burrow extensively leaving tunnels and irregular shaped holes.</li> <li>• Feeding produces large quantities of flour.</li> <li>• Larval feeding and burrowing contributes further to adult damage.</li> </ul>
Lesser grain borer <i>(Rhyzopertha dominica)</i>	<ul style="list-style-type: none"> <li>• Adult is 2-3mm.</li> <li>• Are- dark reddish brown.</li> <li>• Larvae (5-6mm) are white and c-shaped.</li> </ul>	<ul style="list-style-type: none"> <li>• Sweet odour in the grain.</li> <li>• Large amounts of flour.</li> <li>• Tunnels and irregularly shaped holes in grains.</li> </ul>	<ul style="list-style-type: none"> <li>• Damage is done by adults and larvae which develop within the grain.</li> <li>• Adults and larvae feed on grain reducing them to shells of bran.</li> </ul>



Pest	Identification	Signs of infestation	Damage
<p>Angoumois grain moth (<i>Sitotroga cerealella</i>)</p> 	<ul style="list-style-type: none"> <li>• Adult moths are greyish brown with a wingspan of 12—14mm.</li> <li>• Moths have a single black dot on the centre of each front wing.</li> </ul>	<ul style="list-style-type: none"> <li>• Presence of moths flying is an indication of infestation.</li> <li>• Heating of grains may also be an indication of infestation.</li> </ul>	<ul style="list-style-type: none"> <li>• Adults do not feed on grains.</li> <li>• Larval feeding produces cavities within infested grains.</li> <li>• Infestation produces heat and moisture which may encourage mould growth.</li> </ul>
<p>Red flour beetle (<i>Tribolium castaneum</i>)</p> 	<ul style="list-style-type: none"> <li>• Adults are small reddish brown to blackish brown (4mm).</li> <li>• Larvae are whitish with brown bands.</li> </ul>	<ul style="list-style-type: none"> <li>• Heated grain</li> <li>• Pinkish colouration of grain products.</li> <li>• Is fond of flour.</li> </ul>	<ul style="list-style-type: none"> <li>• Infested grain has a pungent smell, rendering the flour unfit for consumption.</li> </ul>

Pest	Identification	Signs of infestation	Damage
Rodents <i>(Rattus spp)</i>	<ul style="list-style-type: none"> <li>• Grey or brown animal with generally grey stomach and small eyes.</li> <li>• Have scaly ringed tail with only scattered hairs.</li> </ul>	<ul style="list-style-type: none"> <li>• Presence of vermin high-ways and foot prints.</li> <li>• Presence of droppings and nesting sites.</li> <li>• Presence of dirty marks in places through which they pass.</li> <li>• Grains scattered around droppings or foot prints.</li> </ul>	<ul style="list-style-type: none"> <li>• Partially consumed grains, which are inedible and unsalable.</li> <li>• Unconsumed grain contaminated with urine and droppings.</li> <li>• Impaired germination capacity of seed.</li> </ul>



### Recommended Management Practices

To reduce the potential of infestation, (i) the stored grain must have grain moisture content not higher than 9-12%, (ii) the store should be cleaned and treated with some chemicals such as Actellic 25% EC spray at 400ml/20l or 20ml/l of water) to avoid insect attack and (iii) the store and grains should be regularly monitored.

Always use insecticides approved for application to grains to keep them insect free. These include (i) Skana Super (Malathion + permethrin), Actellic super (Pirimiphos-methyl + permethrin), Actellic Gold (Pirimiphos-methyl + Thiamethoxam) and K-Obiol DP2 (Deltamethrin). These are applied at 50g/90 kg of wheat grains.

Rodent pests attack is reduced by keeping the grains dry, sanitising

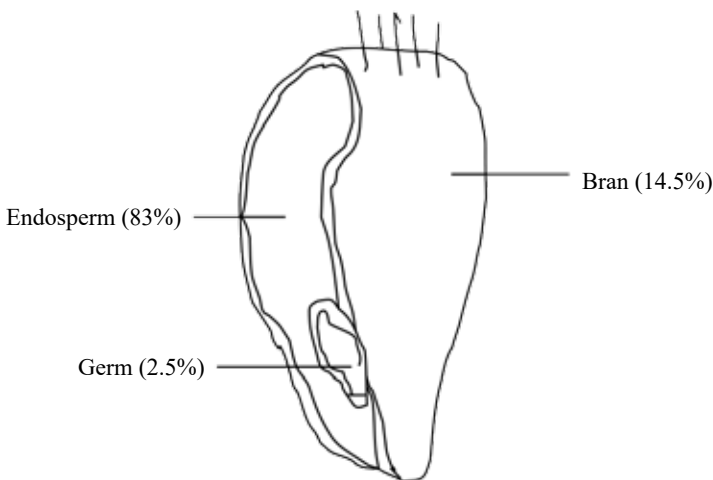
and fumigating the stores, and using rodenticides-poisoned baits. Use recommended rodenticides (Bromadiolone at 0.005% and Zinc phosphide at 2.0%), preferably as ready-made baits.



## Wheat Processing and Utilisation

Ndung'u J., Cheboswony R., Kuria L.

Each year the world produces about 600 million metric tons of wheat that feeds billions of people. No other grain is as widespread as wheat. Wheat continues to provide more food to more people than any other product in the world. In Europe, almost all of America, most of Africa and Asia, and in Australia, wheat is essential to human nutrition. In Kenya, maize is grown more than wheat and it (maize) continues to be the main staple food for the majority of Kenyans. Wheat is however utilized more by the urban than the rural population. This is in most cases in form of processed and packaged products. Comparatively wheat is of higher nutritional value than maize, and can blend well with other foods, thus adding value to them. Such foods include cassava, sweet potatoes, sorghum, millet, soybeans and chickpea. As a cash crop, wheat generally can generate more profit than maize. If smallholder farming communities therefore learnt how to grow and utilize wheat, it would improve their nutritional status and reduce poverty. The wheat grain comprises the endosperm, bran and germ (see figure 32).



*Fig. 32: The wheat grain*

- **Wheat bran** is the outer covering of the grain after removing the straw or shell. It has six layers all of which are rich in fibre (42.8%).
- **Wheat germ** is the grain embryo, from which a new plant will sprout. It contains 75% of all the vitamin B and E in the grain. It contains proteins as well.
- **The endosperm** produces the white flour and contains a considerable amount of proteins (gluten).

### Uses of wheat

- As human food.
- As livestock feed- bran, germ and straw.
- For industrial use- starch, gluten, protein.

### Nutrient composition of wheat as compared to maize

Wheat provides more nutrients than maize. Wheat has more vitamins and minerals than maize. Carbohydrates supply energy to the body while proteins are responsible for building the body. Wheat contains high quality fats (polyunsaturated and cholesterol-free) which supply energy to our bodies. Whole wheat contains 12.5% fibre necessary for proper digestion. Wheat is a good source of vitamins B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, niacin and vitamin E which boost immunity. Wheat contains good amounts of minerals such as phosphorous, magnesium, iron and potassium and trace elements like zinc, copper and manganese. Minerals assist in controlling body processes.

**NB:** : Whole wheat flour (brown) has more of these nutrients than highly milled or white flour. However, the white flour is highly valued because of its better baking and keeping quality than brown flour.

### Adding value to wheat

Value addition is the process that changes a raw product into a product that has a higher value in terms of nutrition, storage life, portability, and even the price that it eventually fetches for the business person or the producer.

### Importance of Value Addition

- Provide opportunities for income generation and employment.
- Improves food security (food is available and accessible).

- throughout the year).
- Reduces food insecurity by reducing losses and increasing the range of food products.
  - Processed products have a longer shelf life.
  - Bridges the gap between peak harvest and planting season.
  - Can raise food value of poor people's diet.
  - Improves the safety of the food.
  - Processing industries can mop up farm surpluses and ensure fair price to the producer.
  - Reduces transport costs per unit volume.
  - Maximised consumption.
  - Increases market opportunities.
  - Improves quality (taste, colour and flavour) and especially in fried and baked products.

## Value added wheat products

### Bread

#### Soft wheat products

- Cookies-cakes, biscuits
- Crackers
- Chapatis
- Sweet goods-sweet rolls, doughnuts
- Pancakes, waffles
- Sauces and gravies
- Prepared mixes e.g. self-rising flour, cake mixes

#### Pasta products

These are food products, which are made from a basic mixture of wheat endosperm and water (other ingredients may be added), formed into some convenient shape, and then either immediately cooked and eaten or dried for consumption later. They include:

- Macaroni-hollow tubes of various sizes and diameter.
- Spaghetti-solid rods, generally of small diameter.
- Noodles-strips, either flat (rolled and cut) or oval (extruded).
- Shaped pasta-shaped into various forms from sheets of dough.

## Wheat Blended Products

- Sorghum/wheat products
- Cassava/wheat products
- Sweet potato/wheat products
- Soya/wheat products
- Millet/wheat products
- Chickpea/wheat products

## Other Products

- Wheat *Githeri*
- Wheat flakes
- Wheat sprouts
- Breakfast cereals e.g. *Weetabix*

## Wheat Grouping

Bread wheat cultivars grown in Kenya are categorized into four groups depending on the baking characteristics.

GROUP I: Weak wheats

GROUP II: Strong stable wheats (red and white)

GROUP III: Strong extensible and balanced wheats

GROUP IV: White wheats

## Baking Quality

GROUP I wheat is not ideal for bread baking but can be blended with superior wheats for bread baking.

Group II wheat has good bread baking qualities.

GROUP III wheat has excellent bread baking qualities.

Group IV wheat is used for confectionary and home baking

## Additional Groups

GROUP V: Durum wheat used for pasta making.

GROUP VI: Triticale; used for blending with weak wheats for confectionary/morning cereals

# Social Economic Considerations in Wheat Production

**Mahagayu C.**

Social economic considerations play a major role in showing whether a technology is acceptable or not. Evaluation of these technologies can be at macro and micro levels, see table 9. Macro levels reflect on the effects of a technology on the society and other sectors of the economy which encompasses:

- Cost to the government
- Welfare gain
- Implications for the market and industry
- Implications on food security

Micro levels reflect the costs and benefits that accrue when the farmers adopt a particular technology or farming system

- Profit
- Risk
- Gender, institutions, infrastructure, social and cultural acceptability.

### Economic benefits

Involves estimation of benefit that is, Gross Field benefits (GFB). Given by output and the field price of the commodity. It enables farmers to choose the most profitable enterprise at micro level. This is estimated as:  
$$\text{GFB} = \text{adjusted yield} \times \text{field price of the product}$$

**Table 9: Estimated gross margin analysis for Njoro 2015**

<b>Output</b>			<b>Output/Acre</b>
Acreage			1
Yield Bags (assumption 20 bags/acre)			20
Price/90kg bag KES.			3,000
Gross income			60,000
<b>Variable costs</b>	<b>Unit</b>	<b>Unit price (KES)</b>	<b>Variable costs/ acre (KES)</b>
Land Rent	Acre	5,500	5,500
Roundup Turbo + spraying	Acre	1,500	1,500
Ploughing	Acre	2,000	2,000
Harrowing	Acre	1,800	1,800
Certified seeds	50 Kg bag	3,750	3,750
Seed dressing (various pesticides)		1,000	1,000
Planting operation		1,000	1,000
Fertilizer (DAP) 1 bag/ acre	50 Kg bag	4,000	4,000
Weed control (Hussar + spraying)	1litre/ acre	1,500	1,500

Pests control (Bulldock Star + spraying)	1litre/acre	1,500	1,500
Rust control (Folicur+ spraying)	1litre/acre	2,500	2,500
Top dressing urea @Ksh.1250/acre	25 Kg/acre	50	1,250
Labour on top dressing 1 man-day/acre	1 man-day	200	200
Harvesting	Acre	2,000	2,000
Handling and loading	bag	20	400
Transport to the market	bag	200	4,000
Total variable costs			33,900
Gross margin per acre KES			26,100

### Assumptions

No interest is foregone by the farmer during the cropping season.  
 Harvesting by machine. Labour has been hired.  
 Wheat yield on average is 20x90 kg bags per acre.

# APPENDIX 1: SAFE USE AND HANDLING OF PESTICIDES

Amadi D., Mbanda G.

Pesticides are poisons so it is essential to follow all safety precautions on labels

## A: Read the Label

1. Purchase pesticides in containers with approved labels.
2. Read the label on the container carefully before preparing the spray solution. It provides a guide to safe handling, storage and use.
3. Pay special attention to warnings and precautions.

## B: Safe techniques

1. Always keep pesticides in their original containers. They should never be kept in containers where they might be mistaken for food or drink.
2. Keep pesticides away from children and livestock.
3. Do not store foodstuffs or livestock feed near pesticides to avoid contamination
4. Lock away pesticides so that they are not accessible to unauthorized people or children.
5. Left-over pesticides after application should be disposed of by pouring them in a specially dug hole away from water sources or drinking water.
6. Any unused pesticide should be stored safely.
7. Reuse of empty pesticide containers is risky and not recommended.

## C: Protective clothing

1. Always protect your nose, eyes, mouth, ears, hands and body.
2. Use overall, rubber hand gloves, gumboots, face mask and cover your head with a broad brimmed hat.

## D: Other important considerations

1. Do not stir or scoop pesticides with bare hands. If stirring is necessary, use a stir stick, never your hands.
2. Never attempt to clean clogged nozzles or hose by blowing or



- sucking on them with your mouth.
3. Do not smell pesticides.
  4. Do not eat, drink or smoke when applying pesticides.
  5. Wash the body with soap after applying pesticides.

### **E: Precautions for applying pesticides**

1. Do not apply on hot sunny day or during strong windy conditions.
2. Do not apply pesticides just before and after rains.
3. Do not use leaking/defective sprayers and select the right kind of nozzles.
4. Mix and apply carefully. While applying pesticides, care should be taken for proper application in terms of dose, volume, timing and coverage as per the label.

### **F: First aid procedures**

1. For skin contact, wash with soap and water, and rinse with clean water.
2. For eye contact, hold eye open under running water for 15 minutes.

## APPENDIX 2: SEED DRILL CALIBRATION

### Kamwaga J.

For a farmer to have a good crop stand of wheat, the farmer must ensure that he or she drills the correct amount of seed and fertilizer per unit area and at the required depth. In order to do this, the farmer needs to calibrate his or her drill to determine the rate of seeding at any of its settings. The following are the steps for calibrating a seed drill

- Jack up the seed drill drive wheel and determine the circumference in metres.
- Fill the seed hopper with seed.
- Place a container or paper bags below the drop tubes.
- Determine width of planter in metres.
- Set the metering system at a known setting.
- Rotate the wheel 10 times and collect the seed delivered through the drop tubes
- Weigh the seed in Kg.
- The circumference of the wheel multiplied by 10 gives the distance covered.
- Distance covered multiplied by width of planter gives the area the planter could have planted if it was actually planting in the field.
- If the machine setting is 4, the amount of seed collected after 10 revolutions is 450g.
- Amount of seed per square metre is weight in kg divided by area covered which is in metres.
- This is multiplied by 10,000 m<sup>2</sup> which is the area of a hectare.
- The result is the seed rate in Kg/ha at that setting.
- This can be repeated at other settings so that a curve that shows seed rates against planter settings can be drawn and the farmer uses it to set the required seed rate.

## APPENDIX 3: COST OF ANALYTICAL SERVICES AT KALRO-NJORO SOILS LABORATORY

**Mwangi H.**

No.	CHEMICAL ANALYSIS	COST KES.
1	Complete soil fertility analysis (pH, carbon, macronutrients and micronutrients): double acid	1,000
2	Complete soil fertility analysis (pH, carbon, macronutrients and micronutrients): Modified Olsen	1,616
3	Soil micronutrients (iron, zinc, copper and manganese)	700
4	Soil pH, carbon and macronutrients	850
5	Soil pH, carbon and macronutrients (N, P and K)	650
6	Soluble cations (including EC)	510
7	Gypsum ( $\text{CaSO}_4$ )	315
8	Calcium carbonate	320
9	Total nitrogen	300
10	Total phosphorus	500
11	Total potassium	450
12	Nitrate nitrogen	255
13	Ammonium nitrogen	255
14	Sulphate- sulphur	220
15	Organic carbon	220
16	Available phosphorus (Olsen)	215
17	Total calcium, magnesium, potassium and phosphorus	800

18	Soil pH and electrical conductivity -EC (each)	50
19	Exchangeable Acidity (Hp)	65
20	Exchangeable cations Ca and Mg (each)	200
21	Exchangeable Cations K and Na (each)	100
22	Each micronutrient	200
23	Dry sieving	100
24	Moisture content	100
25	Microbial analysis	850
26	Manure analysis	1,000
27	Each major element (in manure, fertilizer & amendments)	200
28	Each trace Element (in manure, fertilizer & amendments)	100
29	Plant tissue analysis	850
30	Each major element	200
31	Each trace element	100
32	Water quality analysis for irrigation purposes (pH, E.C., sodium, potassium, calcium, magnesium, sulphates, chlorides, carbonates and bicarbonates)	600
	<b>Miscellaneous charges</b>	
33	Sample pre-treatment (drying, milling, sieving etc)	50
34	Soil/Plant tissue digestion per Sample	50
35	UV/Visible spectrophotometer detection per element	50
36	Atomic absorption spectrophotometer detection per element	100