Chapter 2

Grain Sorghum Poaceae

Sorghum bicolour (L.) Moench

Prepared

by

Prof. Dr. Ali El-Saied Sharief

Faculty of Agriculture Mansoura University, Egypt

Introduction

- Sorghum (Sorghum bicolor L. moench) was probably initially domesticated in central Africa, in the region of Ethiopia and Sudan.
- Subsequently, cultivation of sorghum spread throughout Africa and Asia and finally to the Americas and Australia.
- Today it is one of the world's major food crops, particular in Areas of high temperature and low rain fall.
- Its used for human consumption and to feed different kinds of livestock's such as birds, pigs and cows.

Introduction

- Sorghum is an indigenous crop to Africa. Sorghum is mainly cultivated in drier areas, especially on shallow and heavy clay soils. Sorghum belongs to the grass family, Graminea.
- Grain sorghum can be a suitable crop for ethanol and biomass production in USA because of its high yield potential, water use efficiency, tolerance to abiotic stresses, and because Texas growers have ample experience managing this crop.
- Currently about 12-20% of the US grain sorghum crop goes into ethanol production and its co-products.
- The oldest cultivation record dates back to 3000 B.C. in Egypt

Sorghum Taxonomy

- Kingdom Plantae.
- Subkingdom Tracheobionta.
- Superdivision Spermatophyta.
- Class Liliopsida.
- Subclass Commelinidae.
- Order Cyperales.
- Family Poaceae (Grass).
- Genus Sorghum.
- Species Sorghum bicolor.
- Subspecies Sorghum bicolor ssp. Bicolor-grain sorghum.

Statistical of Production

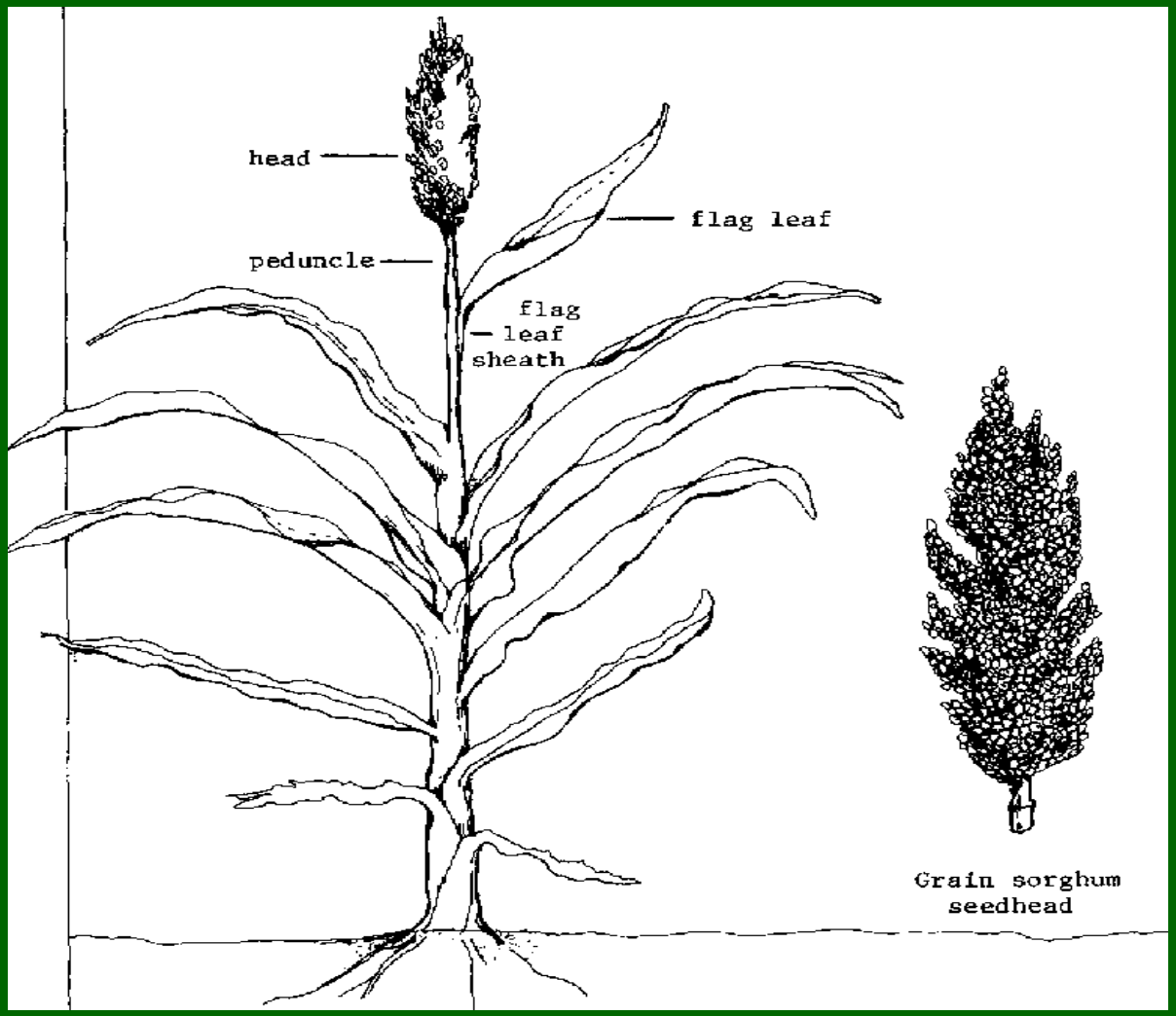
- **The world total planted area from sorghum was 40.76 million hectares produced about 57.6 million tons with average of 1416 kg/ha.**
- **The highest harvested area from Burkina Faso cultivated 1.67 million hectare, and highest production from China was 2.79 million tons. The highest productivity per unite area from Argentina was 4662 kg/ha.**
- **In Egypt, the total cultivated area was 147961 hectares produced about 7427648 tons with an average 4917 kg/ha. (FAO State, 2017)**

Growth and development

- **Root system:** The primary roots are those, which appear first from the germinating seed. The primary roots provide the seedling with water and nutrients from the soil. Primary roots have a limited growth and their functions are soon taken over by the secondary roots. Secondary roots develop from nodes below the soil surface. The permanent root system branches freely, both laterally and downwards into the soil.
- **Leaves:** Sorghum leaves are typically green, glasslike and flat, and not as broad as maize leaves. Sorghum plants have a leaf area smaller than that of maize. An unique characteristic of sorghum leaves is the rows of motor cells along the midrib on the upper surface of the leaf.These cells can roll up leaves rapidly during moisture stress. Leaves are covered by a thin wax layer and develop opposite one another on either side of the stem.

Plant height

- **Sorghum can reach a height from 1-2 meters.**



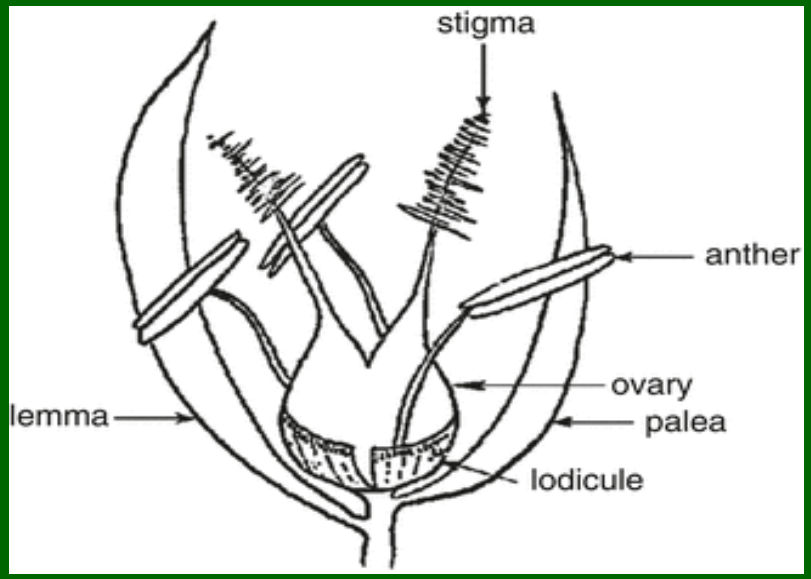
Sorghum roots can growth 2 meters depending of the soil and water available to the crop.

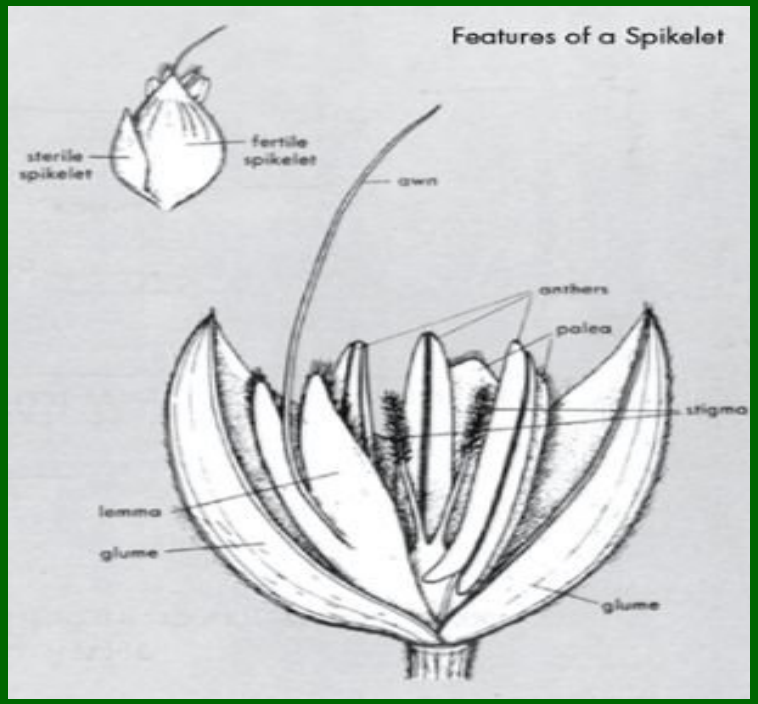

cm 10
20

- **Stem:** The stem of the plant is solid and dry, to succulent and sweet. The stem consists of internodes and nodes. A cross section of the stem appears oval or round. The diameter of the stem varies between 5 mm and 30 mm. The internodes are covered by a thick waxy layer giving it a blue-white colour. The waxy layer reduces transpiration and increases the drought tolerance of the plants.
- **Inflorescence (Panicle):** The inflorescence of sorghum is a compact panicle. The shape and colour of the panicle varies between cultivars. Heads are carried on a main stem or peduncle with primary and secondary branches on which the florets are borne. The peduncle is usually straight and its length varies from 75 to 500 mm. Each panicle contains from 800 to 3 000 kernels which are usually partly enclosed by glumes. The colour of the glumes may be black, red, brown or tan.

Sorghum Flowers

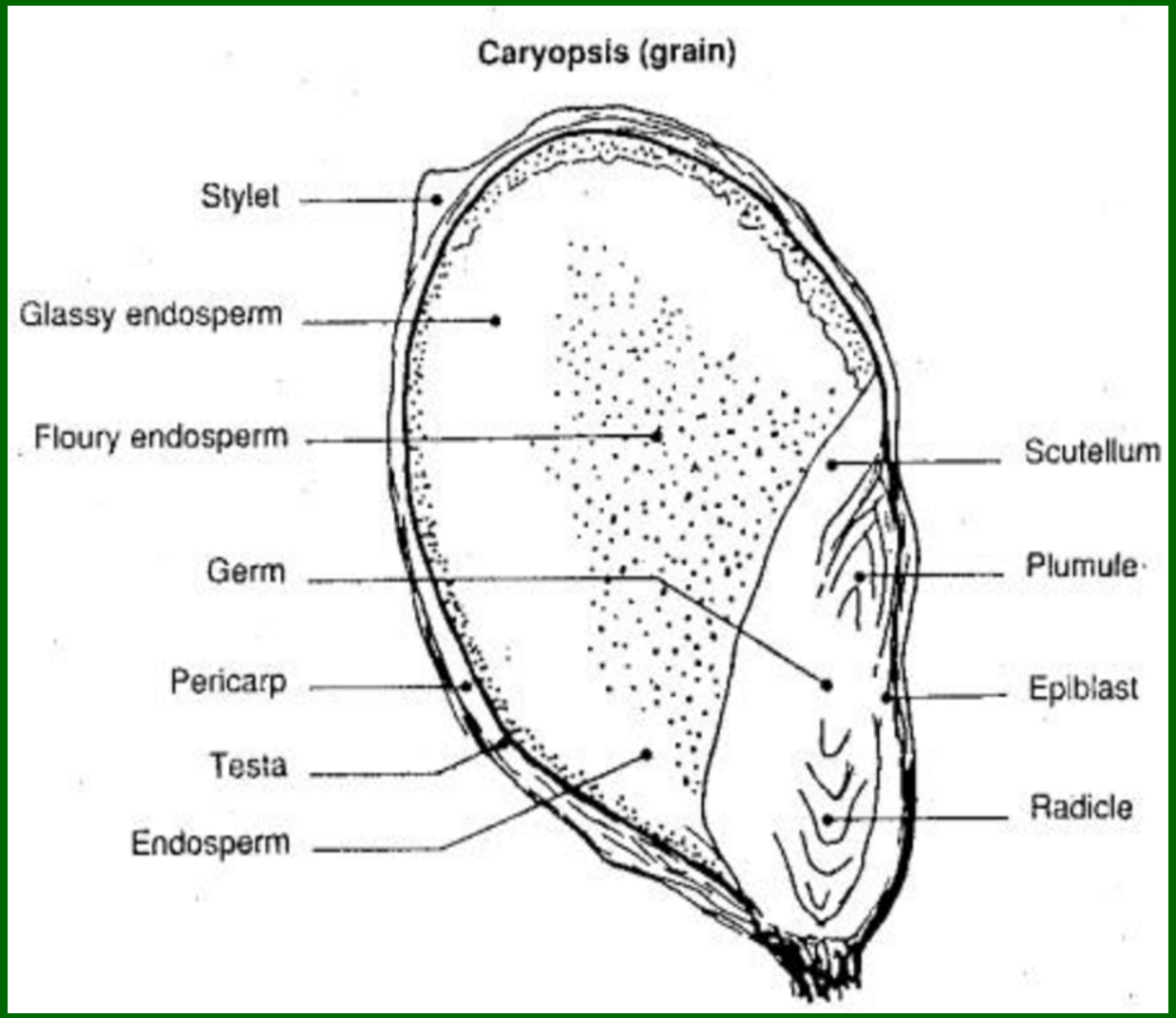
- **It has flowers with stamens and pistils, but in Sudan have been found dioicious varieties.**
- **it has flowers in panicles, and seeds of 3 mm with a circular or egg form, which it depends of the variety, with a color the one can be black, red or yellow.**





- **Seed:** Grain of sorghum is usually partially enclosed by glumes, which are removed during threshing and/or harvesting. The shape of the seed is oval to round and the colour may be red, white, yellow, brown or shades thereof. If only the pericarp is coloured, the seed is usually yellow or red. Pigment in both the pericarp and testa results is a dark-brown or red-brown colour.

Grain of Sorghum



Sorghum the rich food

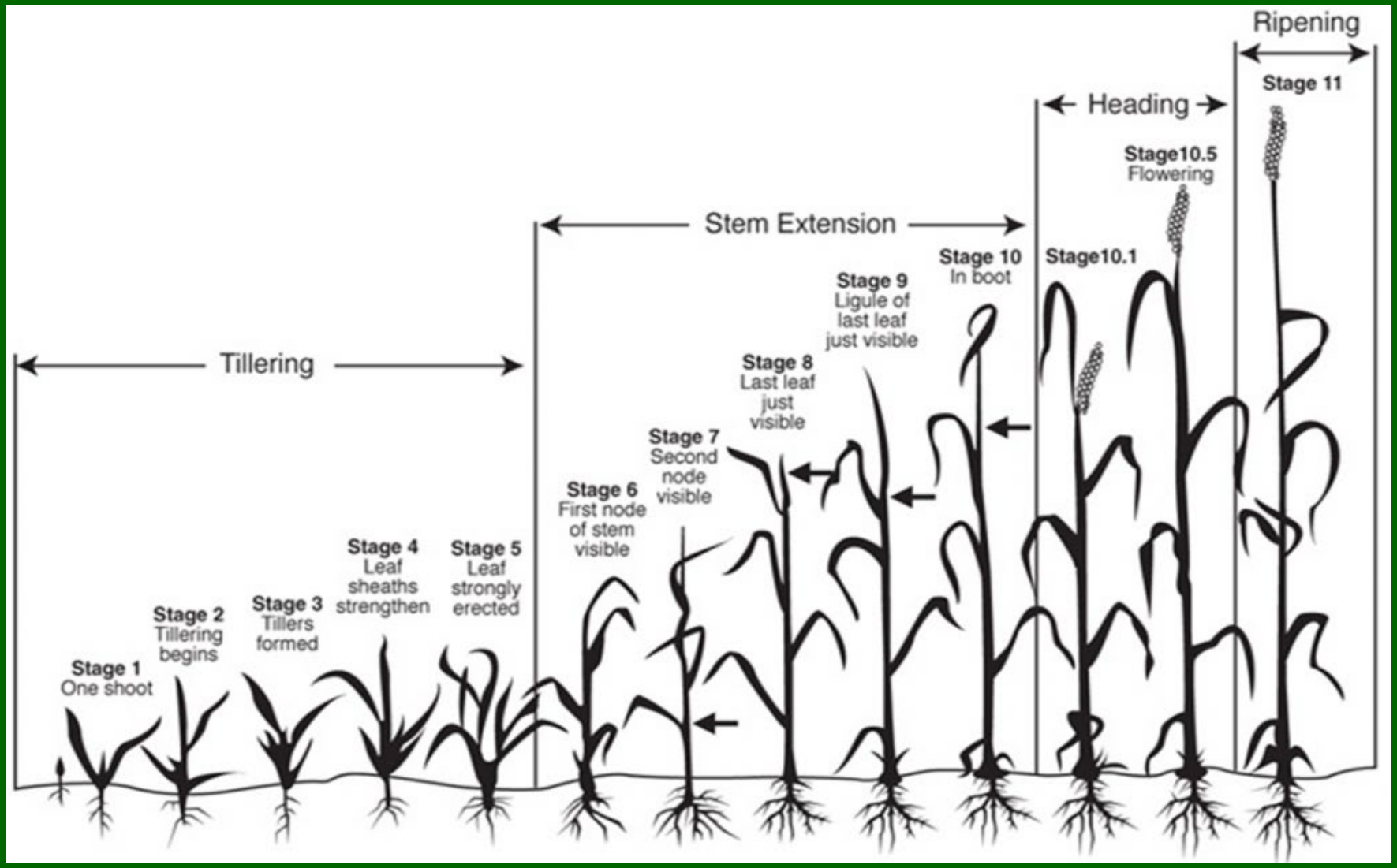
- Carbohydrates 70% High
- Protein 8 –15%
- Mean = 9% Average
- Fat 3.4% Average
- Vitamin A 21 RE Average
- Ash 1.5% Low
- Phosphorus 368mg High
- Iron 5.7mg Average
- Calcium 21mg Average
- Potassium 220mg Average
- Amino Acid Profile Poor
- Micro Nutrients Excellent

Growth stages

- The growth and development of sorghum are divided into the vegetative and reproductive growth stages.
- Vegetative growth stages: Identification of sorghum growth stage during vegetative growth is done according to leaf development.
- Reproductive growth stages: The identification of the reproductive growth stage is done according to the development of grain kernels.

Growing Point Differentiation: ~ 30 days past emergence. Panicle size begins to be determined.

- Boot: Rapid growth and nutrient uptake. Panicle enclosed in flag leaf.
- Half Bloom: 50% of plants in a field are blooming


Ripening
Stage 11
Heading
Stage10.5
Flowering
Stem Extension
Stage 10
In boot
Stage10.1
Stage 9
Ligule of
last leaf
just visible
Stage 8
Last leaf
just
visible
Stage 7
Second
node
visible
Stage 6
First node
of stem
visible
Tillering
Stage 4
Leaf
sheaths
strengthen
Stage 5
Leaf
strongly
erected
Stage 3
Tillers
formed
Stage 2
Tillering
begins
Stage 1
One shoot

Environmental Requirements

- The optimum growth requirements of sorghum plants, in order to exploit its inherit yield potential, are a deep well-drained fertile soil and a medium to good during the growing season, temperate to warm weather (20 to 30 ºC).
- The minimum temperature for germination varies from 7 to 10 ºC. At a temperature of 15 ºC, 80 % of seed germinate within 10 to 12 days. The best time to plant is when there is sufficient water in the soil and the soil temperature is 15 ºC or higher at a depth of 10 cm. A temperature of 27 to 30 ºC is required for optimum growth and development. Sorghum is a short-day plant, which means that the plant requires short days (long nights) before proceeding to the reproductive stage. The optimum photoperiod, which will induce flower formation, is between 10 and 11 hours.

Soil requirements

- Sorghum is mainly grown on low potential, shallow soils with high clay content, which usually are not suitable for the production of maize. Sorghum usually grows poorly on sandy soils, except where a heavy textured sub-soil is present. Sorghum is more tolerant of alkaline salts than other grain crops and can therefore be successfully cultivated on soils with a pH between 5.5 and 8.5.
- Sorghum can better tolerate short periods of water logging compared with maize. Soils with a clay percentage of between 10 % and 30 % are optimal for sorghum production.

Why sorghum is drought tolerance ?

An exceptionally well developed and finely branched root system, which is very efficient in the absorption of water.

It has a small leaf area per plant, which limits transpiration. The leaves fold up more efficiently during warm, dry conditions than that of maize.

It has an effective transpiration ratio of 1:310, as the plant uses only 310 parts of water to produce one part of dry matter, compared to a ratio of 1:400 for maize.

The epidermis of the leaf is corky and covered with a waxy layer, which protects the plant form desiccation.

The stomata close rapidly to limit water loss.

During dry periods, sorghum has the ability to remain in a virtually dormant stage and resume growth as soon as conditions become favourable. Even though the main stem can die, side shoots can develop and form seed when the water supply improves.

Seed bed preparation

- Tillage, in particular primary tillage, is the foundation of any crop production system and is the most expensive practice in the production of sorghum.
- Tillage in a farming system refers to the physical manipulations of the soil with the objective of changing the structure, hydraulic properties and stability to such an extent, that plants will grow and produce optimally.
- The objective of tillage is to maintain the existing structure of the soil or to improve the structure of poorly structured soils. Use of the wrong tillage implements breaks down structural units and reduces the ability of the soil to comply with the growth requirements of the plant.

Planting date and Planting Depth

- The planting date of sorghum is determined by soil temperature and the cultivar to be planted. Normally sorghum is planted in Egypt from mid-May to mid-June. The ideal soil temperature for germination is 15 ^{o}C at a depth of 10 cm.
- It is important to choose the planting date so that the period of critical moisture need (ear initiation) does not coincide with a drought period.
- A planting depth of 25 mm is satisfactory with sufficient water. Under drier conditions the seed should be planted deeper, but no more than 50 mm. Planting depth is also determined by soil type.

Seeding rate

- Sorghum is planted on ridges 60 cm in Width and 20-25 cm between hills. The planting rate about 6-7 kg/fed. Recommendations regarding plant population for sorghum are usually 60000-70000 plants/fed.
- Sorghum is normally planted manually on ridges or with maize planters. Adaptations should be made by using the correct planter plates and gear ratios to obtain the correct plant populations.

Irrigation

- The first irrigation every 12-15 days according soil types. The rest irrigations every three weeks and drainage the extra water.
- Sorghum water use efficiency is improved by using a seeding rate that matches the environment's yield potential.
- Sorghum water use depends on local climate.
- Sorghum has a maximum water use of approximately 75% of maize.

Varieties

- Cultivar planning aims to reduce risks by avoiding drought periods during the most critical growing stages of the plant growth, such as flowering and seed set. Cultivars differ in their reaction to the environment and the climate, which can be used in planning the seed package.
- The lately summer cultivar 90- 110 days such as Giza 54, Giza 114, Giza 3 and Giza 15 cultivars. The early cultivars 70-90 days such El-sabeney cultivar. Short duration cultivars such as hybrids Shandwell 1, Shandwell 3 and Shandwell 6

Fertilization Requirements

- **Fertilizer recommendations made according to the soil analysis should be applied accordingly.**
- **Nitrogen (N) deficiency: young plants are light green or yellow-green, at a more mature stage the older leaves start yellowing first. So, 80-100 kg N/fed for short and tall cultivars, respectively was added at two equal portions, the first and second irrigations, respectively.**
- **Phosphorus (P) deficiency: leaves of young plants may turn dark green with reddish-purple margins and tips. So, 120-200 kg calcium super phosphate at rate of 100-150 kg 15.5 % P2O5/fed was added during seed bed preparation.**
- **Potassium (K) deficiency: a deficiency of K is initially noted as yellow or necrotic leaf margins, beginning at the lower leaves and spreading to the upper leaves. So, 50% potassium sulphate 48% K2O was added during seed bed preparation.**
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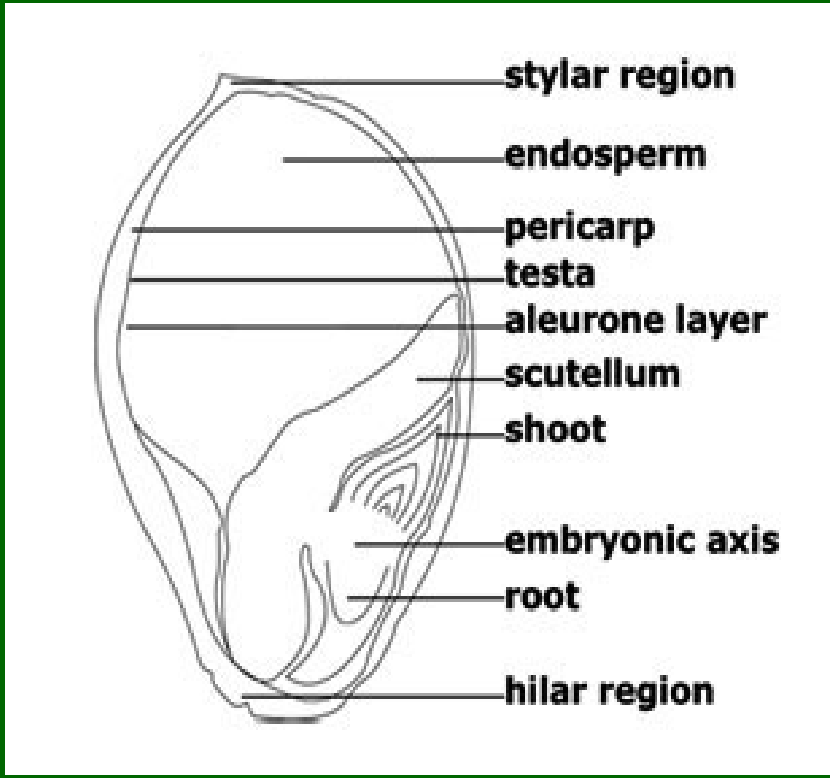
Weed Control

- **Weed control during the first six to eight weeks after planting is crucial, as weeds compete vigorously with the crop for nutrients and water during this period.**
- **In Egypt, Weed controlled by hand hoeing twice, the first three weeks from sowing and the second one after two weeks from the first.**
- **In case of more weeds soil, herbicides must be used such Gesabriem 80% at rate of 750 g in 200 L of water/fed.**

Harvesting

- In the case of tall varieties, the stems are cut at 10 to 15 cm above ground level and afterwards the ear-heads are separated. Then the straw is stacked.

- **Seed Yield:**
- **Most cultivated area from El-Fayoum, Assiut and Sohage Regions in about 400000 fed with an average 17.5 ardab/fed (one ardab = 140 kg)**

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