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Field Corn Production in Iraq

2011

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This manual was prepared to assist USAID-Inma Field staff in working with cooperating growers. It does not cover all issues or answer all questions. The USAID-Inma horticulture team or Ministry of Agriculture Specialists can be consulted to answer additional questions.

INTRODUCTION

Corn production in Iraq saw a sharp declined between the years of 2006 and 2011 due to an erratic supply of irrigation water. The lack of adequate water supply discouraged farmers to adopt "thirsty" summer crops such as corn.

Currently, Iraq requires approximately 300,000 metric tons of corn per year to satisfy the feed consumption of its growing poultry sector. In 2010, Iraq produced 150,000 metric tons of corn, but imported the other 150,000 metric tons to meet the feed consumption requirement.

Corn offers a good opportunity for profitability due to an interesting minimum purchasing price offered for import (ID 550,000 per ton) for unlimited quantities and the possibility to rise yields (which is currently only at half a metric ton per donum) using soon to be available quality hybrid seed corn. The new hybrid seed corn varieties have the potential to raise productivity to a level of 1.5 metric tons per donum.

CROP SELECTION

There are many factors to be considered in selecting a crop for production. For instance, a

farmer's previous experience producing a crop or the availability of a contract for the purchase of a crop can weigh in the decision-making process. However, there are two factors that must always be considered.

- Market demand for the period. When you could reasonably expect to be able to deliver the product to the market with some historical data to give you an idea of the normal volume and price during that period.
- Soil type, climate/micro climate, equipment, irrigation capacity and experience to be able to have a reasonable expectation that an acceptable quality product can be delivered to the market during the identified period at a unit cost, which allows the farmer to make a profit at the lower end of the accumulated range of historical price data.

If a farmer can satisfactorily answer these questions, he has probably identified a sustainable opportunity.

CROP ROTATION

Crop rotation should be a basic part of any sustainable cropping plan. It is an effective, low cost and widely used cultural practice to prevent or

reduce the buildup of populations of soil-borne plant pathogens, weeds and insect pests. An effective rotation sequence includes crops from different families that are poor or non-hosts of the pathogen(s) and pests of concern. In general, the longer the rotation, the better the results. For example, a 3- to 5-year rotation is generally recommended.

From a practical standpoint, however, the number of years and crops to include in a crop rotation will depend upon the availability of land, the markets, the selection of commercially viable alternate crops suited to grow in the area, the pathogen(s), and the purpose of the rotation (prevention versus reduction).

Crop rotation along with the judicious use of appropriate herbicides is also important in controlling the buildup of different weed species.

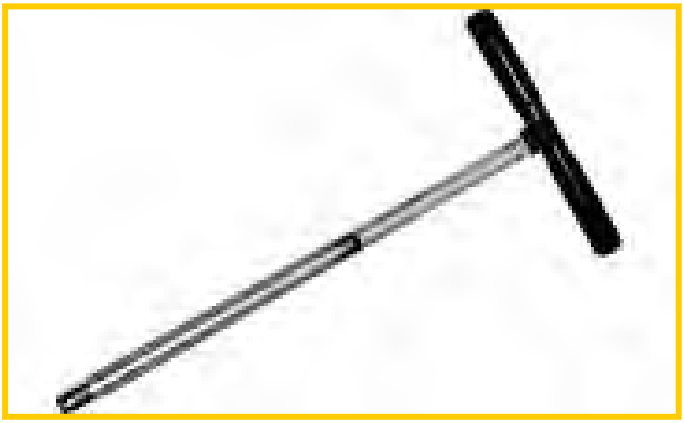
Field corn is a valuable crop in a rotation as it can add great quantities of organic material back into the soil. It is very competitive with weeds once a stand is established and is useful in the rotation for weed control.

PREPARING THE FIELD

Soil Tests

Soil tests provide an estimate of nutrient availability for uptake by plants and are most useful for assessing the fertility of fields prior to planting. Soil sampling methods are critical, since soil samples must adequately reflect the nutrient status of a field. Although a single rep-resentative sample of an entire field provides an average value, it is not the best way to develop recommendations for parts of the field that are less productive. The best technique is to divide each field into two or three areas, representing good, medium, and poor crop growth areas.

The best time to sample soil is soon after irrigation or rainfall, when the probe can eas-ily penetrate the moist soil. Before taking a soil sample, remove debris or residual plant mate-rial from the soil surface. The sample can be taken with a shovel, but a hollow, open-faced soil probe, is pre-ferred. ***(See photo - right)*** Sample the top15 to 20 cm of soil unless a salt problem is suspect-



ed. If this is likely, then the second 30 to 60 cm should also be sampled. Take 15 to 20 cores at random from each area and mix them thoroughly in a plastic bucket to produce a single 0.5 L composite sample for each area. Since there is usually less variability, only 8 to 12 cores need to be composited for the deeper, sec-ond 30 cm samples. Place each sample in a separate double-thick paper bag and air dry the soil at room temperature before taking it to the laboratory.

Soil samples should be tested for Nitrogen (N), Potash (P) Potassium (K), Salinity (ECe), pH and the minor elements of Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo) and Zinc (Zn).

Water Samples should be tested for Salinity (ECw) and pH.

Corn requires a soil ECe of less than 1.7 to achieve the full yield potential of the variety. The ECw of the water should be less than 1.1 for the same result. Ninety percent of yield potential requires a soil ECe of 2.5 or less and water ECw of 1.7 or less.

Corn Planting Dates	Summer Planting	Spring Planting
Northern Iraq	July 1 to 15	March
Central Iraq	July 15 to 31	March
Southern Iraq	July 20 to August 5	Mid February-March

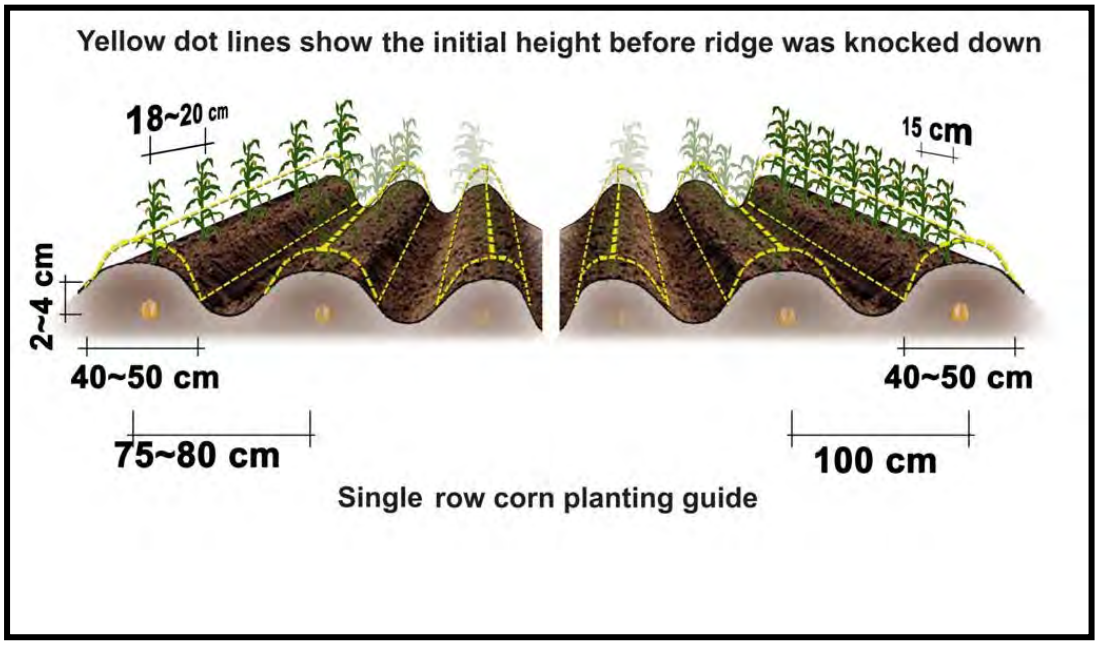
Soil Preparation

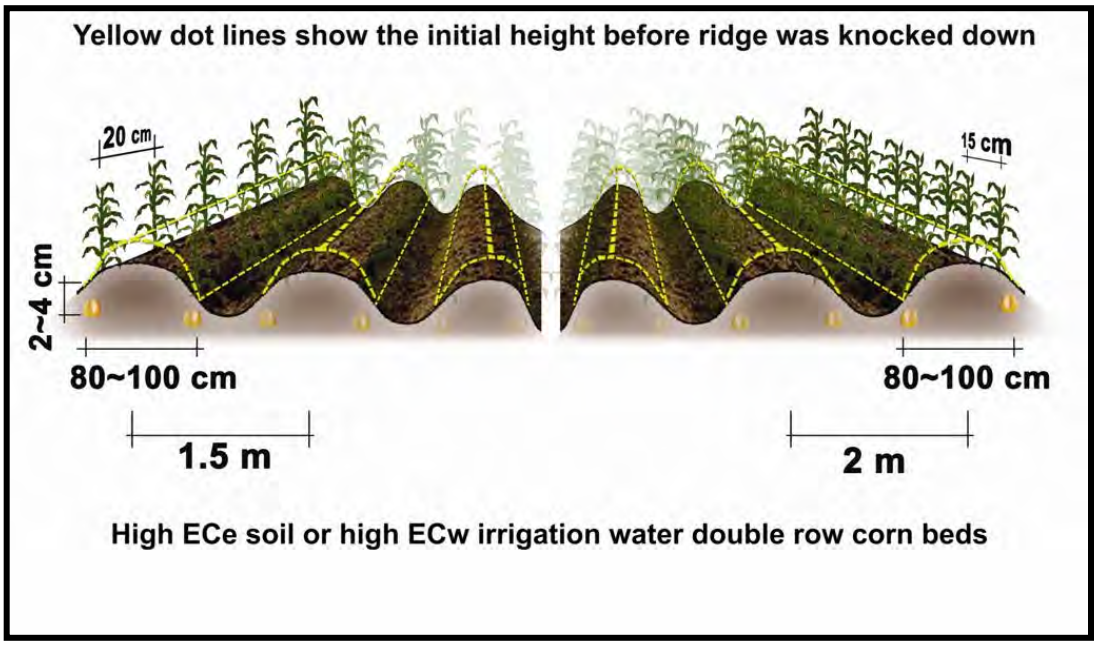
A good soil management program protects the soil from wind erosion, provides a good, weed free seed bed or planting and destroys hardpans, salt layers or compacted layers that may limit root development. In order to accomplish this:

- Till soil as deep as possible using a plow and a ripping or chiseling implement
- Prepare a good seedbed, breaking up all clods with a disc and smoothing with a harrow or roller
- Apply pre-plant fertilizer based on soil test results
- If soil test results are not available apply 50 Kg DAP per donum

  Make Beds:
- Spacing between beds should be 75 to 100 cm wide depending on equipment available.

75 to 80 cm is preferred for high yielding high density plantings. If corn is being planted on high ECe soils or irrigated with high ECw water, a grower may wish to consider planting two rows on a bed, one line on each side of a 1.5 meter bed, so that furrow irrigation will push the salt to the center of the bed. Drip irrigation on 80 cm beds is another alternative to be considered if the soil ECe is high and the water ECw is 1.1 or less.





Pre-Irrigate

Iraqi farmers have not yet learned to appreciate the value of pre-irrigating beds and knocking them down to plant into good moisture. The value comes from;

- Planting into clean conditions with good moisture, and all germinated weeds have been killed. The crop seed sprouts and achieves early growth before the second flush of weeds can overtake it.
- The crop is still planted onto a slightly raised bed even after the bed has been knocked down. If crops are planted in flat fields followed by cultivating or spraying to kill the weeds, the seeds actually end up being

planted down in a trench in order to be planted in good moisture.

- The technology that is being introduced in this manual includes mechanical cultivation. Mechanical cultivation is much easier to implement if the planting is on a slightly raised bed, as opposed to being down in a trench. It is very difficult to cultivate small plants which are growing in a depression. Mechanical cultivation throws loose dirt over the plant base and covers weeds to kill them. It is impossible to throw dirt to the center of a trench to cover weeds without also covering the emerging crop.
- Mechanical cultivation of crops on slightly raised ridges also allows the retrenching of furrows for early irrigation, if needed.
- The value of pre-irrigation applies to all crops, but the practice above is particularly important in large seeded crops, which can be planted and germinated on pre-irrigation moisture.

It is best to completely wet the beds. Pre-irrigation should fill the soil profile to the depth of rooting, and leach accumulated salts below the root zone. The wetting depth for corn should

be 1.5 m. Pre-irrigation will also germinate weed seeds which can be cultivated to clear the field before planting. Pre-irrigation will activate pre-plant herbicides if they have been applied. Finally, pre-irrigation provides the moisture for germination of the corn seed, eliminating the need for irrigation until the corn has emerged from the soil and begun its vegetative growth.

IRRIGATION

Gravity irrigation using furrows is the domi-nant water delivery system in Iraq. In some provinces, center pivot systems installed for wheat are also used. Since furrows are the dominant system, land leveling is required to assure uniformity of irrigation. Apart from this, when furrows are used, the appropriate combination of stream flow size and length of furrow has to be selected. Furrow spacing is mainly dependent on each crop. However, in all instances the furrow spacing adopted should ensure a lateral spread of water between adjacent furrows that will adequately wet the entire root zone. The following table shows practical values of maximum furrow lengths depending on soil type, slope, stream size and irrigation depth for small-scale irrigation (FAO, 1988).

Maximum furrow lengths in meters

		Clay		Loam		Sand	
		Net irrigation requirements (mm)					
Slope (%)	Maximum stream Size/ furrow (l/s)	50	75	50	75	50	75
0.0	3.0	100	150	60	90	30	45
0.1	3.0	120	170	90	125	45	60
0.2	2.5	130	180	110	150	60	95
0.3	2.0	150	200	130	170	75	110
0.5	1.2	150	200	130	170	75	110

To establish the appropriate combination of stream flow size and length of furrow in the USAID-*Inma* corn field demonstration areas, tests were conducted to know how fast the water flows over the furrow. In addition, tests to know how fast water entered into the soil were also performed.

To be fully productive, corn irrigation requirements in the USAID-*Inma* demonstration areas are shown in the following table:

Demonstration Area	Crop Water Requirements (mm/year)	Irrigation Requirements (mm/year)
Basrah	696	696
Muthanna	528	521
Diwaniyah	543	543
Babil	610	610
Abu Ghraib	491	490
Diyala	410	405
Kirkuk	518	507
Al Qosh	455	454
Salah Al Din	547	538

Generally, more water is needed to leach salts and to compensate for irriga-tion inefficiencies, especially in Iraq where water quality is a problem. For that reason, the leaching requirement must be determined.

Frequency of irrigation is dependent on the water holding capacity of the soil, climatic factors,

such as temperature, wind, humidity day length, and the permissible soil water depletion (in the case of corn a soil water depletion level of 50 percent of the total available soil water has been used). Based on these characteristics, irrigation calendars were prepared for the corn demonstration areas (**see the following table**):

When the irrigation frequency is 30 days it means that either rainfall is sufficient, especially in the northern provinces or, only one irrigation will nr required.

Loca-tion	Soil tex-ture	Irrigation Frequency (days)*											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Basrah	Clay loam								5	5	8	18	
Mutha nna	Silty loam								6	6	15	30	
Di-waniya h	Loam								6	6	12	25	
Babil									6	6	15	30	
Abu Ghraib	Loam y clay								7	6	12	30	
Diyala	Loam								8	8	16	30	
Kirkuk									5	5	15		
Al Qosh	Silty clay loam								5	5	16		
Salah Al Din	Silty clay loam								4	5	15	30	

The water holding capacity of soil varies by soil type, with sandy soils having the capacity to store about 40 mm of moisture per meter of soil, while heavy clay soils have the capacity to hold up to 90 mm of moisture per meter. Other soil types fall somewhere between these extremes.

Corn is moderately sensitive to soil salinity. Yield decrease is related to electrical conductivity of the soil. (ECe of extraction saturated paste in dS/m).

Corn Yield Decrease at ECe (soil salinity) Values

ECe Value	Percent(%) of Decreased Yield
ECe 1.7 dS/m	0%
ECe 2.5 dS/m	10%
ECe 3.8 dS/m	25%
ECe 5.9 dS/m	50%
ECe 10 dS/m	100%

MECHANIZATION

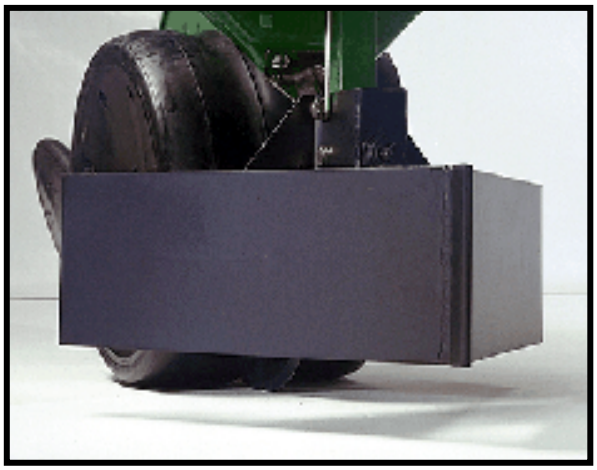
The important thing for mechanization of row crops is that both the front and rear wheels of the tractor and all equipment are the same width track as the furrow width. **(See photo-right)** For example with an 80 cm bed spacing, the distance from the center of one tire to the center of the tire on the opposite side will be 160 cm, or for 100 cm bed spacing the distance will be 200 cm. The wheel spacing on tractors intended for row crop use have adjustable track widths.

Using a bed spacing that matches the wheel spacing allows the tractor to pass through the field during planting and cultivation of the early growth stages without intruding on the planted crop or compacting the soil around and under the planted crop. This is a basic requirement for mechanization. All mechanical operations have to be coordinated to be effective. Thus all

operations have to cover the same number of rows or beds. If beds are shaped four rows at a time, planting should be four rows at a time, cultivation four rows at a time, and harvest four rows at a time. Planting could be done four rows and cultivation done two rows at a time, but there is no advantage in doing so.

PLANTING

About one week after pre-irrigation cultivate the beds to destroy germinated weeds and create a dry-surface-mulch to conserve the moisture below the cultivated layer of soil. If a cultivator is not available, drag a harrow, a pipe, a log, a section of chain link fence or some other device through the field to knock the beds down to about half of their original height. This will kill the germinating weeds and expose cool, moist soil for planting. Some planters have disc or wing openers which will either open or scrape off the previously cultivated bed to the depth of the undisturbed moisture, if the planter does



not have this feature; the farmer should drag off the beds prior to planting using one of the methods listed above. **(See example of V-wing bed sweep).**

Plant the corn seed ***immediately after knocking the beds down***.

- On 75 or 80 cm beds place one seed every 18 to 20 cm down the row
- Plant seeds to a depth of about 2 to 4 cm, into moisture
- On wider bed spacing place one seed every 15 cm down the row

After Planting

Corn seed should germinate and emerge within a week. Watch for signs of cutworms attacking the newly emerged corn plants and birds digging up the seeds before they emerge. Birds are difficult to control. They can sometimes by frightened away from emerging

crops by noise making machines. ***See the insect section on control of cutworms.***

It should not be necessary to irrigate for two weeks or more after planting.

Note the very low bed or ridge that the corn is planted on after knocking the bed down to expose the cool moist soil for seed germination.

CULTIVATION

As the corn grows, the farmer should be cultivating to cut or cover weeds that germinate and to rebuild the irrigation furrow. When corn has reached the height of approximately 15 cm (as shown in the photo to the right) it is possible to throw soil onto the corn roots with each successive cultivation, which accomplishes both the objectives listed above. In Iraq, corn may be cultivated 5 or 6 times before it reaches a height that prohibits further cultivation.

Cultivation does not appear to be a common practice in Iraq. Growers who are not familiar with cultivation equipment can see some examples at the USAID-*Inma* Farm Based Learning Centers (FBLC). There are two FBLCs in each region of Iraq.

PEST CONTROL

WEEDS

Weeds compete with corn for light, nutrients, and water, especially during the first 3 to 5 weeks following emergence of the crop. It is important to control weeds in a corn field until corn is 15 to 20 cm high, which is when weeds impact corn yields. Late-season weed infestations do not reduce corn yield nearly as much as early weed competition; however, late season weeds can harbor destructive insect pests such as thrips, which can vector Fusarium ear rot, and armyworms, which can defoliate corn.

No single weed control regime is effective for all growing conditions. An integrated weed management program utilizes a combination of cultural, mechanical and chemical methods for consistent, effective weed control. It also helps

prevent the development of weed resistance to herbicides and the emergence of a few dominant weeds. A vigorous, competitive crop produced through proper seedbed preparation, variety selection, seeding rates, fertilization, irrigation, cultivation, pest control and crop rotation is the best defense against weed infestations and competition.

Herbicides are important where weed populations are high, with difficult-to-control weeds, or where it is critical to gain time because cultivation equipment is being used elsewhere. Herbicides reduce the early competition of weed infestation, reduce the seed bank, and reduce the potential for competition in the following crop. Pre-plant, pre-emergent, or post-emergent herbicides are available that will selectively control most species of weeds in corn. Select an herbicide based on cost, weeds present, stage of corn growth, soil type, succeeding rotation crop, and adjacent crops. Farmers should consult their Agriculture Extension Specialist for herbicide recommendations for Iraq.

Pre-Plant Weed Control

Several measures can be taken to reduce weed infestations before the crop is planted, beginning with the selection of a relatively weed-free field. Preparing the seedbed so that it is free of large soil clods provides favorable conditions for corn seed germination and early growth, as well as improved performance of pre-plant herbicides. The selection of a vigorous growing variety planted on 75 cm row spacing will help the crop compete with weeds. Uniform plant population densities of 18,000 to 21,000 plants per donum will maintain yields and reduce mid to late season weed growth by maximizing shading.

Pre-plant, pre-emergent herbicides are applied to the soil surface and mechanically mixed in the soil before the crop is planted. Herbicides applied before the corn emerges offer the advantage of controlling weeds before they compete with the corn when it is in the seedling stage. This is the most critical time in regard to yield reduction. Pre-plant herbicides can be applied broadcast on flat ground and incorporated by disking before beds are formed and the corn is planted, or they can be applied in a band on

pre-formed beds, then incorporated with a rolling cultivator or power tillers.

Dicamba 4% EC (Banvel) Sygenta is recommended for use on corn in Iraq. Proper use of this herbicide will give control of growth suppression to many annual, biennial and perennial broadleaf weeds and many woody brush and vine species of plants. Consult the herbicide label for a complete list of weeds that can be controlled. Dicamba 4% is **NOT** registered for use on **sweet corn,** only dent corn. Direct contact with corn seed must be avoided. If corn seeds are less than 3.8 cm below the surface of the soil, delay the application until corn has emerged. Up to two applications of Dicamba 4% can be made during a growing season. Allow at least two weeks between applications. Read the product label for full details on application rate per donum and cautions. Dicamba 4% can be tank mixed with other herbicides. USAID-*Inma* can only recommend a limited range of herbicides listed in the USAID approved PERSUAP. Farmers should contact the local Ministry of Agriculture Extension Specialist or farm chemical dealer for information on corn herbicides registered and available in Iraq.

Pre-irrigation before planting corn can be useful to germinate weed seeds that can subsequently be controlled by cultivation or post-emergent herbicides such as glyphosate. S-Metolachlor + Atrazine 66% SC (Primagram Gold) is recommended for corn. The recommended rate varies from 225 ml per donum to 612 ml per donum depending on the weed to be controlled. Farmers must carefully read the herbicide label for exact application rate recommendations.

Post Emergent Weed Control

Weed wipers are excellent post emergent glyphosate application tools for killing Johnson grass, nutsedge, and weeds that grow above the corn. **(See photo right)**

(The above mentioned herbicides are listed in the USAID-*Inma* PERSUAP).

DISEASES

Diseases which are frequently problems in desert production areas include, but are not limited to:

Charcoal Rot

Macrophomina phaseolini

Symptoms

Charcoal rot first becomes noticeable when corn is in the tassel stage or later. Infected stalks become shredded; the pith is completely rotted, leaving stringy vascular strands more or less intact. Small, black, spherical sclerotia of the fungus are found on and in the vascular strands; they are numerous enough to give the internal stalk tissue a gray color. As plants mature, the fungus grows into the lower internodes of the stalk, causing the plants to ripen prematurely and weakening the stalks, which may cause them to break.

Comments on the Disease

The pathogen overwinters and is disseminated as sclerotia. Plants are infected through roots only after being weakened by water stress. The fungus is favored by high temperatures.

Management

Good water management to avoid stressing plants is important in managing this disease, particularly as the crop approaches the flowering stage.

Crop rotation to non-host crops, such as small grains, can also help reduce the disease potential.

Avoid high plant populations

There are no registered fungicides to control charcoal rot.

Seed Rots and Damping-off

Pythium spp., *Fusarium* spp., *Penicillium oxalicum,* and other fungi

Symptoms

Seed rot causes the corn seed to rot before germination and damping off causes the seedling to die soon after emergence.

Infected tissue may be water-soaked *(Pythium)*, white to pink *(Fusarium)*, or bluish *(Penicillium)*. The stem of infected seedlings becomes brown and soft near the soil line. Aboveground symptoms include yellowing, wilting, and death of the leaves.

Variation in seedling size between healthy and affected seedlings *(Photo credit: J Thomsen)*

Comments on the Disease

Seeds or seedlings may be predisposed to disease by several factors, including planting depth, soil temperature, soil type, seed quality and mechanical injury to the seed pericarp. These diseases are more common in poorly drained, excessively compacted, or cold (less than 13°C), wet soils. Sweet corn, especially the supersweet hybrids, is much more susceptible than dent (field) corn.

Management

Use high quality seed and good cultural practices, such as planting seed in warm soil (above 13° C), proper seedbed preparation and optimum water management. Seed treatments for field corn are usually not warranted.

Covered Smut
Ustilago zeae
Symptoms

The corn plant may be infected at any time in the early stages of growth, but becomes less susceptible after formation of the ear. Above-ground parts may be infected, but it is more common to see smut galls on the ears, tassels, and nodes than on the leaves, internodes or aerial roots. The smut gall is composed of a great mass of black, greasy, or powdery spores enclosed by a smooth white covering of corn tissue. The gall may be 4 to 5 inches in diameter.

When leaves are infected, small pustules develop, usually on the midrib, causing some leaf distortion. After the spores mature, the outer covering becomes dry and brittle, breaks open, and the spores sift out. Greatest yield losses occur when the ear becomes infected or if smut galls form on the stalks immediately above the ears.

Comments on the Disease

Corn smut is an extremely common disease of sweet, pop and dent corn throughout the world. It is usually not economically important, although in some years yield losses in sweet corn may be as high as 20 percent. Corn smut survives as a resistant spore in the soil for as long as three years. These spores can be blown long distances with soil particles or carried into a new area on unshelled seed corn and in manure from animals that are fed infected corn stalks. The spores germinate in moist air and give rise to tiny spores called sporidia. The sporidia bud is like yeast, forming new spores that germinate in rain water that collects in the leaf sheaths. This leads to infections that are visible after 10 days. Plant injuries provide points for the fungus to enter the plant.

The smut fungus is sensitive to temperature and moisture changes. In a warm season, the amount of smut is related closely to the amount of soil moisture. When temperatures are lower than normal, there may be little smut even though soil moisture remains high.

Management

In order to reduce infection points from insect injury, control the corn borers as the first tassels appear by application of insecticides when insect populations are high. Consult the Ministry of Agriculture Extension Specialist for current insecticide recommendations.

Avoid injury of roots, stalks, and leaves during cultivation.

Deep plow diseased corn stalks in the fall to bury surviving spores.

Plant resistant hybrids or varieties. Dent corn is generally more resistant than sweet corn or popcorn

Downey Mildew (Crazy Top)
Sclerophthora macrospora

Symptoms

Partial to complete replacement of the normal tassel by a large, bushy mass of small leaves is the most noticeable symptom of Downey Mildew. No pollen is produced. Ear formation may also stop, causing ear shoots to be numerous, elongated, leafy and barren. Plants may be stunted or taller than average.

Conditions

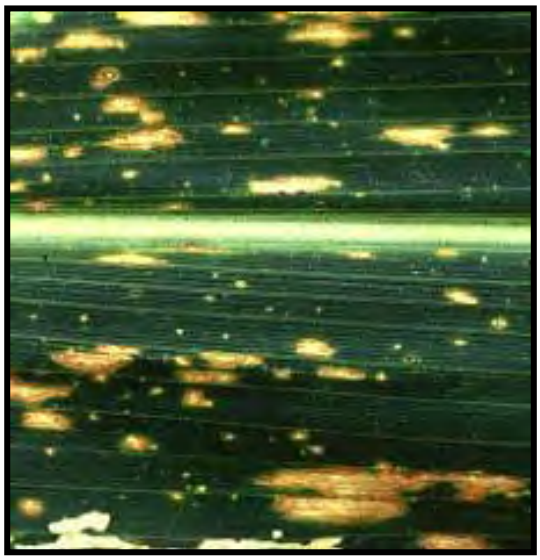
Downey mildew favors saturated soil conditions for 24 to 48 hours. Inoculum survives in infected corn residue and wild grasses. Inoculum is dispersed as waterborne spores in saturated soil.

Management

Provide adequate soil drainage, control grassy weeds, avoid sowing in low, wet spots.

Leaf Blights

Anthracnose *leaf* blight –*Colletotrichum graminicola*, Northern Corn Leaf Blight – *Exserohilum turcicum* Southern Corn Leaf Blight- *Bipolaris maydis*



Symptoms

Cigar-shaped gray-green or tan lesions

Leaf Blight Conditions

Leaf blight may not be a common problem in Iraq because development of the disease favors cool to warm, wet, humid weather, and continuous corn with reduced tillage. Inoculum survives in infected crop residue (leaves, leaf sheaths and stalks), seed (endosperm). Inoculum is dispersed as airborne spores.

Management

Plant resistant hybrids and rotate corn with non-grass crops.
Cleanly plow under infected residue.

There are many Virus diseases, which can be spread by aphids. The best control is resistant varieties. Varietal registration tests currently underway by USAID-Inma will help identify better varieties for production in Iraq.

INSECTS

Local experience shows that the following insect is likely to be a severe problem in Iraq:

Mediterranean Corn Stalk Borer (Pink Stem Borer)

Sesamia nonagrioides

There are other species of corn borers, but *Sesamia nonagrioides* is probably the most prevalent in Iraq. The Mediterranean corn stalk borer is an important insect pest in corn

maize), sorghum, millet, rice, sugar cane and grasses. It is distributed throughout the MENA region and beyond. *(CABI, 2008)*.

Description

Adults have a 30 to 40 mm wingspan, and the fore wings are grey-yellowish, marked with a marginal band and with rounded, indistinct points. Hind wings are entirely white.

Larva

Male antennae are strongly bipinnate (look as if covered with tiny leaflets). Eggs are grooved and whitish at laying and creamy-pink thereafter. Fully developed larvae are 30 to 40 mm long; of variable color ranging from yellowish to brownish with a rust-colored back. Pupas are about 2 cm long and semi-cylindrical. Adults are active in the spring. Eggs are laid under the sheath of leaves in small clusters of about ten. Eggs hatch after 10 to 14 days. Larval development lasts about 45 days. Some individuals may complete their development at the end of summer and then undertake a brief autumnal flight.

The Mediterranean corn stalk borer usually produces three or four generations per year. In south Iraq, adults can appear at the end of March or beginning of April, while in the Kurdistan Region hatching can begin in April to May and continue until June. (INRA, France).

Damage

Early infested maize plants wilt and die. More serious is the direct damage caused to ears that are attacked either from the exterior or from the interior at different instars of larval development. The result is partial ear destruction and a reduction in the number of grains. (INRA, France) The first generation of *Sesamia nonagrioides* species infests young plants, feeding on whorl leaves, which may cause the death of the plant (Anglade, 1961). Second generation larvae infests older corn plants, damaging stems and ears, and causing

Pupa

substantial yield losses due to lodging, dropped normal formed ears, and kernel damage. (Velasco, et al., 2002)

Management

Integrated Pest Management manufacturers supply pheromone lures, traps and complete monitoring systems for *Sesamia nonagrioides,* or the Corn stalk borer. Pheromone trap data gives early warning of the infestation and also exhibits the density of the insect population.

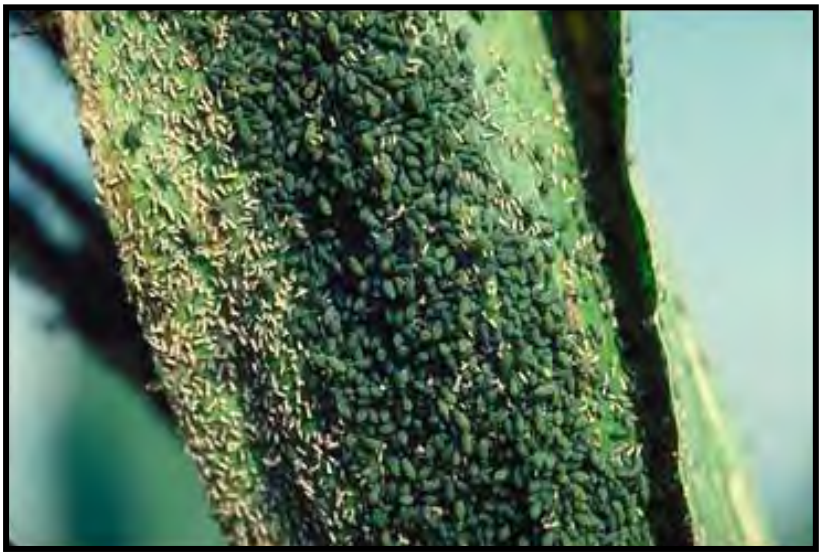
Aphids

Corn leaf aphid: *Rhopalosiphum maidis*
Greenbug: *Schizaphis graminum*
Green peach aphid: *Myzus persicae*

Description of the pests

Several species of aphids may be found in corn, but the corn leaf aphid and greenbug are the primary aphid species infesting corn. Corn leaf aphids are small to medium in size and bluish green in color and also infest small grains.

The greenbug is a moderate-sized aphid. The color of the abdomen is light green with a darker stripe down the middle. Both winged and wingless forms of both aphids occur on corn plants.



Numerous other aphid species may attack small grains, corn and sorghum in Iraq throughout the growing season. Proper aphid management requires accurate identification, as economic thresholds are developed for individual species.

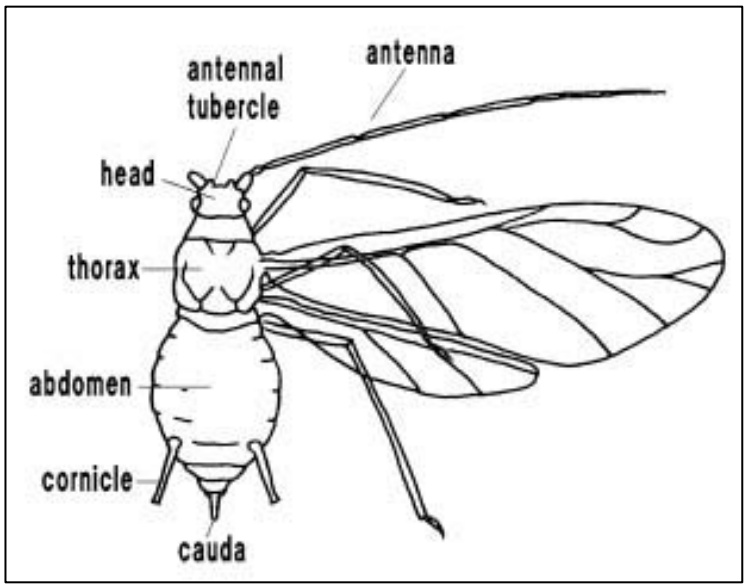
Corn Leaf Aphids

Identification of Aphids

Use the following key to identify winged and wingless adult aphids. While aphids appear to be very simple insects, they are really very complex, both in their biology and their morphology. As with other insects, external morphological features are used to identify individuals to

the species level. A complete key to identifying various types of aphids can be found at: www.ipm.ucdavis.edu/TOOLS/KEYAPHIDGRAIN/

Damage



Corn leaf aphid infestations usually start in the plant whorl. Heavy infestations may curl leaves and stunt the plant. Later infestations may completely cover the tassels and upper leaves. Corn leaf aphids excrete a sticky substance called honeydew, which accumulates on the plants. The honeydew eventually turns blackish as sooty molds grow on it. Heavy amounts of sooty mold may be more damaging to silage corn than to corn for grain.

Greenbugs and green peach aphids also infest corn, but usually do not build up to the high numbers of corn leaf aphids. Red lesions often form at the feeding sites of greenbugs. High numbers

of greenbugs on small plants can kill the plants. All three species transmit the maize dwarf mosaic virus to corn from nearby weed sources.

Management

Transmission of virus disease is the primary damage caused by aphids and the potential for this varies significantly from year-to-year and area-to-area. Insecticide sprays will not prevent virus transmission, but can reduce population levels. There are no established thresholds for aphids on field corn. Only on rare occasions do aphids reach damaging populations. Obtaining good coverage of the plant, which is essential for effective control, can be difficult when the plants are over 1.5 meters tall. Insecticide treatments may increase problems with mites by killing natural enemies.

Biological Control

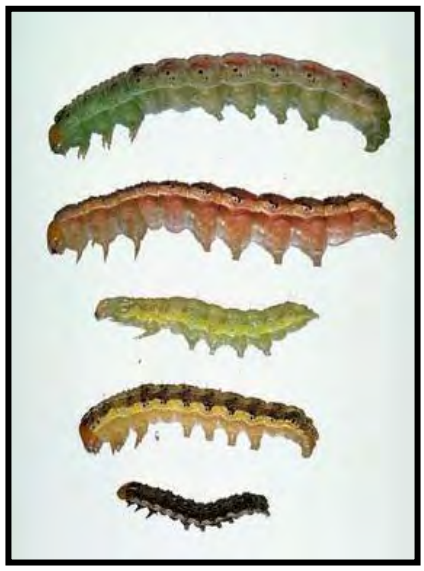
Aphids can be kept below economic levels of feeding damage by the parasite, Lysiphlebus *testaceipes* and by predators such as lacewings, lady beetles, and syrphid flies. However, biological control cannot prevent transmission of virus diseases. Oil and soap sprays are acceptable for

use on organically grown crops.

Corn Earworm

Helicoverpa zea

Color variations of corn earworm (also called tomato fruitworm and cotton bollworm) See photo right.



Description of the pest

Corn earworm moths (right) are most active during evening and night. They are approximately 1.9 cm long, rather robust, with a wing span of 2.5 to 3.75 cm, and adults range from olive green, to tan, to dark reddish brown in color. Egg laying occurs throughout the corn growing season. The tiny, white eggs are laid singly on the foliage and fresh corn silk, which is the favorite site for egg deposition. After about a day, eggs

develop a reddish brown ring in the top portion. Eggs are spherical with 12 or more ridges radiating from the top. Young larvas are greenish with black heads and conspicuous black hairs on the body. Fully grown worms are about 3.5 cm long and range in color from pale green or pinkish to brown.

Damage

The corn earworm may be present throughout the season but is most abundant during August and September. Larvae feed on leaves, tassels, the whorl, and within ears, but the ears are the preferred sites for corn earworm attack.

Ear damage is characterized by extensive excrement at the ear tip. Young larvae feed on corn silks, clipping them off. Shortly thereafter, they feed their way into the ear where they remain, feeding in the tip area until they exit to pupate in the soil.

Management

Corn earworm is primarily a problem in sweet corn where treatments should be timed to coincide with egg hatch. Carbaryl (Sevin) Generic is approved for treatment of corn earworm. It may be applied up to a total of four times per year but not more often than 14 days. Good timing and full coverage are critical to good control. Consult product label for rate of application.

Biological Control

Many predators and parasites attack corn earworm eggs, including several species of Trichogranna. Most parasitized eggs turn black, but there may be a lag period before they do so. General predators such as lacewings, minute pirate bugs and damsel bugs feed on corn earworm eggs and small larvae.

Cultural Control

In corn, very early plantings require fewer treatments than late-season corn because earworm population densities increase as the season progresses. Biological and cultural controls and sprays of *Bacillus thuringiensis* and the Entrust

formulation of spinosad are acceptable and listed for use on the USAID-*Inma* PURSUAP for use on the crop.

Monitoring and Treatment Decisions

Insecticidal control of corn earworm is difficult and depends on proper timing and thorough coverage. Begin sampling soon after corn emergence but pay particular attention to corn that is silking in late summer/early fall. The presence of large numbers of eggs on fresh corn silks indicates the potential for damaging populations. Eggs hatch in 5 to 7 days. Once larvae enter the corn ears, control with insecticides is difficult. Direct insecticide control towards young larvae that are feeding on the exposed ear tips. Treatments are usually not needed on field or silage corn. In sweet corn, where tolerance for worm damage is low, timing of insecticide treatments is critical. Begin treatments during silking stage, at the start of egg hatch.

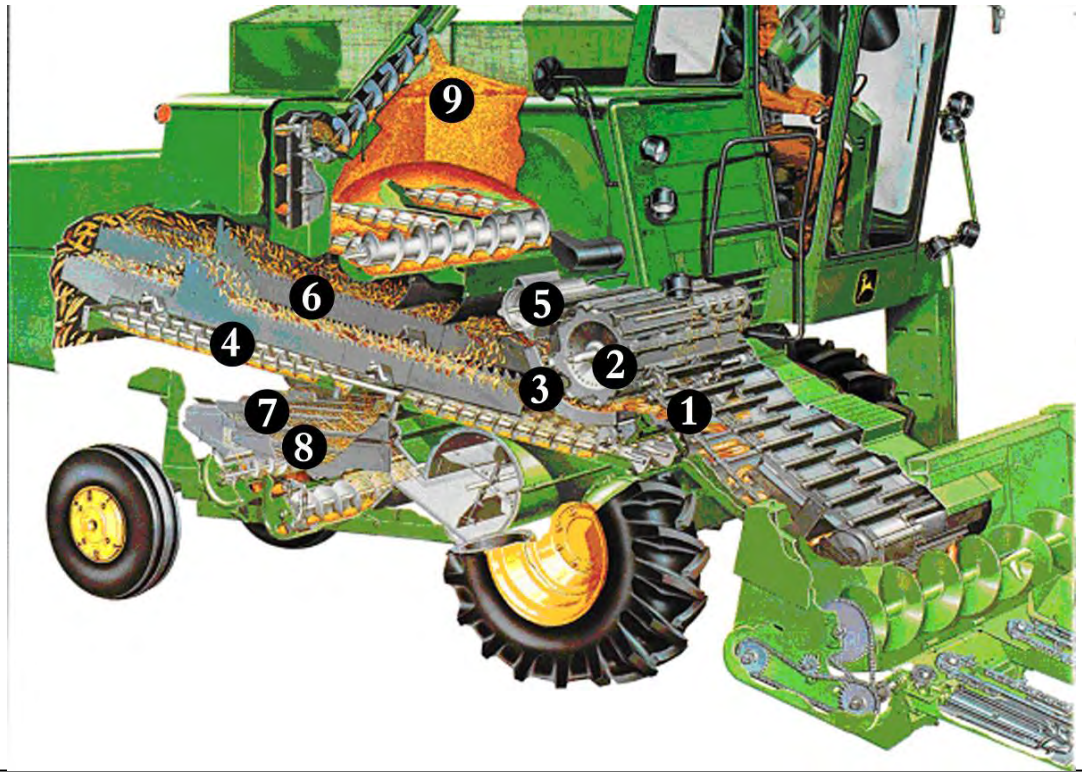
HARVEST

Corn ears may be harvested by hand in small plantings and run through a stationary thresher, but the commercial practice is to harvest with a combine with a corn header. The header strips the ears off of the corn stalk and feeds them into the threshing area. **Header row spacing should match the planter row spacing**. (**See Photo above**) Research indicates gathering loss can increase 40 kg per donum if the gathering opening is 10 or 12 cm off the row. If damage from windstorms or corn borers cause ears in misaligned rows to drop off, field losses often exceed 150 kg per donum. Corn heads

aligned with combine wheels and matched with planters and row bedders improve combine performance.

A rasp-bar cylinder, concave and filler bars, or a threshing rotor are needed for corn. The machine must be set per the manufacturers recommendations to achieve an efficient harvest. Converting from a spike-tooth cylinder reduces the combine's ability to handle down rice, weedy fields and rank, green stalk. A rasp-bar cylinder normally improves head rice yield and reduces field loss in corn, grain sorghum, wheat, and soybeans.

Corn Combine Diagram



Combines may have slight differences but they all operate in basically the same way. When ears of corn or cut grain enters the combine paddles on a

(1) Chain, that brings it up to the…

(2) Cylinder, which is a large spinning cylinder covered with rough steel bars. There it is rubbed between itself and the…

(3) Concave. Most of the grain along with some chaff falls through the onto the front of the…

(4) Grain shoe augers, which take the material to the front of the chaffer(7). Anything that doesn't fall through the small holes in the concave, like cobs, are sent out the back of the cylinder where the…

(5) Beater helps to throw them onto the…

(6)Straw walkers. The walkers move back and forth to shake any grain that might be left in the straw or stalks down where it falls onto the back of the shoe augers. The back shoe augers send this small material forward where it drops it on the front of the…

(7) Chaffer. The chaffer shakes back and forth while the fan blows air through it sending small, light pieces of stalk or cob out the

back. Heavier material, like grain, fall through the chaffer onto the…

(8) Sieve. The clean grain that falls through the sieve is sent by an elevator into the…

(9) Grain tank on top of the combine. Anything that makes it through the chaffer but not the sieve is sent by another elevator back to the front of the combine where it goes through the whole process again.

Check the combine settings between fields for fines and cracked kernels. Fines and cracked kernels spoil much faster than whole, sound kernels. If necessary adjust combine settings.

Corn Harvest Moisture

Harvesting causes some kernel damage. The relationship of kernel damage to moisture content is summarized in the illustration to the right. Depending on the variety and seasonal conditions, minimum kernel damage occurs between 19 and 24 percent moisture (% m.c.).

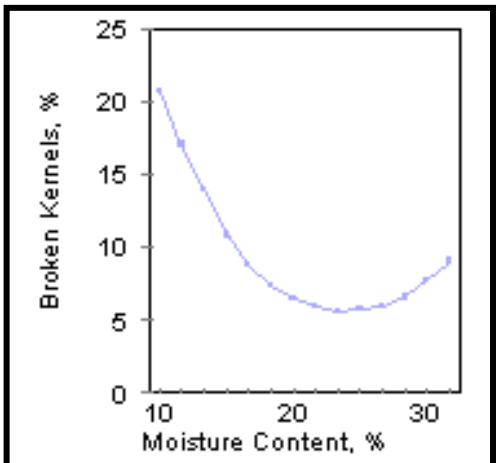


Figure 1. Broken Kernels vs. Corn Moisture Content

In some cases, damaged corn has been discounted as foreign material or dockage. The determination of a recommended moisture level for harvest in Iraq must also consider the cost and availability of grain drying facilities. Corn must be dried down to around 13 percent for storage.

Pre-harvest loss and gathering loss varies with insect damage, lodging, and how tightly ears are held. Ear droppage begins in the 20 percent range (% m.c.) and accelerates as corn dries. Storms can come without much warning. Because of that, verify if stalk rot or insect damage exists. If lodging risk is high, harvest early (around 20% m.c.) to avoid a potential 150 to 300 kg per donum field loss.

Aflatoxin is not likely to be a problem in well-managed corn. (Aflatoxin is a class of toxic compounds that are produced by certain molds sometimes found in stored grains, produced by *Aspergillus flavus* and related fungi. Moldy feedstuffs contaminated with aflatoxins have caused severe disease and mortality in livestock, particularly poultry.) However, aflatoxin may proliferate rapidly under the right conditions, so a grower should consider his options.

If corn can be dried to 15 percent or below within a day, the spread of aflatoxin is minimized by early corn harvest. Corn as wet as 28 percent moisture can be harvested by adjusting the combine for reduced kernel damage and improved separation.

Economical harvest timing depends on the drying cost or high-moisture discounts and field loss and damage penalty. Farmers should consider their own circumstances, including the risk of field loss, how quickly all the corn can be harvested, drying options, and the market. Recover most of the drying cost by reducing field loss and kernel damage. On this basis, beginning corn harvest at 20 percent m.c. is a sound decision for some; starting harvest around 18 percent m.c. fits many other situations. Exposure to weather risks, shrinkage, field loss and damage are compelling reasons to complete all corn harvest before the corn reaches 14 percent m.c.

GRAIN STORAGE

Grain storage in Iraq is primarily done by the government. The following information may be useful to feed mills, feed lots and other private

enterprises, which have or need grain storage facilities

Grain storage involves more than just placing grain in a suitably sized receptacle until it is needed. The grain is a major asset in which the grower has a large investment. The asset must be protected because while grain is in storage its quality, and thus its value, deteriorates.

Grain Storage Principles

High temperature and high moisture are the most significant factors affecting grain quality in storage. Each can cause rapid decline in germination, food quality, colour, oil composition, and many other quality characteristics. High temperatures are a constraint to long term grain storage in Iraq.

Insects and moulds impair the quality of grain directly by their feeding and development, and indirectly through generation of heat and moisture. High temperatures and moistures favour development of insects and moulds. Development of insects is limited by temperatures below 15°C, and by moistures below 9 percent in cereal grains.

Development of moulds is limited by temperatures below 10°C, and by moistures below 13 percent in cereal grains.

Spraying with insecticides or fumigating minimises insect problems but leaves chemical residues in grain, which break down with time. The presence of residues, and their concentration, affects acceptability of the grain to markets. Some markets prefer grain without residues. Grain buyers will not knowingly accept grain treated at rates higher than those specified on the label, or within the specified withholding period.

Storage Capacity

Different grains have different densities and settle to different angles in the bulk pile. The angle also changes with moisture content. Grain settles during storage. Therefore, all figures given are approximate. To obtain storage capacity in tons, multiply the storage facility volume (in cubic metres) by the appropriate conversion factor from the Conversion Factor Table.

Conversion Factor Table

Factors for converting storage capacity in cubic metres to tons

Grain product	Conversion factor
Barley	0.62
Chickpea	0.60
Faba Bean	0.71
Oat	0.50
Rapeseed	0.67
Rye	0.71
Safflower	0.53
Wheat	0.75
Corn	0.71

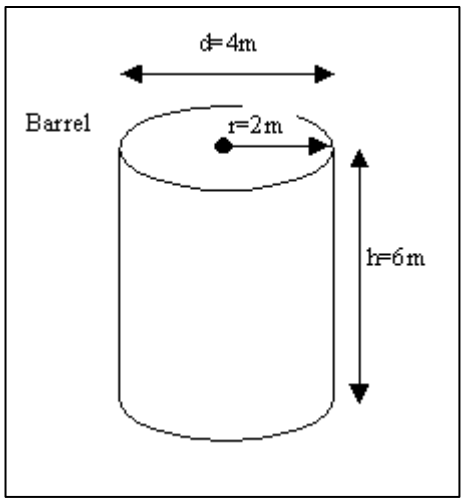
Example:

A weldmesh silo with a heaped grain volume of 124 cubic metres will hold 93 tons of wheat (124 m^3 x 0.75 = 93 tons).

Determining Storage Capacity

Tower silo

To determine the storage capacity of a tower silo, segment the silo into a barrel or cylinder and a cone.

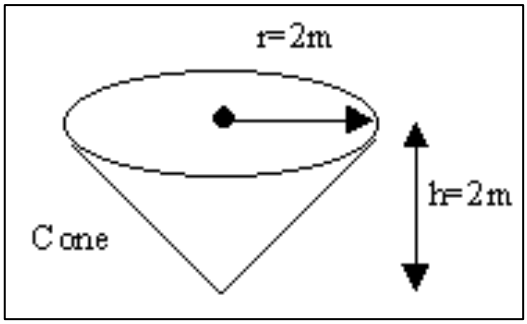


The barrel's flat circular end has a:

- diameter (d) -- 4 m;
- radius (r) which is half the diameter -- 2 m;

barrel height (h) -- 6 m.

The flat circular top of the cone has similar dimensions to the barrel:



- diameter (d) -- 4 m;
- radius (r) -- 2 m;
- cone length (h) -- 2 m.

The volume of the barrel of the silo

= $\pi r^2 h$

= $\frac{22}{7} x2x2x6$

= 75.4 m^3

The volume of the cone of the silo = $\frac{1}{3} \pi r^2 h$

= $\frac{1}{3} x \frac{22}{7} x 2 x 2 x 2$

= 8.4 m^3

Therefore, total volume of the silo = (75.4 + 8.4)m^3 = 83.8 m^3

Maintaining Quality of Stored Grain

Moisture

High moisture grain should not be stored long-term. Accepted moisture limits for trading and storage of grains (**See table below)** are generally below the limits at which molds develop. Moisture moves around inside a silo. Daily and seasonal temperature changes near the silo walls set up air movements that carry moisture to the coolest parts of the grain. Pockets of high moisture grain (e.g. grain harvested early in the season, late at night, early in the morning, or soon

after rain) or inclusion of green leaf material with the grain can affect quality of all the grain in a storage bin or silo because of moisture movement.

Illustrative upper moisture limits for trading and storage of grains in commercial grain trading

Grain	Moisture limit (% dry weight)
sunflower	9
barley (malting), faba beans, mungbean, oats	12
barley (feed), wheat	12.5
chickpea, pigeon pea, soybean	13
sorghum	13.5
Maize or corn	14

Aeration will slow the rate of deterioration of high moisture grain, but if the moisture is more than two or three percent above the limits in table above it should be dried before long term storage.

Early harvesting of grain at higher moistures produces higher quality and higher yield of grain, but those advantages are lost unless aeration and drying are used to minimise losses in storage.

Hot-air drying is necessary to maintain the quality of high moisture grain. However, holding grain at too high a temperature for too long in the dryer will reduce grain quality. Operate the drying equipment according to specifications of the dryer manufacturer. Using higher airflow rates is a safer way to speed up drying than increasing temperature.

Selling grain at a moisture content below that allowed by market results in economic loss. Grain loses approximately 1.2 percent of its weight for every 1percent of moisture content reduction (for example, selling grain with a 9 percent moisture content when up to 12 percent is allowed means a loss of about 3.6

percent of the value).

Temperature

Aeration will markedly reduce grain temperature, and minimize the deterioration of grain quality. Aeration will also even out temperature differences that result in moisture migration from warmer to cooler patches in the grain. A zinc or white finish on the silo exterior will also contribute to a reduction in temperature.

Insects and Chemical Residues

Good hygiene is an essential component of insect control in stored grain. Other options for insect control include:

- cooling grain with aeration
- treating storages and equipment with inert dusts or residual chemicals
- treating grain with inert dusts or residual chemicals
- treating infested grain with appropriate insect cide
- fumigation of infested grain with proper mate rial, or
- controlled atmosphere treatment (e.g. carbon dioxide).

Contact the Ministry of Agriculture grain storage extension specialist for insecticide and fumigation recommendations.

Good hygiene combined with automatically controlled aeration is sufficient for some growers to maintain grain quality without using any residual treatment. Fumigation with proper material leaves minimal residues, provided tablet formulations are not mixed with the grain. Check with buyers before spraying grain with insecticides.

Inspect Stored Grain

Stored grain should be inspected frequently. Mold activity gives a distinct odour to air moved through the grain. By operating the aeration system and smelling the air coming through the grain, storage problems can be detected. Any 'hot spots' should be cooled as soon as possible by aeration. If the problem is due to insect activity, the grain should be fumigated.

Storage Management

Grains have a “shelf life” (maximum storage time) just like any food product. Shelf life is primarily determined by moisture content and temperature.

The table below gives the shelf life for corn at varying moistures and temperatures.

Maximum Storage Time for Corn in Months							
Corn Temper-ature, ^{0} C	Moisture Content %						
	13%	14%	15%	16%	17%	18%	24%
10^0	150	61	29.0	15.0	9.4	6.1	1.3
15^0	84	34	16.0	8.9	5.3	3.4	0.5
20^0	47	19	9.2	5.0	3.0	1.9	0.3
27^0	15	6	2.9	1.6	0.9	0.9	0.06

Some cautions in using the Table:

- *The numbers assume that temperatures are held constant – such as with aeration. Grain heats when it spoils, and gives off moisture. Un-aerated grain will shorten its own shelf life through moisture and heat.*
- *Lower test weight corn will spoil faster than the Table indicates. The difference can halve the shelf life.*
- *If corn is held at higher moisture then dried, the shelf life can be used up by the wet conditions. Dry corn will still experience hot spots or other problems in the summer.*

Every action taken after harvest affects the ultimate length of time grain can be stored and the quality of the grain at the time of use. Grain that starts to heat or get moldy has essentially used its shelf life. The goal of grain storage management is to reduce the rate at which the shelf life is lost. Always cool grain quickly and minimize temperature variations both from the dryer and from the field.

Wet Corn Management

Always get wet corn into an aerated storage immediately. Holding wet grain shortens shelf life considerably. Fungi grow very fast in corn above 20 percent moisture. Overnight storage of wet corn in a wagon or truck can have a marked effect on future storability. Likewise, holding medium moisture corn (16-20 percent) for future blending or feeding will cause future storage problems, even after drying.

Aeration Practice

Phase 1: After harvest

Cool Down

- *Lower grain temperatures*

It will be difficult in Iraq to get temperatures below the 15^0 to 20^0 C range even in mid winter, thus shortening the potential storage life of corn

Phase 2: Winter Maintenance

- *Maintain temperatures with intermittent aeration*

The preferred range would be -2^0 to $+1^0$ C, but this is not possible in Iraq circulating air at ambient temperatures.

Wet corn should be checked weekly and monitored for temperature increases. Wet corn

should have a minimum of 0.025 cubic meters per minute / 100 kg of corn of well-distributed aeration double the normal rates for dry corn. Problems will start to show up in February and March as temperatures rise. Wet corn should not be held in bunkers, piles, flat storages, sheds or other structures where airflow is not well distributed.

Selecting Corn to Store

Be selective about what corn is placed in storage versus sold at harvest. Deliberately decide which corn and bins are going to be kept into the summer. Store the best (highest test weight) corn, harvested below 20 percent moisture with careful combine settings to minimize trash and placed in storages with good aeration rates/airflow distributions.

Low test weight corn should not be put in temporary storages or outdoor piles. It is not wise to mix corn of different crop years in the same storage bin; the mix is less stable than each year's crop stored separately. Holding wetter corn should be done with a plan for drying or other options to halt spoilage if it starts.

Remove the center core and use a grain distributor if possible. Check the temperature of stored grain at least every two week. If a slow rise is noted, aerate. If a hot spot starts, make that the next corn to be moved out of storage and utilized or sold.

Understand corn buyers' requirements, and match storage and drying practices to the intended marketing time.

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