DEPARTMENT: AGRICULTURE
REPUBLIC OF SOUTH AFRICA

Maize production

Jéan du Plessis

2003

Compiled by Directorate Agricultural Information Services
Department of Agriculture
in cooperation with ARC-Grain Crops Institute

Printed and published by the Department of Agriculture
and obtainable from Resource Centre
Directorate Agricultural Information Services
Private Bag X144, Pretoria, 0001 South Africa

This publication is available on the web: *www.nda.agric.za/publications*

ARC • LNR

Information provided by
ARC-Grain Crops Institute
Private Bag X1251, Potchefstroom 2520
Tel. (018) 299 6100
Fax (018) 294 7146

INTRODUCTION

Maize (*Zea mays* L.) is the most important grain crop in South Africa and is produced throughout the country under diverse environments. Successful maize production depends on the correct application of production inputs that will sustain the environment as well as agricultural production. These inputs are, *inter alia,* adapted cultivars, plant population, soil tillage, fertilisation, weed, insect and disease control, harvesting, marketing and financial resources.

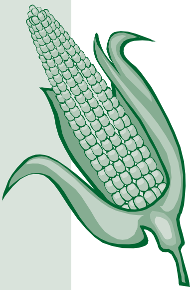
In developed countries, maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, maize is consumed directly and serves as staple diet for some 200 million people. Most people regard maize as a breakfast cereal. However, in a processed form it is also found as fuel (ethanol) and starch. Starch in turn involves enzymatic conversion into products such as sorbitol, dextrine, sorbic and lactic acid, and appears in household items such as beer, ice cream, syrup, shoe polish, glue, fireworks, ink, batteries, mustard, cosmetics, aspirin and paint.

Approximately 8,0 million tons of maize grain are produced in South Africa annually on approximately 3,1 million ha of land. Half of the production consists of white maize, for human food consumption.

Maize needs 450 to 600 mm of water per season, which is mainly acquired from the soil moisture reserves. About 15,0 kg of grain are produced for each millimetre of water consumed. At maturity, each plant will have consumed 250 l of water. The total leaf area at maturity may exceed one square metre per plant.

The assimilation of nitrogen, phosphorus and potassium reaches a peak during flowering. At maturity the total nutrient uptake of a single maize plant is 8,7 g of nitrogen, 5,1 g of phosphorus, and 4,0 g of potassium. Each ton of grain produced removes 15,0 to 18,0 kg of nitrogen, 2,5 to 3,0 kg of phosphorus and 3,0 to 4,0 kg of potassium from the soil.

No other crop utilises sunlight more effectively than maize, and its yield per ha is the highest of all grain crops. At maturity, the total energy used by one plant is equivalent to that of 8 293 15 W electric globes in an hour.



The number of kernel rows may vary between four and 40, depending on the variety. Up to 1 000 kernels may be produced by a single plant. In spite of only one pollen grain being required to produce one kernel, each tassel produces some 25 000 000 pollen grains, i. e. 25 000 grains for each kernel. As a result, up to 40 % of the tassels in a planting may be lost without affecting pollination, other factors remaining optimal.

MORPHOLOGY, GROWTH AND DEVELOPMENT

Root system

The plant has a profusely branched, fine root system. Under optimal conditions, the total root length, excluding the root hairs, can reach 1 500 m.

If root growth is not restricted, the root system of a mature plant extends approximately 1,5 m laterally and downwards to approximately 2,0 m or even deeper. The permanent root system has adventitious and prop roots. Adventitious roots

develop in a crown of roots from nodes below the soil surface. Normally four to six adventitious roots are formed per band. After tasselling, prop roots develop into bands from the first two to three aerial nodes. These roots are comparatively thick, pigmented and covered with a waxy substance. Prop roots have the dual function of providing support to the plant and taking up nutrients.

Numerous root hairs occur on young plants. Root hairs increase root surface area that is exposed to the soil, and play an important role in absorption of water and nutrients.

Leaves

The eight to 20 leaves that may form are arranged spirally on the stem, and they occur alternately in two opposite rows on the stem. The maize leaf is a typical grass leaf and consists of a sheath, ligules, auricles and a blade. The leaf blade is long, narrow, undulating and tapers towards the tip and is glabrous to hairy. The leaf is supported by a prominent mid-rib along its entire length.

Stomata occur in rows along the entire of the leaf surface. More stomata occur on the underside of the leaf than on the upper surface. On the upper surface motor cells are present. These large, wedge-shaped cells occur in rows, parallel to and between the rows of stomata. During moist conditions, these cells rapidly absorb water, become turgid and unfold the leaf. During warm, dry weather, the cells quickly lose their turgor with the result that leaves curl inwards exposing a smaller leaf surface to evaporation.

Stem

The maize stem varies in height from less than 0,6 m in some genotypes to more than 5,0 m (in extreme cases) in others. The stem is cylindrical, solid and is clearly divided into nodes and internodes. It may have eight to 21 internodes. The internodes directly below the first four leaves do not lengthen, whereas those below the sixth, seventh and eighth leaves lengthen to approximately 25, 50 and 90 mm, respectively. Tillers may develop from nodes below the soil surface.

The lateral shoot bearing the main ear develops more or less from the bud on the eighth node above the soil surface. The five or six buds directly below the bud give rise to rudimentary lateral shoots of which one or two develop to produce ears.

Inflorescence

Male and female flowers are borne on the same plant as separate inflorescences. Male flowers are borne in the tassel and female flowers on the ear.

Maize ear

The maize ear (the female inflorescence) terminates one or more lateral branches, usually halfway up the stem. Bracts enclose the ear. The silk of the flowers at the bottom appear first and thereafter those on the upper part of the ear. It remains receptive to pollen for approximately three weeks but after the tenth day, receptivity decreases.

Maize kernel

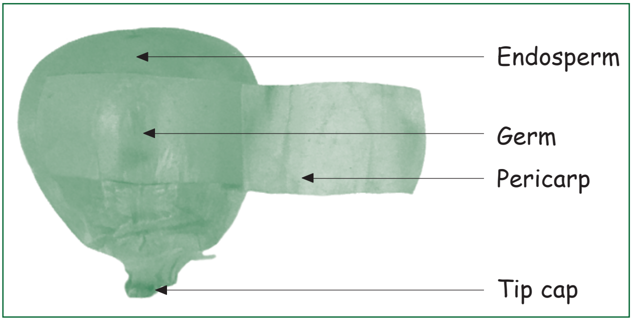
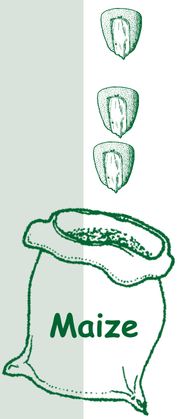


FIG. 1. Maize kernel

The maize kernel consists of an endosperm, embryo, a pericarp and tip cap (Fig. 1). The endosperm contains the main carbohydrates. The embryo contains the parts that give rise to the next generation, while the pericarp and tip cap enclose the entire kernel.

The endosperm contains approximately 80 % of the carbohydrates, 20 % of the fat and 25 % of the minerals, while the embryo contains about 80 % of the fat, 75 % of the minerals and 20 % of the protein found in the kernel.



The starch part of the kernel is used in foods and many other products such as adhesives, clothing, and pharmaceutical tablets and in paper production. The starch can be converted into sweeteners and used in products such as soft drinks, sweets, bakery products and jams, to name but a few.

The oil from the embryo is used in cooking oils, margarine and salad dressings. The protein, hulls and soluble part of the maize kernel are used in animal and poultry feed.

TABLE 1. Composition of maize kernels

Components	Dent kernels %	Flint kernels %
Endosperm—hard	54,2	
Endosperm—soft	27,5	
Endosperm—total	81,7	80,6
Embryo	11,0	13,5
Pericarp and tip cap	7,2	5,8

TABLE 2. Chemical composition of the maize kernel

Components	%
Carbohydrates	84,0
Protein	10,9
Fat	4,5
Minerals	1,3

Kernels can be of the dent or flint (round) types. Dent kernels have a dented crown, which is formed during drying when the softer starch in the middle of the kernel shrinks faster than the outer more translucent sides. The dent kernel has two flat sides opposite each other and the one side contains the embryo.

The embryo contains all the parts that give rise to the next generation.

Flint kernels can be round or flat in appearance and contain mainly translucent starch, with only a small part of soft starch in the middle, hence the name. The pericarp and tip cap enclose the entire kernel.

Maize with a high percentage of translucent of hard endosperm is preferred by the dry milling industry, because it produces more of the popular high-quality and high-value products sought after than does soft maize.

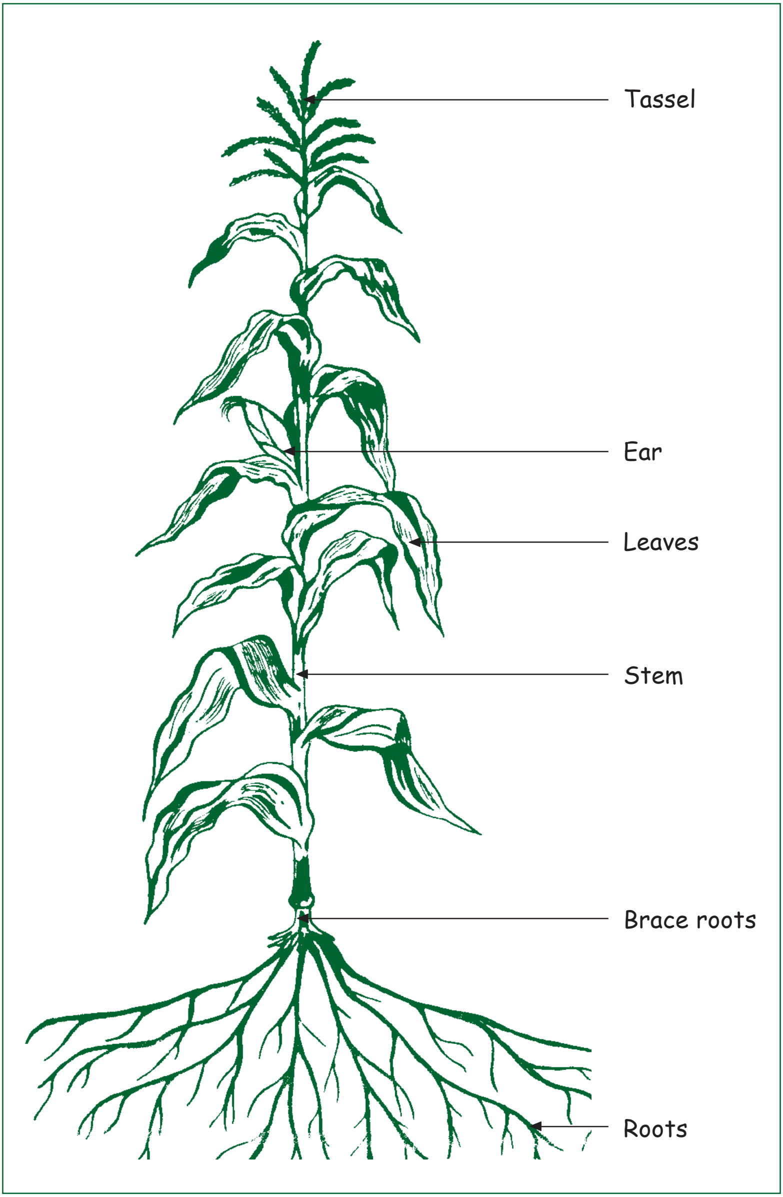
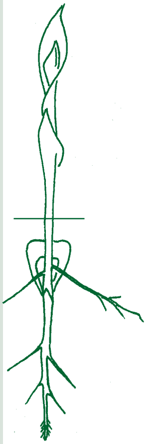


FIG. 2. Mature maize plant



Growth and development

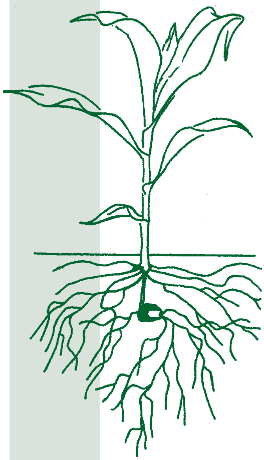
Different growth stages are numbered 0 to 10. Growth stage 0 lasts from planting of the seed up to when the seedling is just visible above the soil surface. Growth stage 10 is reached when the plant is biologically mature (Fig. 2).

Growth stage 0: from planting to seed emergence

During germination, the growth point and the entire stem are about 25 to 40 mm below the soil surface. Under warm, moist conditions seedlings emerge after about six to 10 days, but under cool or dry conditions this may take two weeks or longer. The optimum temperature range for germination is between 20 and 30 °C, while optimum moisture content of the soil should be approximately 60 % of soil capacity.

Growth stage 1: four leaves completely unfolded

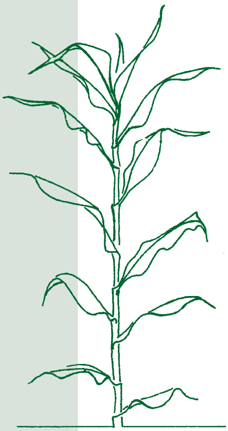
The maximum number of leaves and lateral shoots is predetermined and a new leaf unfolds more or less every third day. The growth point at this stage is still below the soil surface and aerial parts are limited to the leaf sheath and blades. Initiation of tasselling also occurs at this stage.



Growth stage 1

Growth stage 2: eight leaves completely unfolded

During this period, leaf area increases five to 10 times, while stem mass increases 50 to 100 times.



Growth stage 3

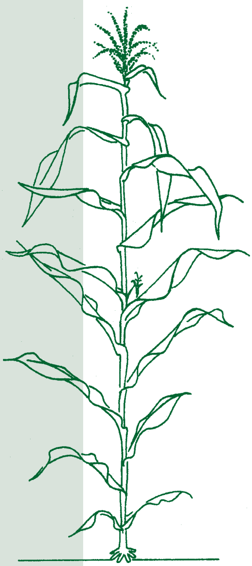
Ear initiation has already commenced. Tillers begin to develop from nodes below the soil surface. The growth point at this stage is approximately 5,0 to 7,5 cm above the soil surface.

Growth stage 3: twelve leaves completely unfolded

The tassel in the growth point begins to develop rapidly. Lateral shoots bearing cobs develop rapidly from the sixth to eighth nodes above the soil surface and the potential number of seed buds of the ear has already been determined.

Growth stage 4: sixteen leaves completely unfolded

The stem lengthens rapidly and the tassel is almost fully developed. Silks begin to develop and lengthen from the base of the upper ear.



Growth stage 5

Growth stage 5: silk appearance and pollen shedding

All leaves are completely unfolded and the tassel has been visible for two to three days. The lateral shoot bearing the main ear as well as bracts has almost reached maturity. At this point demand for nutrients and water is high.

Growth stage 6: green mealie stage

The ear, lateral shoot and bracts are fully developed and starch begins to accumulate in the endosperm.

Growth stage 7: soft dough stage

Grain mass continues to increase and sugars are converted into starch.

Growth stage 8: hard dough stage

Sugars in the kernel disappear rapidly. Starch accumulates in the crown of the kernel and extends downwards.

Growth stage 9: physiological maturity

When the kernel has reached its maximum dry mass, a layer of black cells develops at the kernel base. Grains are physiologically mature and only the moisture content must be reduced.

Growth stage 10: drying of kernels (biological maturity)

Although grains have reached physiological maturity, they must dry out before reaching biological maturity. Under favourable conditions, drying takes place at approximately 5 % per week up to the 20 % level, after which there is a slowdown.

ADAPTATION AND PRODUCTION POTENTIAL

Total yield on any farm is the product of climate and soil that can be regarded as the yield potential of that area.

Climatic requirements

Temperature

Maize is a warm weather crop and is not grown in areas where the mean daily temperature is less than 19 °C or where the mean of the summer months is less than 23 °C. Although the minimum temperature for germination is 10 °C, germination will be faster and less variable at soil temperatures of 16 to 18 °C. At 20 °C, maize should emerge within five to six days. The critical temperature detrimentally affecting yield is approximately 32 °C. Frost can damage maize at all growth stages and a frost-free period of 120 to 140 days is required to prevent damage. While the growth point is below the soil surface, new leaves will form and frost damage will not be too serious. Leaves of mature plants are easily damaged by frost and grain filling can be adversely affected.

Water

Approximately 10 to 16 kg of grain are produced for every millimetre of water used. A yield of 3 152 kg/ha requires between 350 and 450 mm of rain per annum. At maturity, each plant will have used 250 ℓ of water in the absence of moisture stress.

Soil requirements

The most suitable soil for maize is one with a good effective depth, favourable morphological properties, good internal drainage, an optimal moisture regime, sufficient and balanced quantities of plant nutrients and chemical properties that are favourable specifically for maize production.

Although large-scale maize production takes place on soils with a clay content of less than 10 % (sandy soils) or in excess of 30 % (clay and clay-loam soils), the texture classes between 10 and 30 % have air and moisture regimes that are optimal for healthy maize production.

Production potential

Several methods can be used to determine yield potential, each with its own limitations. One of the most reliable methods is long-term yield data collected by each individual producer, as this reflects inherent yield of the specific environment, as well as the effect of agronomic practices such as fertilisation, soil cultivation and plant population and managerial abilities of the producer.

CULTURAL PRACTICES

Soil tillage

Soil tillage, particularly primary tillage, is the foundation of any crop production system and is the biggest cost factor in maize production.

Effect of tillage practices on soil physical properties

Soil tillage in a farming system refers to the physical soil cultivation practices, changing the soil's structure, hydraulic properties and stability to such an extent that plants will grow and produce optimally.

Soil physical properties affected by tillage

Texture and structure

Texture refers to size of mineral soil particles and is the single most important physical property of soil. It involves a ratio of sand, silt and clay in a specific soil. This ratio determines the capacity and strength of structures that are formed, as well as ability to store water.

The objective of soil tillage is to maintain the existing structure of soil or to improve the structure of poorly structured soil.

Effect of tillage on soil

Infiltration and evaporation

The most important processes affected by soil tillage include infiltration and evaporation of water. Because water availability during the growing season is the single most important factor in crop production in South Africa, it is essential that soil tillage be aimed at optimising infiltration and minimising evaporation.

Germination and root growth

Germination and root growth are affected by tillage methods in that the soil temperature can be manipulated and evaporation reduced.

Erosion

The type of tillage affects vulnerability of the soil to either wind or water erosion. Finely-structured topsoil is susceptible to both types of erosion, while a coarse structure limits erosion.

Implements and soil tillage

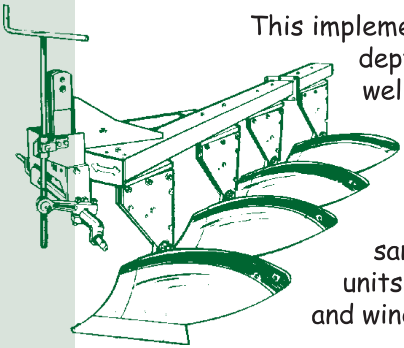
The aims of soil tillage are weed control, incorporation of residue, reducing wind and water erosion and improving soil structure.

Secondary tillage is applied to control weeds and prepare a seedbed.

Primary implements are basic implements used to loosen the soil with the object of improving structure and countering compaction. These include mouldboard ploughs, disc ploughs, chisel ploughs and rippers.

Primary tillage implements

Mouldboard ploughs



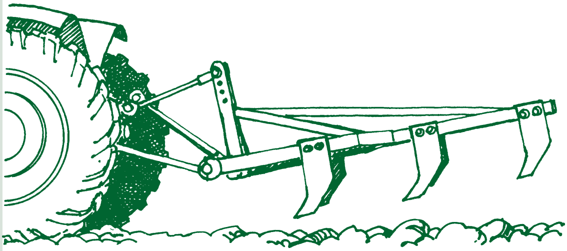
This implement is used to turn sods up to 300 mm depth and is particularly useful on heavier well-structured soils. Turning the soil also has the advantage that weed seeds and unwanted crop residues can be buried deeply. Mouldboard ploughs are not recommended on sandy soils, because poorly-structured units which may exist, can be destroyed and wind erosion be promoted.

Disc ploughs and discs

The disc plough has a slicing action with the main advantage that better penetration is obtained under dry, hard conditions, with an additional advantage that wear is lower than in the case of a mouldboard plough. The implement is useful on hard, dry soils where loss of structure is not too critical. It is on no account recommended for sandy soils.

Chisel ploughs

Chisel ploughs are used mainly to loosen the soil to a limited depth of 250 mm. Best results are obtained if the soil is relatively dry, because the chisels break the soil, creating structural units. If conditions are too dry, however, big clods are formed, restricting plant development.



Rippers

Rippers are used when deep cultivation is necessary and turning of the soil is undesirable. If soils are tilled annually to the same depth, a plough-sole develops. This confined layer prevents infiltration and root development. To ensure better drainage, conservation and utilisation of water, it is essential to break this layer regularly. Under wet, clay conditions, the main disadvantage of the ripper is that it compacts the soil laterally and inwards, which can limit lateral root development.

Secondary tillage implements

Rotary tiller

Under ideal conditions, on moist clay soils, this useful implement can prepare the seedbed in one operation. On dry, sandy soils it can, however, destroy the structure within a very short period.

Tined cultivators

Tined cultivators include a variety of hoeing implements, which are used mainly for controlling young weeds, but also utilised for breaking surface crusts. These implements are only effective on moist soils. They are completely ineffective on dry, clay soils. These implements are often used for seedbed preparation.

Harrows

Harrows include a variety of implements. The tined harrow is primarily used to level the seedbed once it is in a fine condition. The primary objective of the disc harrow is to break surface crusts, but it can be used to break clods to obtain a fine seedbed.

Tillage systems

No-till

With this system, soil is left undisturbed from planting to harvesting. A prerequisite for this type of cultivation is that 30 % of the soil must be covered with plant residue after planting to reduce water erosion effectively.

Stubble-mulch tillage

In this case, soil is disturbed before planting without burying or destroying. For this action chisel ploughs, discs, spring-tooth implements or V-type blades are used. Weeds are controlled chemically and/or mechanically.

TABLE 3. Major advantages and disadvantages of different tillage systems

Tillage system	Advantages	Disadvantages
No-till	• Lowest fuel consumption • Quicker adaptation to optimum planting date • Lower machinery costs • Best control of wind and water erosion	• Higher application of herbicide and intensive herbicide management necessary • Requires: – management inputs – special or adapted planters – more expensive equipment • Possible compaction of soil and accumulation of nutrients in topsoil • Earlier occurrence of leaf diseases • Possible insect populations
Stubble-mulching	• Fuel saving (compared to ploughing) • Good control/better management of: – wind and water erosion – soil compaction – weed control	• Soil preparation dependant pendent on spring rains • Greater possibility of leaf diseases
Reduced tillage	• Greater fuel economy (than e.g. ploughing) • Control of: – Wind erosion – Insect population • Accumulation of nutrients not a problem	• Poor management of water erosion • Better weed management
Conventional tillage	• Good weed and insect control • Lowest management inputs	• Highest: – fuel consumption – machinery costs • Waiting period for suitable soil water • No control of water and wind erosion

Reduced tillage

This could be any type of tillage practice which leaves 15 to 30 % of the soil surface covered with stubble. Weeds are controlled chemically or mechanically.

Conventional tillage

This includes tillage that leaves less than 15 % of the soil surface covered with stubble. Conventional tillage usually implies a plough action or an intensive range of cultivations.

It is important to bear in mind that 1 ton of grain/ha delivers one ton of plant residue, which is sufficient to cover 10 % of the soil. If conservation tillage is considered as an alternative, a minimum yield of 3,0 ton/ha must be obtained to provide a surface cover of 30 %.

When conservation tillage is practised with the aim of conserving moisture, at least 50 to 60 % of the soil surface should be covered.

With any tillage system, it is of paramount importance to ensure that a compacted layer, that may impair plant growth, does not occur in the effective root zone. Any soil has the potential to form a compacted layer and therefore all cultivated soils should be inspected regularly for such restrictions. If a confined layer is detected, it should be broken using a ripper implement to ensure better drainage, conservation and utilisation of water.

ESTABLISHMENT PRACTICES

Planting date

Planting can commence as soon as groundwater and soil temperature are suitable for good germination. If a minimum air temperature of 10 to 15 °C is maintained for seven successive days, germination should proceed normally. Virtually no germination or growth takes place below 10 °C. Planting should be scheduled such that the most heat and water sensitive growth stage of maize (i.e. the flowering stage) does not coincide with midsummer droughts.

Planting depth and plant technique

Planting depth of maize varies from 5 to 10 cm, depending on the soil type and planting date. As a rule, planting should be shallower in heavier soils than in sandy soils.

Plant population and row width

Plant population per unit area is more important than specific row width. Row widths under dryland conditions can vary from 0,91 m to 2,1 or 2,3 m, depending on mechanical equipment available and type of soil tillage system used.

TABLE 4. Guidelines for choosing row width

Wide rows (1,5 to 2,1 m)	Narrow rows (0,91 to 1,0 m)
• Low and medium yield target	• Medium and high yield target
• Low and medium rainfall	• Medium and high rainfall
• Wind erosion problems	• Water and sloping contours
• Weed problem; weeds controlled chemically in	• Good weed control with complete spraying
• Strip tilage only in rows	• Total tillage

TABLE 5. Guidelines for a realistic plant population

Yield potential (ton/ha)	Cooler areas	Temperate areas	Warmer areas
Dryland			
2	16 000	12 000	10 000
3	19 000	16 000	14 000
4	25 000	21 000	19 000
5	31 000	26 000	24 000
6	37 000	31 000	28 000
7	43 000	36 000	
Irrigation			
8–10	55 000	50 000	45 000
10+	65 000	60 000	55 000
Ultrashort			
10+	80 000	80 000	90 000

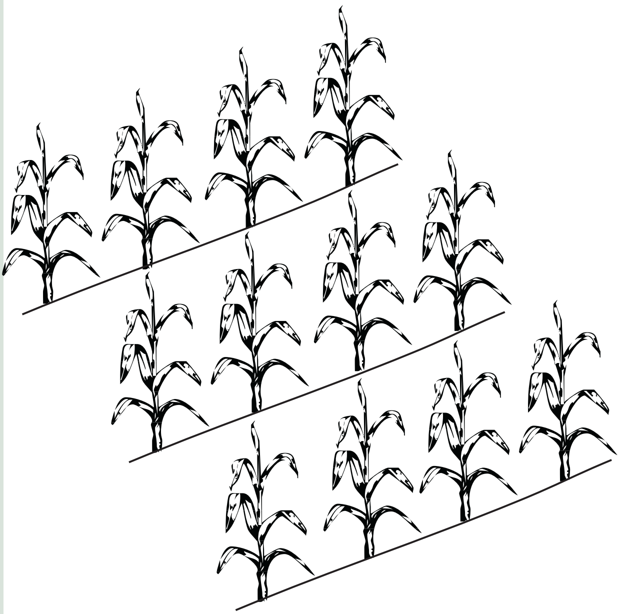


TABLE 6. Within row spacing (cm) at different populations and row widths

Plant population	Spacing within row (cm)				
	Row width (m)				
	0,75	0,91	1,5	0,91 x 2,3	2,3
90 000	15	12			
80 000	17	14			
70 000	19	16			
60 000	22	19			
50 000	27	22			
45 000	30	25			
40 000	33	28			
35 000	38	32	19		
30 000	44	37	22	21	
27 500		40	24	23	
25 000		43	26	25	
22 500		50	29	28	
20 000		56	33	31	22
18 000			37	35	24
16 000			42	39	27
14 000				45	31
12 000				53	36
10 000				62	44

CULTIVAR CHOICE

Guidelines for selecting maize cultivars

Cultivar choice, if correctly planned, can make a great contribution to risk reduction and should constitute an important part of production planning.

Cultivars differ from one another with regard to a variety of characteristics. Therefore, every cultivar has its own adaptability and yield potential. These differences between cultivars leave a producer with alternatives that can be utilised fully. The producer should, however, first verify the reaction of new or foreign cultivars before abandoning proven cultivars.

Yield potential and adaptability

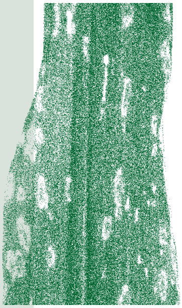
As a result of a wide diversity of conditions under which maize is produced in South Africa, it is essential that cultivars that are eventually planted should be adapted to specific production conditions.

Cultivars with wide adaptability can be used to stabilise yields under variable weather conditions of South Africa. Together with adaptability, stability of cultivars should also be considered. Greater stability of a cultivar, leads to predict ability of yield reaction at a specific potential.

For further information, consult the *Maize Information Guide* (MIG) published annually and obtainable from: The Director, ARC-GCI, Private Bag X1251, Potchefstroom 2520.

Length of growing season

The length of the growing season of cultivars plays an important role, especially in cooler production areas. The cooler environment causes large differences among cultivars in the period from planting to flowering and physiological maturity and accentuates differences among the various growing periods.



Grey leafspot

Disease resistance

Cultivars differ in their susceptibility to diseases such as ear rot, maize streak virus disease, grey leafspot, rust, cob-and-tassel smut, stemrot as well as root rots. Cultivars with the best levels of resistance or tolerance to a disease should be selected for planting where a specific disease occurs.

Lodging

Lodging of plants has a financial implication for the producer, because a number of ears may be laying on the soil, making it uneconomical to be picked up by hand. Good progress has been made with cultivars showing less lodging, but differences among cultivars still occur.

Ear rot

Ear prolificacy

Prolificacy can be described as the potential of a cultivar to produce more than one ear at maturity. This characteristic is linked to the adaptability of a cultivar and can be used to good advantage where lower plant populations are required or where it develops spontaneously unintentionally.

FERTILISATION OF MAIZE

It is of the utmost importance that the correct soil sampling methods be used when submitting samples for laboratory analysis. Recommended sampling methods to be used are available in the *Fertilizer Guidelines for Maize*, and can be obtained from: The Director, ARC-GCI, Private Bag X1251, Potchefstroom 2520.

Recommendations supplied by the Institute should be strictly adhered to, to obtain the required results in the field.

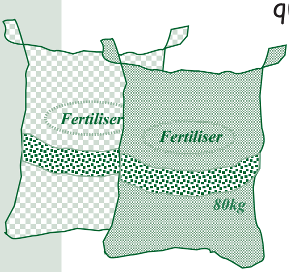
Application methods

Nitrogen (N)

The following rates of application, band-placed at planting 50 mm to the side of the seed and 50 mm below the seed, should not be exceeded:

0,9 m rows: not more than 40 kg N/ha
1,5 m rows: not more than 30 kg N/ha
2,1 m rows: not more than 20 kg N/ha

N and K applications should not exceed 70, 50 and 30 kg/ha for the respective row widths. Larger quantities can, however, be applied, provided that these are placed 70 to 100 mm to the side and below the seed.



N should always be included in the fertiliser plant mixtures, but weather conditions and residual N in the soil will determine when most N should be applied.

Deficiencies in nitrogen give rise to young plants that are pale, light green or yellow. During later stages older leaves begin yellowing, showing at first a characteristic inverted V-shape.

Phosphorus (P)

The general practice is to band-place P at 50 mm to the side and 50 mm below the seed.

Deficiency symptoms usually occur on young plants, especially under cool, wet conditions. Leaves are dark green with reddish-purple tips and margins.

Potassium (K)

The general practice is to band-place K, 50 mm to the side and 50 mm below the seed in a fertiliser mixture at planting. The following application rates should not be exceeded:

0,9 m rows: not more than 40 kg P/ha

1,5 m rows: not more than 30 kg P/ha

2,1 m rows: not more than 20 kg P/ha

K and N applications should not exceed 70, 50 and 30 kg/ha for the respective row widths. Larger quantities can, however, be band-placed, provided that these are located 70 to 100 mm to the side and below the seed.

A potassium deficiency is initially noted as yellow or necrotic leaf margins, beginning at the lower leaves and spreading to the upper leaves. Mature plants lodge easily when suffering a K deficiency, because stems are predisposed to stalk rot under such conditions.

Zinc (Cn)

The microelement, zinc, is mostly applied, as it is included in many fertiliser mixtures. A deficiency is characterised by light streaks or bands between the veins from the leaf base to the tip. Under cool overcast conditions, these symptoms suddenly appear but disappear just as quickly once the sun appears.

WEEDS

Successful cultivation of maize depends largely on the efficacy of weed control. Weed control during the first six to eight weeks after planting is crucial, because weeds compete vigorously with the crop for nutrients and water during this period.

Large thorn apple

Annual yield losses occur as a result of weed infestations in cultivated crops. The annual yield loss in maize because of weed problems is estimated to be approximately 10 %. The loss occurs as a result of weed competition for nutrients, water and light.

The presence of weeds during harvesting may slow the process, pollute grain with seeds, transmit odours to grain, causing downgrading, or incur additional costs for removal of seeds. Certain seeds, such as those of the thorn apple (*Datura*), may be poisonous when consumed by animals or humans.

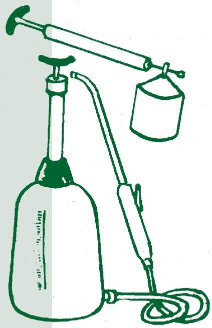
Methods of weed control

Physical methods

Weeds can be removed mechanically, by implements or by hand. Dense stands of weeds may be burnt as an emergency measure.

Cultural practices

Ploughing during winter or early spring is an effective method of destroying the majority of weeds. To control weeds during the season, crops may be planted in wide rows for mechanical control. Certain problem weeds in maize can be controlled by an alternative crop where crop rotation is practised.



Chemical methods

Chemical liquids, granules or gases are used to kill germinating or growing weeds, or even weed seeds.

Control of nut grass with pre-emergence herbicides is not effective when applied after emergence. It is important to cultivate fields before applying herbicides.

PRINCIPLES OF PEST CONTROL

Integrated pest management

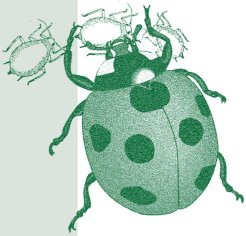
Integrated pest management is a system whereby various strategies are used to protect crops by suppressing the insect population and limiting damage. These management practices incorporate all practical methods of pest control in a pest management system. These measures include chemical control, biological control, plant resistance and cultivation control.

Preventive control

Although preventive control measures may often seem to be "effective", this effectiveness can be ascribed to relatively low population levels of specific insects during certain years, when epidemic outbreaks do not occur. If very high infection levels do occur during epidemic years, preventive control will be ineffective and large losses may be experienced. It is therefore important to determine the infestation level before spraying or seed treatments are applied.

Cultivation control

This implies that pest populations are suppressed by cultivation practices, which are detrimental to the pest. These practices include soil cultivation during winter, eradicating volunteer plants, cultivar choice and adapting planting times.



Ladybird feeding on aphids

Biological control

Natural control of pests occurs continually in fields where natural enemies attack all the life-stages of insect pests. Aphids and hibernating larvae of stem borers in particular are killed by natural enemies. The natural enemy complex can be protected to a certain extent by using insecticides which are more environmentally friendly, and which are not very toxic to nontarget organisms.

Insect-resistant plants

The use of plants which are resistant to insects, is extremely beneficial, because of both short and long-term benefits. The short-term benefit of plant resistance is that it limits pest damage, while economic threshold values are often not reached.

Skilled advice regarding the combination and use of the different control measures is available at the Plant Protection Division, ARC-GCI, Private Bag X1251, Potchefstroom 2520.

Nematode control

Plant-parasitic nematodes are present in all production areas of South Africa. A progressive yield loss over a number of seasons is usually the only indication of nematode infestation. Yield loss is normally a response to damage to the root system of the maize plant.

Economic control of nematodes in maize is difficult, mainly because of the high cost of nematicides. Maize price fluctuations, different cultivation practices and differences in production potential must be taken into account to determine economic justification of chemical nematode control.

Irrigated maize

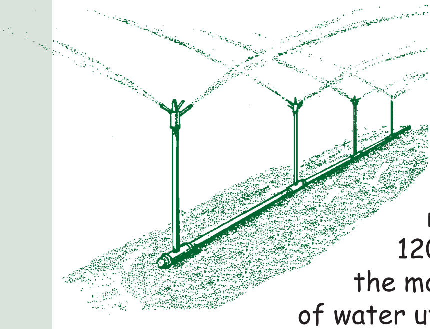
When infestation levels are high, chemical control in irrigated maize can readily be recommended from an economic point of view.

Dryland maize

Yield increases as a result of chemical nematode control are very erratic, the exception being with the presence of high infestations of rootknot nematodes in dryland maize. Rootknot nematode populations may, under favourable conditions and within one season, increase to such an extent that economic yield losses are incurred. In such cases, it is essential to control the nematode population, even though the control measures when regarded over one season, are not economically justifiable.

Economic nematode control is therefore a complex strategy, which cannot be effectively applied without proper knowledge of the infestation levels and considering various other factors.

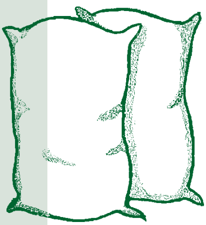
IRRIGATION



Maize can be regarded as an important grain crop under irrigation, as it produces very high yields. It can produce from 80 to 100 tons/ha green material and 16 to 21 tons/ha of dry material within a relatively short period (100 to 120 days). It is therefore one of the most efficient grain crops in terms of water utilisation. Maize is usually produced under full irrigation in order to obtain the highest yields.

HARVESTING PROCESS

Maize is predominantly harvested mechanically, although exceptions do occur in the case of hand harvesting.



Hand harvesting

The entire plant can be cut and placed into stacks (stook) while still green. Once it is dry, the ears can be picked and threshed, or the entire plant with the ear can be utilised as maize hay. Alternatively, the plants can be left in the field to dry and the ears harvested.

Mechanical harvesting

In South Africa, maize is usually left in the field until moisture percentages of 12,5 to 14,0 are reached before it is harvested and delivered to a silo.

PRODUCTION MANAGEMENT GUIDELINES

Growth stage 0: from planting to emergence

Planting depth affects the period from planting to emergence, because the seedlings of deeply-planted seed will take longer to emerge than shallowly-planted seed. If planted too deep, the mesocotyl may open below the soil surface and cause the seedling to die off.

The seedling obtains its nutrients mainly from seed reserves. Primary roots may be in contact with band-placed fertiliser even before emergence. Too much fertiliser close to the seed may cause burning.

Growth stage 1: four leaves unfolded

Some of the problems encountered during this stage should not have a permanent effect on yield, provided the problems are rectified promptly.

During this stage plants are very susceptible to drift-sand damage.

Hail and light frost may damage the exposed leaves, but because the growth point is still below the soil surface, damage should be negligible.

Waterlogging at this stage may be harmful to the seedling, because the growth point is still below ground level.

Tilling close to the plants may harm the roots, which will put the plants under stress and detrimentally affect yield.

Growth stage 2: eight leaves unfolded

Nutrient deficiencies will restrict leaf growth. If necessary, this is the correct stage to apply a fertiliser as side dressing. Nitrogen should, however, be applied to moist soil and roots should damaged as little as possible.

Defoliation by hail or other factors may cause a yield loss of 10 to 20 %.

As long as the growth point is still below ground level, waterlogging may cause damping off of plants. Flooding at later stages, when the growth point stays above the water, is not as detrimental.

Growth stage 3: twelve leaves unfolded

Stress as a result of water or nutrient deficiencies during this stage will affect the ultimate size and yield of ears.

Plants, breaking below the growth point, will not recover.

Growth stage 4: Sixteen leaves unfolded

Hot soil surfaces may affect the development of prop roots.

The tassel begins to show in the calyx. Water and nutrient deficiencies may detrimentally affect silk development and therefore the number of kernels per ear.

Hail damage may detrimentally affect yield.

Growth stage 5: appearance of silks and pollen shedding

Planting dates should be chosen so as to ensure that this stage coincides with normally favourable growing conditions. Water supply is important because wilting of plants (water stress) early in the morning detrimentally affects pollination.

Growth stages 6 and 7: hard dough

Denting of kernels begins and this is the right stage to make silage.D

Growth stage 9: Physiological maturity

Monitor moisture content of grain regularly to start harvesting as soon as possible (below 14 %) to reduce grain losses.

ENQUIRIES

For further information on maize production, contact:

- ARC-Grain Crops Institute
  Private Bag X1251
  Potchefstroom
  2520
  Tel. (018) 299 6100

  Contact persons: Jéan du Plessis, Dirk de V Bruwer, Justinus Mashao, Apie Pretorius, Thinus Prinsloo

- Resource Centre
  Tel. (012) 319 7141/7085

This publication is based on information from *Guide for the production of maize in the summer rainfall area* by W du Toit and is available at the above address.

NOTES