THE ESSENTIAL ABOUT GRAIN MAIZE

Technical guide for successful growing

A BRAND OF MAÏSADOUR

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GENERAL INFORMATION ABOUT GRAIN MAIZE

MAIZE : AN INDISPENSABLE CEREAL

Over the next 20 years the demand for grain maize will increase due to the growing populations and improved living standards in the emerging countries, which will go hand in hand with a changing demand towards more animal products.

To address these needs the world maize production requirements are expected to increase by 50% by 2050… while the amount of arable land decreases by 24%!

Maize is the most cultivated cereal worldwide and has many advantages to meet this challenge :

Producing more than the other major crops with the same quantity of water due to its exceptional water efficiency and its production potential.

Producing better by its exceptional adaptability and by being particularly economical in terms of treatments (average of 1.75 sprayer passes per crop).

Producing usefully for the environment, respecting the climate and biodiversity.

Producing variety, usefully for the society, with many outlets in sectors of the future.

All these qualities have been greatly enhanced by genetic improvement and make maize a leading crop for sustainable agriculture!

Maize is above all destined for :

- animal feed (70% of the quantities produced in Europe),
- the starch industry (20%),
- the semolina industry (8%).

The importance of maize grain in animal feed comes from its high energy content due to its starch (66-70%) and fat (4.7) contents.

It contains more energy than any other cereal (but is relatively low in protein and calcium).

WHY USE HYBRIDS ?

Yield potential

In most cases, sowing hybrids multiplies yields by 6.

Stability and reliability

Advantage of hybrids :

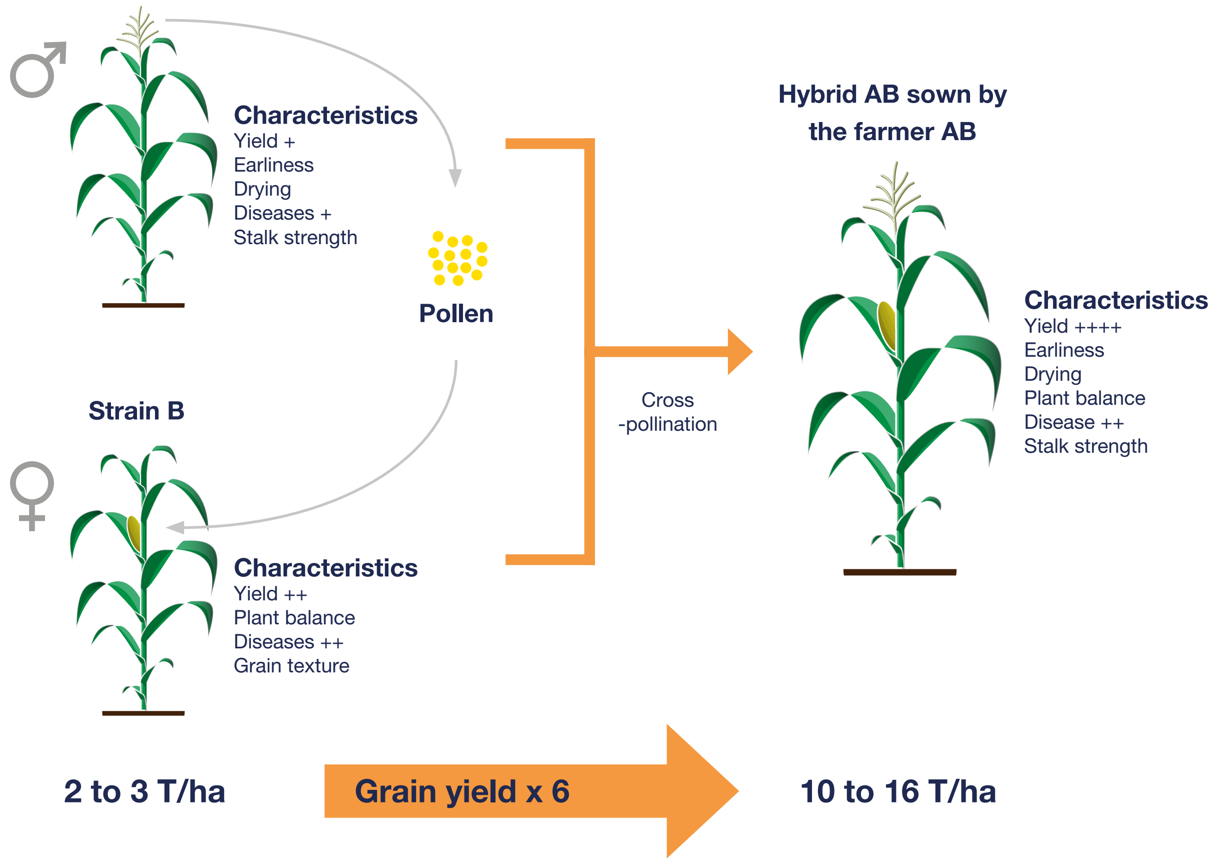
- More regular yield
- Greater tolerance to diseases
- Better tolerance to stresses

The heterosis effect, also called hybrid vigour, gives a performance gain.

The hybrid exhibits the best of both parents and a bonus with respect to many agronomic characteristics. The more genetically distant the initial populations, the greater the heterosis effect.

Self-fertilization of elite lines

Heterosis effect



Notes

PHYSIOLOGY OF GRAIN MAIZE

What are the temperature requirements for maize ?

What are the yield components ?

What are the key stages of maize ?

MAIZE TEMPERATURE REQUIREMENTS

Maize is a plant of tropical origin and has been selected for northern regions but requires a specific temperature range.

- Germination zero is around 6 °C.
- Emergence requires a soil temperature over 10°C.
- 80°C (base 6) is necessary from sowing to emergence.
- 44°C (base 6) is needed to produce a leaf.

Calculation of effective temperatures (degrees/day) base 6°C
Calculation of effective temperatures/day = ((T°max + T° min)/2) - 6 E.g. : T°max >30°C, use the value 30 for the calculation
Ex : T°max = 24°C T°min = 10°C *Effective T° = ((24+10)/2) - 6* *= 17 - 6 = 11°C*

Requirement for a base 6 Temperature according to the FAO earliness figures
(international earliness index)

	FAO 180-220	FAO 220-280	FAO 280-380	FAO 380-480	FAO 480-560	FAO 560-700
Needs in degree days (base 6 ° C) of sowing at harvest (32% water content grain)	1 650-1 555	1 775-1 655	1 875-1 775	1 925-1 880	2 000-1 930	2 200-2 005
Total number of leaves	15-16 f	16-17 f	17-18 f	18-20 f	19-21 f	20-22 f

Need of temperature to gain a point of dry matter (DM) in fodder: 22 ° C (base 6 ° C)

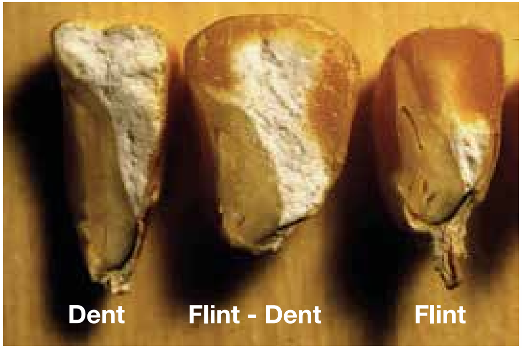
MAIZE GRAIN TEXTURE

- The maize grain mainly contains starch which can be glassy or floury.
- The grain texture has, of course, an effect on the type of starch.

Type of grain	Dent	Flint (origin : Europe)	Flinted - Dented
Type d'hybrides	FAO 280 to 700	Early	FAO 180 to 300 hybrids from 2 other families
Type of hybrids	Flat and rather long, retracts when mature giving the grain a toothed shape at the top	Round and often orangey, does not retract when mature	Wide variety of textures with grains rather dented to rather flinted
Starch	Floury	Glassy	Intermediate vitreousness and starch digestibility slower during silage
Advantage of genetics	Yield potential and dry-down qualities	Early maturity and tolerance to cold	Early slots to mix tolerance to cold with yield potential
Usage	Animal feed		
	Starch industry	Semolina and cornflake industry	Semolina industry

Cross-sections of different types of maize grains

Floury albumen   Glassy albumen

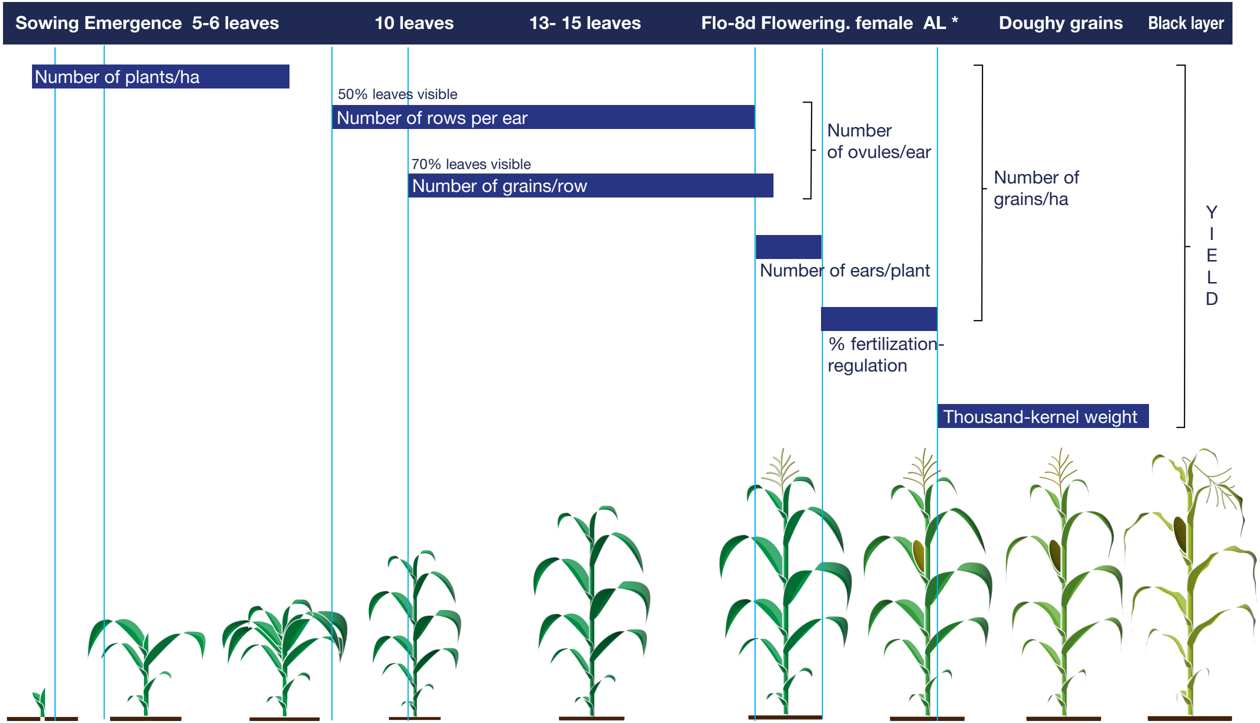


Dented grain

Flinted grain

DEVELOPMENT OF MAIZE YIELD COMPONENTS

Yield components of grain maize build step by step from sowing till black layer.



*AL : Grain abortion limit stage

THE 8 KEY STAGES OF MAIZE

1. Emergence

- **10°C required in the soil for germination**
- Need for sufficiently fine and moist soil around the seed
- 12-17 days required to reach emergence

2. 4-5 leaf stage : Weaning

- Appearance of new roots (crown roots)
- The plant is no longer dependent of the seed’s reserves : it is weaned
- Sensitivity to deficiencies (phosphorous)
- **Reaches final density**

3. 8-10 leaf stage : Initiation of ears (ovule)

- **Initiation of the ears (number of rows)**
- 10 leaves : Elongation stage = need for water and nutrients
- Sensitivity to cold T° (<8°C), to low sunlight and to the application of weedkillers

4. Tassel visible

- **Stage which determines the number of ears per plant, the number of ovules is 90% determined**
- Stage of great sensitivity to lack of water and nitrogen

5. Female flowering

- **Fertilization of ovules by the pollen**
- High sensitivity to water deficit :
  - if water stress
  - grain development disrupted and high temperatures
  - no exit of the bristles
  - fertilization problem
  - disturbed grain development

6. Grain abortion limit stage

- 3 weeks after fertilization, i.e. 250 dd after flowering. Beyond this stage, grain abortions are no longer possible
- Final number of grains
- Stage marking the end of maximum sensitivity to water stress

7. 50% H2O stage = doughy grain stage

- Last irrigation stage
  = 32% whole plant DM stage

8. Black layer , 32% grain moisture

- **Grain physiological maturity : end of grain fill**
- Formation of black layer : closing of vessels between grains and cob

GROWING GRAIN MAIZE

Cultural interventions : When and how ?

WHAT MAKES GOOD SOWING ?

Maize is a short-cycle plant. Emergence and rooting problems are very difficult to overcome. From germination to the 4-leaf stage, the maize limiting factors are cold, excess water and parasites (wireworms, slugs, cutworms, etc.). They can have a significant effect on population and yield.

Early maturity	Densities
FAO 180-280	80 - 110 000 gr/ha
FAO 280-480	70 - 90 000 gr/ha
FAO 480-700	65 - 80 000 gr/ha

To maximize your yields :

- Plant early. It often gives better yields

- Monitor the sowing speed. The slower the sowing, the more is precise
- Sow in a dried soil at a minimum of 10°C
- Plant the seed in cool soil at a depth of 4 at 7 cm
- Adapt the density to the type of early seed and soil

A regular sowing depth

- Plant the seeds at the same depth, 4 cm, in cool soil.
- Seed bed with fine soil (be careful of the risk of surface sealing in silty soil)
- Some small surface clods
- A good moisture level around the seed

A seed drill in very good condition

- Tyres pressures : 2 kg/cm²
- Blades in very good condition for a V furrow
- Perfect pickup of sowing elements
- Perfect coulter pressure and clod clearer setting

For good sowing

- Regularly check the settings and distribution
- Respect the sowing densities and depths adapted to the soil

Controlled distribution of seeds on the line

- Verified and controlled density : adjust the sowing rate to adapt it to each field. Take into account each field’s yield potential in the criteria used to determine the appropriate sowing rate
- No doubles or misses

TWO ADVANTAGES OF EARLY PLANTING

The best yields are regularly to be obtained with early planting. Anticipate manuring and working the soil to be ready for end March-early April.

Early crops also have the advantage of dryer harvesting and therefore bring savings in drying. But planting too early can also reduce yields.

The maize germinates and develops when the soil temperature reaches 10°C. At lower temperatures than those indicated above, the seed remains dormant and will become more vulnerable to attack by diseases, insects and animal predators. It is therefore recommended to take the soil temperature, check the 5-day and 7-day weather forecasts to see if they are favourable.

Soil T°	Effective T°/day	Number of days needed for emergence
10°C	4	20 - 22 d
11°C	5	16 - 18 d
12°C	6	13 - 15 d
13°C	7	12 - 13 d
16°C	10	8 - 10 d
21°C	15	5 - 7 d

Maize germination dynamics in relation with soil temperature

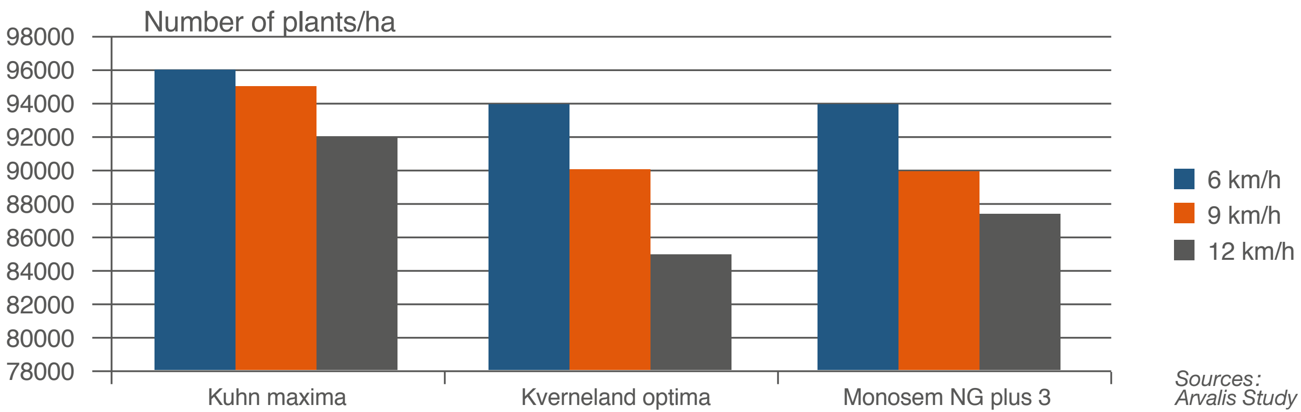
THE SOWING SPEED AND AN INCORRECTLY SET SEED DRILL DISRUPT DENSITY

The ideal sowing speed is normally between 5 and 7 km/h. Sowing at excessively high speeds causes misses, more doubles and an unequal sowing depth.

The following graph shows the loss of density at different speeds and with different seed drills.

New seed drills are arriving on the market which claim to sow at over 12 km/h (Verderstad tempo, Amazone EDX, etc.)

Plant losses as a function of sowing speed linked to sowing heterogeneity



Sources: Arvalis Study

MAIZE WEED CONTROL STRATEGIES

The farmer has different weed control strategies available to him according to the plot

- **A plot to weed :** use a pre-emergence control product and a post-emergence control product
- **A relatively easy plot to weed :** (or land with a long rotation) : use a pre-emergence control product
- **Visual weed control :** use one or two post-emergence control products

Weed control strategy

	Pre-emergence	Post-emergence
Product type	Broad spectrum germination inhibitor	General application of products up to 7-8 maize leaves then used for directed spray application after this stage
Soil type	Moist, slow drying soil or difficulty to enter the land	Use on soil rich in organic matter ➔ Problem of persistence of pre-emergent plants
Usage/ Advantages	Use in priority if high presence of grasses	Can be a totally «post» strategy for visual treatment of grasses. Combats perennial weeds
Remark	Avoid weed control on spiking maize (phyto), and after maize 7-leaf stage with certain products (sulfonylurea). A treatment at this stage can cause stress and sterility of the ears and tassels	

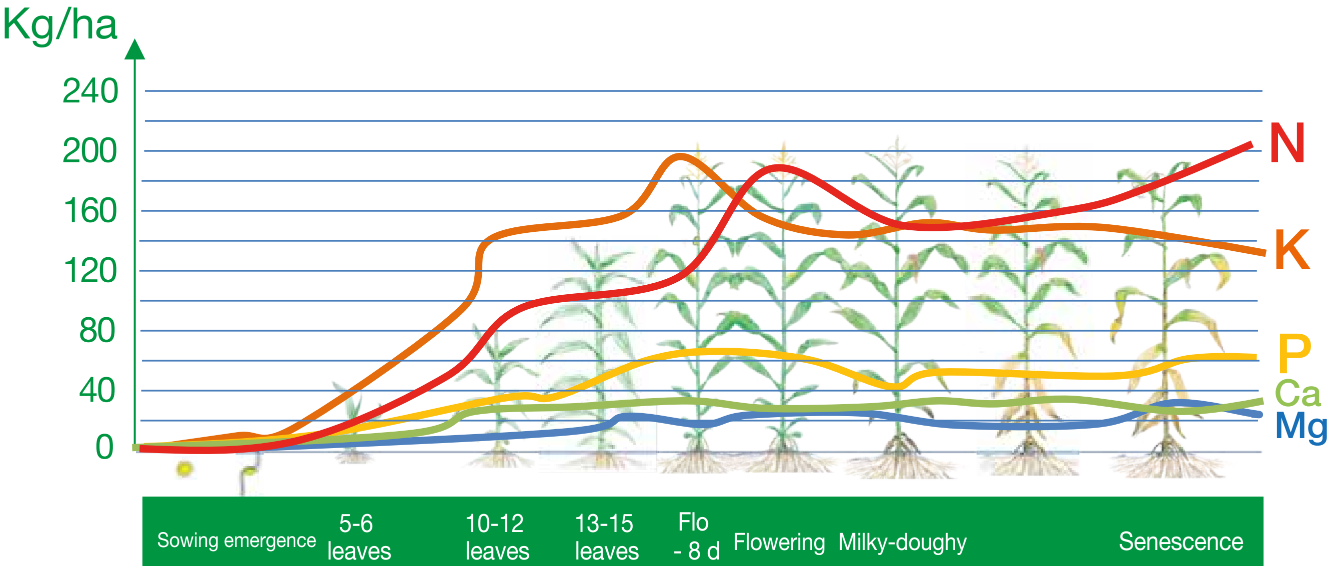
All the mineral elements have a role to play when cultivating maize and an optimum supply of these will contribute to achieving the highest yields.

NITROGEN FERTILIZATION

The maize growth period coincides with the time when organic matter mineralization is optimum, particularly if water is not a limiting factor.

Quantity of nitrogen to be supplied =
needs according to the yield objective
⊖
nitrogen from the soil

The main mineral needs of maize and change during development



Nitrogen needs according to the potential

Grain maize	Nitrogen needs (kg/q)
< 100 q/ha	2.2
> 100 q/ha	2

Some benchmarks : estimation of nitrogen doses to be applied to grain maize (in situations not receiving an organic input)	**Yield objective Grain maize**	
	80 q/ha	100 q/ha
Topsoil poor in OM (< 1.5%)	130 - 180 U/ha	170 - 190 U/ha
Soil moderately fertile (> 2% and < 5%)	110 - 130 U/ha	150 - 170 U/ha
Fertile soil rich in OM (> 5%)	180 - 100 U/ha	100 - 120 U/ha

It is strongly recommended that the nitrogen supply should be staged because maize absorbs practically no nitrogen during the 1st month of growth. From 8 leaves, the maize must have a sufficient quantity of nitrogen. Between 20 and 50 units should be given at the sowing stage and completed at the 7-8 leaf stage.

Standard recommendations for the different forms of nitrogen

Fertilizer type	Nitrogen units in 100 kg	Use after maize emergence		
		General application	Local application	Burial
Ammonitrate	27 or 33.5% N • 50% nitrates • 50% ammonia	Not recommended after 5 leaves (burns)	Recommended	Recommended particu-larly if ground is dry
Urea	46% N • 100% urea	Possible on dry leaves and incorporation recommended	Possible	Recommended to pre-vent volatilization
Anhydrous ammonia	82 of which 100% ammonia	None	Mandatory : Avoid excessively dry soils (volatilization) and excessively damp soils (soil smoothing and evaporation of ammonia)	
Solution of urea and ammonium nitrate (UAN)	39 U of N per 100 l • 25% nitrates • 25% ammonia • 50% urea	No	Mandatory : Use down tubes	Recommended

PHOSPHO-POTASSIC FERTILIZATION

The crops use a small part of the phosphorous and potassic fertilizers applied the same year.

Phosphorous exports are 0.6 kg P205/q of grain and the potash exports are 0.5 kg K20/q of grain.

Oligo-elements
Monitor the manganese, magnesium or zinc deficiencies in excessively acid or excessively basic soils

Some benchmarks : estimation of phospho-potassic fertilization

Grain maize	Phosphoric (P) fertilization		Potassic (K) fertilization	
Yield objective	80 q/ha	110 q/ha	80 q/ha	110 q/ha
Well-supplied soil	50-55 U	40-85 U	20-45 U	40-65 U
Normally supplied soil without input of manure	45-55 U	80-90 U	45-55 U	70-80 U

IRRIGATION

Maize crops are mostly rainfed.

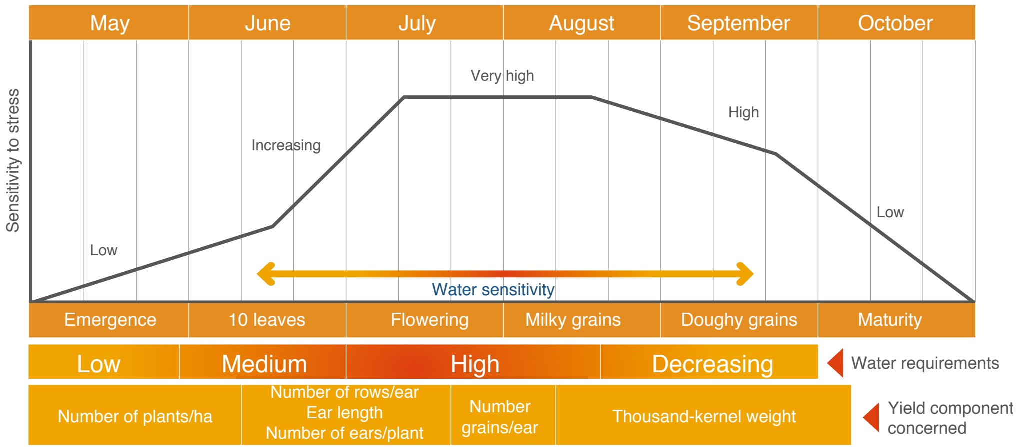
25% of the maize surfaces in Europe are irrigated.

Maize is highly sensitive to a water deficit over the period from 20 to 30 days before flowering (8-10 leaf stage) to 10-15 days after and even during the grain fill phase (from end June to mid August).

For irrigated situations, and depending on the soil and the year's climatology, the following must be provided :

	Before Flowering	Flowering	After Flowering
Number of water towers	2	1	2 to 3
mm	25 to 30	25 to 30	25 to 30

Maize water requirement throughout its cycle



HARVESTING GRAIN MAIZE IS A COMPROMISE BETWEEN QUANTITY, QUALITY, DRYING AND LOCAL CONDITIONS

- Aim for a moisture level which will both limit field losses (lodging or falling ears) and keep drying costs at an acceptable level.
- The optimum yield is reached when assimilate transfer is terminated (black layer).
- The thousand-kernel weight is then at the maximum for the number of grains/m^2.
- Set the combine-harvester to limit the damage to the grain and maximize cleaning.
- Shred quickly and finely after harvesting (the same day if possible to efficiently destroy the caterpillars present in the stalk : European corn borer, Mediterranean corn borer).
- Rapid disking to incorporate the shredded stalks and boost their degradation.

ADVICE FOR STORING THE HARVEST

- Reduce the grain moisture level by 13-14% before storage.
- Keep the grain cool (0 to -6 °C).
- Periodically check the temperature and for the appearance of hot spots or damp zones and signs of insects.

WEATHER DATA FOR EUROPE

2000-2010 average

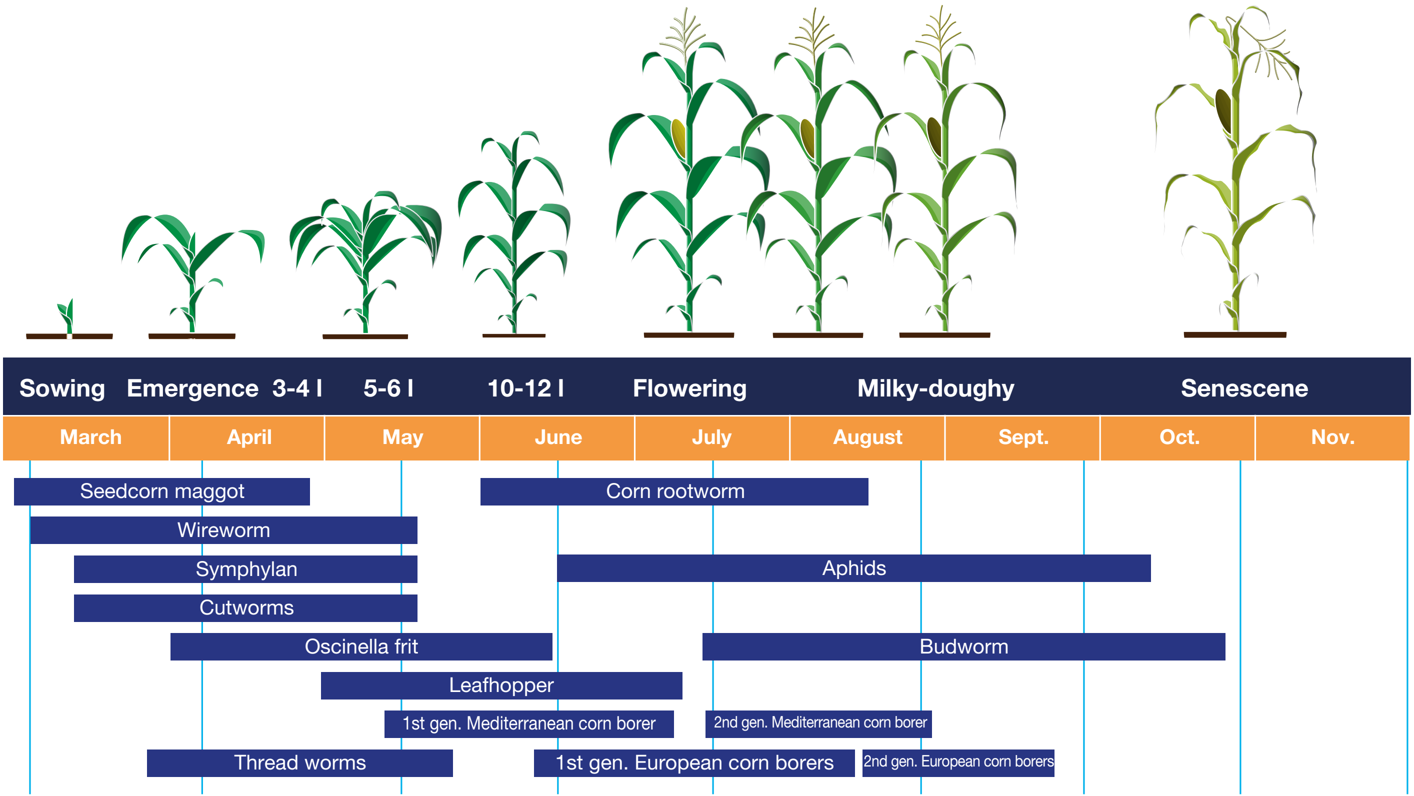
Grain. number of days to lose 1 pt (22°C base 6)	Number of days to lose one point of moisture												
	France	Germany	Poland	Belgium	Austria	Czech Republic	Hungary	Romania	Italy	Spain	Bulgaria	Ukraine	Russia
	Paris	Munich	Poznan	Brussels	Vienna	Prague	Budapest	Bucharest	Milan	Madrid	Pleven	Kiev	Krasnodar
From 15 to 30 August	1.6	1.9	2.6	1.8	1.6	1.8	1.5	1.3	1.2	1.1	1.3	1.6	1.2
From 1 to 15 September	1.8	2.3	4.2	2.1	2.0	2.3	1.8	1.6	1.5	1.4	1.7	2.3	1.6
From 16 to 30 September	2.2	3.0	7.0	2.6	2.4	3.0	2.2	1.9	1.8	1.5	2.1	3.0	1.9
From 1 to 15 October	3.5	7.0	7.0	4.2	4.7	8.0	3.8	3.5	3.0	2.4	3.2	8.0	4.1

Notes

PESTS AND DISEASES

What are the pests and
the most common diseases of corn ?

MAIZE INSECT PEST CALENDAR



SEEDCORN MAGGOTS

Germination

Larvae on grains

OSCINELLA FRITS

Sowing to 4-5 leaf stage

Fly and plants damaged

MEDITERRANEAN CORN BORERS

1st generation : 3 to 10 leaves

2nd generation : flowering to harvest

Larvae and plants damaged

WIREWORMS

Sowing to 8-10 leaf stage

Larvae and plants damaged

LEAFHOPPERS
May to July

MRDV virus caused by the leafhopper

APHIDS
June to September

Aphid on leaves

SYMPHYLANS
March to May

Insects on roots

CORN ROOTWORM - LEAF BEETLE
10 leaves to end of flowering

Larva and adult

EUROPEAN CORN BORERS

1st generation : 10-12 leaves to end of flowering
2nd generation : Flowering to harvest

Eggs and larvae

THREAD WORMS

Roots atrophied on the right

CUTWORMS

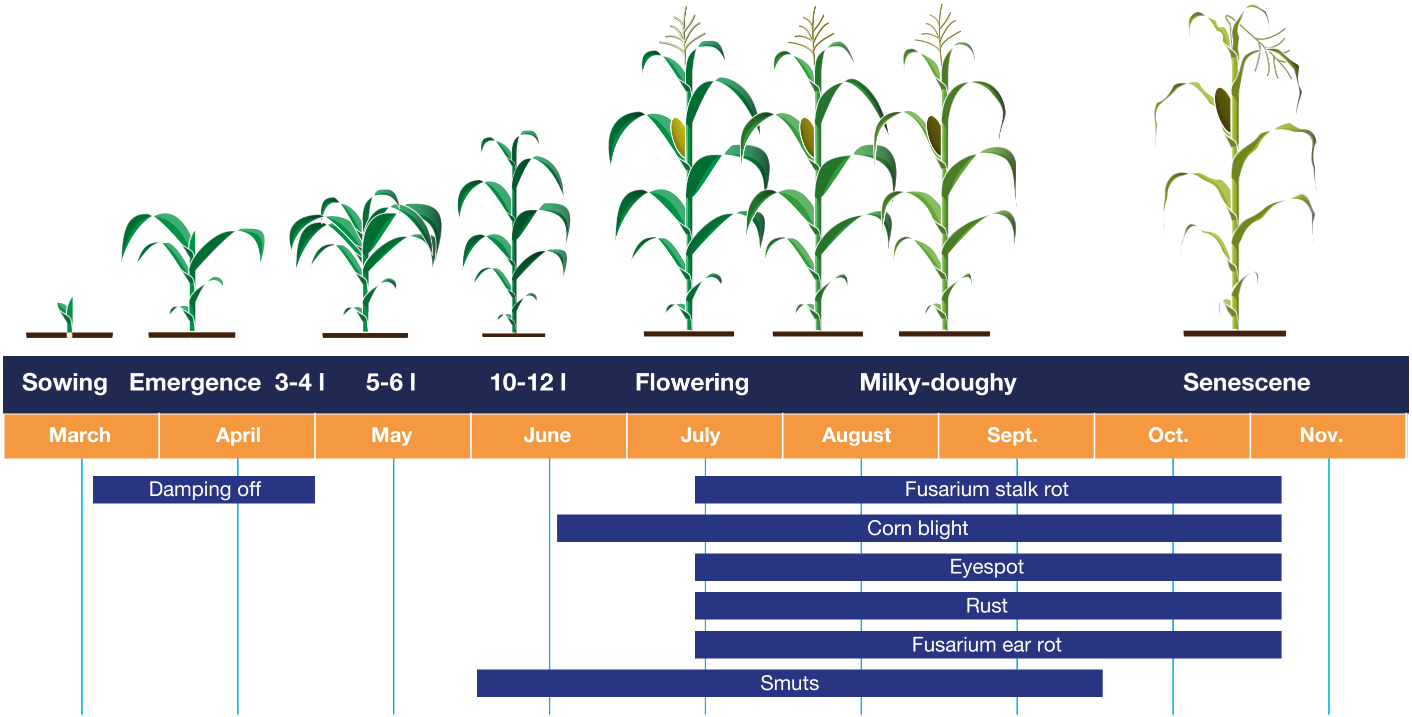
Sowing to 8-10 leaf stage

Larvae and plants damaged

BUDWORM

Flowering to harvest

MAIZE DISEASE CALENDAR



DAMPING OFF
Germination

Pythium, Fusarium stalk rot, etc.

FUSARIUM STALK ROT
Sowing to flowering stage to maturity

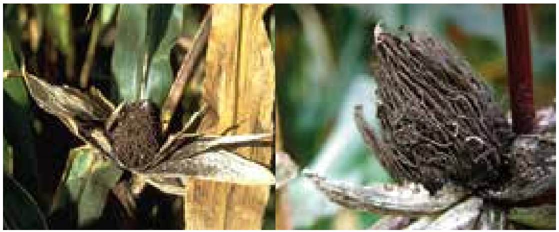
Damaged stem and plants

EYESPOT
June to September

Damaged leaves and plants

COMMON SMUT
(Corn smut)

INFLORESCENCE
(Sphacellotheca)

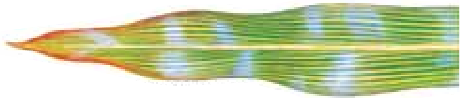


DEFICIENCY SYMPTOMS

Phosphorous deficiency

Potash deficiency

Nitrogen deficiency



Magnesia deficiency

Ammonia or
weed control product burn

CORN BLIGHT

10 leaves to maturity

RUST

Flowering to maturity

FUSARIUM EAR ROT

Moniliforms

European corn borer attacks or grain cracking

GRAMINEARUM

Infestation at flowering
Attacks top of ear
Rotten cob

Notes

Notes

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