A COMPLETE CURRICULUM AND GUIDE TO MAIZE PRODUCTION IN GHANA

2015

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AN OVERVIEW OF THE MAIZE VALUE CHAIN IN GHANA

Maize (*Zea mays*), is a versatile crop; growing across a broad range of agro ecological zones. In Ghana it is grown in the forest, transition, southern regions, upper west, upper east and northern regions of Ghana. Every part of the maize plant has economic value: the grain, leaves, stalk, tassel, and cob can all be used to produce a large variety of food and non-food products. Maize is also an important component of poultry feed and to a lesser extent the livestock feed sector as well as a substitute for the brewing industry.

According to the publication Investment opportunity in Ghana maize, soya and rice by the Millennium Development Authority, maize is the largest staple crop in Ghana and contributes significantly to consumer diets. It is the number one crop in terms of area planted (about 1,000,000 hectares) and accounts for 50-60% of total cereal production. Additionally, maize represents the second largest commodity crop in the country after cocoa. Maize is one of the most important crops for Ghana's agricultural sector and for food security.

With regard to the high production regions of maize, according to the publication Analysis of incentives and disincentives for maize in Ghana, Technical notes series, MAFAP, by the Food and Agriculture Organization, maize is grown throughout Ghana however the leading producing areas are mainly in the middle southern part (Brong Ahafo, Eastern and Ashanti provinces) where 84 percent of the maize is grown, with the remaining 16 percent being grown in the northern regions of the country (Northern, Upper East and Upper West regions). The total maize production in Ghana is done by about 70% of small holder farmers. Maize average yield registered by the Ministry of Agriculture in 2013 was 1.7 Mt/ha against an estimated achievable yield of around 6 Mt/ha (Facts and Figures by Ministry of Food and Agriculture, 2013).

Domestic maize production seems to be meeting the local demand for human consumption. The maize supply in Ghana has been increasing steadily over the past few years with an average supply at 1.4 million MT over the period 2005-2010. However, human consumption is competing with the poultry industry and to a lesser extent the livestock industry. While there is no reliable data for maize used in animal feed, the Government of Ghana estimates that 85 percent of all maize grown in Ghana is destined for human consumption and the remaining 15 percent is used for the animal feeding sector (mainly poultry). According to the publication Analysis of incentives and disincentives for maize in Ghana, Technical notes series, MAFAP, by the Food and Agriculture Organization, data obtained from major feed mills in Ghana indicates that about 250 000 MT of maize is used for poultry feed annually.

According to the publication Investment opportunity in Ghana maize, soya and rice by the Millennium Development Authority, in addition to the current shortfall in domestic supplies to fulfill

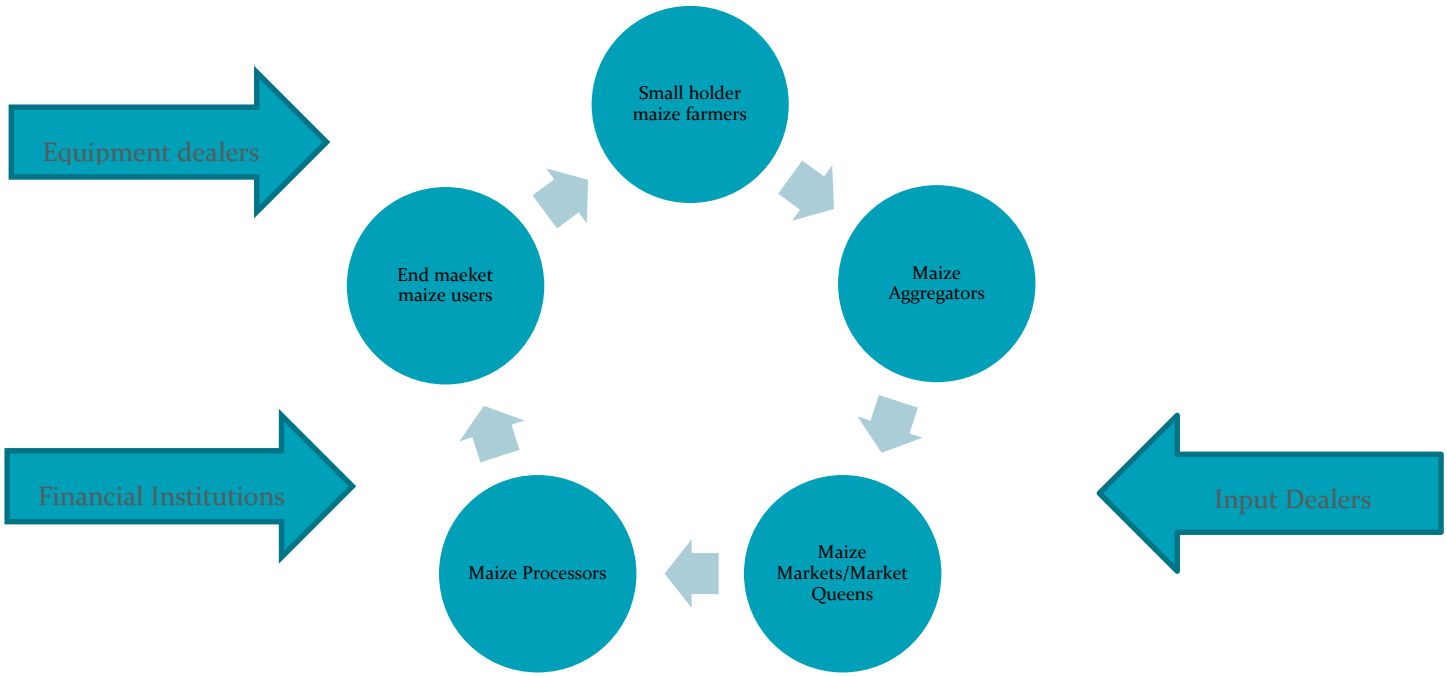
demand, maize consumption is projected to grow at a compound annual growth rate of 2.6% based on population growth and increasing per capita income. Based on the most recent domestic production data, the shortfall between domestic production and domestic consumption would reach 267,000 metric tons by 2015. Further, beyond these projected figures for household consumption, there is considerable unfulfilled demand for processed maize uses and for the growing animal feed sector within Ghana.

There are substantial opportunities for increased maize utilization for feed mills. Currently less than 10% of maize supplies go into the poultry feed industry, although demand is much greater than this supply. In 2008, the government granted special import permits for more than 26,000 metric tons of yellow corn to supply the poultry feed industry. Limited supply of maize for feed production has led to constraints in the growth of the poultry industry, resulting in significant growth in imports of poultry and other meats for consumption. According to the publication Investment opportunity in Ghana maize, soya and rice by the Millennium Development Authority, estimated demand for maize for poultry feed is projected to grow from 73,000 metric tons in 2010 to 118,100 tons by 2015.

MARKETING AND TRADE

Domestic maize trade relies largely on a network of traders linked by personal and ethnic ties. The so-called "market queens", women engaged in maize trading, dominate the local and regional markets while larger groups of wholesalers engage in spatial arbitrage across regions/districts. In the Techiman district, Aggregators/wholesalers normally obtain their maize either directly from farmers with whom they have long standing relationships or from district assemblers. The local Aggregators/wholesalers then sell to long-distance traders serving urban markets throughout the country (FAO, 2006). Techiman serves as one of the main feeder markets in Ghana because of the maize coming from the main producing areas in Brong-Ahafo. From Techiman the maize is then directed to Accra and/or Bolgatanga, at the border with Burkina Faso, and/or Cote d'Ivoire. Other high maize production are Afram Plains, Ejura and Ashanti region and their environments also have their maize markets where aggregators/wholesalers sell to traders serving the urban markets and also maize processors. Also another important feeder market for maize is Tamale located in the Northern region.

DESCRIPTION OF KEY MAIZE VALUE CHAIN ACTORS



Small holder farmers

The vast majority of maize is produced by smallholder farmers under rain fed conditions, leading to annual variations. Smallholder farmers account for a significant maize production of 70% in Ghana and are mainly in the Brong Ahafo, Ashanti, Eastern, Northern, Upper East, and Upper West regions of Ghana. However, overall maize production in the country has remained relatively stable both in terms of area harvested and volume because of reliance on traditional farming. Under traditional production methods and rain fed conditions, yields are well below their attainable levels – maize yields in Ghana average approximately 1.7 metric tons per hectare. However, yields of 6 metric tons per hectare and higher have been realized by farmers using improved seeds such as Dupont Pioneer hybrid maize.

Aggregators

The Aggregators buys the maize in sacks and re-bags the maize into 100 kilos or 50 kilos and sells them to the markets, poultry farmers, schools, feed millers, and breweries. Some of these Aggregators in the maize markets pre finance the small holder farmers in the form of agricultural inputs, seeds and cash. After production and harvesting of the maize, the small holder farmers pay back the money in the form of maize bags. There are also "market queens" who competes with the Aggregators and also buys from the smallholder farmers. They resell some of the maize in the maize markets where

they operates and also sells to other buyers such as poultry farmers, schools, feed millers, and breweries.

The following is a list and contact of key maize aggregators in the value chain.

Aggregator	Town	Region	Contact
Afena Yorke	Techiman	Brong Ahafo	0272783004
Joseph Addai	Techiman	Brong Ahafo	0208209809
Kwadwo Fosu	Apesika	Brong Ahafo	0244810822
Kojo Matu	Kwabia	Brong Ahafo	0540748325
Obiri Yeboah	Techiman	Brong Ahafo	0245605610
Shaibu Mumuni	Techiman	Brong Ahafo	0243589104
Baffour Kusi	Kobedi	Brong Ahafo	0276977599
Johnson Kyere	Nsoatre	Brong Ahafo	0271126781
Peter Okrah	Badu	Brong Ahafo	0208299440
David Yanful	Adidwan	Ashanti	0249290071
Prince Owusu Danso	Ejura	Ashanti	0243802762
Grace Owusu Manu	Kwame Danso	Brong Ahafo	0243532283
Reuben Kumah	Bassa	Brong Ahafo	0241030459
Daniel Asomani	Maame Krobo	Eastern	0275869085
Daniel Osei	Asanyansu	Eastern	0244488015
Benjamin Addo	Maame Krobo	Eastern	0570580146
Alfred Adusu	Fosu	Eastern	0242562492
Issifu Bukari	Hwanyaso	Eastern	0546421832
Kwame Jagri	Maame Krobo	Eastern	0242254610
Kofi Tangbe	Odomasua	Eastern	0206195582
Michael Opoku	Drobonso	Eastern	0248969446
Samuel Yaw	Bonkron	Eastern	0273497466

Maize markets

The maize markets are specialized market that buys maize from their small holder farmers and sells it to their customers in the market. The following is a list of key markets in the maize value chain.

Market	Town	Region
Techiman Maize market	Techiman	Brong Ahafo
Dormaa maize market	Dormaa	Brong Ahafo
Badu Maize market	Badu	Brong Ahafo
Odumase Maize market	Odumase	Brong Ahafo
Ejura market	Ejura	Ashanti
Kumasi Central Market	Kumasi	Ashanti
Maame Krobo Maize market	Maame krobo/Afram Plains	Eastern
Agbogbloshie	Agbogbloshie	Greater Accra
Tamale Maize market	Tamale	Northern

Financial Institutions

There are some Financial Institutions and rural banks that have adapted their financial products to support small holder farmers, aggregators, input dealers and processors in the value chain. The table shows key financial institutions in the maize value chain.

Financial Institution	Location	Contact number
Sinapi Aba Savings and Loans Limited	Techiman	0201853135
Opportunity International Savings and Loans Limited	Sunyani	0203249945
Amantin and Kasei Community Bank Limited	Kasei	0244229570
Sekyeredumase Rural Bank Limited	Ejura	
BACCSOD Catholic Cooperative Society Limited	Techiman	0244173636
Yapra Rural Bank Limited	Kwame Danso	
Kintampo Rural Bank Limited	Kintampo	

Input dealers in the maize value chain

There are some input dealers that work with the banks, aggregators to supply agrochemical inputs and seeds to the farmers. The table below shows the key input dealers in the maize value chain.

Input dealer	Location	Contact
B. Kaakyire Agrochemicals Limited	Kumasi	0244511123
Bentronic Productions	Kumasi	0208110831
Dizengoff Ghana Limited	Kumasi	0576518350
Yennuman Agrochemicals	Ejura	0205997930
Prince Owusu Agrochemicals	Ejura	0243802762
Benjamin Addo Agrochemicals	Afram Plains	0570580146
The Young Shall Grow	Sunyani	
Chinese Woman	Kumasi	
K. Badu Agrochemicals	Kumasi	0207366820

Tractor and Farming Equipment dealers

The table below shows Tractor and Farming Equipment dealers in the maize value chain.

Tractor/Farming Equipment dealer	Location	Contact
AFRI Ghana-(John Deer)	Dobro near Nsawam	0508939400
Mechanical Lloyd Company Limited	West Industrial Area, Accra	0244260364
Bambros Investment Limited	Kumasi	0243727583

Processors in the value chain

The table below shows processors in the maize value chain

Processor	Location	Contact
Premium Foods Limited	Kumasi	0249105972
High and Mighty Agro processing Company Limited	Techiman	0272783004

End market buyers

The table below shows the key end market buyers in the maize value chain.

End market	Value Chain Actor	Region	Contact
Techiman Maize Traders Association	Aggregator	Brong Ahafo	
Premium Foods	Processor Foods	Ashanti	0249105972
CDH Commodities	Aggregator	Greater Accra	0268676529
UT Logistics	Aggregator	Greater Accra	
Akate Farms & Trading	Poultry Farm	Ashanti	0208124719
Fosuka Farms	Poultry Farm	Ashanti	
Aglow Farms	Poultry Farm	Greater Accra	
Samtak Farms	Poultry Farm	Ashanti	
Topman Farms Ltd	Poultry Farm	Ashanti	
Gundaa Produce Company	Aggregator	Northern	0244050504

AGRO-ECOLOGICAL ZONES AND PLANTING SEASONS

There are 5 main agro-ecological zones defined on the basis of climate, reflected by the natural vegetation and influenced by the soils. These are

Rain Forest,

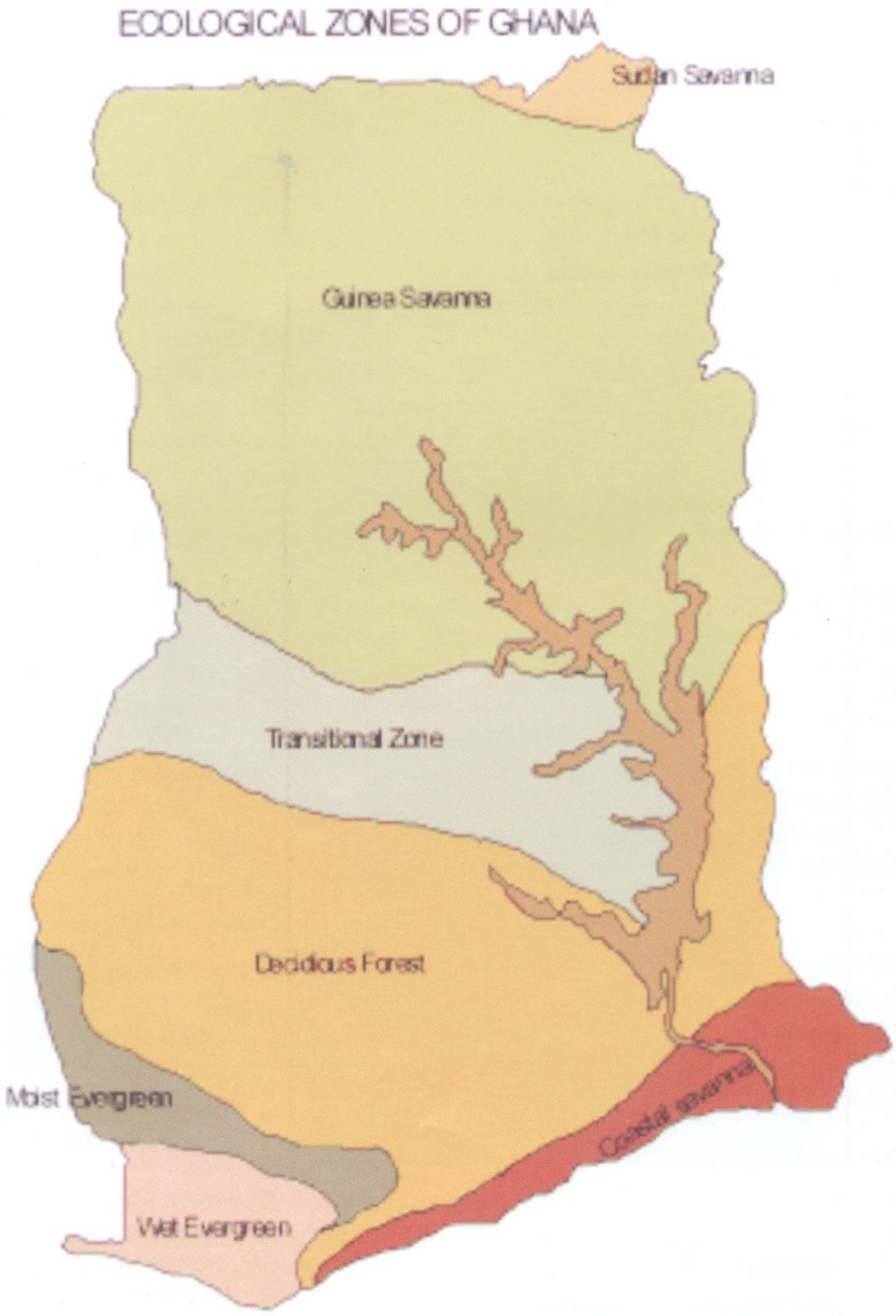
Deciduous Forest,

Transitional Zone,

Coastal Savanna and

Northern Savanna (Guinea and Sudan Savanna)

The map below shows the 5 main Agro-ecological zones in Ghana.



The following table shows normal planting time for the major and minor seasons in Southern Ghana

Season	Normal Planting Month(s)

Major Season	Plant in early May through the third week of May after rains have established good soil moisture (3 rains in a week)
Minor Season	Plant third week of August through the end of September after rains have established good soil moisture (3 rains in a week)

The following table shows normal planting time for the Northern Ghana

Season	Normal Planting Month(s)
Mono Season	Plant in July through early August after rains have established good soil moisture

AGRONOMY OF MAIZE

Soil Test

Take a sample of your soil to the Soil Research Institute or University Laboratories for it to be analyzed to know the pH, Nitrogen, Phosphorus, Potassium, percentage Organic Matter, Cation Exchange Capacity and others to help you formulate a fertilization program for maximum yields.

Site Selection

Avoid sites with trees, ant hills, shady areas, hard pans, compacted soils, muddy and clayey soils for good yields.

Land Preparation

Seedbed preparation

Maize needs to be planted carefully and accurately to achieve the best germination and emergence possible. Seeds will be slow to emerge or fail to germinate if the soil is too wet or dry. The soil should be kept free from weeds by manual weeding or spraying as required.

Field Management Practices

If planting is to be done manually, plant each seed and 10g of fertilizer at a depth of 5cm and 10cm in the soil respectively. With machine planting, a fine seedbed is necessary to avoid interference from large clods. This will allow even, uniform and rapid germination and create a relatively weed-free environment. However, a fine seedbed has the risk of soil erosion (especially when the field is on a slope), silting, soil compaction that will lead to poor aeration. For proper germination of maize requires moist soil is important.

Soil Type

Maize can be grown on a wide variety of soils, but performs best on well-drained, well-aerated, deep warm loams and silt loams containing adequate organic matter and well supplied with available nutrients. Although it grows on a wide range of soils, it does not yield well on poor sandy soils and

heavy clay soils, except with heavy application of fertilizers, deep cultivation and ridging is necessary to improve drainage. In sandy loam soils, good yield could be obtained with increased fertilization and water management.

Maize can be grown successfully on soils with a pH of 5.0 - 7.0 but a moderately acid environment of pH 6.0 - 7.0 is optimum. Outside this pH range results in nutrient deficiency as a result of unavailability of nutrients and mineral toxicity. High yields are obtained from optimum plant population, number of ears and kernels with appropriate soil fertility, and adequate soil moisture. Where possible, it's advisable to have soils routinely analyzed in order to know the characteristics of the soils and to get advice on how to improve soil fertility and/or correct soil pH for optimum maize production.

Temperature

The optimum temperature for plant growth and development ranges from 30°C - 34°C. The cool conditions at high altitude lengthen the cycle or growing period. Temperatures below 5°C and above 45°C result in poor growth and death of the maize plant.

Conservation tillage

This method is used by large and medium scale farmers. In this system, maize is grown with minimal cultivation of the soil. The stubble is not completely incorporated and thus contributes to run off control.

Seed quality for planting

It is important to test the germination and vigor of your planting seed before sowing. The following processes should be undertaken:

First look at seed for signs of weathering, disease or physical damage. 2 weeks before sowing, it is advisable to do your own germination test in soil. Seed should be plump and free from visible damage such as broken seed coats.

Planting

There are three major considerations to be taken into account:

1. When to plant
2. Depth of planting
3. Plant population

When to plant

As a result of changes in the rainfall pattern, it is recommended to plant the major season in early May through the third week of May after the rains have established good soil moisture and the minor season in the third week of August to end of September. Planting is generally recommended to be done at the onset of rain but since Pioneer hybrid maize is a drought resistant, dry planting can be done when rain is expected. Delayed planting in relation to the onset of rains will lead to reduced yield especially when there is drought in the critical window of 45 to 70 days after planting when there is tasseling, silk and cob formation. Good soil moisture at sowing time is required before the crop is planted. It is recommended that there be at least 30 cm of wet soil throughout the soil profile

before sowing. Because of this higher water requirement, the majority of corn is planted at places where rainfall is more reliable and there is more of it.

Depth of planting

Planting and basal fertilizer application is recommended at the same time. The depth of planting should be 5cm deep and fertilizer is 10cm deep respectively. Deep seed placement under dry planting is recommended so that seed germinate only after adequate rains have fallen. However the depth of planting should be uniform to allow uniform plant growth.

Plant population

Most of the hybrids such as Mamaba and open pollinated varieties such as Obatanpa are planted at a distance of 80cm to 90 cm between rows and 40cm between plants giving a plant population of 10,833 and 11,875 plants respectively per acre (26,000 and 28,500 plants per hectare respectively). The recommended spacing for Pioneer maize hybrid is 75 cm between rows and 25 cm between hills when planting one seed per hill. With this planting distances the plant population will be 20,000 plants per acre or 50,000 plants per hectare. Plant populations that are higher than the optimum will lead to competition among the maize plant resulting into slender plants that will give low yield. Lower plant population will result into low yields (though with bigger cobs) due to reduced number of ears per unit area. Planting should be planted in rows, without planting in rows, a farmer will never achieve an optimum plant population. In addition, rows ease field operations like weeding and will facilitate harvesting.

METHODS OF PLANTING

Planting can be done either mechanically or manually by the hand.

Hand planting

Hand planting is the most commonly used method in Ghana. If properly used, the method can produce excellent results because it gives a proper and uniform plant stand. The table shows the planting distances between rows and plants and their plant populations.

Maize Hybrid/Variety	Distance between plants/cm	Distance between rows/cm	Plant population/acre	Plant population/hectare
Obatanpa	40	80	10,833	26,000
Mamaba	40	90	11,875	28,500
Dupont Pioneer Hybrid	25	75	20,000	50,000

A measuring tape is used to mark 25cm/40cm depending on maize variety along a measuring line for the distances between the seeds. A second measuring line is measured at a distance of 75cm/80cm/90cm between rows depending on maize variety.

A planting stick is used to make two holes at the same time, one at a depth of 5cm for seed and the other at a depth of 10cm for an application of 10g of fertilizer.

Place the seed and make the final covering. Make sure that the seed is well holed in to ensure good contact with moisture. All seeds must be well covered.

Crop establishment

It is important to plant maize seeds at an even depth 5 cm into firm, moist soil to ensure good seed-to-soil contact for moisture uptake and subsequent germination. Plant density and row spacing are critical agronomic factors to get right when sowing maize to maximize yield.

Mechanical planting

This type of planting has the advantage of being quick, and if well supervised will give excellent results. However, if it is poorly supervised, it will give poor-to-disastrous results. It allows you to plant a large acreage within your pre-determined planting period. Adapt a spacing compatible with other mechanical operations like fertilizer application and weeding. Check the machine well before the anticipated planting date to make proper adjustment. Always read the operator's manual and seek advice from the suppliers for effective usage. Every season, make sure that the planter is calibrated to avoid making costly mistakes.

Below are some guidelines for calibration:

- Each planter must be tested separately.
- Select plates that will allow the largest seed of your seed sample to go through. Make sure the plate does not allow two seeds at a time.
- Make sure that the driving wheel drops seeds in the furrow opener.
- Count the number of seeds dropped by the planter over a measured length in the field at a set driving speed. The number can be multiplied to get total number dropped / ha. The correct operating speed is normally indicated in the operator's manual e.g. 5 km/h.

After planting, once the seed absorbs water, germination commences. The seedling uses starch reserves in the endosperm to germinate and a root, called the radicle, sprouts from the kernel. At the same time or soon after, a shoot emerges at the other end of the kernel and pushes through the soil surface. This breaking through the soil surface is called emergence. When the tip of the shoot breaks through the soil surface, elongation of the middle section of the shoot, called the mesocotyl, ceases, and the first leaf, which is termed the plumule emerges.

The primary roots develop at the depth at which the seed is sown. The first adventitious roots (roots other than those growing from the radicle) start developing from the first node at the mesocotyl, which occurs just below the soil surface. These adventitious roots continue to develop into a thick web of fibrous roots and are the main anchorage for the maize plant; they also facilitate water and nutrient uptake.

Maize vegetation morphology

In the early growth stages, the leaves and stem are not readily distinguishable. That is because the growing point (whorl) remains underground until the first five leaves have emerged series of enlargements that encircle the stem are called nodes. The space between two nodes is called an internode. The earliest internodes elongate only slightly, so that the space between internodes is only

small. However, internodes of older plants elongate much more and account for height in maize. Leaves are made up of a blade which extends from the stem at a node. The stem has two functions: to support the leaves and flowers and to transport water and nutrients. Nutrients are carried in vessels, called xylem and phloem, which are connected to the roots. The xylem transports water and mineral nutrients from the roots and flow one way whiles the phloem flows in both directions and transports organic nutrients in a water based solution. The major function of the leaves is to carry out photosynthesis for grain production.

Reproductive structures

Maize is a monoecious plant, which means that each individual plant has both male and female flowers. Male flowers produce pollen and are on the tassel. The tassel arises from the growing point of the plant. When the tassel becomes visible, the innermost leaf in the growing point is the last leaf produced. The female flowers receive the pollen and are carried in the ears. The pollinated female flowers develop into the kernels.

Pollen grain and silk

The tassel has a central spike and several lateral branches, each of which has many flowers. The flower, called a spikelet, consists of a pair of functional florets with three anthers, which produce pollen, borne on filaments. The round, slightly sculptured pollen grains begin dropping from the anther two or three days before the silks (styles) on the female flower are ready to receive them. However, the process continues after female receptivity as pollen is shed from the anthers over a five to eight day period. The functional ear floret partly encloses the ovule, which contains the embryo sac with the egg inside it. Pollen from the tassel passes down the silk to fertilize the egg. The embryo sac eventually becomes a maize seed.

GROWTH STAGES OF MAIZE

Flowering

During Pollination and fertilization there is a high demand for water, and the uptake of N and P is rapid, although K uptake is almost complete. If maize is flowering during hot, dry weather this places extra stress on the plant's resources and the silks may wither and burn off before the pollen reaches the ear. Hence fertilization does not occur for all kernels and seed set is greatly reduced. This is commonly referred to as pollen blasting.

Cob and kernel development

Cobs, husks and shanks are fully developed by day 7 after silking. The plant is now using significant energy and nutrients to produce kernels on an ear. Initially the kernels are like small blisters containing a clear fluid; this is referred to as the kernel blister stage. As the kernels continue to fill, the fluid becomes thicker and whiter in color. This is called the 'milk stage'.

Denting of the grain occurs around 20 days after silking; this is an indicator that the embryos are fully developed. Initially at denting a line can be seen which slowly moves to the tip of the kernel through

until physiological maturity. This line is called the 'milk line' and marks the boundary between the liquid (milky) and solid (starchy) areas of the maturing kernels.

Maturity

Approximately 30 days after silking the plant has reached the maximum dry weight, a stage called physiological maturity. This is where a 'black layer is noticeable at the tip of each kernel, where cells die and block further starch accumulation into the kernel. At this stage the milk line has completely disappeared. Kernel moisture at physiological maturity is around 30%. The grain and husks begin losing moisture while healthy stalks remain green. Eventually the leaves will dry off.

Harvesting can commence when grain moisture is below 20%. The grain is dried down to 14% for delivery to storage or market.

WEED CONTROL

Effects of weeds on maize

Weeds compete with the maize plant for water, nutrients, space and light. The early stage of a maize plant (first three weeks) is very sensitive to weed competition. Weeds should be controlled and minimized for the first 10 weeks to maximize final yield. Some weeds become alternative hosts of pests and diseases. They reduce profits by lowering the quality, quantity, yields and value of maize. Inefficient weed control is one of the main causes of low maize yields in Ghana. Some weeds are parasitic and poisonous to maize. A thick growth of weeds in maize makes harvesting difficult.

After planting the maize, usually weeds will germinate from their seed faster than the rate at which maize will be germinating. They will definitely interfere in the growth of the crop during the critical period of the first three weeks. One of the most notorious weed in maize production is striga. Striga spp. are parasitic weeds that attack mainly cereals like maize.

This weed produces numerous tiny seeds (50,000 - 500,000 seeds per plant). The seeds are normally dispersed by wind, water, livestock, man, farm machinery and contaminated crop seeds. Once shed, the seeds can stay viable in the soil for up to 20 years. The seeds normally germinate only in response to chemical stimulants exuded by the host roots. Once germinated, the weed establishes parasitic attachments with the root of the host and starts deriving all nutrients from the host.

There are other types of weeds that multiply through roots and stems. Mechanical weeding only cuts off the tops but the bottom continue consuming the nutrients and water meant for the maize plants. These should be controlled early before the beginning of the season as later attempt to control them will damage the crop.

Methods of Weed Control

Crop rotation: Rotation of maize with leguminous crops such as cowpea and groundnuts will help to reduce Striga in the fields. The striga is not adapted to the root system of the leguminous plants and will therefore die. However, this cannot completely eradicate striga because seeds can stay viable in the soil for a long time.

Proper spacing: If crops are planted at recommended spacing of 25cm/40cm between rows depending on variety and 75cm/80cm/90cm between rows depending on variety, the plants cover the ground quickly reducing the need for weeding. To ensure good yields, weed-free conditions should be maintained until flowering to minimize the risk of moisture stress at this critical stage.

Timely planting: Maize planted at the right time has vigorous growth and could be well established before the growth of weeds. The seeds should be planted at the earliest opportunity so that they can establish before weeds develop.

Hoeing and hand pulling: Hoeing is the weed control method commonly used by small scale farmers. This is commonly followed by hand weeding to remove the weeds that will establish after hoeing.

Improving soil fertility: Application of fertilizers or adopting any other soil fertility improvement practice such as using poultry manure will enable the maize plants to have quick and vigorous growth, which will cover the ground and suppress weeds at an early stage.

Good seed: Planting must be done with improved seeds of good quality such as Pioneer seeds that are free from weeds. It is always advisable to use treated seed bought from a recognized Agrochemical shop.

Mechanical methods

This involves the use of simple farm tools and implements such as hoes and cutlasses in controlling weeds. Weeding should be done twice or three times and it must start as early as possible because a young maize plant is very sensitive to weed competition.

Chemical methods

This method of weed control makes use of herbicides. The most commonly used herbicide for maize is Atrazine. Herbicides that contains active ingredients such as nicosulfuron and 2,4-D should not be used in weed control with the Pioneer hybrids. If there is a need to use it should be done at a maximum of 2 weeks after planting.

FERTILIZER APPLICATION

Apply a basal fertilizer of 20g of Nitrogen in bands next to seed at 10 cm deep at planting.

Nitrogen

Apply approximately 35-50 Kilos/acre or 125 kilos/hectare, one-third at planting stage, and two-thirds as top dressing during 3-4 weeks after planting.

Phosphorus

Apply most at planting at a rate of 35 Kilos/acre or 85 Kilos/Ha

Potassium

Apply most at planting at a rate of 35 Kilos/acre or 85 Kilos/Ha

Organic Application-Poultry Manure

When an organic maize production is to be done, 60 bags of poultry manure per acre should be placed on the soil for at least 3 months before planting to enable the manure to cure well and benefit fully with the soil release of nutrients to the plants. The soil will also benefit from the improving mulching, and improvement of the chemical and physical properties of the soil in the long term.

Two main physical properties were measured: moisture content (i.e. plant available water) and bulk density. Application of poultry manure increased moisture content of the soil, both doing better than the chemical fertilizer. Poultry manure, with its high organic carbon content, adds organic matter to the soil. Organic matter has the ability to retain appreciable amounts of soil moisture, hence, probably the rise in level of moisture content of soil upon application of the manure.

Application of poultry manure would improve the acidity of soil and help to neutralize the soil pH especially for acid soil. Soil acidity might be corrected by using manure instead of lime or gypsum because the materials such as Ca and Mg contained in manure help to increase the soil pH over short-term and long-term applications.

Organic Application-Organic Fertilizer

If an organic fertilizer will be used the application rate should be 125 kilos of Nitrogen, 85 kilos of Phosphorus and 85 kilos of Potassium,

PLANT DISEASE CONTROL

Visit your corn field regularly. Immediately remove corn plants that manifest symptoms of diseases, such as leaf blight and stalk and stem rot.

Leaf diseases

Some maize diseases are as follows:

Northern Leaf Blight:

Symptoms

Long, elliptical, greyish-green or tan lesions ranging from 2.5-15cm in length develop first on the lower leaves. The lesions vary in their morphology when gene HT_2 is utilized. The HT_2 gene conditions a long, chlorotic, linear streak that may extend the length of the leaf on some host genotypes; the lesion may be very easily mistaken with those caused by *Erwinia stewartii*. The disease progresses upward on the plant. Severe infection causes a prematurely dead and grey appearance that resembles frost or drought injury. In damp weather, large numbers of greyish-black spores are produced on the lesions, often in concentric or target like zones. The ears are not infected, although lesions may form on the outer husks.

Causal Organisms

Helminthosporium turcicum Pass. (Syn. *Exserohilum turcicum* (Pass.) Leonard & Suggs, *Bipolaris turcica* (Pass.) Shoemaker, *Drechslera turcica* (Pass.) Subram. & Jain.) Perfect state is *Trichometasphaeria turcica* Luttrell. (Syn *Setosphaeria turcica* (Lutrell) Leonard & Suggs.)

The spores are olive-grey, spindle shaped-shape, slightly curved, three to eight septate, 20 x 150µm with a protruding hilum, and germinating by polar germ tubes. The conidiophores are olivaceous, two to four septate, and 7-9 x 150-250µm. Sporulation can be induced in a moist chamber.

T. turcica, the sexual stage, occurs rarely, if ever, in nature but produces black, globose pseudothecia in the laboratory. The asci are cylindrical with a short stripe and contain one to eight, but usually two to four, ascospores, which are hyaline, straight or slightly curved, typically three septate, and 13-17 x 42-78µm in size.

Two biotypes of *H. turcicum* from maize isolates have been described. One biotype is avirulent to maize carrying genes $HT1$, HT_2, HT_3 and HtN. The other biotype is avirulent to maize carrying genes HT_2, HT_3 and HtN, but is virulent to maize carrying HT_2A or B.

Disease Cycle –

H. turcicum overwinters as mycelia and conidia in infected leaves, husks, and other plant parts, except in the northernmost areas where maize can be grown. Conidia cells can be transformed into chlamydospores. Conidia are windborne over long distances to leaves of maize plants. Secondary spread within and between fields occurs by conidia produced abundantly on leaf lesions.

Epidemiology –

Northern corn leaf blight occurs sporadically in most humid areas of the world where maize is grown. Disease development is favoured by moderate temperatures (18-27ºC) and heavy dews during the growing season. It is retarded by dry weather. If the disease is established before silking, losses in grain yields up to 50% may occur. If infection is moderate or delayed until six weeks after silking, yield losses are minimal.

H. turcicum attacks sorghum, Sudangrass, Johnsongrass, gamagrass and teosinte. Races of *H. turcicum* on sorghum and Sudangrass apparently do not infect maize, but some maize isolates can infect Sudangrass.

At least two types of resistance are known: small lesion size and few lesions (polygenic), and chlorotic lesions with little or no sporulation and yellowish halos (monogenic).

Common Maize Rust:

Symptoms –

Pustules (sori) may appear on any aboveground part, being most abundant on the leaves. The pustules occur nearly simultaneously on both leaf surfaces in contrast with southern rust (see below), which has very sparse pustule development on the lower leaf surface. The circular to elongate, golden-brown to cinnamon-brown pustules are sparsely scattered over both leaf surfaces becoming brownish black as the plant matures and teliospores develop. When severe, chlorosis and death of the leaves and leaf sheaths may occur. The pustules become erumpent and powdery early in their development.

Causal Organism

Puccinia sorghi Schw.

The uredospores are cinnamon brown, mostly spherical to broadly ellipsoidal, and 21-30 x 24-33µm. The spore walls are golden or cinnamon brown, 1.5-2µm thick and moderately echinulate with three to four equatorial germ spores. Each spore is binucleate as is the mycelium that develops on germination. The teliospores, which replace the uredospores in the pustules, are chestnut brown to golden brown, smooth, oblong to ellipsoid, two-celled with slight constrictions at the septa, measure 14-25 x 28-46µm, and are attached to pale yellowish to brownish pedicels, (up to 80µm long) once or twice the length of the spores. The aeciospores are pale yellow, verrucose, mostly spherical or ellipsoid, 13-19 x 18-26µ, and occur in "cluster cups" on species of *Oxalis*. *P. sorghi* can be cultured on detached maize leaves floated on a solution containing 5% sucrose and 20 ppm of kinetin.

Disease Cycle –

Teliospores germinate in the spring in certain areas of the world to form basidia on which small, thin-walled, hyaline, haploid basidiospores are produced. These spores germinate and penetrate the leaves of wood sorrel (*Oxalis* spp.) forming spermagonia with minute spermatia on the upper leaf surface. The spermatia fuse with flexuous (receptive) hyphae of the opposite mating type initiating the aecial stage on the lower surface of *Oxalis* leaves. The binucleate aeciospores in the "cluster cups" are windborne and infect maize leaves. These infections give rise to uredospores, the repeating stage of the fungus. In most temperate areas of the world, including the USA, the fungus does not infect Oxalis. Spores are wind blown into temperate areas from nearby subtropical and tropical areas where the pathogen persists on living maize plants.

Epidemiology

Cool temperatures (16-23ºC) and high relative humidity (100%) favour rust development and spread. Some inbred lines show a resistance to *P. sorghi*. Numerous physiologic races of *P. sorghi* can be separated by their reactions on lines of maize having specific genes for resistance. Resistance in mature plants is polygenically controlled.

MAJOR DISEASES OF MAIZE

It is difficult to determine the extent of maize yield losses as a result of disease. However, maize diseases can reduce yield potential, interfere with normal physiological development, lower grain quality and cause lodging, which affects harvest. The occurrence and impact of a disease depends on a number of factors such as climatic conditions and the health, abundance and varietal resistance of the host plant. It is important to identify diseases in order to implement management strategies during the season and for subsequent crops. Diseases can be difficult to identify and should be diagnosed by a suitable plant pathologist

Peronosclerospora spp.

Downy mildew is still considered the most damaging disease of maize

There are numerous types of the disease.

Symptoms

Symptoms include white and yellow striping of leaves and leaf sheaths and stunting of the whole plant, which produces no yield. The other major symptom is downy growth on or under the leaf due to conidia formation.

Management

It is advisable to choose resistant varieties.

Late plantings also favour the disease, so plant on time.

Avoid planting maize after maize in the same field.

Southern Maize Leaf Blight

Symptoms

Leaves are affected by lesions which when they first form are small and diamond shaped and elongate as they mature.

The final lesion is rectangular and 2 to 3 cm long. Each lesion is light brown with a reddish-brown border and a light yellow ring around it. Lesions may merge, producing a complete burning of large areas of leaf. This may lead on to stalk and cob rot, which can cause significant yield loss.

Management

It is advisable to choose resistant varieties. If varieties are not resistant, farmers must at least plant disease-free seed, as the disease is seed borne. Do not plant maize after maize in the same field.

Fusarium spp. (Stalk rot and ear rot)

Symptoms

- These different species of fungi produce stalk rots, ear rots and seedling blights.
- Whitish-pink cottony fungal growth develops on and between the kernels and sometimes on the silks.
- Infected plants are weakened and can break easily during strong winds and rains.
- Mycotoxins, which are harmful to humans and livestock, are also produced.

Management

These diseases can be controlled by the use of resistant varieties together with the use of optimum plant populations and nitrogen applications.

Maize Dwarf Mosaic Virus

Symptoms

Light and dark green patches form a mosaic pattern on leaves, with some ring spots. Highly susceptible varieties may have many yellow leaves as well. Plants infected early are very stunted, with significant yield loss.

Management

The spread of the virus is due to aphids transmitting the virus from one infected plant to another. Control volunteer grasses such as Johnson grass, which is a host for the virus. Avoid having plants at seedling stage during peak aphid flight time. Grow more tolerant varieties.

Meloidogyne hapla (nematodes)

Symptoms

Patches of stunted, drought-stressed plants across the field. Roots are stunted and have small nodule-like cysts and sometimes dark lesions. The nematodes are too small to see and they live inside the roots.

Management

Control weeds, which may act as hosts for the nematodes in between crops. Clean equipment well before using on a different field as nematodes are spread by dirt, water and plant material.

Aspergillus flavus (aflatoxin)

Symptoms

Masses of yellow to dark green spores develop on kernels, which may be slightly enlarged. Crop symptoms include terminal drought stress such as permanent wilting of the foliage, receding canopy cover between rows, and leaf drop.

Management

Aflatoxin is a fungus toxic to humans that affects maize kernels. Its onset is encouraged by drought. It affects not only the quality of the crop but also the safety of anyone who consumes affected kernels. Growing maize during the MWS should decrease the chances of aflatoxin becoming a problem as there is reduced likelihood of drought during this period. When growing maize in the early wet season (EWS), do not delay harvest.

Puccinia polyspora (corn rust)

Symptoms

Small round to oval, brown or orange pustules distributed uniformly over the upper leaf surface. Brown to black circles may appear around the pustules. Severely affected leaves turn yellow and die early. Ears on severely affected plants are much lighter than normal and the seeds are pinched and loose on the cob.

Management

Control volunteers and other grass weeds that may act as a host to the fungus. Avoid planting two maize crops in a row. Plant resistant varieties if available.

MAJOR INSECT PESTS OF MAIZE

The first step in managing insect pests is to identify the insect and determine the numbers present. Crops should be checked regularly to determine the extent of an insect infestation and assess the damage it is causing. This information can then be used to determine whether control is required and to decide on the most suitable management method.

Macrotermes (Termites)

Insect description

Three separate genera of termites have currently been identified as a problem in maize crops, including *Microtermes sp., Hypotermes sp., Globitermes sp. and Macrotermes gilvus. Build* short, broad based, dome shaped mounds in the field whilst the other species build their nests entirely below ground. Termites are small, white and honey coloured insects with a soft body and live in colonies in the soil. You will always find them in groups and the termites may be different sizes. The workers are the smallest and soldiers are significantly larger.

Damage

Traditionally termites are fungus producers and they harvest plant material to feed the fungus which they then feed on themselves. The termites chew maize roots and dry the plant out, usually resulting in patches of crop death. They may also tunnel up the inside of the stem, resulting in crop lodging and significant yield loss.

Management

Locate the queen and kill it or mix the soil with termiticides eg. Termidor SC Ostrinia furnacalis (maize borer)

Insect description

Young larvae are pink or yellow grey with black heads. Older larvae are whitish and spotted.

Eggs are laid in clusters on the top side of the leaf or husk and turn black just before hatching.

Damage

Larvae mainly damage the maize ear, feeding soon after emergence, working on the silk channels.

They not only cause direct damage to the kernels but also allow infections to occur if conditions are conducive by ear-rot pathogens.

Management

Spray with recommended insecticides such as larvae survive in the overwintering crop debris, exposing crop residue to direct sunlight or using crop residue for livestock feed or compost can reduce the incidence of larvae. Pheromone and light traps can be used to trap adult moths. Modifying sowing periods to avoid periods of heavy infestation can reduce crop damage. Intercropping with legumes or cassava can reduce the incidence of stem borer infestation on maize.

Helicoverpa armigera (heliothis)

Insect description

Hatchlings are pale with dark heads. As they grow, dark spots become clearer. Medium larvae have lines running down their body and their colour varies depending on what they are eating. White hairs are evident on their head and when medium sized, they develop a dark band on the fourth segment back from the head.

Damage

Larvae mainly damage the maize ear, feeding soon after emergence, working on the silk channels. They do not only cause direct damage to the kernels but also allow infections to occur if conditions are conducive by ear-rot pathogens.

Management

Control measures include the growing of resistant varieties, weeding, inter-row cultivation, removing crop residues, deep autumn ploughing, winter watering to destroy the pupae, the use of insecticides or biological control through the release of entomophages such as *Trichogramma* spp. and *Habrobracon hebetor*. Monitoring is possible by the use of sex pheromone traps Spodoptera litura (armyworm)

Insect description

As larvae grow they develop obvious black triangles along each side of their body. Larvae grow up to 3 cm long and are narrowest at the head. Eggs are laid in clusters of up to 300.

Damage

Mass hatchings of armyworms begin feeding on leaves, scraping the surface off and creating a 'window pane' effect. The damage becomes progressively worse, starting at the margins and moving inward, with the armyworms eating entire leaves or defoliating plants.

Management

The use of *Bacillus thuringiensis* (BT) may effectively control this pest. Other forms of biological, horticultural, and cultural control that have been studied include: planting near derris and garlic plants, breeding resistant plants from wild plants for example groundnuts from wild groundnuts, breeding resistant plants using bacterium *Bacillus thuringiensis* genes, using a Baculovirus, using the nematode *Steinernema carpocapsae*, and using the fly *Exorista japonica*

Nezara viridula (green vegetable bug)

Insect description

Adults are 15 mm long and bright green all over. Nymphs go through five different instar stages where they change colour and pattern. They start by being orange and black, then black, red and yellow patterns develop and eventually green is dominant.

Damage

Adults and nymphs pierce and suck developing seeds and cobs, which may be lost, deformed or have dark marks on them.

Management

It may be possible to utilize trap-borders of preferred hosts such as Crotalaria (rattlepod) to attract and hold stink bug populations. Stink bugs will usually remain on the plants where parasites can readily find them. Insecticidal applications are usually not required, however sprays may be needed if stink bug populations are high Bio-Control such as Predation by the big headed ant, *Pheidole megacephala*, has been reported

BENEFICIAL INSECTS

There are some beneficial insects, including predators and parasitic wasps that commonly occur in maize crops. Farmers should be able to distinguish these insects from maize pests and use them as a tool in integrated pest management.
When present in high numbers these beneficial insects may be effective in controlling pests and preventing yield loss.

Oechalia schellenbergii - Predatory shield bug

Insect description

Adults are 15 mm long, shield-shaped with obvious spines sticking out either side of their shoulders and a light mark in the middle of their backs. Nymphs are almost black with a red ring on their backs.
Impact on pests

The adult and nymphal stages of this predator use their beaks to pierce insects, especially heliothis, loopers and other caterpillars, and suck out the body contents.

Predatory Ants

Insect description

Ants consist of workers, soldiers and queens. Soldiers have large heads and are in charge of defence and protecting the queen. Workers are smaller and have smaller heads, and there are more of them. Queens are obviously larger than all other ants
Impact on pests

Predatory ants attack termites, wireworms, moth eggs, small larva and leafhoppers.

Earwigs

Insect description

Adults are approximately 25 mm long with a flat, brown body. They have lighter colored legs, a pale cream panel on either side of the thorax and a pair of distinctive curved pincers at the end of the body. They hide on the plant or in the ground during the day, becoming active at night.

Impact on pests

Earwigs commonly occur in field crops such as maize and beans as a predator of caterpillars, pupae and wireworms.

Lady Beetles (Various Species)

Insect description

Lady beetles have four distinct growth stages – egg, larval, pupae and adult. Adults are 5 to 8 mm long with two pairs of wings and are oval in shape with obvious spots or lines on their backs in black, red, orange or yellow.

Impact on pests

The adults and larvae of ladybirds are important predatory insects in field crops. Adults mainly feed on eggs and aphids, whilst nymphs will also eat hatchlings. Two or more per plant may make a useful contribution to IPM.

Calleida sp. (Ground beetle)

Insect description

Beetles are long and thin with a shiny black shell divided into definite segments

Impact on pests

Both nymphs and adults are predators. The larvae of this beetle walk from plant to plant in the crop to prey on *Spodoptera sp., Heliothis sp. and other defoliating caterpillars.*

STORAGE PESTS

Stored maize is susceptible to infestation by insect pests and attack by diseases and can also be damaged by rodents and birds.
It is important to fumigate or periodically expose grain to the sun to kill storage insect pests such as the lesser grain weevil.
Cleaning of the grain store to remove all traces of previous crop, preferably by disinfecting the structure before use, is important.
It is also necessary to monitor the condition of the stored grain throughout the storage period for insect pests, disease, temperature and moisture.

Sitophilus oryzae (Lesser grain weevil)

Insect description

Adults are 2 to 3 mm long, with a long snout and four reddish spots on the wing covers.

The larvae spend all their time inside the grain.

Damage

Management of this insect is very important. The larvae chew large irregular holes in the kernel and when adults emerge they make an irregular shaped hole about 1.5 mm in diameter.

Tribolium castaneum (red flour beetle)

Insect description

Adults are reddish brown with a flat, oval body 2.5– 4.0 mm long with wings. Larvae are mobile in the grain sample.

Damage

Larvae prefer feeding on the grain germ. Damage is particularly serious in grains such as rice and wheat, which have either been de husked or processed into other products. When infestation is severe, these products turn greyish-yellow and become mouldy with a pungent odor.

Oryzaephilus surinamensis (sawtoothed grain beetle)

Insect description

Adults are 2.5 to 3.0 mm long, with a slim, grey body with distinct ridges on the thorax and teeth like projections on each side.

Damage

Adult beetles of *O. surinamensis can be seen moving rapidly over stored food, but the immature stages are inconspicuous (CPC 2000). They are a* major pest of stored grain and milled products, as they can easily eat through packaging.

Araecerus fasciculatus (areca nut weevil)

Insect description

This is a fungus weevil that is a mottled dark brown all over its 3- to 5-mm long body.

Damage

Maize is a primary host of these grain-boring insects. Infestation may cause stored grain to be hollowed out or tunneled by the larvae. Adults bore circular holes when they emerge from the grain. Adult feeding causes irregular ragged patterns of damage, particularly if feeding occurs on a commodity previously damaged by larvae

STORAGE PEST CONTROL

The best form of controlling storage pest of maize is by Fumigating with Phosphine.

HARVESTING

Maize is harvested when it reaches physiological maturity-black layer

Traditionally, when maize cobs have dried down and it is time for harvest, the cobs are handpicked, hand shelled and dried in the sun. This is very labor intensive, which has a significant impact on the gross margin for maize. Another option is to machine harvest when moisture levels drop below 18% to 24% and then dry down to below 14% for delivery or storage. Harvesting can be done with a **machine** called combined harvester or by **hand**.

DRYING

After threshing, the maize kernels are dried in the sun either on mats, plastic tarpaulins or on a cement pad until the moisture content is below 11%, when the kernels are ready for sale. During the drying process the kernels are raked across the pad to ensure even drying. The moisture level in maize must remain below 11% if the maize is stored for long periods, otherwise aflatoxin may develop, producing toxic side effects for consumers of the grain

Drying methods

Plastic sheets and Concrete slab can be used in drying. Concrete slabs are usually 5 × 5 m or 10 × 10 m and can be enlarged depending on requirements. Maize can also be dried with a grains drying machine.

STORAGE

- Maize is packaged in sacks are place a warehouse where has a room temperature (25 degree Celsius).
- Maize are susceptible to a lot of pest during storage.

- The storage environment must be free from pest.
- The environment must not have too much moisture which can cause root of the maize.

Harvested Maize Ears

NORMAL EAR on well fertilized high-producing corn weights about 300gr. It has well filled tips.

BIG EARS weighing up to 500gr indicate that plant population was too small for most profitable yields.

SMALL EARS usually are a sign of low fertility. For better yields, boost fertilizer application.

POTASH shortage shows up in ears with poorly filled tips and loose chaffy kernels.

PHOSPHATE shortages interfere with pollination and kernel fill. Ears are small, often are twisted and with undeveloped kernels.

NITROGEN is essential throughout the growing season. If plant runs out of nitrogen at critical time, ears are small and protein content is low. Kernels at tip do not fill.

GREEN SILKS at maturity may be caused by too much nitrogen in relation to other elements.

DRY WEATHER slows silking behind tasseling; kernels aren't pollinated

Guide to Nutrient Deficiency Symptoms

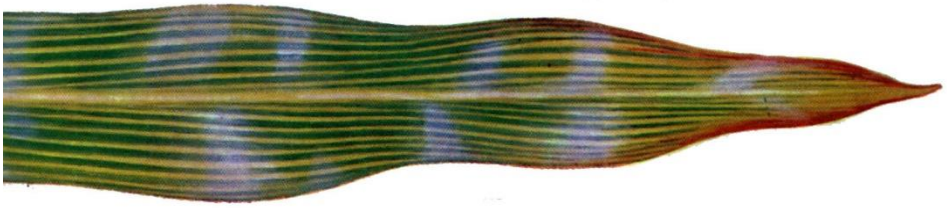
HEALTHY leaves shine with a rich dark green color when adequately fed

PHOSPHATE shortage marks leaves with reddish-purple, particularly on young plants

POTASH deficiency appears as a firing or drying along the tips and edges of lowest leaves

NITROGEN hunger sign is yellowing that starts at tip and moves along middle of leaf

MAGNESIUM deficiency causes whitish strips along the veins and often a purplish color on the underside of the lower leaves



DROUGHT causes the corn to have a grayish-green color and the leaves roll up nearly to the size of a pencil

DISEASE, helminthosporium blight, starts in small spots, gradually spreads across leaf

CHEMICALS may sometimes burn tips, edges of leaves and at other contacts. Tissue dies, leaf becomes whitecap

CHEMICAL damage