Cultivating our passion for Sorghum Crop

A comprehensive journey into the heart of sorghum.

A global leader in
sorghum technology

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Transforming Sorghum Agriculture

Advanta Seeds, as a leader in the agricultural inputs market, is committed to providing comprehensive and valuable resources for growers and technicians. In line with our dedication to support the success of farmers and advance agricultural practices, we recognize the importance of developing a Sorghum crop information resource. Sorghum is a vital crop with diverse end-use applications, and there is a growing need for accessible, detailed guidance on its characteristics, attributes & benefits, and best practices for its cultivation and general crop management.

Through this initiative, we aim to consolidate our expertise and knowledge in the field, offering growers and technicians a trusted resource that addresses the specific challenges and opportunities associated with sorghum cultivation. This initiative aligns with our mission to empower agricultural professionals with the information and tools they need to optimize yields, enhance sustainability, and navigate the complexities of modern global farming.

Through the development of comprehensive information, Advanta Seeds will further demonstrate our commitment to **advance agricultural knowledge, foster innovation, and support the success of farmers worldwide.** We believe that this endeavor will not only strengthen our position as industry leaders but also contribute significantly to the continued growth and prosperity of the agricultural community.

VISION

A single seed holds within itself the power to change the future of this planet. Our aim is to protect the circle of life that begins with a seed. And contribute to the larger good of the world while doing so.

MISSION

With sustainable actions create seed technologies that fight climate change, add value to farmer lives and enhance nutrition for the world.

Sorghum Crop

ADVANTA AT A GLANCE

1200 EMPLOYEES — Representing 25 countries

2nd & 4th IN ASEAN & AFRICA — In enhancing productivity of smallholder farmers (UNSDG - ASI).

+60 YEARS — Research experience in plant genetics.

+20 R&D — Stations worldwide in the Americas, Africa, India, Thailand, Indonesia and Europe & Australia

20 STATIONS — Of seed production & processing sites across 21 countries

+80 COUNTRIES — With commercial presence & employees in 25 countries

+900 HYBRIDS — In +40 crops

Our global footprint

We are a part of UPL Group, adapting to rapidly increasing food insecurity and climate change, by providing farmers with innovation and new technologies. Through the years we have been working in seed industry in many parts of the world, have evolved a global footprint for seed research and development, seed production and commercial activities in every continent of the globe. Apart from the intensive and state-of-the-art in-house R&D, through strategic merger and acquisitions, Advanta Seeds has established a robust genetic and germplasm foundation that accounts for great products performing in all main sorghum production countries. Through acquiring germplasm, Advanta Seeds has also integrated well-established seed brands from key markets. Thus, we have in **4 stablished seed brands** in our portfolio, i.e., Alta Seeds in USA and Europe, Pacific Seeds (blue) in Australia, Pacific Seeds (green) in Thailand and Advanta Seeds in the rest of the world.

We are **a global seed company**, adapting to rapidly increasing food insecurity and climate change by providing farmers with innovation and new technologies.

Our brands

ADVANTA

Alta seeds

Pacific Seeds

PACIFIC SEEDS

Production
+20 Stations

R&D
+20 Biotechnology and research centers

Commercial
+80 Countries

Chapter **02**

Advanta Seeds sorghum history

Advanta Seeds & Sorghum Contritutions

Advanta Seeds operates in the sorghum market worldwide, being the world leader in this crop. Our unique, superior, and highly diverse germplasm provides our customers with hybrids suitable for all grain and forage cultivation segments. Providing high-quality sorghum seeds has long been our core business – and that commitment is stronger than ever. **Advanta Seeds is a leader in sorghum genetics worldwide.** No other company has dedicated as many resources to developing elite sorghum germplasm as we have. Our international breeding programs have clear breeding strategies across the globe.

Drawing on a global network of subsidiaries; along with key partnerships with leading technology companies for innovative added value traits, biotech and high-quality forage and yield traits, diseases, pest and herbicide resistance and drought as well as salinity tolerance, Advanta **ensures offering cutting edge agronomic practices and crop protection solutions** to its customers worldwide and can share what are the general strategies for sorghum breeding.

Breeding focus in sorghum for adaptation, maturity, phenology, genetic potential, and quality characteristics is crucial for developing varieties that can thrive in diverse environments and meet the needs of farmers and consumers. Sorghum, **a versatile cereal crop**, is grown for food, feed, fodder, and industrial purposes. To ensure its continued success, breeders

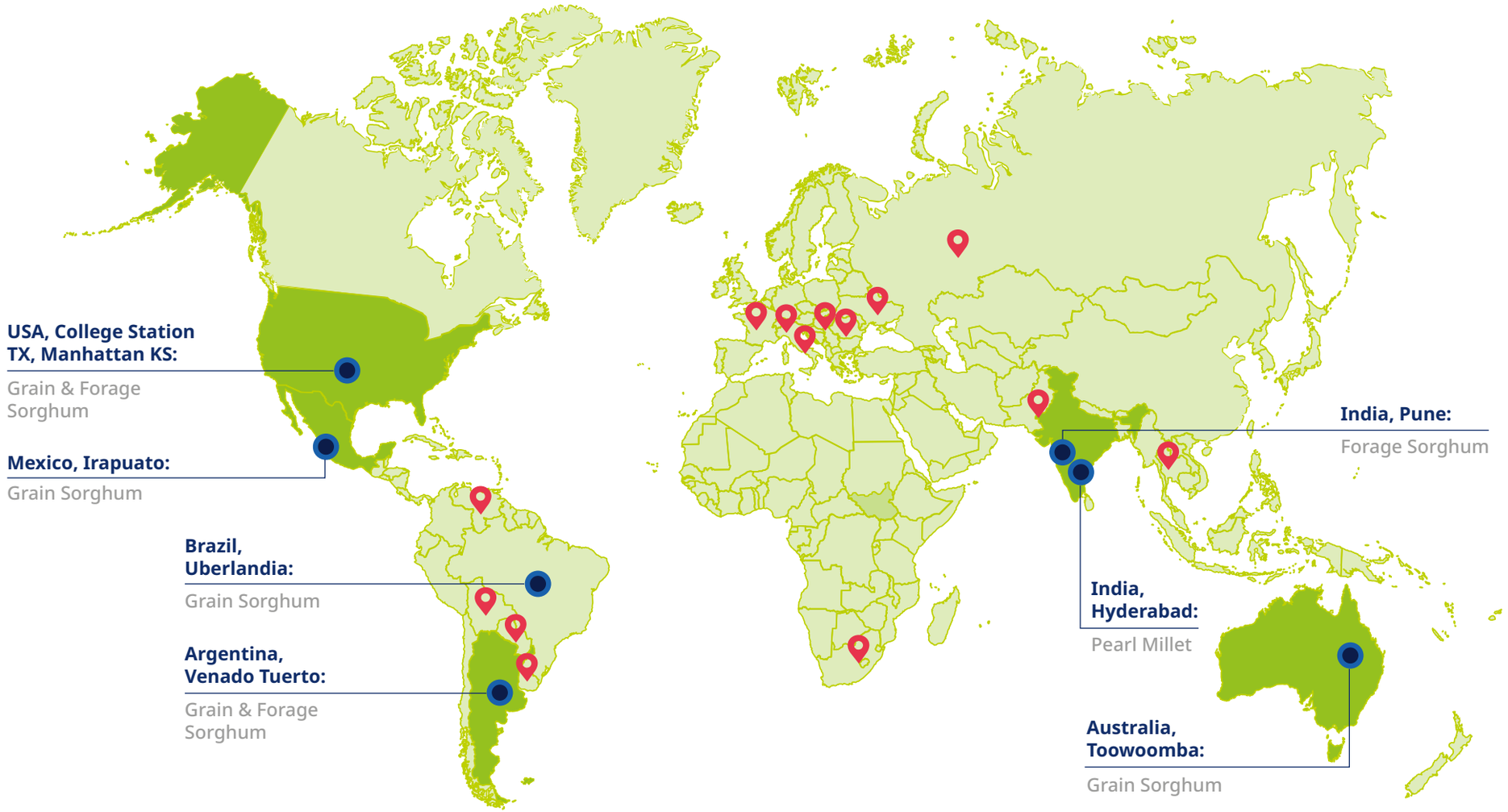
focus on several key aspects to improve the crop's performance and utility. Sorghum breeding programs aim to **develop varieties** that are adapted to a wide range of growing conditions, including varying climate, soil types, and pest pressures. This involves identifying traits that contribute to stress tolerance, such as drought, heat, and salinity resistance. By selecting for these traits, breeders can **develop sorghum varieties that can thrive in challenging environments**, ultimately increasing productivity and stability in different agro-ecologies.

Maturity and phenology are critical considerations in sorghum breeding. Varieties with different maturity durations to suit specific growing regions and production systems. Early-maturing varieties, for instance, can be essential in areas with short growing seasons or where farmers need to stagger planting to manage risk. Conversely, late-maturing varieties may be preferable in regions with longer growing seasons. Understanding the phenological development of sorghum also allows breeders to optimize flowering and grain filling, which can impact yield and quality.

Breeders strive to unlock the genetic potential of sorghum by identifying and harnessing desirable traits through genetic improvement. This involves utilizing traditional breeding techniques, integrating new technologies, such as genomic selection, gene editing, and precision phenotyping, to accelerate the development and introgression these desired traits from diverse germplasm sources into elite breeding lines to create new hybrid combinations with improved characteristics. Traits of interest include yield potential, disease resistance, insect tolerance, and nutritional quality. By enhancing the genetic potential of sorghum, **hybridization** is conducted to generate diverse hybrid combinations by crossing selected parental lines with complementary traits breeders can create new hybrids that are more productive, resilient, and valuable to farmers and end-users.

Improving the quality characteristics of sorghum is integral to enhancing its value for various end-uses. Quality traits encompass attributes such as grain size, color, nutritional composition, and processing suitability. Breeders work to develop sorghum varieties with improved nutritional profiles, including higher protein content, essential amino acids, and micronutrients. Furthermore, they aim to enhance the grain's suitability for food, feed, and industrial applications, ensuring that it meets the diverse needs of consumers and industries. Continuous improvement efforts aim to further address emerging challenges and opportunities in sorghum production, ensuring that hybrids remain competitive and resilient.

Global Advanta Sorghum R&D Breeding Programs



R&D Testing operations | R&D Sorghum Breeding Programs

Sorghum breeding strategies

01

Yield Improvement: Increasing grain or biomass yield is a primary focus in sorghum breeding. Breeders aim to develop varieties with higher yield potential through genetic improvements, including traits related to photosynthesis, biomass accumulation, and efficient nutrient utilization.

02

Agronomic Traits: Breeding efforts focus on improving agronomic traits that contribute to crop performance and ease of cultivation. This includes traits such as early maturity, plant height, uniformity, lodging resistance, shattering resistance, and response to management practices like fertilization and irrigation.

03

Disease and Pest Resistance: Developing sorghum varieties with improved resistance to diseases and pests is a crucial breeding focus. Breeders target specific diseases such as anthracnose, downy mildew, and grain mold, as well as pests like aphids, stem borers, midges, and birds. Genetic resistance, including host plant resistance genes, is sought after to reduce crop losses.

04

Drought and Heat Tolerance: Sorghum is known for its natural resilience to drought and heat stress. Breeding programs focus on enhancing drought and heat tolerance by identifying and incorporating genes and traits related to water-use efficiency, improved root architecture, osmotic adjustment, and heat shock proteins.

05

Nutritional Quality: Breeding programs aim to improve the nutritional quality of sorghum grain. This includes enhancing protein content, amino acid composition, micronutrient bioavailability, and reducing anti-nutritional factors. Improved nutritional quality makes sorghum more suitable for human consumption and animal feed.

06

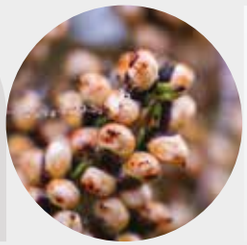
Bioenergy and Industrial Uses: Some sorghum breeding programs have a specific focus on developing varieties for bioenergy production or industrial applications. These programs aim to enhance traits related to biomass production, sugar content, cellulose digestibility, and optimized biochemical composition for biofuel or bioproducts production.

07

Climate Adaptation and Resilience: Breeding for climate adaptation involves developing sorghum varieties that can thrive in diverse agro-climatic conditions, including regions with variable rainfall patterns and extreme temperatures. Enhancing resilience to climatic uncertainties contributes to sustainable sorghum production.

08

Genetic Diversity Conservation: Preserving and utilizing the genetic diversity present in sorghum germplasm is essential for breeding programs. Focus is placed on collecting, conserving, characterizing, and utilizing diverse sorghum genetic resources to broaden the genetic base and introduce novel traits. These focus areas drive the selection and development of improved sorghum varieties that address the needs of farmers, consumers, and different industries, while also ensuring the resilience and sustainability of sorghum production systems.



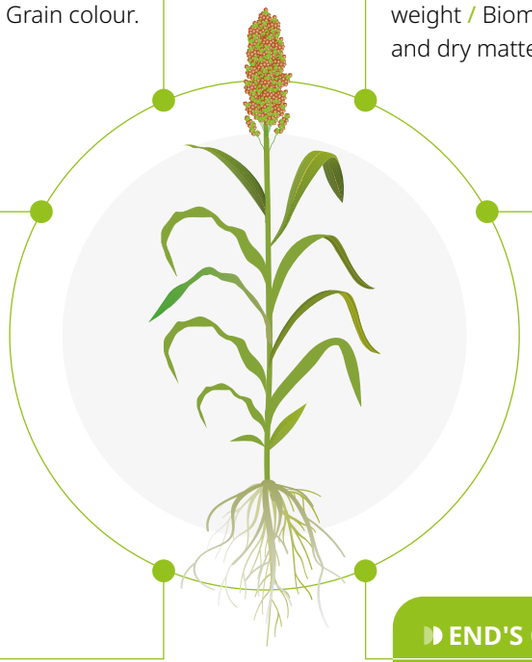
Sorghum Breeding Traits

PHENOLOGY

/ Plant architecture / Head type / Head exortion / Grain colour.

GENETIC POTENTIAL

/ Yield improvement / grains per head / Grain size / Grain weight / Biomass (green and dry matter).



MATURITY

/ Cold tolerance
/ Early blooming
/ Grain desiccation
/ Photoperiod sensitivity

QUALITY CHARACTER

/ Nutritional & Industrial uses
/ Tannin level
/ Protein / Starch
/ BMR digestibility
/ High Sugar (Brics) / Brewery

ADAPTATION

/ Lodging / Drought tolerance / Heat tolerance / Stay green / Wide adaptation / Fertility adaptation / Disease pack / Salt tolerance.

END'S OF USE:

/ Grain for food, feed, brewery and starch / Dual purpose for grain and Fodder / Forage (Single and Multicut SSG) hybrids.

In conclusion, breeding focus in sorghum for adaptation, maturity, phenology, genetic potential, and quality characteristics is essential for advancing the crop's productivity, resilience, and utility. By targeting these key aspects, breeders can develop sorghum varieties that are well-suited to different agro-ecologies, have optimized growth and development patterns, expressed their genetic potential, and possess enhanced quality attributes. These efforts contribute to the continued success and relevance of sorghum as a vital crop for food security, agricultural sustainability, and economic development.

Evaluation and Advancement Process of Sorghum

The evaluation and advancement process for sorghum hybrids involves several key pillars and stages to ensure the development of improved and commercially viable hybrids this is a comprehensive and systematic process that integrates genetic improvement, trait evaluation, multi-environment testing, and technological innovation to develop superior hybrids with enhanced performance and quality characteristics.

Research & Development - Advanced research in plant genetics utilizing most advanced R&D technologies available.

Seed Production & Testing - Seed technology is tested across a range of environments to ensure high crop productivity & produced under the highest industry standards.

Reach farms, grow profitability - Farmers are provided best quality high-performing product seeds & agronomic advice to maximize profitability.

The resulting hybrids from a breeding program undergo rigorous evaluation in multi-location trials to assess their performance across different environments, considering traits such as yield, maturity, stress tolerance, and agronomic characteristics. Multi-environment trials are conducted across diverse agro-climatic regions to assess the stability and adaptability of hybrid performance. These trials provide valuable insights into the genotype-by-environment interactions and help identify hybrids that exhibit consistent and superior performance across different growing conditions. Selection of superior hybrids is based on comprehensive phenotypic data and statistical analyses.

Promising hybrids that have successfully passed the evaluation and advancement stages are scaled up for seed production and commercial release. Certified seed production ensures the availability of high-quality planting material for farmers, enabling the widespread adoption of improved sorghum hybrids.

This complete breeding and product advancement process is essential for meeting the evolving needs of growers, consumers, and industries while contributing to the sustainable advancement of sorghum agriculture.

Chapter **03**

Sorghum History & Diversity

Source: Thakur, Niranjan. Research Fellow at ICRISAT, Patancheru, India. Personal photograph.

a. Overview of sorghum as a crop

Sorghum is an **important agricultural cereal crop**, grown in many parts of the world, especially in those areas where crops tolerant to heat and drought can only be grown. It seems to have its origins and domestication in northeastern Africa around 8,000 B.C., where earliest record of sorghum was from a dig at Nabta Playa, near the Egyptian-Sudanese border. More than 5,000 years ago in the region where is today Sudan, it had its domestication from its wild type of ancestor. While being spread throughout Africa, sorghum demonstrated good adaptation to many environments from semi-arid to highlands. Later, it spread out to India, China, Australia, North and South America.

Nowadays, sorghum is a key crop globally, in West Africa as Guinea corn, jowar in India and kaoliang in China. It plays a crucial role in food security and economic stability in many communities. Being a truly versatile crop, it can be grown as grain sorghum (most commonly for human consumption as whole grain, flour, a key ingredient in gluten-free products and a valuable source of animal feed), forage sorghum (grown for animal feed and fodder such as pastures, silage and hay), sweet sorghum (grown for the sweet juice in its stalks, which can be used for syrup or as well as for ethanol and biofuel production), and broomcorn (the tassels of certain sorghum varieties are used for making brooms and brushes).

Sorghum *(Sorghum bicolor)* is a grass species belonging to the Poaceae family. It is a hardy, drought-tolerant crop that is well-suited for cultivation in semi-arid and tropical regions. It has a wide range of heights from 0.6 to 2.4 metres for grain and forage production, being possible to reach 4 to 5

meters in biomass and sweet sorghum production. The leaves are large, typically long, and broad to narrow, and they are arranged alternately along the stem. The leaves and stem can vary in size and shape depending on the specific variety of sorghum, where its drought tolerance characteristics come from the coated waxy stem and the stomata present in the leaves. It's robust root system consists of numerous branching roots that extend horizontally and vertically into the soil. The roots can penetrate to considerable depths, especially in search of water.

Sorghum plants produce different types of inflorescences or panicles or heads, which refer to the flowering part of the plant. The specific type of panicle or head can vary based on the sorghum variety or cultivar, the panicle types being Open, Semi-Compact, Compact, Clubhead, Finger millet-type, and so on. The variation in the color of sorghum grains is a very visual characteristic that include various shades of white, yellow, bronze, brown, red, and black.

b. Grain and Forage sorghum segmentation

Grain sorghum and forage sorghum are two distinct sorghum segments with different plant characteristics and purposes and proposed uses.

Grain sorghum, also known as milo, is primarily grown for its grains, which are used for human consumption, animal feed, brewing and industrial applications. It features relatively dwarf plants, with roundish seeds and is cultivated specifically for grain production.

Forage sorghum is grown for its tall, leafy stalks that are harvested and utilized as livestock feed as green chop, or silage or hay. Forage sorghum varieties are characterized by their taller plant stature and higher volume of stems and leaves with greater green mass production compared to grain sorghum. Forage sorghum plays a crucial role in providing nutritious forage for livestock, supporting grazing animals and serving as a valuable feed source in livestock production.

c. Types and main end of uses of sorghum

Grain sorghum

Sorghum bicolor

Grain sorghum is the most widely cultivated type of sorghum and is primarily grown for its edible grains, which are used for human consumption and animal feed. It includes various cultivars with different grain colors, including white, cream, red, brown, and black.

Characteristics:

- High grain yield potential, dwarf to medium tall plants with high proportion of panicles (≥50%).
- Lesser whole plant dry matter yield compared to dual-purpose or forage hybrids.
- High grain drying rate.
- Crop life cycles- Short, intermediate, and long.

Forage sorghum

Sorghum bicolor

Forage sorghum is primarily grown for animal feed and silage production. It is bred to have high biomass production with good nutritional value for livestock.

Characteristics:

- Maximum plant height and high green biomass
- Very high whole plant dry matter productivity
- High grain content in silage varieties (≥30%)
- Longer life cycles (late flowering) for better chopping window.

Dual purpose sorghum

Some sorghum varieties are bred for dual-purpose use, combining characteristics of grain sorghum and forage (silage) sorghum. These varieties are cultivated for both grain production and silage purposes, offering flexibility to farmers.

Characteristics:

- Usually have a Brachytic dwarf short stature
- High leaves content with shorter internodes
- Good grain and forage content (≥40%)
- Can be harvested for silage and grain production
- Usually, medium late to long life cycles

Biomass

Sorghum bicolor

Sorghum, also known as energy sorghum, is a specific type of sorghum cultivated for its high biomass production. It is primarily grown as a dedicated energy crop for various applications, including bioenergy production, biofuels, and industrial uses from the accumulation of above-ground biomass, specifically the stalks and leaves, rather than grain production.

Characteristics:

- Highest biomass production
- Efficient source for bioenergy production
- High growth rate (more dry matter production per day)
- Very long cycles being able to be photoperiod sensitive

Broomcorn

Sorghum bicolor var. technicum

Broomcorn sorghum is cultivated for its long, stiff fibers in the seed heads, which are used for making brooms, brushes, and decorative items. The seeds of broomcorn sorghum are not typically used for food purposes.

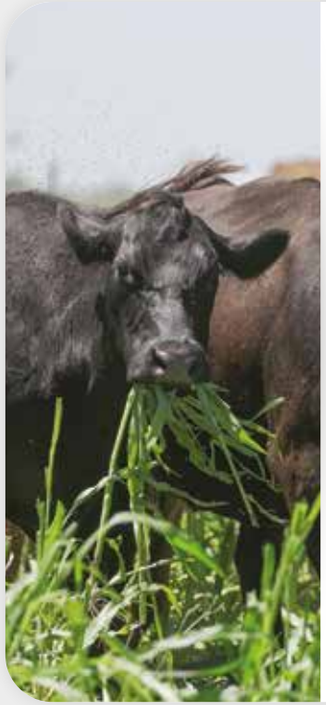
Sweet sorghum

Sorghum bicolor

Sweet sorghum is specifically bred for its high sugar content in the stalks. It is primarily used for producing syrup, molasses, and bioethanol. Sweet sorghum can also be used as forage for livestock.

Characteristics:

- High sugar content in stalks
- Usually, tall plants with high biomass production
- Shorter growing season compared to sugar cane



Sudan Grass/ multi cut forage sorghum

Sorghum bicolor var. sudanensis

Sudan grass is a type of sorghum that is primarily used as a forage crop. It is often grown in warm climates for grazing, hay production, or as a cover crop to improve soil health.

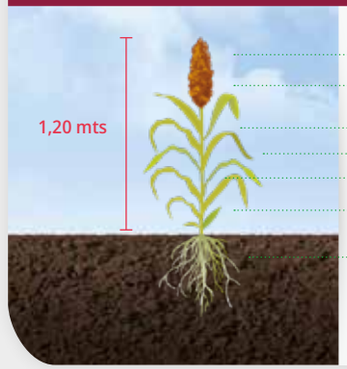
Characteristics:

- High dry matter yield
- Multiple tillers per plant
- Very high regrowth capacity
- Very low grain yield
- Low desiccation rate
- Very long cycles being able to be photoperiod sensitive

d. Sorghum Phenology and development Stages:

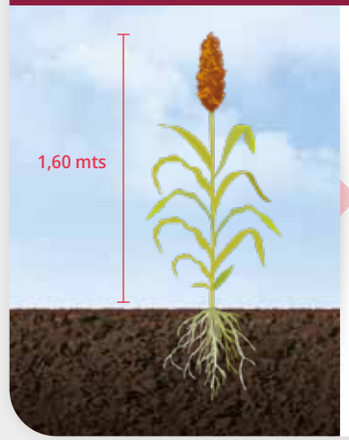
Sorghum Plant Phenotypes

Grain sorghum



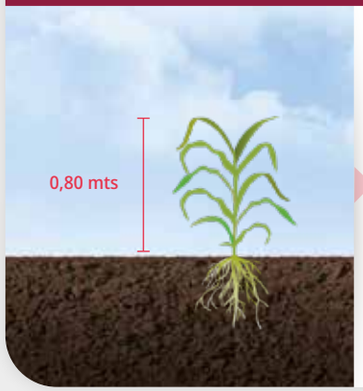
Selected for their excellent performance in grain yield, adaptability and rusticity combined with shorter plant height (1,1 - 1,4 m).

Silage/ Dual Purpose



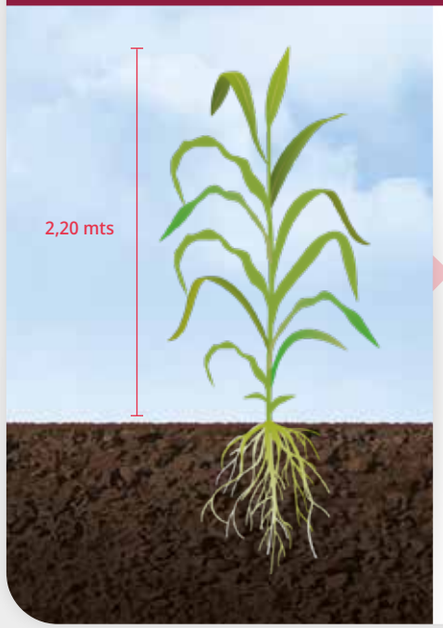
Dual purpose sorghums are differentiated materials with high grain yield potential combined with high leaf/stem ratio. These characteristics allow them to generate greater whole plant dry matter production.

Multicut / Sudan



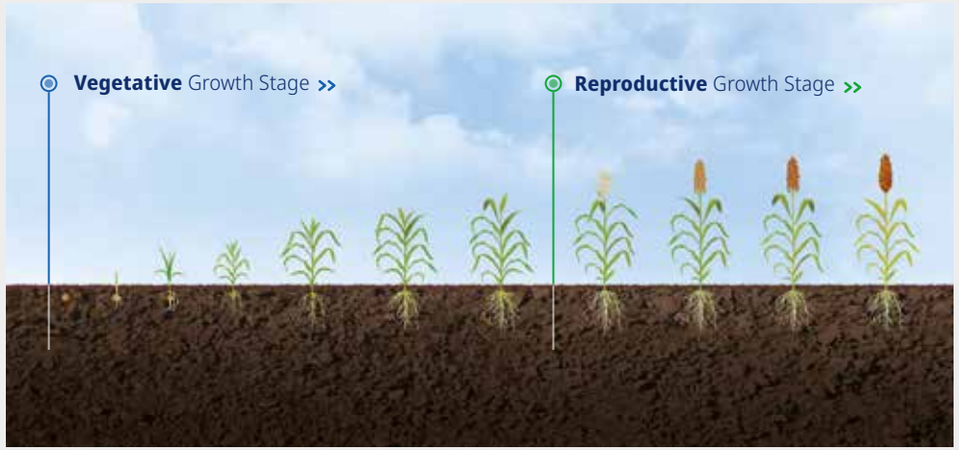
Sorghums characterized by their high biomass production, great regrowth capacity after grazing and an excellent leaf/ stem ratio with very little grain production. Grassing height is arround 0,80 meters, it can also grow taller when used for hay production or one cut only.

Biomass



Biomass plants are usually very tall, up to 3 meters, with high biomass production for energy and industrial purposes.

Grain Sorghum Development Stages



Grain sorghum is known for its remarkable versatility of adaptation, resistance to drought and soil salinity, being a crop highly adapted to adverse conditions. It can be considered a short life cycle crop, easily mechanizable, being an attractive option for different agricultural production systems around the globe.

Grain sorghum has a robust root system that can reach up to 160 cm deep in the soil. Most roots (80% approximately) are concentrated in the first 30 cm of the soil profile, which contributes to its great capacity to absorb water and nutrients, especially in conditions of water stress during its development.

Development cycle of grain sorghum varies according to life span of the variety or hybrid, regional and seasonal adaptation, date of sowing; it generally completes its life cycle in a period that varies from 90 to 150 days, depending on climatic conditions and management practices

adopted. This development cycle comprises several phases, from sowing, germination, and emergence of seedlings to the maturation of seeds, through the establishment of plants, the vegetative period, the substantial reproductive period and the formation of grains. Understanding these phases presented and described below is fundamental for the appropriate management of the crop.

Vegetative Growth Stage | Stage 1 0-5

01

Stage 1 refers to the vegetative growth stage of the sorghum plant's life cycle. Period from seedling emergence to the apex differentiation that starts the development of the panicle.

Focus on plant establishment and a **strong root system** and developing a **healthy leaf canopy**. Goal to maximize photosynthesis and nutrient uptake to support its growth and prepare for reproductive stages.

Here are some **key characteristics** and activities that occur during **Stage 1** sorghum:

- Leaf development
- Root groowth
- Stem elongation
- Tiller formation
- Nutrient uptake and abundant accumulation of dry matter.

• **Weed control and pest management** are important during this stage for maximizing growth and dry matter production per day.

The **duration of Stage 1** would vary depending on environmental conditions, sorghum variety, and management practices. Typically, it lasts for several weeks until the plant reaches a stage where it **starts transitioning into the reproductive phase**, initiating panicle development and flowering.

Reproductive Growth Stage | Stage 2 6-9

02

Stage 2 refers to the reproductive growth stage of the sorghum plant's life cycle. Period from the development of the panicle to grain formation and maturity.

Focus from **transition from vegetative growth to reproduction**, terminating with grain maturation. It involves differential allocation of plant resources towards the development of flowers, pollination, and the formation of grain.

Here are some **key characteristics** and activities that occur during **Stage 2** sorghum:

- Grain Filling
- Flowering and pollination
- Grain desiccation
- Leaf and plant senescence
- Grain Maturity
- Panicle development (booting)

• At the end of this stage, sorghum crop is ready for harvest.

The **duration of Stage 2** would vary depending on factors such as sorghum variety, climatic conditions, and growing practices. Adequate **moisture, proper nutrient management, and pest control** are essential during this stage to ensure optimal grain development and yield.

The phenological development stages of sorghum plant under stage 1 (vegetative) involves phases zero to 4. The stage 2 (reproductive) consists of phases 5 to 9. The developmental changes during these phases and crop management practices required to be followed are described below.

PHASE 0

• **Sowing:** When sowing sorghum, there are a few key considerations to keep in mind to ensure successful growth and yields: soil temperature, planting depth, spacing, soil moisture and seed dispersion.

• **Germination:** Under ideal moisture conditions sorghum seed absorbs water and begins to sprout. It involves the swelling and cracking of the seed coat, leading to the emergence of the radicle (primary root) and the coleoptile (protective sheath).

• **Emergence:** Seedling emergence refers to the growing shoots breaking through the soil surface. The first set of leaves, unfold and become visible and begin to photosynthesize.

• **Seedling establishment:** The seedling develops a root system and additional leaves, increasing its ability to absorb water and nutrients from the soil and increase photosynthesis. The plant focuses on establishing a strong foundation for further growth.

PHASE 0

Management Tips

Sorghum needs warm soil with adequate moisture for its germination. Early plant growth is slow and depends on environmental conditions (soil temperature, moisture, seed distribution, planting depth and vigor. Seed treatment and pre-emergent herbicides are critical for good crop stand establishment.

• **Timing:** Sorghum should be sown when the soil has warmed up to around 60°F (15°C) or higher. Planting too early in cold soil can lead to poor germination and growth. The exact timing will depend on your location and local climate conditions.

• **Temperature:** Sorghum is a versatile crop that can grow in a wide range of temperatures, but it thrives best in warm to hot climates. The ideal temperature range for sorghum cultivation is typically between 25°C to 35°C (77°F to 95°F) during the growing season.

• **Soil Preparation**: Prepare the soil by tilling or plowing to break up clods and create a fine seedbed. Sorghum prefers well-drained soils with good fertility. Conduct a soil test to determine if any soil amendments or fertilizers are needed.

• **Seed Rate:** The recommended seeding rate for sorghum can vary depending on the variety and intended use (grain, forage, etc.). Typically, sorghum is planted at a rate of 6-10 pounds per acre when drilled or 15-30 pounds per acre when broadcast. Seed rate must be defined according to end of use and recommended by a local consulting specialist.

• **Planting Depth:** Sorghum should be planted at a depth of 1-2 inches (2 to 5 cm). Planting too shallow can result in poor germination, while planting too deep can delay emergence and weaken seedlings.

• **Spacing:** Row spacing for sorghum can vary depending on the equipment used, and the intended use of the crop. Generally, row spacing of 15-30 inches is common for grain sorghum, while wider spacing may be used for forage sorghum. Spacing may vary regionally with common agronomic practices and can be determined by a local consulting specialist.

• **Fertilization:** Based on soil test results, apply the appropriate fertilizers before planting to provide the necessary nutrients for sorghum growth. Nitrogen, phosphorus, and potassium are key nutrients for sorghum production.

- **Weed Control**: Proper weed control is essential for maximizing sorghum yields. Consider using pre-emergent herbicides or mechanical cultivation to control weeds before they compete with sorghum plants.

- **Watering:** Adequate moisture is crucial for sorghum germination and early growth. Ensure that the crop receives sufficient water, especially during dry periods. Irrigation may be necessary depending on local rainfall patterns.

PHASE 1 to 5

• Stage 1	• Stage 2	• Stage 3	• Stage 4	• Stage 5
Three-Leaf	Five-Leaf	Growing Point Differentiation	Flag Leaf Visible	Boot

- **Vegetative growth:** The plant experiences rapid leaf and stem growth. It develops a leaf canopy to maximize photosynthesis and nutrient uptake. The primary objective is to build biomass and prepare for reproductive stages.

- **Tillering:** Lateral shoots, known as tillers, emerge from the base of the main stem. Tillering contributes to the overall plant size, biomass, and grain yield potential. Some grain sorghum varieties do not produce tillers.

- **Stem elongation:** The main stem and tillers elongate, allowing the leaves to reach sunlight and optimize photosynthesis. This stage is characterized by vertical growth and the continuous development of the stem.

- **Booting:** The panicle, which contains the flowers, is enclosed within a protective sheath called the boot. The boot gradually opens as the panicle develops.

Management Tips

- **Phase 1** (Three leaf) occurs 10 to 20 days afteremergence, since the growing point is still under the ground surface, leaf damages (e.g., hail) do not kill the plant.

Management Tips

- **Phase 3** (growing point differentiation) occurs 30 to 40 days after emergence, the growing point is above the ground surface with rapid plant growth and maximum nutrient uptake.
- **Phase 5** (booting) occurs 50 to 60 days after emergence; herbicide injury of drought stress can impact panicle exertion and thereby yield potential.
- **Controlling** insects, diseases and weeds is highly essential to maximize yield.
- **Nutrients and water** required for growth development.
- Since weeds compete for water and nutrient during crucial peak growth phases, they should be removed. Poor weed control can reduce yield.
- **Nutrients uptake requirement up to:** >30% Nitrogen; >40% Potassium; >20% Phosphorus.

Physiological Maturity
Black Layer

PHASE 6 to 9

- **Stage 6**
  Half-Bloom

- **Stage 7**
  Soft-Dough

- **Stage 8**
  Hard-Dough

- **Stage 9**
  Physiological Maturity

- **Heading and flowering:** The panicle emerges from the boot and becomes visible above the upper leaves. Florets within the panicle open, releasing pollen for pollination. This stage is crucial for successful reproduction and grain formation.
- **Maturation and harvest:** The grains develop and mature, reaching their final size, color, and dry weight. The plant begins to senesce, turning brown and drying down. Harvest is to be done when the grains have developed a black layer (spot) near the hilum at the bottom and have reached the desired moisture content for storage or processing.

Chapter **04**

Crop Overview

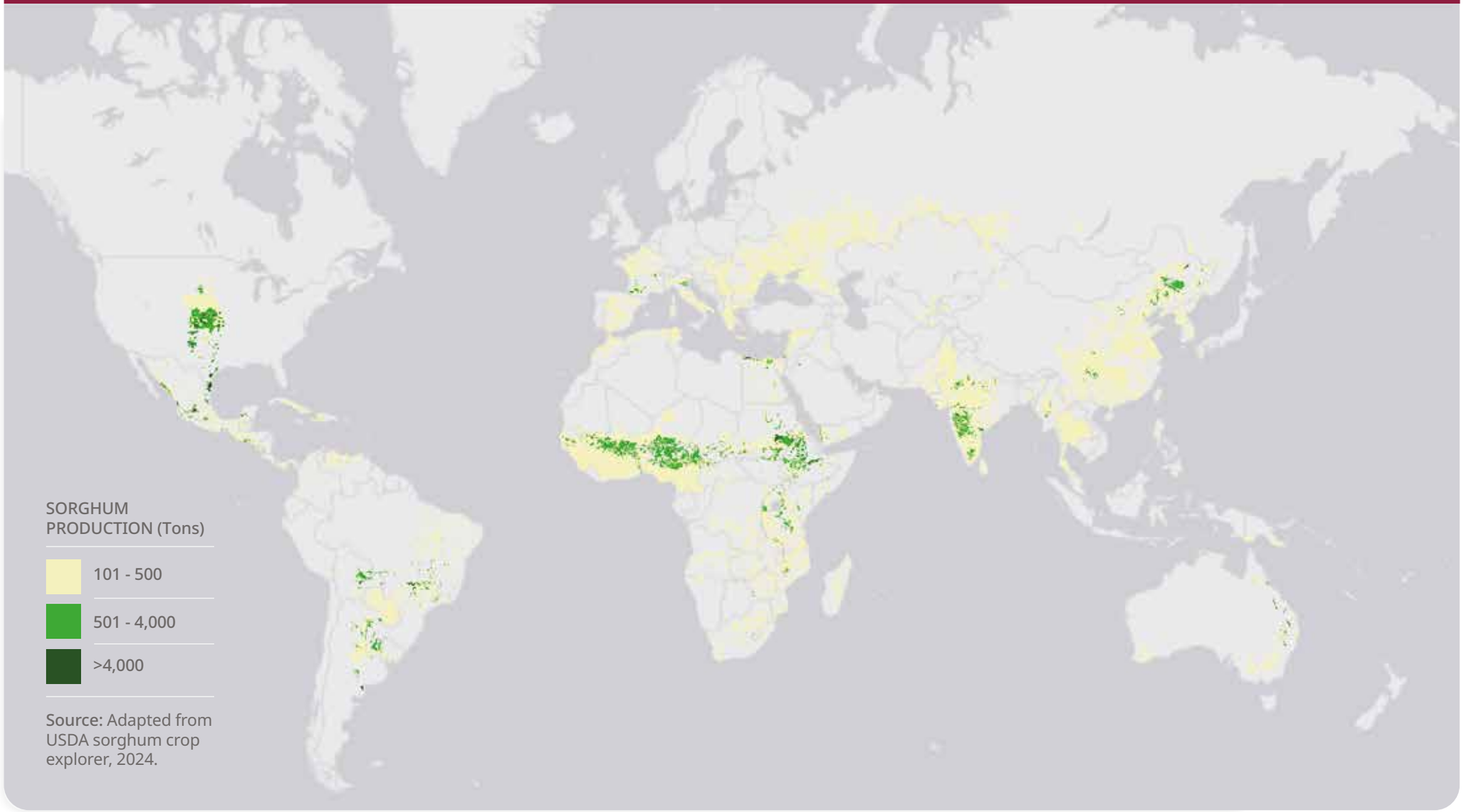
Sorghum crop management: from planting to end use

Sorghum is a **versatile crop** that can be grown in various climates and soil types worldwide. A good and effective crop management practice is essential to maximize yield and quality of production. Here we describe the general crop management practices for sorghum cultivation across the sorghum growing countries (more detailed and region-specific information need to be gathered locally as cultivation practices and production characteristics change from one country to another):

What are the main regions of sorghum crop cultivation worldwide?

The world map below depicts the main regions of sorghum crop cultivation corresponding to suitable regions for sorghum crop establishment, development and production. This is a crop that is suitable for many countries since it`s requirements are mostly related to temperature and water, as its cultivation area is growing due to increased levels of aridity linked to climate change.

Global Sorghum cultivation areas



Source: Adapted from USDA sorghum crop explorer, 2024.

Sorghum as a crop has a huge potential and is grown in various regions around the world. **The main crop-growing zones for sorghum include:**

1| Africa: Sorghum is native to Africa and is an important staple food and crop in many African countries, including Nigeria, Sudan, Ethiopia, and Mali.

2| Asia: Sorghum is widely grown in countries such as India, China, and Thailand. In India, sorghum is an important staple food and is commonly grown in the states in the drier regions of the country such as Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh, Gujarat, Tamil Nadu, Rajasthan, and Uttar Pradesh. In Northern and Western India, sorghum is grown for green forage. Sweet-stalked sorghum is a potential feedstock for bioethanol production. China and Japan use sorghum for animal feed and making beverages.

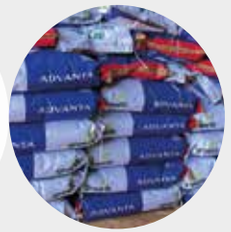
3| North America: In the United States, sorghum is mainly grown in the Great Plains region, particularly in states like Kansas, Oklahoma, Nebraska and South, Central and Texas panhandle. Grain sorghum is used for animal feed, ethanol production, and human consumptions food products in North America.

4| South America: Sorghum is also grown mostly in countries like Argentina, Bolivia and Brazil. In South America, sorghum is used mostly for animal feed (grain and forages), with new projects being developed for grain sorghum ethanol based production.

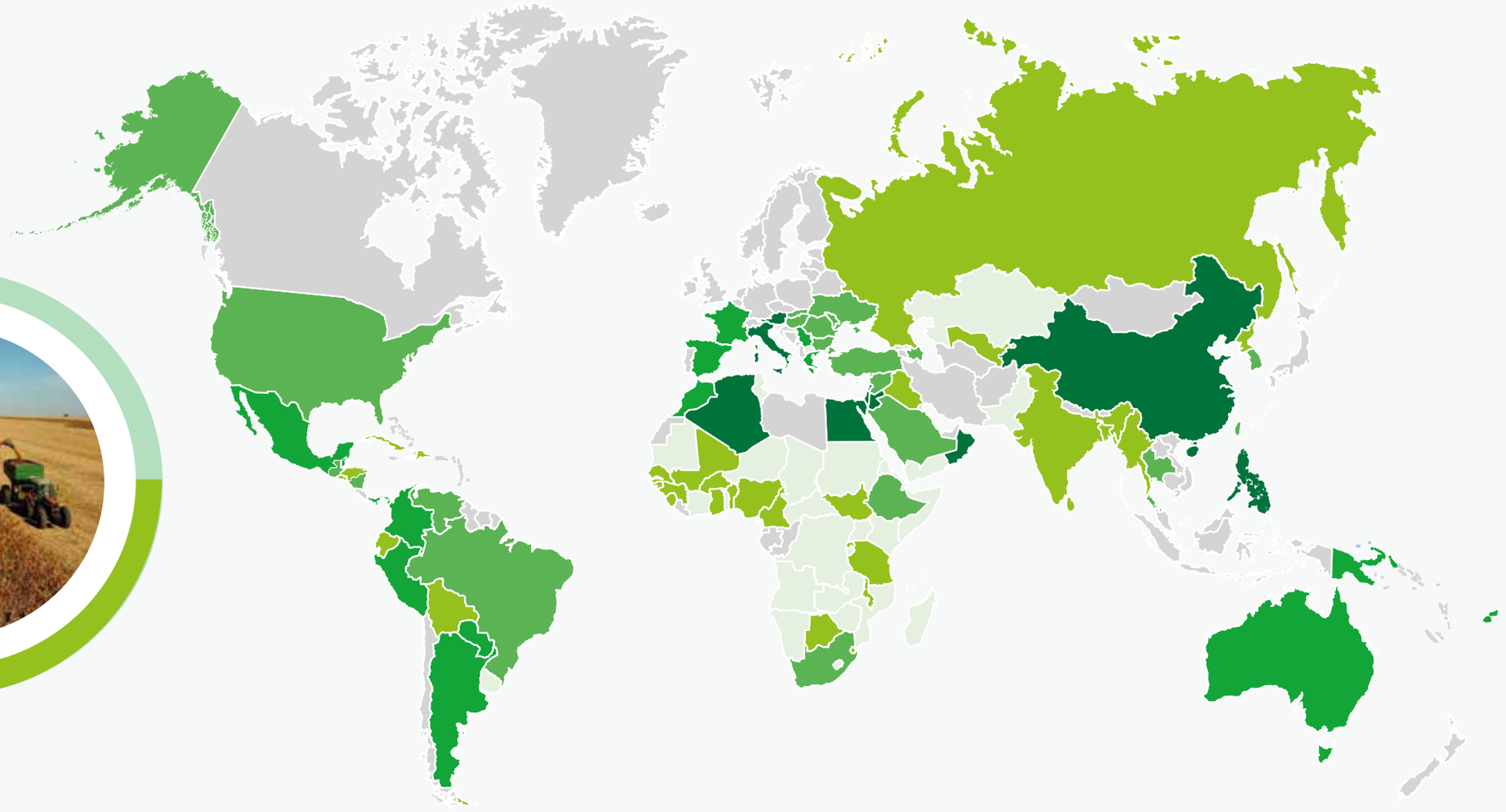
5| Australia: Sorghum is an important summer crop in Australia, particularly in the northern regions of the country. It is used primarily for stockfeed, especially for cattle, pigs, and poultry. Additionally, sorghum can be utilized in biofuel production, alcohol production, and as an ingredient in breakfast cereals.

6| Europe: European farmers are turning to sorghum for its drought tolerance and low input requirements, making it a sustainable alternative in the face of climate change and water scarcity. Western Europe France, Italy and Spain show strong adoption, Eastern Europe presents Romania. Also Ukraine, Bulgaria, Moldova and Russia are expanding rapidly. Sorghum in Europe is used for food, animal feed, and increasingly for biofuel, aligning with the continent's push for sustainable agriculture.

All these regions have different climatic conditions (temperature, rainfall, soil texture and fertility) and growing seasons (summer and winter / rainy and dry), which influence the use of varieties (open pollinated) and hybrids of sorghum that are cultivated using different and regional agricultural practices used for sorghum production.



Grain Sorghum Global Yield Estimates 2024



Data source: adapted from UN Food and Agriculture Organization (FAO).

Independent of the production region, a good crop planning roadmap is essential for successful agricultural operations, whether on a small-scale farm or a large commercial farming operation, to accomplish success.

What are the best enviromental conditions for sorghum crop?

Temperature

- 16 to 38 degrees is the best fit for the crop.
- Higher or lower temperature levels may impact in yield potential.
- Crop is sensitive to low temperatures during the night.

Water

| General sorghum crop water requirement (Dogget, 1970)

- 25 mm after sowing
- 250 mm for growth and development
- 25 – 55 mm for maturity

| Sorghum requires **less water** compared to other crops to produce 1 kg of dry matter. (Source: Aldrich et al. 1982)

- **Crop:** kg H2O/kg Dry Matter
- **Sorghum:** 271
- **Corn:** 372
- **Wheat:** 505
- **Cotton:** 562

What are the main benefits of growing shorghum?

- Higher drought tolerance
- Lower cost of production
- Great organic matter input with high C/N ratio
- Highly mechanized crop
- Good liquidity
- Lower grain mycotoxin incidence
- Lower nematode reproduction factor

Chapter **05**

Key Practices for crop success

Sorghum cultivation involves **several key activities** to ensure a successful harvest. Planting dates for sorghum vary depending on the region and climate conditions. The **timing of planting is crucial** for sorghum as it is a warm season crop that requires a certain amount of heat and water availability to grow properly. By understanding the optimal planting dates for sorghum in different regions and aligning them with the local calendar, farmers can maximize their yields and ensure a successful harvest.

Sowing

Growing

Harvesting

Sorghum crop planting, growing, and harvesting estimate calendar for different growing regions throughout the globe.

COUNTRY/ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
USA Great Plains					Sowing	Sowing	Growing	Growing	Harvesting	Harvesting		
USA South Texas		Sowing	Sowing	Growing	Growing	Harvesting	Harvesting					
MEX Tamaulipas		Sowing	Sowing	Growing	Growing	Harvesting	Harvesting					
MEX Bajio					Sowing	Sowing	Growing	Growing	Harvesting	Harvesting		
Brasil (Safrinha)		Sowing	Sowing	Growing	Growing	Harvesting	Harvesting					
Bolivia			Sowing	Sowing	Growing	Growing	Harvesting	Harvesting				
Argentina	Growing	Growing	Harvesting	Harvesting							Sowing	Sowing
Europe				Sowing	Sowing	Sowing	Growing	Growing	Harvesting	Harvesting		
South Africa	Growing	Harvesting	Harvesting							Sowing	Sowing	Growing
India Kharif *(rainy season)*						Sowing	Sowing	Growing	Growing	Harvesting	Harvesting	
India Rabi *(post-rainy season)*	Growing	Growing	Harvesting	Harvesting							Sowing	Sowing
Australia	Growing	Growing	Harvesting	Harvesting							Sowing	Sowing

What can impact sorghum yield?

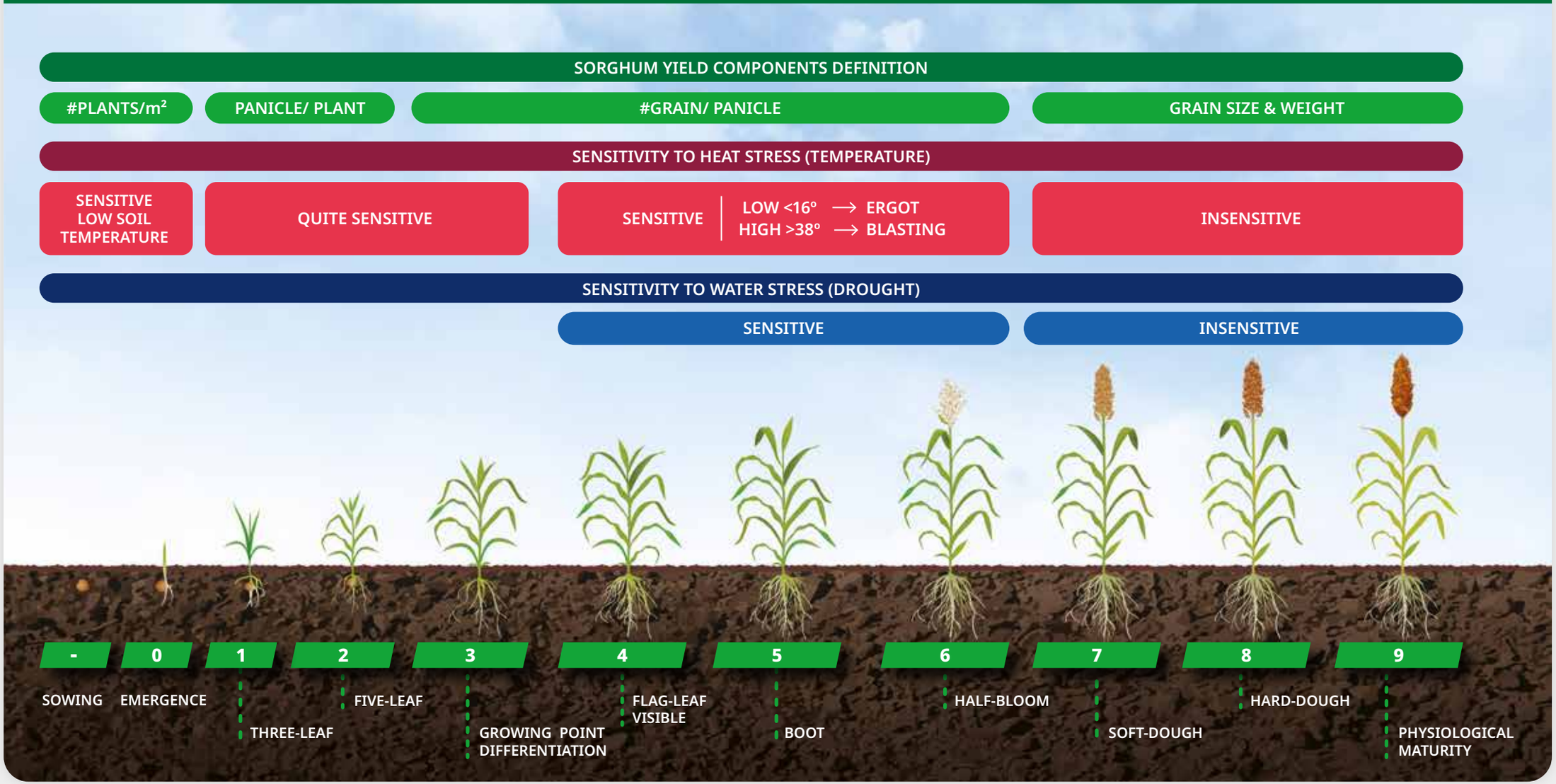
Sorghum yield components refer to the various factors that contribute to the final harvest of the crop and yield achievement.

1| These components typically include the **number of plants** per meter (stand establishment), the **number of heads** per plant, the **number of grains** per head, the **size and weight** of individual grains, contributing to the yield estimate per unit area.

2| Sorghum is known for its resilience to heat and drought stress, which are common challenges in many growing regions. However, extreme heat and prolonged drought conditions can significantly impact sorghum yield by affecting key growth processes such as growth point differentiation (vegetative vs. reproductive), photosynthesis, water uptake, nutrient absorption, flowering, pollination, and grain filling. **Heat stress** can lead to reduced grain set by affecting pollination and fertilization, blasting, lower grain weight, and overall yield losses. **Drought stress** can limit water availability, stunting plant growth and reducing the number of grains produced.

3| Low temperatures below 16 degrees during blooming can negatively impact sorghum by reducing pollen viability, seed set, and crop development, potentially prolonging exposure to environmental stresses and the damage due to incidence of ergot, a fungal disease.

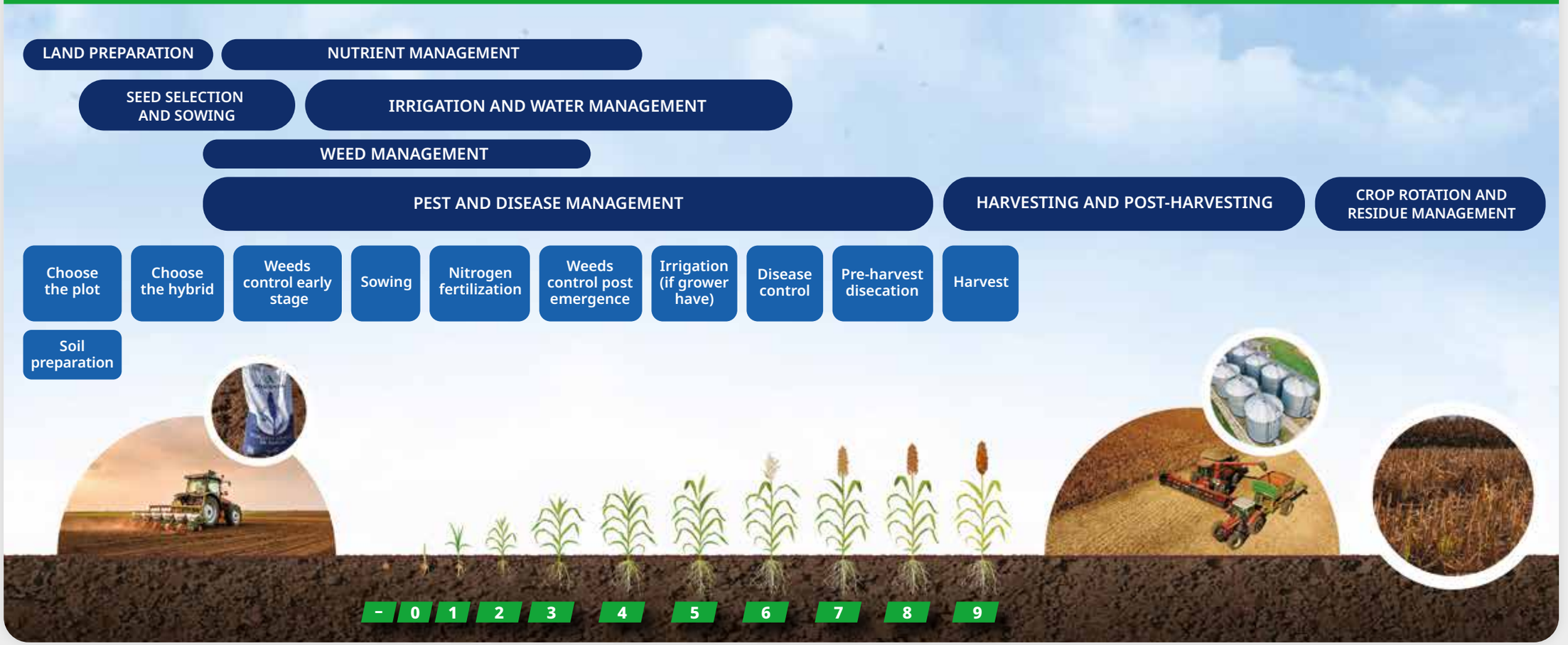
Sorghum Devolpment Stages and Critical Yield-Impacting Factors Across the Crop Cycle



Agronomic Practices and Key Cultivation Activities in Sorghum

Can we maximize sorghum potential?
The answer ir: **YES!**

To maximize sorghum potential, **it is essential to adopt comprehensive agronomic practices** at every stage of its growth cycle.



Next you will find a comprehensive table that outlines the main objectives for each activity, along with common practices and key considerations. Each section is enriched with examples and regional insights from around the world, providing a global perspective. This approach ensures that readers gain a thorough understanding of the objectives, practices, and considerations; while also appreciating the diverse ways these elements are applied in different regions. Whether you are looking to implement these activities locally or internationally, this book offers valuable guidance and practical examples to help you succeed.

	LAND PREPARATION	SEED SELECTION AND SOWING	NUTRIENT MANAGEMENT	IRRIGATION AND WATER MANAGEMENT	WEED MANAGEMENT	PEST AND DISEASE MANAGEMENT	HARVESTING AND POST-HARVEST MANAGEMENT	CROP ROTATION AND RESIDUE MANAGEMENT
OBJECTIVE	Have a good soil structure and a great seed bed for sowing.	Hybrid that best fits technology input and production target, Good planting for great stand establishment.	Supply soil nutrients based on ability of the crop to extract them from soil.	To optimize water usage and increase yields.	To suppress weeds and maximize crop yield.	Reduce Economic Losses, Enhance Crop Yield and Quality.	To maintain quality, reduce losses, and ensure food safety.	To improve soil health and increase crop productivity.
PRACTICES	Soil testing (physical and chemical analysis), Tillage or No-Tillage, Residue Management.	Seed Selection (Maturity, yield, herbicide tolerance, aphid and shoot pests tolerance, lodging), Seed Treatment (fungicide, insecticide), Sowing Time, Planting Method.	Fertilization (NPK), Split nitrogen applications (1/3 planting and 2/3 at tillering and flowering). Phosphorus and Potassium are generally applied at planting. Organic amendments as suitable.	**Water Requirements:** adequate moisture during critical growth stages (germination, flowering, and grain filling). Efficient Irrigation Practices (drip or furrow irrigation, central pivots).	Pre-Emergence Herbicides, Post-Emergence Control, Integrated Weed Management.	Monitoring for pests and diseases, Integrated Pest Management (IPM), Chemical Control for Pests and Diseases.	Harvest Timing (physiological maturity), Mechanical and Manual Harvesting, Drying, Storage.	Crop Rotation with Legumes, Residue Utilization as Mulch or Organic Matter.
KEY CONSIDERATIONS	Ensure optimal soil fertility and pH. Prepare fine seedbed with reduced erosion.	Use certified seeds. Match variety to climate. Follow optimal spacing and depth.	Base application on soil tests. Add compost or manure for sustainability.	Monitor irrigation based on crop water needs and soil moisture levels.	Control weeds early to reduce competition. Use multiple control methods.	Regular scouting, implement IPM strategies (combination of biological, cultural, mechanical, and chemical methods), and minimize chemical resistance.	Harvest at physiological maturity. Dry to 12-14% moisture before storage.	Enhance soil health and break pest cycles with rotation. Use residues effectively.

Sorghum: Purpose and Growing Methods

	LAND PREPARATION	SEED SELECTION AND SOWING	NUTRIENT MANAGEMENT	IRRIGATION AND WATER MANAGEMENT	WEED MANAGEMENT	PEST AND DISEASE MANAGEMENT	HARVESTING AND POST-HARVEST MANAGEMENT	CROP ROTATION AND RESIDUE MANAGEMENT
USA	Deep plowing and conservation tillage to retain moisture.	Use of drought-tolerant hybrids, ensure timely planting to mitigate summer drought stress	Soil testing to determine NPK needs, split applications of nitrogen.	Efficient irrigation scheduling, use of soil moisture sensors.	Use of pre emergence and post-emergence herbicides.	Use of resistant hybrids and integrated pest management (IPM) practices.	Mechanical harvesting, drying to 12-14% moisture.	Rotation with legumes to improve soil health.
BRAZIL	Minimum tillage to preserve soil structure and moisture.	Hybrids adapted to safrinha season, planted after soybeans.	Balanced fertilization based on soil tests, focus on NPK.	Rainfed crop, with shortage of rains during the evolution of the crop, with usual drought stress before or after polination.	Integrated weed management with herbicides, herbicide tolerant hybrids, active ingredients rotation.	Field scout monitoring and use of chemical and biological controls with enphasis in Integrated Pest Management.	Crop desiccation for ease of harvest and efficiency, Mechanical harvesting, storage & aeration.	Rotation with soybeans and maize, use non or minimum tillage sistems.
ARGENTINA	Minimum tillage to preserve soil structure and moisture.	High tannin hybrids used as grain, double purpose or forage hybrids.	Base the application of NPK fertilizers on soil tests.	Dryland sorghum production across summer sorghum production.	Integrated weed management with herbicides.	Monitoring and use of chemical, biological controls and IPM.	Chemical plant desiccation prior mechanical harvest at 15% moisture.	Crop rotation with legumes, utilization of residues as mulch or organic matter.
INDIA	Plowing and harrowing to prepare a fine seedbed.	Selection of high yielding varieties suitable for sowing in the matching season kharif (Rainy) / rabi (post-rainy)/ summer.	Use of organic and inorganic fertilizers, emphasis on nitrogen.	Rainfed with supplemental irrigation during dry spells.	Manual/ mechanical weeding and use of herbicides.	Seed treatment, Regular monitoring and use of chemicals and biopesticides.	Manual harvesting, sun drying, storage in dry conditions.	Rotation with pulses and oilseeds, incorporation of residues.

Sorghum: Purpose and Growing Methods

	LAND PREPARATION	SEED SELECTION AND SOWING	NUTRIENT MANAGEMENT	IRRIGATION AND WATER MANAGEMENT	WEED MANAGEMENT	PEST AND DISEASE MANAGEMENT	HARVESTING AND POST-HARVEST MANAGEMENT	CROP ROTATION AND RESIDUE MANAGEMENT
AUSTRALIA	Conservation tillage to reduce soil erosion and store water.	Use of Stress tolerant early maturing hybrids, moderate density precision planted, planting in spring.	Soil testing and targeted fertilization, NPK & Zn.	Use of deficit irrigation strategies to optimize water use.	Herbicide-tolerant varieties, Crop rotation and Crop competition.	Use of resistant varieties, crop rotation and natural bio-pesticides.	Crop desiccation for moisture conservation and harvest efficiency, Mechanical harvesting, Aeration, drying and sealed silos for grain preservation.	Rotation with winter/summer crops, cereals, Canola, Cotton and pulses , conservation tillage.
AFRICA	Minimum tillage and use of cover crops to improve soil health for large scale farmers while small scale ones prepare fine seed bed by ploughing & harrowing.	Small scale farmers use OPVs/farm saved seed while large scale ones go for improved ones including hybrids, planting at the onset of the rainy season.	Use of organic fertilizers and micro-dosing techniques to optimize nutrient use for large scale commercial farmers while small scale ones hardly use organic fertilizers.	Predominantly Rainfed agriculture with very few farmers applying supplementary irrigation in drought-prone areas.	Manual weeding and use of cover crops to suppress weeds. Pre-emergence herbicides used by large scale farmers.	Use of traditional pest control methods and IPM practices.	Manual harvesting, sun drying, and storage in traditional granaries for small scale farmers while large scale commercial ones apply Mechanical harvesting, storage in specialized silos.	Rotation with legumes and use of crop residues to improve soil fertility.
EUROPE	Ensure optimal soil fertility with moderate tillage to prepare a fine seedbed. Avoid soil compaction.	Use certified seeds suitable for European climate. Plant in late spring or early summer with optimal spacing.	Base application on soil tests. Apply balanced fertilizers with emphasis on nitrogen, phosphorus and potassium.	Monitor irrigation needs based on local climate conditions; use efficient irrigation systems like drip or sprinkler if necessary.	Implement integrated weed management using pre-emergence herbicides followed by mechanical weeding if needed.	Regular monitoring; use resistant hybrids and integrated pest management (IPM) strategies combining biological controls with minimal chemical usage.	Harvest at physiological maturity; dry grains to 12–14% moisture before storage to prevent spoilage.	Rotate sorghum with legumes or other crops like wheat or barley to improve soil health and break pest cycles; incorporate residues into the soil for organic matter improvement.

Fertilization

Fertilization is a crucial step in sorghum crop management, requiring careful consideration of the crop's macro and micronutrient needs.

What should growers consider when creating a fertilization strategy?

01 Conduct a **soil analysis**, to assess the nutrient levels in their soil and determine the appropriate investment to meet the required amounts of nitrogen, phosphorus, and potassium for their cropping system.

02 Understand local nutrient **uptake and extraction**, along with global standard fertilization recommendations.

Recommended sorghum fertilization practices based on nutrient uptake and extraction through to grain harvest

NUTRIENT	UPTAKE (kg/ton)	EXTRACTION (kg/ton)	GLOBAL STANDARD FERTILIZATION STRATEGY
NITROGEN (N)	30,00	0,15	Apply 100-150 kg/ha, split applications recommended to match crop uptake during rapid growth stages.
PHOSPHORUS (P_2O_5)	4,50	0,03	Apply 30-50 kg/ha, with placement near the seed to enhance early growth.
POTASSIUM (K_2O)	16,30	0,03	Apply 80-120 kg/ha, ensuring adequate levels to support stalk strength and reduce lodging.
SULFUR (S)	5,20	1,30	Apply 10-20 kg/ha, especially in soils with low organic matter.
ZINC (Zn)	0,024	0,018	Apply 1-2 kg/ha, particularly in high pH soils or where deficiencies are known.

Fun facts about nutrients and their importance for sorghum:

P_2O_5 **Phosphorus (P_2O_5):** Phosphorus is essential for root development and early plant growth. Placement near the seed can enhance uptake and early vigor.

K_2O **Potassium (K_2O):** Potassium supports overall plant health, including stalk strength and resistance to lodging. Adequate potassium levels are vital for high-yielding crops.

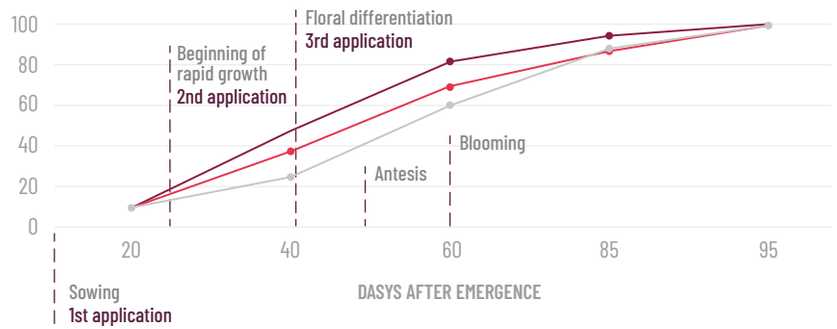
S **Sulfur (S):** Sulfur is important for protein synthesis and enzyme function. It is particularly needed in soils with low organic matter.

Zn **Zinc (Zn):** Zinc is a critical micronutrient for enzyme activation and growth regulation. It is especially important in high pH soils where zinc availability is reduced.

N **Nitrogen (N):** Nitrogen is crucial for sorghum, especially during the vegetative growth phase. Split applications are recommended to ensure availability during critical growth periods.

Additionally, proper timing and application of NPK fertilizers can significantly influence sorghum yield and quality. The graph below highlights the typical NPK absorption rates during key growth phases, helping growers make informed decisions to enhance crop performance and achieve optimal yields.

Nutrient intake (% of total)



NPK absorption by sorghum. The 1st, 2nd, and 3rd applications refer to the periods typically recommended for fertilizer application (adapted from Tisdale et al., 1985).

Potas sium — Nitrogen — Phosforus —

Chapter **07**

Pest management

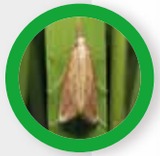
aphix® APHID TOLERANCE

Pest pressure in sorghum: a growing threat to global yields

Sorghum crops are susceptible to numerous pests, making it crucial to understand when these pests attack, how to identify them, and the economic damage thresholds for effective control. Identifying these pests early is essential to prevent significant yield losses. To achieve this, you must know the usual timing of pest attacks and where to scout and monitor. Additionally, understanding the economic damage threshold is necessary to implement control measures effectively and avoid economic losses.

What are the main global pests affecting sorghum?

01 | Shoot Fly *(Atherigona soccata):* This pest is particularly damaging to young sorghum plants, causing deadheart symptoms which can severely reduce yields.



02 | Stem Borer *(Chilo partellus and Sesamia inferens):* These pests bore into the stems, disrupting nutrient flow and weakening the plant structure.

03 | Stalk Borer *(Diatraea saccharalis):* The borer grows within the plant stems, making it difficult to detect and control.

04 | Fall Armyworm *(Spodoptera frugiperda):* It can cause significant damage to leaves, stems, and reproductive parts of the plant, leading to reduced yields.

05 | Aphids *(Melanaphis sacchari and Rhopalosiphum maidis):* Aphids suck sap from the plants, leading to reduced vigor and potential transmission of viral diseases.

06 | Sorghum Midge *(Stenodiplosis sorghicola):* This pest lays eggs in the flowering heads, causing grain loss and poor seed set.

It is important for growers to learn how to identify the most significant pests affecting their crops and how to conduct monitoring activities to assess economic damage thresholds for effective control. Control methods can vary from country to country, so it is essential to seek the guidance of experts, such as agronomists, who can support insect resistance management practices. Modern control methods include both chemical and biological tools to ensure sustainable production.

aphix®
APHID TOLERANCE

aphix® | Provides tolerance to sorghum aphids reducing the yield losses and optimizing the chemical insecticide use.

Effective aphid management solution for farmers:
aphix® technology provides sorghum hybrids with high, measurable tolerance to Yellow Sugarcane Aphids (*Melanaphis sacchari* Zehntner,1897) & Sorghum Aphids (*Melanaphis sorghi* Theobald, 1904). This minimizes yield losses and optimizes insecticide use, delivering a sustainable and profitable solution for sorghum production. Growers get bigger returns on their investment and the environment is taken care of simultaneously.

aphix®, the very best tool to prevent Aphid's Damage:
Developed at Advanta's Biotechnology Center at Texas A&M University, **aphix®** is Advanta Seeds' latest technology in sorghum hybrids, **aphix®** confers tolerance to elite sugarcane aphid and protects grain and forage sorghum crops anywhere aphids' strike. It is a sustainable solution to ensure healthy sorghum cultivation.

The USDA standards have defined the aphix labelling trait as delivering a superior performance and the highest level of sorghum aphid tolerance. It works as an outstanding alternative to chemical insecticides as it assists better and more profitable farming and preserves the environment as well.

aphix® sorghum hybrids have a better rate of sorghum aphid tolerance compared to non-aphix hybrids. In a season with favorable environmental conditions, where the sorghum aphid attack pressure is high, a single preventive insecticide spraying is enough to keep the crops free of aphids, while in a non-aphix crop an average of 3 to 4 sprayings might be necessary.

Sow safely, sow aphix®

Integrated management for controlling yellow Sugarcane Aphids *(Melanaphis sacchari Zehntner,1897)* & Sorghum Aphids *(Melanaphis sorghi Theobald, 1904)*

Advanta has had a research and development program in sorghum cultivation for more than 60 years.

Today, this trust and commitment to the crop allows us to continue advancing with the arrival of **aphix®** technology for the integrated management of sorghum aphids.

Hybrids with this new technology exhibit maximum tolerance to the yellow aphid, minimizing the risk of losses and protecting the yield potential that characterizes our Advanta sorghums. This is possible because the reproduction rate of the yellow aphid in **aphix®** sorghum is lower than in conventional sorghums.

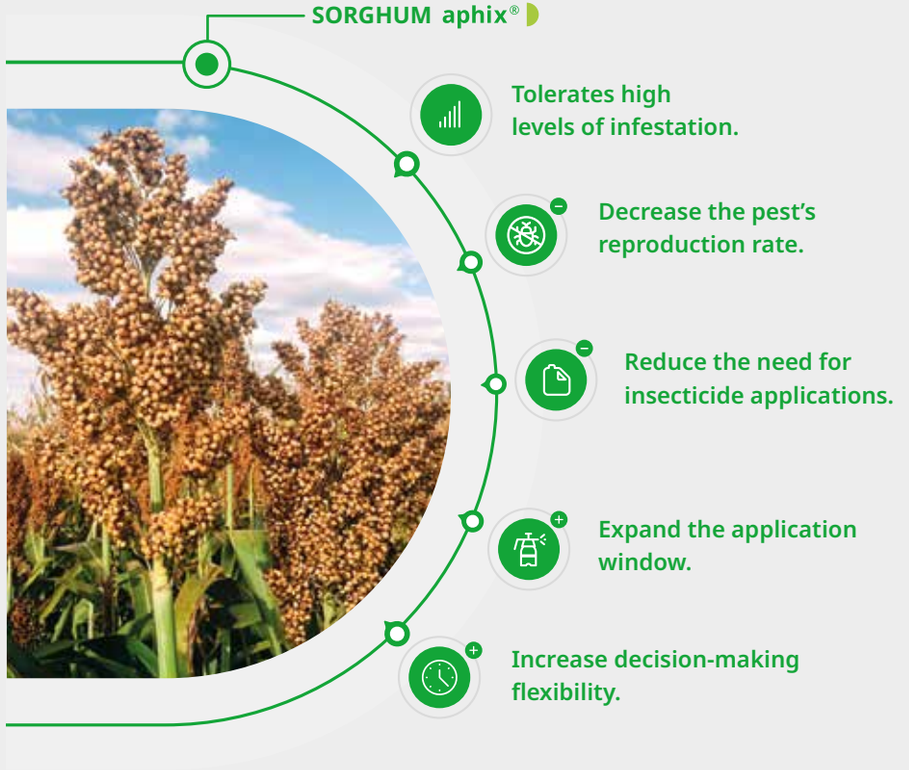
This greatly expands the application window and reduces the use of insecticides. Consequently, it gives us more time to make the right decision.

The three key drivers of its effectiveness:

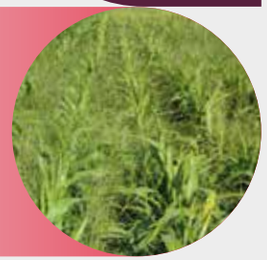
01 Molecular marker assisted selection.

02 Performance in endemic regions of the plague.

03 Tolerance assessment carried out by third parties.



Weed management



Sorghum crops are susceptible to competition by weeds for water and nutrients, making it crucial to understand when these weeds emerge, how to identify and control them to prevent significant yield losses. Control can be made with mechanical weeding, chemical spraying in pre or post emergency stages with selective products or utilizing herbicide tolerant hybrids.

Weed management

Competition between crops and weeds occurs for resources, often limited by the need for nutrients, water, light, and space. The so-called “critical competition period” is the period during crop development when weeds cause the most damage, and control during this period is vitally important. In the case of all biotypes of sorghum, it is essential to ensure a weed-free field from planting through the early stages of growth and development.

1. What is igrowth® ?

igrowth® is a sorghum herbicide-tolerance technology developed by Advanta Seeds in Argentina. It was created through mutagenesis methods and is classified as a non-transgenic (non-GMO) technology.

This technology provides sorghum with **tolerance to imidazolinone herbicides.** Growers can safely apply herbicides registered for use with **igrowth®** sorghum at recommended rates, without causing harm to the crop. Applying these herbicides to sorghum varieties without **igrowth®** technology may result in severe damage or irreversible injury, including crop death.

2. What is the benefit in the lot?

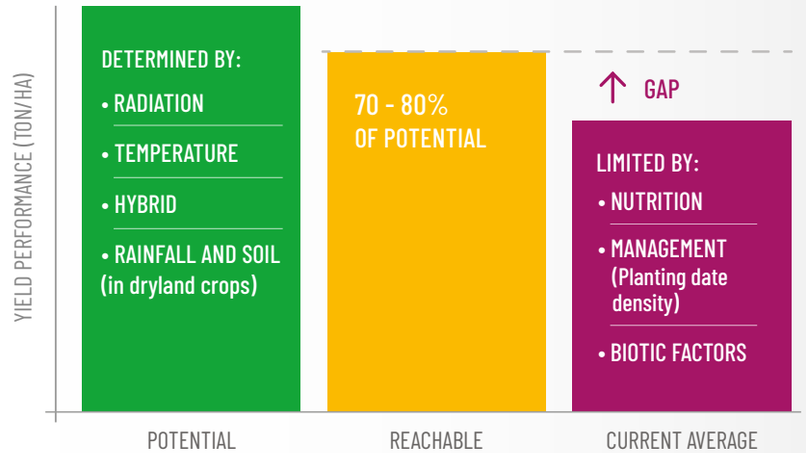
Hybrids with **igrowth®** technology aim to close the sorghum yield gap.

To fully understand the potential of this innovation, it's essential to explore the three pillars of production that support its performance.

Maximum potential: yield that a crop could achieve without any limitations.

Potential yield in dry land: where the main limitation is water availability and is influenced by a combination of factors, including solar radiation, temperature, genotype, sowing date, plant density, and soil characteristics.

Current yield: refers to the national average achieved by growers, often limited by several constraints such as suboptimal genetics, nutrient deficiencies, insect pressure, weed competition, and disease incidence.



3. How does igrowth® contribute to narrowing the sorghum yield gap?

Facilitates weed control → **Less competition for nutrients** → **Greater performance**

It also provides...

- Greater flexibility in herbicide application.
- Lesser use of herbicides.
- Enables cleaner fields.
- Ease of harvest in weed-free fields.
- Improves rotation with following crop.

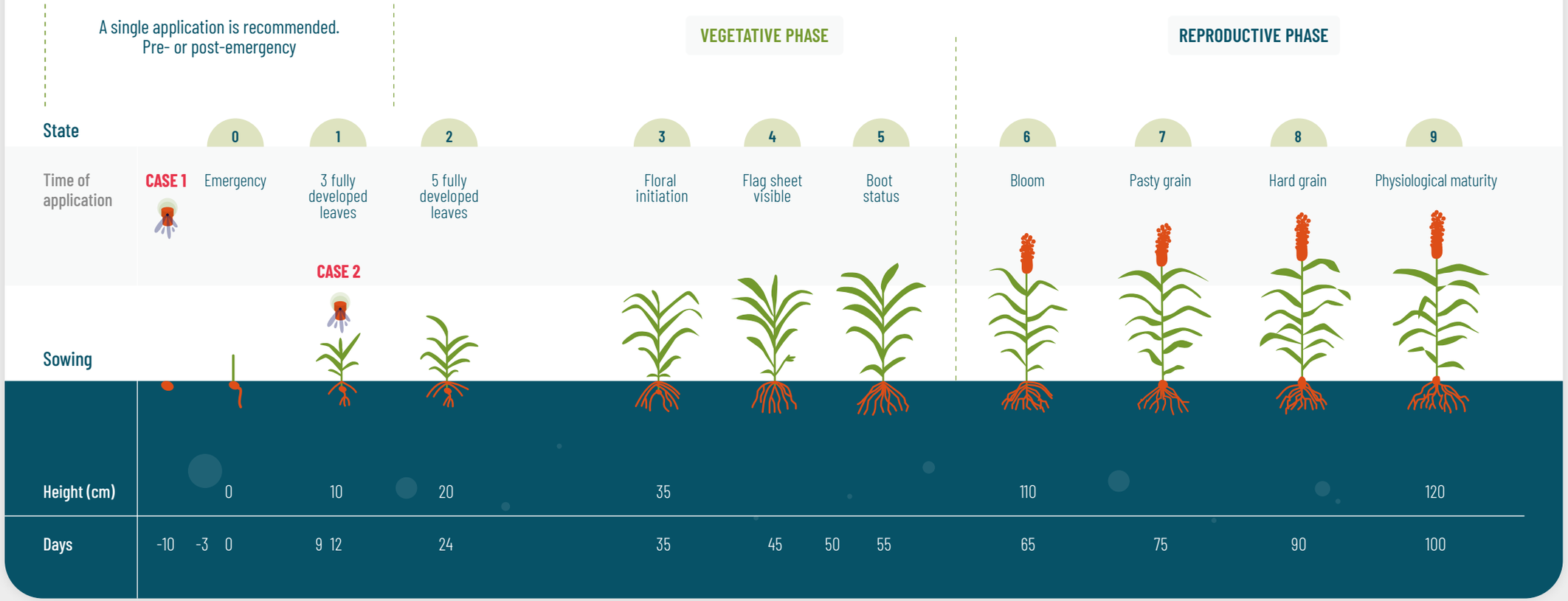
Herbicides use for weed control

The igrowth® technology gives sorghum tolerance to the imidazolinone family of herbicides in pre-emergence as well as early post-emergence crop situations. To obtain good output of sorghum with effective management of weeds, it is important to consult your local agronomist to evaluate for the presence of weeds, identify the species, level of infestation and their phenological stages. Growers should evaluate fields and use agronomic practices suitable for each situation, always monitoring weeds in the decision-making process. Always use those herbicides legally registered by local regulatory authorities for use on sorghum seeds and/or sorghum seed containing **igrowth®** technology.

To effectively use this technology and delay the proliferation of resistant weeds, the combination of imidazolinone active ingredients with atrazine is recommended. The different modes of action from the additional herbicides such as atrazine provide more effective control of grass and broadleaf weeds that could not be controlled with imidazolinone herbicides in isolation/alone.

General pre or post emergence herbicide application

Depending on the weed control strategy and the crop growth stage, two distinct approaches can be identified for herbicide application in igrowth sorghum.



Above you can see the general recommendation for pre or post spray of the imidazolinone herbicides in igrowth sorghum.This use must follow registered chemical label recommendations that may vary for each country.

CASE 1 | Spray as Pre-Emergence application

Spray in pre-planting (spray and plant) or post-planting of sorghum (plant and spray) considering the pre-emergence of weeds, both in no-till and conventional planting.

In case of the presence of weeds that emerged on the planting day, **it is recommended to burndown the area with an herbicide recommended by your agronomist** or consultant, based on the species present and possible herbicide resistance.

CASE 2 | Spray on Weeds POST-Emergence application

Spray after the emergence of sorghum and weeds, considering the application period between 2 to 4 fully developed leaves of most weeds.

CASE 3 | Utilizing igrowth® in Imidazolinone chemical residue areas

Cultivate **igrowth®** sorghum as a subsequent crop in areas previously planted with imidazolinone-tolerant species —such as wheat, sunflower, canola, lentils, or corn (when available in the market)— that may still contain residual herbicide activity in the soil.

This practice is especially recommended in fields where imidazolinone residues could pose a risk to non-tolerant crops, ensuring crop safety and maintaining rotation flexibility.

Additional information

In the igrowth sorghum crop, we recommend the application of registered herbicides from the imidazolinone family in pre-emergence or early post-emergence of the crop and weeds up to the phenological stage of 2 to 4 tillers, performing only one spray per crop cycle.

Advanta recommends the use of atrazine in sorghum only in countries where its use is permitted. Further, in soils with high sand content and less than 1% organic matter, the use of atrazine is not recommended for sorghum.

Volunteer control & crop rotation

Volunteer sorghum plants with imidazolinone tolerance may pose challenges for future crops cultivation, especially those that are not herbicide-tolerant.

To effectively manage and control volunteer **igrowth®** sorghum plants, the following active ingredients (AIs) can be used:

- **Clethodim:** A selective, systemic herbicide effective for post-emergence control of annual and perennial grasses.
- **Glufosinate:** Another non-selective herbicide that can be used to manage volunteer sorghum plants.
- **Glyphosate:** A non-selective, systemic herbicide widely used for controlling a broad spectrum of weeds, including volunteer sorghum.
- **Quizalofop:** A selective herbicide effective against grassy weeds, including volunteer sorghum.

It is recommended that herbicides be used with careful consideration and only after receiving proper guidance from a local authorized agronomist or crop consultant.

Recommendations should take into account the crop rotation plan and the specific requirements of the subsequent crop, to ensure safe and effective application.

Imidazolinone herbicide crop restrictions

Imidazolinone-tolerant crop hybrids were developed to facilitate weed control using various approved and registered active ingredients, which may differ in dosage and residual effects on the soil. The planting of subsequent crops must follow the minimum re-cropping intervals to avoid any type of crop injury caused by susceptibility to residual chemical effects in the soil.

Between the application and the planting of the subsequent crop not tolerant to imidazolinones, at least **300mm** of rainfall must accumulate or **120 days** must pass until more information is available.

To avoid potential damage to subsequent crops, it is essential to observe the waiting periods specified on product labels or recommended by the chemical provider after applying imidazolinone active ingredients. Conducting a test planting is recommended in all situations.

DO NOT apply imidazolinone group herbicides more than once on the same field within a single season, unless explicitly stated on the product label.

If you have any questions or concerns, please consult an Advanta Seeds representative and refer to the registered chemical label for detailed guidance.

Responsible management of herbicide tolerant crops

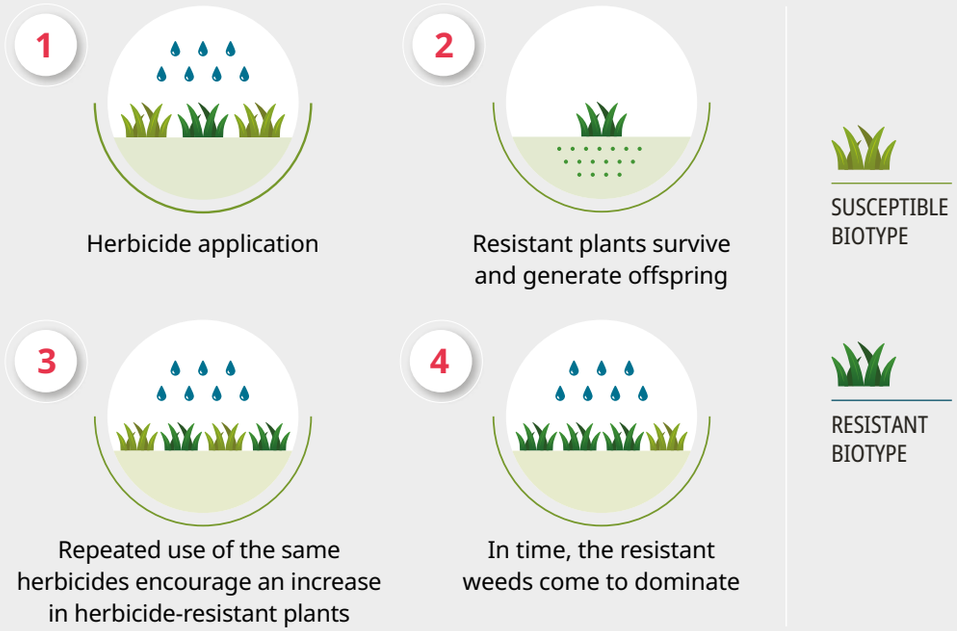
Proper management of herbicide-tolerant crops is essential to preserve the long-term effectiveness and value of these technologies. To reduce the pressure of weed resistance, several agronomic practices are recommended. The following strategies can help delay the development of herbicide resistance:

Avoid the exclusive and repeated use of herbicides from the same herbicide group code.

Alternate or tank mix with products from different herbicide group codes.

Integrate chemical and cultural control methods into weed control programs.

How do herbicide resistant weeds develop?



Best agronomic practices:

Start clean – utilize a burndown herbicide at planting.

Maintain the use of pre-emergent herbicides.

The use of a certain herbicide-resistant crops does not limit the grower to using only that herbicide. Conventional herbicides registered for cultivation can and should remain part of the overall weed management system.

Limit the number of applications of the same herbicide, or herbicides in the same mode of action, in a single campaign.

Apply the dose rates indicated on the label and at the recommended stages on the product label.

Use sequential mixtures or treatments by effectively alternating modes of action to control target weeds.

Always use those herbicides legally registered for use with sorghum seeds and/or sorghum seed containing **igrowth®** technology.

Control of igrowth® sorghum volunteer plants on a subsequent crop must be done with other herbicides, rather than imidazolinone mode of action (ALS inhibitors).

After spraying herbicides, assess the quality of field coverage to detect possible failures of control.

If a potential resistant weed or resistant weed population is found, use another available control method to prevent its spread in the field, that could also be non-chemical options.

It is important to note the residual period of the herbicide in the soil for scheduling subsequent crop planting. Pay attention to crops that may be susceptible to imidazolinone family herbicides.

The use of chemical products must be recommended by an agronomist duly qualified, as well as prescribed by agronomic prescription. These chemicals must be used for agricultural use only.

Crop Rotation: Avoid continuous cropping of **igrowth®** sorghum on the same field or any other IMI herbicides family tolerant crop for volunteer control and active ingredient weed control rotation.

Rotate to another crop that will use alternate herbicide mode of action for weed management and control.

Resistance warning:

Imidazolinones are herbicides classified under Group B. Weed populations may include individuals that are naturally resistant to Group B herbicides. **If an imidazolinone treatment fails to control the target weeds, do not reapply herbicides from the same chemical group.** Repeated use of these herbicides can lead to the dominance of resistant weeds within the population. Such resistant weeds must be controled by other control method.

ADVANTA

Learn more about our
sorghum business:

SUSTAINABLE DEVELOPMENT GOALS

Advanta Seeds supports the United Nations Sustainable Development Goals (SDGs).

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