

Guidelines for Good Agricultural Practices

Embrapa's input to FAO's Priority Area of Interdisciplinary Action on Integrated Production Systems

Organizers

Maria Leonor Lopes Assad , Unb / Embrapa Meio Ambiente (coordinator)

Andrew Speedy, FAO-AGA

Boyd Haight, FAO-AG

Eric Kueneman, FAO-AGPC

Fernando Antônio Araujo Campos, Embrapa-DPD

Jamil Macedo, Embrapa-SCI

Juan Izquierdo, FAO-RLC

Márcio Carvalho Marques Porto, Embrapa-SCI

Sebastião Barbosa, Embrapa-SCI

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Viale delle Terme di Caracalla, 00100 Rome, Italy
www.fao.org

Brazilian Agricultural Research Corporation – Embrapa

Parque Estação Biológica – Pq EB
Final Av. W3 Norte
70770-901 Brasília DF, Brazil
www.embrapa.br

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Technical Reviewer

Maria Leonor Lopes Assad

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Foreword

Since the beginning, agriculture has been quite a dynamic process in order to meet the need for more and better food and shelter of an increasing population. Either by clearing new land or by developing improved production technology, mankind succeeded to survive quite well and famine due to lack of food on a global basis has been rather rare.

Over the second half of last century, some technologies caused non-acceptable effects on the environment and the quality of food began to be questioned by consumers on its integrity and possible side effects on human health due to various chemical and organic residues. The degree of environmental degradation present nowadays in rural areas and the non-observance of well-established labor rights may justify a crescent worry that agriculture is no longer safe or socially and environmentally correct.

The adoption of Good Agricultural Practices (GAP) is an attempt to rescue agriculture from its present situation, making it benign to the environment, assuring the supply of better quality products more acceptable to consumers and improving the lot of people who depend on agriculture for their survival and well-being. Practices like Integrated Pest Management (IPM), minimum or no-tillage and many others which reduce the impact of agriculture on human health and the environment are much welcome but their incorporation into most production systems will still require much effort.

FAO places much importance on GAP and believes its implementation worldwide will eliminate most undesirable side effects of the agricultural activities. FAO and Embrapa are well known for their efforts and successes to make agriculture more sustainable, competitive and environmentally safer by incorporating many good agricultural practices in the production systems of various farm products. These guidelines are a joint effort between FAO and Embrapa to consolidate GAP in Brazil and, possibly, to offer the experience to other countries where food security and the national economies depend on agriculture.

Boyd Haight

Márcio Carvalho Marques Porto

Executive Summary

Most of the food consumed by the great majority of the Brazilian population is still acquired in its raw form. Therefore its quality is directly related to different degrees of chemical and biological contamination occurred during the production phase. In cases where transformation takes place, industry faces difficulties to guarantee high quality food standards due to contamination of the raw materials before they leave the farm gate. Most important food contaminants are usually pesticide residues and biological and/or chemical pollutants present in improper irrigation and/or cleansing water. Although most contamination takes place in the production process, it may also happen during harvesting, transportation, drying and storage.

Good Agricultural Practices (GAP) is a set of principles to make agriculture less dependent on chemicals, less aggressive to the environment and more socially conscious, therefore, more sustainable. The Food and Agriculture Organization of the United Nations (FAO) and the Brazilian Agricultural Research Corporation (Embrapa) have joined efforts to develop a set of guidelines on GAP for crops and animal production systems. These guidelines will be tested under Brazilian conditions and possibly adapted to the conditions of other FAO member countries worldwide.

The preparation of the guidelines herein presented took into consideration the realities of the Brazilian agriculture in its most diverse ecological and socioeconomic aspects; therefore, they are broad enough to accommodate from low to high income agriculture; from arid to humid zones and from subtropical to tropical agroecosystems. As guidelines they should not be seen as rules and much less as controlling devices but, rather, as a general frame where different scenarios can be seen in their peculiarities. Whatever the case, GAP should prevail.

In a first attempt, GAPs guidelines were developed for vegetables, maize, soybeans, mangoes, melons, beef, milk, swine and broiler production. Their selection was based on ready available technologies within Embrapa's research centers and on interests expressed by FAO.

The guidelines are holistic as they cover aspects from soil selection/conservation to the use of agrochemicals within the Integrated Pest Management (IPM) and Integrated Plant Nutrition Management (INPM) paradigm and other pre/post harvest activities, but also consider economic, social and environmental aspects of the Brazilian agribusiness. As much as possible, the GAP reflect the most usual production systems but there were cases where they were very general (vegetables) or very specific (beef).



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Broiler production



Author: *Cláudio Bellaver, Embrapa Suínos e Aves, Concórdia, SC.*
bellaver@cnpsa.embrapa.br

Co-authors: *Elsio Antônio Pereira de Figueiredo, Embrapa Suínos e Aves, Concórdia, SC.*
elsio@cnpsa.embrapa.br

Júlio César Pascole Palhares, Embrapa Suínos e Aves, Concórdia, SC.
palhares@cnpsa.embrapa.br

Laurimar Fiorentin, Embrapa Suínos e Aves, Concórdia, SC.
laurimar@cnpsa.embrapa.br

Paulo Giovanni de Abreu, Embrapa Suínos e Aves, Concórdia, SC.
pabreu@cnpsa.embrapa.br

Valdir Silveira de Ávila, Embrapa Suínos e Aves, Concórdia, SC.
vavila@cnpsa.embrapa.br

Carlos Alberto Fagonde Costa, Embrapa Suínos e Aves, Concórdia, SC.
ccosta@cnpsa.embrapa.br

Fátima Jaenisch, Embrapa Suínos e Aves, Concórdia, SC.
fatima@cnpsa.embrapa.br

Paulo Antônio Rabenschlag de Brum, Embrapa Suínos e Aves, Concórdia, SC.
pbrum@cnpsa.embrapa.br

Introduction

Good Agricultural Practices (GAPs) for broilers are rules to be followed by producers in order to adjust profitability of the operation with other non-tangible factors such as environment, food safety, social aspects and animal welfare. The use of these GAPs is important to all broiler producers, since the sector of poultry meat is growing more than other species and the consumption of this meat has increased in the last decade. The objective is to improve quality and maintain the global competitiveness of producers. The essential aspects in broiler production are described in this document. The focus is the application of productive and sustainable technologies, which could lead to an improvement of quality in the production of broilers.

GAPs should attend government directives, such as the socio-economical and environmental improvement and food safety conditions.

The inclusion of the GAPs for broilers in production systems contributes to the productive efficacy, increases employment and helps to obtain a safe, healthy and sustainable product. The producer who follows the GAPs can be sure that legal conflicts are reduced to a minimum and that a higher quality of the broiler meat is achieved. The improvement of broiler production systems is unequivocal in Brazil, since it has reached levels of production comparable to the most developed nations in this sector. By year, 3.6 billion of one-day chicks are produced, generating around 7 million metric tons of broiler meat. From this amount, 5.7 million tons stay within the domestic market and 1.3 million tons are exported. Broilers represent 9% of the agricultural gross national product, which will be around US\$ 100 billion in 2002. These figures are obtained because it is known that the limit of broiler growth and its quality is related to factors like health, biosecurity programs, water supply and consumption, ventilation, temperature, moisture and light, bird density, feed intake,

phase feeding, seasons, sex and genetic lines, as well as management. The increase in consumption is due to the improvement of meat quality and the low cost of the production of broilers.

In all systems, broilers must receive protection and comfort, plenty of fresh and enough water, freedom to move and exercise with other birds, lights to inspect and illuminate at any moment, avoid extreme temperatures, gases and moisture, maintain a quick diagnosis and prevention of vices, parasites, injuries and shortage of supplies.

Broiler's meat is nutritious and all efforts must be made in the production systems to avoid improper usage of agrochemicals and drugs. Growth promoters are not condemned, but must be used prudently, according to specific rules from the Ministry of Agriculture, Livestock and Supply. Avoiding microbial contamination of meat is another important issue, since diseases caused by food are still present in many communities.

The reduction of the rural population is a common phenomenon in most of the developing countries. Brazil maintains a relatively large population on the farms (around 20%) and poultry production, in general, can contribute to maintain the producers in rural areas. Excessive automation, as verified in other sectors, is not recommended to broiler production, since there are around 700 thousand of direct jobs in this field. By all means, the government and sector partners should conduct politics to maintain this population in the rural area. Labor laws are essential in order to warrant proper wages and children work is allowed only according to the law and if accompanied by part time into the elementary and/or secondary school.

The GAPs here recommended consider a conventional production system adopted in Brazil, with the usage of advanced technologies. The GAPs presuppose respect to the environmental and labor legislation as well as to the Children and Adolescent Statute, and the ethical principle of equal pay for all types of rural labor.

Planning

Environment

A good poultry production depends on the environment where it takes place. Feed and water must be of good quality in broiler production. The wastes must be well managed and used in other agricultural sectors.

- Manage and monitor an environmental plan characterizing the severity and probability of environmental risks due to the project implementation.
- Respect the Federal Forestry Code/ Reference Document 12.1, Environmental Legislation and State Sanitary Code, especially about the minimum regulatory distances between buildings, roads, houses, property limits, water fountains when locating new poultry houses.
- Warrant the execution of the activities according to the region, respecting its environmental capacities, so that environmental problems (soil, water, plants and human beings) are avoided during the development of the activities.
- Consider the availability of natural resources of the land and of the watershed.
- Present the project to the environmental authorities for licensing and authorization before the installation and operation of the system.

The present focus in animal production systems is on the use of sustainable technologies in addition to the technical and economical considerations.

Environmental Management

It is not only important to establish rules that consider the environment in a new unit of production but also to provide information that can

help in the management of already installed production systems. In any case, the biggest concern is to protect water sources from pollution and dispose appropriately of wastes.

- Calculate the management of the residues, using them conveniently and adequately in other agricultural sectors.
- Follow the norms and recommendations to minimize the environmental impacts.
- Avoid the contamination and transport of organisms and residues (poultry litter and dead birds), which are harmful to human beings.
- Extract water for poultry production only from sustainable fountains, preferentially from deep sources.
- Protect water springs from polluting discharges and from the access of people and animals.
- Obtain a formal license for using water in poultry production.
- Store and treat the residues in appropriate installations for this type of material observing the legal principles and to nullifying the risks of environmental contamination and eventual accidents.
- Use the poultry litter as fertilizer in crops, respecting the needs of the soil (Document 12.12), maintaining proper distances from the poultry house.
- Collect and dispose wastes separating the organic from the inorganic and from the veterinary garbage in containers especially defined for it.
- Consider the environmental risk when disposing residuals in the soil, based on the previous use and the application of fertilizers the soil characteristics, the type of crop and the impact of cultivating adjacent areas (including from a third parties).
- Take notes on the frequency, amount and time of application of the residues in the soil.
- Optimize the forms of transportation and application of the residuals on the soil to avoid nutrient loss due to superficial scouring and percolation.

- Choose compatible material for poultry litter with availability and fertilizer value.
- Remove the dead birds daily from the buildings and destine them to the composting chamber or to incineration (Document 12.10).
- Use an emergency composting system (in line) or incineration, whenever there is a massive mortality.
- The washing water of the pesticide recipients should be used in the last application of the respective product.
- Collect and tear the plastic recipients avoid other uses, store the empty medicine and pesticides recipients in an appropriate manner, in secure containers with lid.
- Identify the collection places in the region to dispose the recipients for recycling.

Technical project

Develop a complete technical project, defining production goals, production flow, installations facilities and equipment layout, descriptive recommendations of husbandry, budgeted and schedule of execution and absorption of the production by the market.

Location of buildings

- Chose the area to locate the poultry house according to the project requirements.
- Maximize the natural ventilation, reduce the sun radiation, and facilitate the flow of people, animals and feed.
- Install the poultry house in a level area or with a light slope.
- Construct the poultry house with its major axis oriented in the East-West direction.
- Reserve enough space for possible enlargement of the poultry house.
- Plant trees that do not produce fruits in the North and West sides of the poultry houses.
- In temperate climate regions, plant trees that shed their leaves in the fall, and prune their lower branches, preserving the superior arms.
- In warm regions, the trees may shed their leaves or not.
- Allow enough space between the buildings to facilitate natural ventilation.
- Install the poultry houses isolated from other surroundings by thick vegetation lines.
- Assure easy access to the poultry houses with good traffic conditions in all seasons of the year.

The poultry house

This is the place where the chicks are raised. Material for construction, dimensions of the building, environment and other aspects are described below.

- Foundations and the structural should be designed by a specialized firm.
- Before construction, run a soil test to calculate correctly the foundations.
- Execute foundations in concrete at the appropriated depth to support the charges from the columns, roof, wind and from other sources of pressure on the foundations.
- Use minimum wall height of three meters.
- The minimum slope of the roof should be 33%.
- The brick wall at the sides should be 30 cm height, with the top end sloped to avoid that birds stand on and to facilitate cleaning.
- Use anti-bird wire mesh in the sides from the brick wall to the roof.
- Install a shallow pit to disinfect shoes at the poultry house entrance.
- Calculate the dimensions of the building according to the expected production (kilogram/m²).
- Use concrete, metal or a wooden pre-built structure taking into account the required charges and pressure from the roof.
- Use aluminum or brick tiles.
- Use wood, fiberglass, metal, isobar or brick for the walls at the ends of the poultry house.
- In hot climates (without prevailing south winds) use mash wire with curtains on the side and end walls.
- Raise the walls up to the ceiling at of the ends of the poultry houses.
- Protect the walls at both ends by painting then walls with light colors and by providing shade from vegetation, house eaves and light reducing nets.

- Install doors (2.10 X 1.50 m) at the ends to facilitate the flow of people and management practices.

Equipment

There is a variety of important equipment for broiler production in the market and it is necessary to consider the information furnished by different industries to make choices. As the birds are very sensitive to temperature, the equipment for adjustment of environmental temperature is essential, especially if different stocking densities are proposed.

- For open sided houses, install external, curtains in both sides of the poultry houses.
- Install drinkers, feeders, heaters and ventilators.
- Use curtains of special mash reinforced plastic, canvas or PVC.
- Fasten the curtains at half way of the sidewall (at 15 cm height) covering all the height of the sidewall, providing total isolation of winds.
- Use pressure drinkers, bell drinkers or automatic nipple drinkers (according to manufacturer recommendation).
- Use tray feeders, tube feeders or automatic feeders (according to manufacturer recommendation).
- Install wood, electric or gas heaters (according to manufacturer recommendation).
- Use preferentially infrared gas heaters with automatic temperature control devices.
- Install ventilation systems with or without automatic temperature control device by using ventilators of 300 m³/min (1/2 HP) – placed transversally to blow in the direction of the major axis of the building at half way from the top of the side wall, slightly inclined –, or exhausters of 600 m³/min (1/2 HP) – installed in the West End of the house with the air inlet at the opposite end.

- Sprinkle water over the roof across the longitudinal axis to reduce internal temperature.
- Install a refrigeration system by evaporative plates or misting pump.
- Adopt, preferentially, high pressure misting systems, with a pump with an appropriate nozzles distributed in transversal and longitudinal lines.
- Install, if possible, a double filter in the misting system to protect the system.
- Install wet bulb thermometers in different points inside the poultry house.

Electric installation

- Execute the electric installation according to the norms EB-3 and NB-57 (ABNT) and according to the requirements of the regional supplier of energy.
- Install boxes for the switches, distributors and electric outlets at 1.5 m from the floor.
- Mount all the automatic control devices in a protected box for energy distribution.
- Install the controls in an integrated manner allowing independent operation.
- The light points in the ceiling could be of incandescent, fluorescent or mercury steam.
- Use rigid PVC pipelines for electric wire protection and placed internally.

Water installation

- The water system should be composed of a central tank with sufficient capacity for three days demand at peak production.

- A chlorine treatment pump and a filter should be placed at the system's inlet.
- The water pipelines should be calculated according to the technical flow compensation with terminals of $\frac{1}{2}$ inch.
- If a misting system is installed use an independent water tank.
- Water reservoirs must be outside of the broiler house in a shade and pipe lines from the reservoir must be layed at a depth of at least 20 cm.

Biosecurity

Broiler production depends on proper care to avoid disease contamination. Prevention of diseases is the main point to be considered in all systems. The best approach is to avoid unnecessary movement around the buildings and restricting visitors in the area. Buying healthy birds is the initial point to follow.

Prevention of diseases is the main point to be considered in all broiler production systems.

Isolation and entrance facilities

- Fence the poultry farm and surrounding areas with wire and protection hedges.
- Access to the poultry farm should be through a single gate located at the best point to strictly control and record the movement of people, vehicles and poultry shipments.
- Any material to be introduced into the poultry farm should be examined to detect the risk of contamination. In case of contamination risks, the material should be disinfected before it is allowed into the poultry farm.
- Plant a lawn in the areas around the poultry houses and keep the grass well mowed.

Communicate any event with high mortality in the flock to sanitary authorities, especially when such events may not be related to management faults.

General broiler health care

- Acquire chicks from hatcheries registered in the Ministry of Agriculture, Livestock and Supply.
- Acquire chicks previously vaccinated against Marek's disease.
- Follow a vaccination program compatible with the diseases prevalent in the region.
- Acquire chicks from breeders free from Salmonellosis and from Micoplasmosis.
- Respect the guidelines from the National Program on Poultry Health, from Ministry of Agriculture, Livestock and Supply, which requires the breeder flocks to be negative for *Salmonella pullorum*, *Salmonella gallinarum*, *Salmonella enteritidis*, *Salmonella typhimurium* and *Mycoplasma gallisepticum*.
- Monitor the flocks to control infections by *Mycoplasma synoviae*.
- Use only *Salmonella* free feed and coliform free water.
- Offer coliform free water to chicken.
- Conduct programs of fly control, rodent control and beetle control on the poultry farm.
- Have the broiler vaccination program periodically evaluated by a veterinarian.
- Avoid poultry house proximity to other livestock, especially birds, but also to other animal species.
- Avoid excess of vehicles, people and animals in transit near the poultry houses.
- Control coccidiosis by anticoccidial medicated feed or by the vaccination of chicks.
- Install a litter and wet manure composting system.
- Control rodents by cleaning, constant space organization, and by the use of anti-rodent baits.

- Destroy beetles by removing or composting the litter between use periods of poultry houses.
- Use insecticides against beetles only if technically required.
- Transport the broilers only with the proper Animal Transit Permit, signed by an accredited veterinarian.
- Keep records for flock technical control, with housing date, number of birds housed, vaccinations, administration of medicines, and daily flock mortality.

Cleaning and disinfection

- Burn the cardboard boxes used for chick transport immediately after housing the birds.
- Proceed the cleaning and disinfection of the poultry house immediately after delivering the flock.
- Take all equipment out of the poultry house after delivering the flock.
- Wash the water reservoir between use by each broiler flock.
- Reutilize the litter only after composting it for at least 14 days.
- Wash all poultry house equipment (feeders, drinkers, curtains, walls, and bird's protection screen) with water under pressure.
- Use quaternary ammonium, formaldehyde, chlorine, iodine, cresols or phenols to disinfect the poultry house.
- Periodically change the disinfectant chemical group used in the facilities.
- Remove and dispose of the litter using it as fertilizer.
- Distribute the dry new litter acquired from a safe origin for the new flock to be housed.
- When the litter is reused, place the new litter in the brooder circles or guards to receive day old chicks.

Strain and chick selection

Obtain broilers with certain characteristic traits such as gain and productive efficiency. The chicks must be purchased considering the following points:

- Buy chicks from strains recognized by the market, vaccinated against the Marek's disease.
- Transport the chicks from the incubator (where they are kept in controlled environment) to the place of housing in adequate vehicles that provide well-being for the baby chicks.
- Preferentially, raise the birds separated by sex.

Keep only chicks with healthy appearance such as shining eyes, belly button well healed, uniform size and color, shiny shank without deformities, dry plumes, soft and without adherence in the vent.

Management

Management includes a series of procedures to minimize adverse factors that may interfere with the production system.

- Care should be taken with chicks at the entrance of the system as well as proper feeding and other practices through the growing phases.

Management of chicks in the poultry house

Before receiving the one-day old chicks, be sure that:

- The brooding place is ready to receive the chicks.
- Poultry houses have shallow pits to disinfect shoes.
- The building is clean and kept free of birds for at least 10 days.
- Curtains should be kept open in the hot hours of the day, depending on the age of the birds.
- In the first days of life, double curtains should be used in cold regions, fastened in the internal part of the poultry house so that it covers the wire mash.
- Use a curtain operating system with cog wheel and a reel system.
- Operate the curtains (open/close) according to the temperature, wind and rain.
- Be sure that:
 - The litter is dry with a uniform height (10 cm) across the floor.
 - Less than half of the poultry house is used for protection circles.
 - The temperature under the heater and 5 cm above the litter is at 32°C.
- Feeders and drinkers one hour before the arrival of the chicks.
- House only birds of the same age in each poultry house ("all in all out system").

Management of the productive phases

- Clean drinkers and feeders at least twice a day.
- In the third day, start to widen the protection circles keeping the right temperature.
- Keep the chicks distributed uniformly around the heat source.
- Regulate the height of drinkers and feeders according to the age of the chickens.
- Start to operate the ventilation equipment whenever the temperature surpasses the comfort zone of the birds.
- Clean the drinkers and feeders at least twice a day.
- Fill the tray feeders with small amount of feed several times a day, being sure the consumption is *ad libitum*.
- Use a lamp with energy from 2 to 3 watts/m², for a number of hours of light corresponding to the age of the chick:
 - 1st day = 24 hours
 - 2nd day = 22 hours
 - 3rd day = 20 hours
- Use natural light from the fourth day on.
- Use a light program in addition to the natural light for lots whose feed intake is low.
- From the fourth day on, replace 1/3 of the initial equipment (tray feeders, pressure drinkers) by definitive equipment.
- From the second week on, keep the base of the bell drinkers at the height of the dorsal line of the broilers and for the nipple drinkers the height should be slightly above the broilers heads.
- From the second week on, keep the base of the feeders at the height of broilerchest.
- Keep the bird density between 10 and 20 birds/m², with maximum production of 35 kg of meat/m²; however, consider that the density is

variable according to the season, weight of the broilers at slaughter and the presence of a temperature control system.

- Finish changing the equipment at the 6th day.
- Be sure that, in the 8th day, the definitive feeders and drinkers are uniformly distributed.
- Be sure that, in the 8th day, the protection circles (or the area defined as brooder) be completely opened using all the house space.
- Make sure that the space is increased in such way that in the 28th day the entire house floor is occupied.
- Start the moisturizer device and after that the ventilation equipment only when the air humidity is low (55% to 80%).

Evaluation of the lot performance

Producers must evaluate the performance of broilers is compatible with the ones considered as efficient. An index of productive efficiency (IPE) was generated and helps in this task. Values above 280 indicate good performance.

- Estimate the standard performance of the strain by taking the weights of about 1% of the broilers in any time, comparing with the tables presented in the strain guides.
- Adopt mechanisms to keep mortality rates lower than 3% per lot.
- Evaluate the performance of the lot by an index of productive efficiency (IPE), which considers the live body weight (BW, kg), the viability (V, %), the age in days (A) and the feed conversion (FC), placed in the following formula:

$$\text{IPE em \%} = ((\text{BW}) * \text{V}) / (\text{A} \times \text{FC}) * 100$$

Pre-slaughter transportation and preparation for slaughter

Good quality carcasses depend on the management of the birds during capture and transport to slaughterhouse, as well as on the feeding in the last day.

- Remove feed and keep the broilers in feed restriction by 6 to 8 hours prior to loading.
- Provide water *ad libitum*.
- Do not allow untrained people to gather the birds.
- Reduce the space for easy capture of the broilers using a mobile board.
- Reduce light intensity to facilitate the capture and to reduce stress.
- Do not gather the broilers by the thighs.
- Place the broilers in crates, specially designed for transportation, placed inside the house.
- Use 25 kg of birds/m² of crates.
- Keep the loaded crates in ventilated places or in appropriate vehicles.
- Minimize the transportation time and/or the retention time to reduce stress and dehydration.
- Assure carcasses of good quality managing the broilers in an appropriate manner, prior to loading.
- Avoid scaring the broilers and minimize bruises and other injuries.
- Remove all the equipment from the floor prior to the capture to facilitate the task.
- In large poultry houses, make divisions to avoid disturbing the broilers that are not being loaded yet, to allow them free access to water.

- In case of controlled environment houses, with high bird density, observe that open doors alter the comfort conditions of the house and cause malfunctioning of the refrigerating equipment and may lead many broilers to die of suffocating prior to capture.
- Whenever possible, capture birds, in the cooler hours of the day and preferentially in the night shifts.
- Capture the broilers by the whole body and wings with both hands, or, alternatively, gather by the legs/shanks always avoiding wing flapping.
- Allow enough space between the piles of crates in the truck so that there is enough air circulating, avoiding the suffocation of the birds.

Feeding

Quality standards for ingredients and premixes as well as animal requirements should be specified in feed formulation. Also, the processes for feed manufacturing have to be followed in order to warrant quality. In this aspect, the Federal regulations and recognized sources of technical information must be observed (Documents 12.2, 12.3, 12.7, 12.8, 12.9, 12.11). Present concerns are related to meat contamination with microorganisms, drug residues in carcasses and general quality of meat. Antimicrobials may be used under strict technical and legal recommendations (Documents 12.4, 12.5, 12.6).

- Only gram-positive growth promoters approved by the Ministry of Agriculture, Livestock and Food Supply may be used.
- Gram-negative antimicrobials may be used only if prescribed by a veterinarian and respecting a withdrawal period prior to slaughter.
- Chloranphenicol, 3-nitro acid and nitrofurans are not allowed in any circumstances due to a prohibition of the Ministry of Agriculture, Livestock and Food Supply.
- Quality specifications should be available for all feed ingredients, as well as for processes for production of by-products, feeds and ingredient mixtures.
- Feed mixture should be prepared based on nutrient and energy requirements of broilers and the composition of ingredients in the diet.
- At the final phase, supply feed without any growth promoter or medicines.
- Follow good manufacturing practices for feed production on the farm.
- Utilize animal requirements and feed composition tables from recognized institutions, to formulate the diets.
- Use balanced feed to meet poultry requirements for fast and healthy growth.
- Use feed produced by industries registered at the Ministry of Agriculture, Livestock and Supply, which are legally and technically ready to use, without remixing with other ingredients.

- Mix protein concentrates and mineral-vitamins mixtures (available at farm supply stores) with ingredients available in the farm (corn, soybean meal, wheat bran etc.).
- Follow directions of suppliers regarding recommended quantities.
- When producing feed on farm, the following facilities and installations are necessary:
 - Feed mill area with bins to store cereals.
 - Weighing room for ingredients and controlled storage of drugs, additives, vitamins and minerals.
 - Scale with capacity of 10kg and sensitivity of 1g.
 - Scale with capacity of 200kg and sensitivity of 10g.
 - Cereal grinder.
 - Horizontal or vertical mixer with adequate capacity.
 - Helicoidal conveyors.
 - Feed transporting trailer.
 - Feed receiving bins.
- Adjust the broilers to the production dividing the growing curve according to the following phases:
 - Pre-starter: from 1 to 7 days.
 - Starter: from 8 to 21 days.
 - Growing: from 22 to 35 or 42 days.
 - Final: from 35 to 42 or 42 to 49 days.
- When expertise to formulate diets is not available, ask for advice with extension, mixers or feed companies.

The quality pattern of ingredients and mixes, as well as the animals' nutritional needs must be specified by feed suppliers.

Ingredients

The inspection and monitoring of products destined to animal feeding is regulated by the law (Reference Documents 12.2 and 12.3).

- Follow animal feeding guidelines prescribed by the government, which establish feed standards.
- Whenever possible, analyze ingredients at specialized laboratories, or consult feed tables to calculate the feed formula.
- Use quality ingredients, free of molds, toxins, micotoxins, pathogenic microbes or agrochemical.

All industrial production or commerce of feeds for animals must be registered, and produced according to Ministry of Agriculture, Livestock and Food Supply standards. Farm feed production must follow the same standards of safety as the industrial production.

Water

Water is an important nutrient and all efforts must be directed to improve its quality. Sources of sustainable production have to be protected from prospective contamination caused by broilers.

- All phases of production, require plenty of fresh water at a temperature near 20°C.
- The water consumption is variable according to the age, the temperature and the feed type.

Use 3 liters of water per kilogram of ingested feed as a reference value.

- Chemical and biological analysis of the water should be than regularly.
- Water should be treated with 0.3 g of chlorine (sodium hypochlorite) per 1000 l, whenever fecal coliforms are present in any amount, or total coliforms are over 3/100 ml of water.

Hygiene, safety and workers' well-being

This is essential to the quality of the broiler meat chain. Hygiene of workers is the starting point that leads to the health of worker and, by consequence, favors the broiler flock.

- Employees must be adequately trained.
- Observe labor laws.
- Employees should submit to periodic health check up.
- Train employees to adopt personal hygiene care.
- Store chemicals in proper places with good ventilation and adequately labeled.
- Employees responsible for handling chemicals and residues must use safety items (gloves of long sleeves, apron, and mask).
- Workers that use agrochemicals must be trained to use IPE.
- Adequate places for meals and for personal hygiene should be available.
- Maintain a program for toilet cleaning and supply of hygiene materials.
- Maintain records of health and labor safety.
- Have a telephone list with addresses of laboratories, research and extension services and environmental agencies.
- Machinery should be well maintained and properly working.
- Notify neighbors when working with residues.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Beef cattle production



Author: *Kepler Euclides Filho, Embrapa Gado de Corte, Campo Grande, MS.*
kepler@cnpqc.embrapa.br

Co-authors: *Eduardo Simões Corrêa, Embrapa Gado de Corte, Campo Grande, MS.*
eduardo@cnpqc.embrapa.br

Valéria Pacheco Batista Euclides, Embrapa Gado de Corte, Campo Grande, MS.
val@cnpqc.embrapa.br

Introduction

According to the Brazilian Geography and Statistics Agency — IBGE, the National Beef Cattle Production Council — CNPC and the National Forum for Beef Cattle Production, the country's beef cattle herd corresponds to 170 million animals kept in 2.2 million farms, distributed over all states, in an area of 225 million hectares, generating 7.2 million direct jobs.

The total beef production will probably be above 7 million tons in 2002, according to the National Beef Cattle Production Council estimative, of which about 900 thousand tons may be exported, generating an income of 1.1 bilion. The GNP generated by this segment represents US\$ 1.5 billion, but only a small part of the total production has competitive quality for the international market.

Beef cattle production is growing annually in Brazil and is also becoming more competitive. Pressures stemming from the globalization process, however, are requiring from this and all other production sectors, a restructuring based on efficiency. The opening of markets of several countries to global competition in the past few years made production with efficacy and efficiency a mater of survival in business. In an attempt to cope with this demand the different production segments have tried to adjust by establishing new models, innovating and adopting a comprehensive, more wide-ranging view.

Among the factors that still represent problems in this chain, the need to improve the quality of the products on a year-round basis, deserve mention. The consumer nowadays also demands that the production process is performed in a sustainable, environmentally correct and socially fair manner. Thus, the use of good, sound production procedures represents the beginning of a certified production system with quality control.

Good Agricultural Practices (GAPs) are a set of practices describing activities that should be applied in a farm, in association with measures to guarantee health, well-being and safety of workers. The principal aims are to supply healthy products and to preserve the environment, as well as increasing the value of products from small, medium and big

farmers. These practices are based on actions for improving product quality, like Hazard Analysis and Critical Control Points (HACCP), and for agricultural certification. The use of appropriate production procedures, based on the Good Agricultural Practices (GAPs) guidelines, is crucial to maintain the market acceptance of beef and to guarantee the success of the agricultural sector and of the food industry.

These guidelines for good practices in beef cattle production might be applied to the various beef production systems used in Brazil.

The GAPs here recommended consider the different production systems adopted in Brazil, from subsistence farming to the most technically sophisticated. The GAPs presuppose respect to the environmental and labor legislation as well as the Children and Adolescent Statute, and the ethical principle of equal pay for all types of rural labor.

Choice of the area

An inadequate choice of the area will result in decreasing profitability of the system, also affecting the environmental integrity, causing social and environmental deterioration.

- Observe current legislation concerning legal reservations.
- Observe minimum required distances from watercourses, to preserve fringe forests.
- Protect flora and fauna.
- Preserve the forests next to watercourses.
- Observe agricultural zoning maps.

Beef cattle production is an activity that is possible and actually occurs in all Brazilian regions.

Soils

- Survey physical, chemical and topographical conditions of the land.
- Use areas according to its agricultural aptitude.
- Maintain or improve the soil organic matter using pasture rotation, appropriate equipment and conservation practices, with emphasis to zero-tillage.
- Maintain the soil cover to minimize erosion losses by runoff and other causes.
- Apply pesticides and organic or inorganic fertilizers when necessary, in doses recommended by the specialists and by the Extension Service.

It is important that beef cattle ranches (small, medium and large) observe the agricultural zoning recommendations.

Water

- Survey the water resources, their spatial distribution in the farm and their suitability for use in cattle production.
- Protect water holes.
- Protect water bodies, especially rivers, water tables and springs.
- Monitor water quality periodically.

In order to satisfy the demands of modern society, which requires care with the environment and special attention to social aspects, it is recommended that any initiative of cattle production strictly observe the Brazilian legislation related to legal reserves and to areas of environmental protection.

Animals

The observance of GAPs is a contribution to the feasibility of the production system, avoiding pasture degradation and soil erosion. It is essential to provide animals with: feed and water of good quality, a comfortable and safe environment, freedom of movement and protection against stress, illness, pain or unnecessary harms. Non-observance of these principles contributes to pasture degradation, land erosion, losses in production and productivity and to illnesses in the herd.

- Bulls and cows should conform to good zootechnic standards and be originated from herds with strict sanitary control, adapted to the particular production system and to market requirements.
- Only animals from genetically selected herds with strict sanitary control should be accepted.
- All acquisitions and sales of animals, acquisitions of food, semen, breeding programs, losses and discards, feeding plans, should be recorded.

The use of adequate animals is essential for the success of the beef production enterprise.

Pasture

The correct establishment, recuperation/renovation and management of pastures are vital factors for competitiveness of the production system. An incorrect establishment and an improper management of this subsystem will hamper environmental conservation and negatively affect beef quality.

Establishment and recuperation/renovation

- Eliminate native vegetation, respecting environmental legislation.
- Keep trees and wooded areas to provide shade for the animals.
- Use adequate soil conservation procedures.
- Chose forage species considering its adaptation to the environment, soil differences in the farm, diversification of pastures and objectives of the business.
- Use fertilizers according to physical and chemical analyses of the soil and demands of the forage species.
- Prepare the soil adequately.

Pastures are the main source of feed for beef cattle.

- Acquire certified seed in amounts recommended by specialists.
- Use grass-legume mixtures whenever possible.
- Plant according to technical recommendations.
- Whenever possible, integrate cropping activities with animal production (agro-pastoral systems).
- Annual maintenance fertilization should be applied in split parcels, during the rainy period, after the animals have been moved from the particular pasture, to other areas.

- Monitor pasture productivity considering the carrying rate (heads per hectare), the yield of the forage producing species and the yield of the land (kg meat /ha/year).

Local technicians should be consulted for the definition of the most suitable practices for pasture establishment and management.

Management

- Use rotational or alternate grazing, allowing pasture regrowth periods.
- Adjust grazing pressure to carrying capacity of the pastures, avoiding over or undergrazing and, thus, soil exposure and poor use of the dry matter produced.
- Assure forage reserve for seasons of less production (winter; dry season).
- Remove weeds from pastures and replenish nutrients periodically.
- Use agro-pastoral systems whenever possible.
- Fire should not be used as normal practical management.
- Chemical weed control, whenever needed, must be carried out avoiding soil and water contamination, and with protection equipment.
- Be sure that pesticides and their containers do not contaminate the soil and water courses.
- Strictly follow legal prescriptions of handling, application and disposal of pesticide leftovers and empty containers, with emphasis to the triple washing method.
- Only trained laborers, using Individual Protection Equipment (IPE) should be allowed to handle and apply pesticides.

- Pesticide application equipment should conform to the safety and maintenance recommendations.

Pesticide containers discarded without the observance of pertinent technical recommendations may negatively affect human health and environmental quality.

Feeding

The use of inadequate feeding affects the competitiveness of the production system and might result in animals and products that do not satisfy the standards of the modern beef supply chains, which require high quality standards of the final product.

- Supply pasture and supplements to all animals, both in the dry and rainy seasons, assuring that the requirements for maintenance and production are met.
- Maintain updated records of the feeding programs for all animals.
- Supervise animals regularly to assure their well being both in pastures and in corrals.
- Supply clean water of good quality year round, with free access to all animals.
- Install weather protected troughs for mineral supplements.
- Maintain enough reserves of roughage (sugarcane, cut-and-carry grass, silage, hay etc.) to prevent possible deficits in the critical seasons.
- Determine the area for producing roughage according to the number of animals, duration of the supplementation period, expected consumption and expected productivity.
- Offer protein/energy supplements according to objectives and goals of the operation, especially during the dry season, to optimize animal performance.
- Offer mineral supplement *ad libitum*, year round to all animals.
- Use only ingredients approved by the Ministry of Agriculture, Livestock and Food Supply in the preparation of supplements.
- Use quality ingredients in the formulation of feeding supplements, making sure they are free of toxin producing fungi, pollutants or other contaminants.

Shelter, space, food and water are essential elements for yield and profitability of beef herds.

- Supplements should be protected from humidity, rodents and possible contaminants.
- Do not use products of animal origin as feed.
- Do not use antibiotics, hormones, additives or any other chemical products as feed.
- Use ionophores and other growth promoting substances observing legal and technical recommendations.
- Plan feed supplementation for the critical period during the previous rainy season.
- Manage pastures during rainy season in order to provide forage to the next critical period.
- Do stockpiling in two ways:
 - All pasture deferred at once — in this case, the animals are removed during the rainy season allowing its utilization during the following critical period.
 - Deferment in two stages — the animals are removed from pastures on a rotational schedule.
- The amount of forage to be deferred should be, approximately, 2.0 to 3.5 times the calculated consumption.
- Defer forages based on their ability to retain leaves.

The use of ionophores and other growth promoting substances must observe governmental regulation.

Animal management

Adequate animal management assures animal welfare, the safety of personnel and the traceability and certification of the final product.

- Identify all animals on the farm.
- Identify and record the origin of all animals introduced in the production system.
- Supervise regularly the productive and reproductive performance of all animals.
- Perform andrological and gynecological examination of bulls and cows yearly.
- Establish a breeding season of 90 to 120 days.
- Perform a pregnancy exam on cows 50 days from the beginning, and 60 days after the end of the mating season.
- Remove animals with substandard performance.
- Eliminate cows with any type of problem or that produce calves below the average weaning weight.
- All cows in the last gestation month should be concentrated in the same pasture.
- Supervise, cows in final gestation on a daily basis, assuring that their calves suck colostrum (foremilk); cut the umbilical cord of the newborn, disinfecting it with iodine or a similar commercial product.
- Avoid umbilical infections.
- Identify all newborn animals with ear tags or hot iron number, or any other identifier.
- De-horn all calves until 15 days of birth, mainly those from crosses between European x Zebu breeds.
- Transfer cows and calves to cow-calf pastures, 15 days after birth.
- Keep calves with their mothers in these pastures for 6 to 7 months.

- Wean calves at 6 to 7 months of age.
- Weigh weaned animals and brand them with a hot iron, on the right face, to identify the animal and the year of birth. Property mark should be branded on the left leg, according to recommendations of the Ministry of Agriculture, Livestock and Food Supply.
- Select cows to be kept in the herd, considering weight adjusted to 205 days and most probable maternal ability, femininity, and desirable economical traits.
- Keep weaned animals in the corral for two or three days, providing water and feed *ad libitum*.
- Keep weaned animals separated by sex and age in good pastures.
- Deworm animals in May, July and September, after weaning.
- Supply animals with adequate levels of supplementation during the dry season according to desired performance.
- Avoid submitting animals to unnecessary stress.
- Weigh growing and finishing animals at least at the end of the dry and rainy seasons.
- Castrate males using specific equipment (Burdizo Pliers).
- Avoid the use of dogs, sticks or flags to manage animals.
- Electric shocks and spurs (iron goad) should be used with moderation.

Supervise regularly all animals to assure their welfare and the safety of the personnel responsible for its management.

Health management

A correct sanitary management assures competitiveness for beef cattle production; otherwise it will be impossible to trace the animal and to certify the production. Besides, an inadequate sanitary program endangers the health of final consumers and of the personnel involved in the process of animal management.

- Establish a yearly calendar for health control of the herd with the assistance of a veterinarian, and follow it strictly.
- Maintain veterinarian supervision regularly.
- Transport and keep vaccines and all veterinary products according to specific manufacturer recommendations.
- Keep all vaccines refrigerated between 2°C and 8°C.
- Never freeze vaccines.
- Sterilize syringes and needles.
- Never utilize disinfectants to sterilize needles since residues may inactivate vaccines.
- Use a Styrofoam box with ice to keep vaccine flasks refrigerated during vaccination.
- Apply vaccines and other veterinary products correctly, observing the correct spot, the mode of application and the dosage, according to laboratory specifications.

The veterinarian has a fundamental role in the definition of a health program for the herd.

- Shake the flasks every time the syringe is refilled.
- Never mix different products, unless specified in the containers or instructions.
- Never vaccinate frail or stressed animals, due to long trips, after delivery etc.

- Do not use open flasks of vaccines or remainder products in the flasks.
- After refilling syringes, return the flasks to the refrigerated Styrofoam box and firmly close it.
- After vaccinating groups of ten animals substitute the needle for a new sterilized one.
- Never vaccinate in the hotter hours of the day and avoid moving animals for at least one or two hours after vaccination.
- If feasible, vaccinate against several diseases at once to avoid additional stresses and labor.
- Keep written records of the sanitary control including dates, batch number, laboratory and validity.
- Vaccinate against foot and mouth disease strictly observing the recommendations of the Ministry of Agriculture, Livestock and Food Supply.
- Vaccinate all females with age between three and eight months against brucellosis, with the assistance of a veterinarian and taking necessary precautions to avoid contamination of the workers.
- Vaccinate all calves from four to six months of age, against clostridiosis with polyvalent vaccine. Vaccination must be repeated after one month and yearly, observing laboratory recommendations.
- Vaccinate against botulism with type C and D toxoid, beginning with two doses administered one month apart, beginning at four months of age and after that, yearly.
- Vaccinate against rabies in areas of prevalence of the disease. The calves must be vaccinated at four months of age repeating the dose after 40 days and then yearly, or according to laboratory recommendations. Cats, dogs and horses should also be vaccinated; bats should be controlled in the region.

An efficient beef production enterprise requires good healthy animals in all growth phases.

- Observe the withdrawing period of veterinary products as specified in the instructions, for meat and milk consumption.
- Deworm with recommended products and dosages from weaning until two and a half years of age. Pregnant cows must be dewormed in July or August, and feeder animals before entering deferred pastures or feedlots.
- Introduce the African beetle *Onthophagus gazella* in the farm to help control worms and horn flies, and also to incorporate organic matter in the soil.
- Control horn flies with insecticides using spray, dipping or pour on products during the rainy season whenever numbers of flies affect animals. Products based on organophosphates should be used because they also control screwworms and ticks. Lactating cows, young animals and bulls should be preferentially treated.
- Control ticks starting in September (beginning of the rainy season) and three more times at 21 day intervals. Additional treatment should be done as needed, every time tick number exceeds 50 per animal.
- Observe animals weekly and never treat for ticks when infestation is below 50.
- Consider climatic conditions before dipping for tick control or use of spray/pour on products, since rain may wash products and pollute the environment.
- Incinerate empty flasks or store appropriately, for later disposal.
- Identify diarrhea causes and their frequency to treat accordingly.

- Remove all carcasses from pastures.

The improper use of chemical products might result in soil and water contamination with undesirable economic and environmental consequences.

Facilities

Improper facilities endanger animals and personnel responsible for the animal management, contribute to the reduction of competitiveness and affect hide and beef quality.

- Evaluate the infrastructure of the farm considering the natural resources and the watershed where it is located.
- Water availability must be of 100 liters/animal/day.
- Economic feasibility should be assessed based on the cost of inputs and the market.
- The system of production should be evaluated considering the availability of feed, comfort and health protection for the animals.
- Facilities should be planned accounting the size of the herd, the expansion plans, the cleaning and disinfection needs, the working conditions, the disposal of animal excrements, the materials used and the availability of good quality water.
- The production system should be compatible with the management capacity of the rancher.
- Availability and education of the available labor is an important factor.
- Sanitary legislation and official specifications related to production and installations must be observed.
- Sufficient trough space is necessary to avoid competition of the animals for food.
- Troughs located in pastures should be covered to avoid food losses caused by rain, and to furnish mineral supplement; animals should visit them at least once a day.
- The working environment should be adequate to satisfy the needs of workers enhancing productivity and allowing proper equipment performance.

- Traffic of food, animals, machinery and manure should be planned having efficiency in mind.
- Avoid funneled and narrow corridors, steps and slippery floors, to prevent accidents that may cause serious injuries to limbs of animals.
- Enough area should be assured for each animal, with easy access, good ventilation, sunshine and drainage
- Electricity should be available.

It is essential to observe the official sanitary code.

Fences

- Do not use barbed wire.
- Use electric fences to divide paddocks.
- Use “live-posts” to build fences.

Corrals

- Build the corral in a central location, on firm, dry land; prefer flat areas, with easy access and well positioned in relation to farmstead and pastures.
- Cover the terrain with a layer of compacted gravel.
- The corral should be built to accommodate the size of the herd to be worked upon.
- Design detailed blueprints to facilitate demarcation and construction of the corral.
- Prefer a circular or elliptical form.
- Place the corral in an east/west direction.
- The corral should include, at least, the following components: off loading pens; holding lane; sheltered chute with handlers catwalk; scale; squeeze chute; sorting pens; loading platform. It is recommended to

install a chute for tick treatment, especially for animals of European Stock.

Corrals should be maintained clean and dry to avoid health hazards, for animals.

- The processing area and chutes must be sheltered, ventilated and well drained; they should be functional and sturdy and most important, safe for people and animals.
- Prefer resistant and durable wood for the construction (Aroeira or Imbauba) and solid sides with wood that resist impact (Ipê, Itaúba, Faveiro etc.). Treated Eucalyptus uprights or concrete posts and steel cables are possible alternatives for fencing.
- Avoid protruding splinters, screws and other hardware.
- The landing platform should be built in a way that facilitates moving the animals.
- Keep the corral always clean.

Adequate comfort for animals in terms of space, shelter, cleanliness, ventilation with good sanitary conditions to avoid animal health problems, contributes for the good quality of products and competitiveness.

Feedlot

- Feedlot facilities should include the following elements: a center for animal management, food preparation area and feeding corrals.
- The management center for reception and preparation of the animals should be roofed, and have a squeeze chute for vaccination, dehorning, deworm a scale.
- The feeding area should have adequate space for: feed production (maize, grass forage etc.) storage and conservation (stores for bags, hay, silos for grain and for silage) and an area for feed preparation (covered site for mixer, mill, forage cutter and scale).
- All areas should be kept clean and free of insects and rodents.
- Corrals to fatten the animals should present an area of 15 to 20 m²/head with compacted and graveled surface and a minimum declivity of 3%.
- Height of fencing of corrals should be of minimum 1.80 m, made of wire, steel cables, boards or other materials.

Less animal stress and more worker safety result in higher yields in beef production systems.

- Troughs built from different materials (steel drums, pre-molded concrete, wood etc.) should be placed in the frontal part of paddocks and be of sufficient size to accommodate the volume of feed to be served to the animals.
- Manure to be used as fertilizer should be well fermented.
- An area for grazing should exist close to the cow resting areas, to watering points or to salt troughs.

Water troughs and water reservoirs

- Install water troughs in pastures without natural water sources, preferably at fence crossings to serve two or more subdivisions.

- Water troughs should be constructed of materials such as masonry, galvanized steel, pre-molded concrete etc.
- The area around water troughs should be compacted and covered with gravel to avoid the formation of mud and bog down areas.
- Animals should be kept away from natural springs.
- Maintain reservoirs in high places to allow distribution by gravity.
- Construct reservoirs made of brick or concrete or galvanized sheet.
- The volume of the reservoir depends on the quantity of troughs to be supplied with the addition of a safety margin.

Consult local technicians to define and plan appropriate facilities.

Hygiene, safety and workers' well-being

Satisfaction of all personnel involved in the management of the property, welfare of themselves and of their families is fundamental for maintaining the competitiveness of the production system. All principles, laws and regulations regarding hygiene and safety during any operation related to beef cattle production must be followed, in order to avoid any health hazard to workers or to consumers.

- Treat employees with respect and dignity.
- Offer befitting housing to employees.
- Observe work legislation.
- Observe social obligations including the provision of schooling for all children.
- Provide periodical training to employees.
- Build safe facilities.
- Supply protection equipment and wear to assure safety to all employees.
- Pay just and satisfactory salaries to promote the well being of workers and their families.
- Reward deserving employees with a percentage of profits.
- Do not employ child labor.
- Employ only well trained staff and operators and retrain them as required.
- Make sure all safety rules are observed during the operations.
- Monitor frequently the health status of all workers involved with agricultural and processing operations.
- Keep records related to health and safety properly filed.
- Workers involved in the manipulation of pesticides should be adequately trained and use IPE, and strictly observe all hygienic and safety rules.

- Provide safe transportation and adequate installations for meals and for personal hygiene for staff and operators.
- Observe the Brazilian labor laws, including wages and fringe benefits, housing, education, nutrition, school transportation, holidays and other rights.
- Qualify the employees in good practices of personal hygiene.
- Guarantee compatible work schedules for agricultural activities and workers' well-being.

The human element is the most important factor in the animal production system. Hygiene habits and good work conditions minimize health problems for workers and consumers.

Environmental management

All environmental protection legislation should be strictly followed in all stages of beef cattle production.

- Respect the Brazilian legislation regarding protection of springs, water courses and reservoirs like rivers, creeks, lakes and similar, specially the ciliar vegetation.
- Develop the agricultural activities according to the regional ecology parameters.
- Production activities should always promote sustainable development.
- Execute, control and evaluate plans having in mind the prevention and correction of environmental non-conformities in any stage of production or processing.

Beef cattle production in Brazil can guarantee supplemental income to farmers if GAPs are followed contributing to better quality products.

Technical assistance and associative initiatives

It is important to integrate efforts of the different actors either governmental or private, in order to improve social organization (associations, cooperatives, experience groups) of small and medium ranchers for an adequate insertion in the beef market.

- A professional must supervise beef cattle production from the planning to the commercialization.
- Producers shall be stimulated to organize cooperatives to benefit from the larger scale of common operations, specially input purchase, sale of the production, technical assistance and business management.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Vegetable crops production



Author: *Celso Luiz Moretti, Embrapa Hortaliças, Brasília, DF*
celso@cnph.embrapa.br

Introduction

Good Agricultural Practices are procedures that improve conventional methods of production, beginning with the choice of the cultivation areas reaching post-harvest procedures, emphasizing worker health, well-being and safety. They aim at healthy products and at the preservation of the environment promoting value addition to the products of small, medium and large farmers. These practices are the basis for other incentive programs for quality improvement, like the Hazards Analysis and Critical Control Points (HACCP) or for agricultural certification based on international protocols for quality certification. Considering the worldwide tendency to increase non-tariff barriers, Brazilian producers must keep updated about the changes in export requirements, to protect their economic interests and to take actions in cooperation with the government to assure that Brazilian vegetables are accepted in foreign markets.

Brazil is the 12th in vegetable production volume with a total of 11.1 million tons reported by FAO in 1998. Vegetable crops occupy an area of approximately 740,000 hectares contributing with R\$ 9 billion to the agribusiness GDP. These numbers include only the 27 most important vegetable crops, out of a total of about 50 that are cultivated in the country. Vegetable crops included in the FAO statistics are pumpkin, Swiss chard, water cress, artichoke, lettuce, garlic, chicory, potatoes, sweet potato, eggplant, broccoli, onion, chives, carrot, parsley, collard, cauliflower, peas, spinach, yams, melon, watermelon, cucumber, pepper, green pepper, and tomato¹.

Brazil is a minor exporter of vegetables, compared to a worldwide scale, and considering its own internal production. Although in small volumes, 20 species are being exported. There is still need for imports, to meet the high levels of internal demand. Per capita consumption,

¹ The main vegetable species cultivated in Brazil are: pumpkin, zucchini, water cress, artichoke, lettuce, garlic, purre, chicory, asparagus, potato, sweet potato, eggplant, red beets, broccoli, chinese yam, onion, chives, carrot, chayote, parsley, collard, brussel sprouts, chinese cabbage, cauliflower, peas, spinach, ginger, yams, bitter tomato, taro, west indian gherkin, watermelon, melon, sweet corn, squash, strawberry, mustard, turnip, cucumber, pepper, green pepper, okra, redish, repolho, roquette, cellery, tomato and green beans.

in the eleven most important metropolitan areas is of 45,5 kg/year, an index that is lower than the consumption of fruits and dairy products. Rio de Janeiro has the highest yearly per capita consumption average (54,3 kg) and Belem the lowest (21,8 kg).

The Brazilian population doesn't take advantage of the nutritional value of vegetables considering the potential and diversity of the national production. Vegetables are the major source of vitamins and minerals, with low calorie content, no cholesterol and high fiber content. Their consumption can help breaking the cycle of nutritional deficiencies that cause health problems and affects performance in school and at work.

The Southeast is the most important vegetable crop producing region, contributing with 63% of the volume produced, cultivating the widest range of species. São Paulo is the chief national producer, followed by Minas Gerais and Rio de Janeiro.

The South is the second most important with 15% of the total volume. In the Northeast, Pernambuco and Bahia are important producers of onion, tomato for processing and carrots. 17% of the vegetables are produced in the Northeast. In the Midwest, Goiás is an important producer of tomato, garlic and watermelon. The Federal District exports carrots, tomato and green peppers to the northern states, that have limited vegetable production capacity due to unfavorable climate.

Some vegetables like lettuce, collard, cabbage, water cress etc. are produced using intensive cultivation methods, in areas that average 3 hectares, near metropolitan areas. Other, such as carrots, red beets, sweet-potatoes, eggplant, cucumber, green peppers, garlic and tomato for processing, are cultivated in areas of one to five hectares per product, located at hundreds of kilometers from markets. Species like tomato for processing, potato, melon and watermelon are produced in large scale plantations of tens or hundreds of hectares, generally far from the markets.

In recent years, an increase is observed in the production of vegetables in protected environments, mainly by the use of plastic green houses, to protect plants from low temperatures and rains. This technique allows the production of crops like tomato, green peppers and

cucumber in periods unfavorable for traditional open air cropping, in the southern and southeastern states, where summer rains are intense and winter temperatures are low, affecting the plant development and predisposing to the incidence of pests and diseases. Hydroponics is another technology that interests many producers, especially for lettuce production.

Considering this scenario, it is believed that GPAs can help to enhance the competitiveness, the environmental sustainability and social contribution of the Brazilian vegetable production. The different topics (selection of the area, selection of the parcel, seeds, soil use, fertilization, irrigation and fertigation, soil and water conservation, integrated pest management, pre and post-harvest procedures, hygiene and safety) treated in this outline are a combination of theoretical principles and practical procedures that represent important information to vegetable producers of any scale, about forms to improve environmental conditions (social, economic and ecological) in the productive sector and to attain adequate standards of sustainable production, worker well-being and consumer safety. The described practices help the environmental planning and management of farms and may be rapidly incorporated into the existing production routines.

Good Agricultural Practices (GAP) described in this document refer to the production of vegetable crops in the field (with or without plastic mulching) or indoors (under protected conditions). The guidelines are focused on potential microbial, physical and chemical hazards. Practices related to retail marketing and fresh market sales and any other problem at the consumer level are not the object of this document.

Finally, considering the wide variety of vegetable crops and the diversity of soils and climates in Brazil, the orientations provided are flexible enough to allow their adoption in different growing systems.

Sanitary conditions of fresh food have become an important issue in many parts of the world. There is a growing worldwide understanding of the relation between the sanitary quality of fresh food and human health. The adoption of GAPs in the production of vegetable crops,

from seedling to post-harvest procedures, is therefore important to meet market requirements. The idea of the present document is to provide general information for the standardization of quality assurance procedures of vegetable crops, minimizing chemical, physical and microbial contamination.

The GAPs here recommended consider the different cropping systems adopted in Brazil, from subsistence farming to the most technically sophisticated ones. Those GAPs should respect the environmental and labor legislation as well as the Children and Adolescent Statute, and the principle of equal pay for all types of labor.

Selection of the production area

Vegetables may be planted in most areas of the Brazilian territory, as long as environmental laws are respected. This includes the exclusion for productive purposes of the legal ecological reserve area in each farm and the areas of permanent preservation designated by the government. The adequate selection of the area is essential for the success of vegetable production. Mistakes in this selection bring forth economic losses, environmental damages and will negatively affect final product quality.

- Survey the local infrastructure for the support of cropping and post-harvest activities such as availability of labor, previous use of the area, soil and climate compatibility with the particular crops to be planted, and market availability.
- Identify potential sources of contamination such as sewage storage close to water sources, other organic waste and agricultural chemicals storage sites.
- Plan the utilization of the area, identifying crops and sites of organic and chemical deposits and points of fecal contamination.
- Avoid the access of animals to the production sites and other potential sources of soil and crop contamination.
- Exclude domestic and wild animals from fresh produce growing areas.
- Monitor potential contamination of growing areas due to flooding of contaminated water and due to overflowing of cattle manure storage sites.
- Check the contamination of soil and irrigation water by pathological microorganisms, such as *Salmonella* sp. and *Listeria* sp.
- Check for agricultural chemicals and heavy metals residues in the soil.

- Abandon the area if microbial or chemical contaminants are present and no corrective action is possible.

Verify the general characteristics of the area to be sure that it is suited for the production of vegetables with yields and quality compatible with the market demand and assurance of returns compatible with the needed investments. Vegetable production offers good employment opportunities for the local community.

Choosing the cultivation site

The selection of the cultivation site is an important phase in the establishment of a vegetable crop. Planting in inadequate sites will affect costs, environmental conservation and the quality of the final product.

- Install the crop preferentially in deep soils, not subject to soaking, with low levels of soluble salts.
- Avoid areas subject to waterlogging (poorly drained hydromorphic and alluvial soils) unless drainage is made.
- Prefer level or slightly sloped soils, with no more than 12% declivity.

Vegetable cropping in soils with adequate physical characteristics favors the development of a healthy crop, facilitates cultivation and minimizes the risk of soil degradation.

Seeds and hybrids

It is essential to choose seeds and seedlings well adapted to the region and to the objectives of the plantation. Inadequate seeds or seedlings, increase the risk of mal-development of plants and the attack of pests and diseases. This affects input costs and loss of productivity, reducing potential economic gains, environmental preservation and the quality of the final product.

- Prefer hybrids.
- Use only certified seeds previously analyzed for sanitary conditions.
- Consider seeds and/or hybrid adaptability to the growing region.
- Employ only high quality seeds with high levels of germination, vigor, purity, and uniformity.
- Genetic materials should have high or intermediate tolerance to the most common diseases and insects, be competitive in the potential markets, possess good post-harvest conservation and mechanical resistance to transport.

The use of hybrids of controlled origin, well-adapted to the local conditions reduces the incidence of pests and diseases. Consequently, there is a reduction of pesticide use, less expenditure with other inputs, favoring environmental protection and reduction of hazards to workers and consumers.

Soil management

Good soil and water management and conservation practices favor the plant coverage stimulate biological activity, reduce compaction, soil and nutrient losses and minimize silting of water bodies and the contamination of adjacent areas. Non-adoption of these practices may reduce yields and bring forth financial losses and damages to the environment.

- Control erosion and improve biological soil conditions by contour planting, terraces and strip cropping, based on technical recommendations.
- Use the soil in accordance to its use capacity.
- Use mulching to reduce erosion, increase infiltration, reduce evaporation, and reduce thermal and hydric differentials.
- Promote crop rotation.
- Maintain the plant diversity to favor the ecological stability.
- Use practices to prevent waterlogging around the field crop.
- Use strip cropping where land declivity is higher than 8%.
- Livestock manure must be stored far from streams, water reservoirs and crop fields.
- Adopt techniques to minimize the losses of nutrients by leaching.
- Monitor the quality of the fertilizer dissolution water as well as the pH stability during fertigation.
- Prevent hydric stress by water excess.

Soil preparation

- Chemical, physical, and biological analysis should be made before soil preparation or before the use of the growing area.
- Determine the content of organic matter, pH, free phosphorus, calcium, potassium, sodium, sulfur, electric conductivity of the

saturated extract, bore, copper, iron, manganese and zinc at the first 20 cm soil layer.

- Use the correct soil preparation techniques.
- Avoid the constant utilization of the same soil preparation device, such as plough rail or disc plough.
- Avoid tilling the soil always at the same depth.
- Use soil preparation practices that favor root development.
- Apply organic fertilizers and other ground fertilizers in furrows.
- Use subsoiling in compacted soils only when other methods are not efficient.
- Prepare the soil when it is friable (with the right humidity).
- Adopt rotation systems and/or the crop succession that allow better management of weeds, insects, and diseases, contributing also to the increase of soil fertility.
- Ploughing should be done at a 30 cm depth and rail ploughing at 20 cm.
- Position of beds should be periodically changed.
- Seedbeds should be raised in rainy periods and in deficiently drained soil.

Local technicians should be consulted to plan conservation practices.

Planting

- Use spacing according to regional recommendations and final destination of the product.
- Promote frequent changes of the position of seedbeds.

Good planting practices contribute to high yields.

Fertilizing

Adequate levels of available nutrients in the soil are essential for sustainability of the vegetable cropping system, contributing to good plant development, better vegetable quality and increased yields. Inadequate use of fertilizer and lime causes soil and water contamination, erosion and compaction, causing economic and environmental losses.

- Utilize registered fertilizers and correctives according to federal or local regulations.
- Use fertilizers that are free from toxic substances, especially heavy metals.
- Avoid chemical contamination of ground waters, specifically by nitrates.
- Conduct chemical soil analysis for fertility purposes.
- Establish the history of lime application and fertilization of the area.
- Define the amount of nutrients at planting, based on soil analysis and nutrient removal by the crop during the different growing phases.
- Define the source, quantity, and time of nitrogen application, and make sure that the application is based on leaf analysis and desired productivity.
- Evaluate nutrient leaching especially in sandy soils.
- Evaluate the importance of other agronomic factors such as: hybrids, spacing, plant density, pests and diseases and water availability.
- Apply phosphorus and micronutrients over well-composted organic matter making sure that they are satisfactorily incorporated into the soil.
- Maintain soil pH near neutrality (7.0) and base saturation close to 80%.

Liming

- Liming should be based on soil test and be done 60 days before planting.

- Evaluate the need of new lime application according to the soil base saturation.
- Mix thoroughly the lime with the soil and incorporate it at 20 to 30cm.
- Split lime application, half before plowing and half before harrowing.
- Apply lime according to the specific recommendations for each crop.
- Use dolomitic lime if exchangeable manganese level in the soil is less than 8 mmol dm^{-3} .

Organic fertilizers

- Employ well composted materials of known origin.
- Animal manure should be stabilized for at least 90 to 120 days before use as organic fertilizers.
- Monitor the quality of manure, sewage sludge and other natural fertilizers in order to limit the potential for chemical or microbial contamination.
- Adopt practices such as composting, pasteurization, heating, and UV irradiation to eliminate microorganisms in agricultural inputs.
- Obtain information on treatments given to natural fertilizers produced outside the farm.
- Pasteurize manure, sewage sludge, and other natural fertilizers that may contaminate the edible part of vegetable crops.
- Store manure and place composting heaps as distant as possible from water bodies and from the production site.
- Minimize the use of natural fertilizers close to harvest time.
- Avoid storing natural fertilizers in the vicinity of production areas.
- Avoid the use of organic fertilizers close to harvest time.

Sidedress fertilization

- Split nitrogen e potassium doses to avoid water and soil contamination, due to salification, eutrophication and nitrification.

Irrigation and fertigation

Inadequate management of irrigation and fertigation can cause salification, excessive water and energy consumption, and enhances the need for equipment maintenance. It is necessary to observe pertinent legislation and avoid water losses.

Water quality

- Identify irrigation water sources.
- Verify if the water is reutilized from other systems of irrigation, wells, open channels, lakes or other sources.
- Periodically monitor the microbial and chemical quality of the water, making sure that it is appropriate for irrigation.
- Establish an adequate frequency for the contamination test, based on the water source and on the flooding risks.
- Irrigation water should be carefully controlled when used close to harvest, applied directly on edible portions, applied over structures that accumulate water or on vegetable crops to be consumed without any post-harvest treatment.
- Make sure that water used for fertigation and application of agricultural chemicals is free of microbial contaminants.
- Periodically change the solution used in hydroponic systems.
- Water quality used in recycled systems should be constantly monitored.
- Systematically check physical and chemical characteristics of irrigation water.
- Monitor the quality of water used to dissolve fertilizer and the pH stability in fertigation.
- Exclude domestic and wild animal from the proximity of irrigation water reservoirs.

Irrigation water management

- Manage the quantity of water based on the hydric balance, retention capacity and crop demand.
- Adopt the most suitable irrigation method considering the crop specificity and local environmental conditions.
- Adopt rational water usage to minimize negative environmental impacts.
- Monitor soil humidity and crop evapotranspiration.
- Control the salt level in the soil as well as the presence of pollutants.
- Prepare a detailed plan for irrigation water use, matching crop consumption and extraction potential, especially if the source is ground water.
- Use water-soluble fertilizers to avoid clogging of the irrigation system; fertilizers should also be safe and easy to handle, non-corrosive, highly pure, and shall not react with other chemicals found in irrigation water.
- Systematically perform chemical and physical analyses of the water to monitor pollutants and salt content.
- Monitor the correct amount of water based on hydric balance, soil capacity of retention and plant requirement.
- Optimize the water usage in order to minimize environmental impacts.
- Monitor the soil moisture and the crop evapotranspiration.
- Control both soil salt content and pollutant substances.
- Use only water with electric conductivity below 2.0 dS/m.
- Adopt high frequency of fertigation with small amount and low concentration of fertilization solution.
- When applying fertilizers, irrigation must be done in three time intervals.
- Split application in accordance to soil texture, nutrients, physical state and phenological phase of the crop.

- Avoid irrigation methods with high-energy demand and/or high water wastage.
- Avoid trapping in the irrigation system and improve operational safety use water-soluble fertilizers, non-corrosive, that do not react with salts and other chemicals present in the water.
- Use preferentially drip irrigation.
- Fix the irrigation system in a way that the lateral pipes crosses the major land slope.
- Space the drippers at 25 to 50 cm according to the soil type.
- Use both, reference evapotranspiration (ET_o) and the crop coefficient (K_c) to calculate the water amount. It should be done daily.
- Keep soil moisture in a level that does not block the plant transpiration.
- Before seeding, raise soil moisture up to field capacity through irrigation and keep it close to this level during the entire crop cycle.
- Keep wild and domestic animals away from reservoirs and other sources of water used for irrigation and for other pre or post-harvest operations.
- Perform systematic and periodical filter maintenance.
- If monitoring of water quality is impossible the farmer should use GAPs to minimize vegetable contamination.
- Avoid water soaked or waterlogged areas in the proximity of planting areas.
- Use only non-corrosive and soluble mineral fertilizers, that do not clog irrigation equipment and that do not react with chemicals naturally found in the water used.

Good irrigation practices reduce leaching of nutrients and soil runoff, reduce silting, salification and the contamination of water bodies. Maintenance costs are reduced.

Soil and water conservation

Water and soil conservation practices improve plant cover and diversity, reduce erosion losses and minimize silting. If they are neglected, economic losses and environmental damages occur.

- Control erosion and promote the improvement of biological soil conditions.
- Adopt erosion control practices such as contour cropping, strip cropping and others.
- Adopt integrated weed control management practices.
- Keep the diversity of plant species to favor ecological stability.
- Minimize herbicide utilization.
- Store manure and install composting areas as far as possible from drains, from water reservoirs, and from the cultivation area.
- Mechanical practices for soil conservation should strictly observe technical recommendations.
- Utilize mulching to protect soil against high temperatures and loss of humidity.
- Adopt techniques that minimize nutrient leaching.
- Avoid soaked or flooded areas close to the growing sites.
- Avoid water stress due to excess water.

Consult local technicians and/or extension agents to decide on the most suitable conservation practices.

Precautions in the use of pesticides

Pesticide regulations should be strictly observed to prevent environmental pollution and human health hazards.

Selection and handling of pesticides

- Only legally registered pesticides should be used.
- The legal rules of agronomic prescription should be followed strictly.
- Spraying should be used exclusively in areas under epidemic risk and/or when the target species reach the critical level (economic threshold level).
- Personnel in charge of pesticide application should be well trained and use Individual Protection Equipment (IPE).
- Only adults should be allowed to perform pesticide application.
- Children, domestic animals and people not directly involved, should be excluded from the area where pesticides are being handled or applied.
- Pesticides should be handled only in specially designated, safe and ventilated places.
- It is forbidden to eat, drink or smoke while handling and applying pesticides.
- Pesticides should not be applied close to water sources (streams, lakes, wells etc.) to avoid contamination.
- The water used to clean the pesticide container should be returned to the tank to be mixed with the next batch of pesticide (triple washing method).
- The handling of pesticides should follow all rules recommended by law.
- Pesticide spraying should be avoided during windy periods to reduce jet deflection.

- The product label should be read carefully and all recommendations should be followed regarding the procedure, care, withdrawal interval before harvest and the pesticide container destination.
- Do not manipulate or carry around damaged pesticide containers.
- Avoid direct manual contact with pesticides using always the original container to store or transport the chemicals.
- Avoid spillage when handling pesticides.
- After work is finished, operators should undress and bathe immediately using abundant water and soap.
- Medical assistance should be sought immediately if there is suspicion of intoxication.
- Workers involved in the use of pesticides should be submitted to periodical health check-up.
- Dosage should strictly follow technical recommendation.

Care in pesticide use is a serious matter of human health and safety because they can cause long-term ecosystems contamination affecting the health of human beings.

Pesticide application

- Children, domestic animals and people not directly involved should be kept out of the area where pesticides are being used or prepared.
- The equipment should receive periodical maintenance and calibration, using recommended method and technology.
- The maintenance and use of equipment should be well planned to be available when needed.
- The operators should be well trained and use Individual Protection Equipment (IPE) like gloves, mask, protection glasses, waterproof coat, hat and boots, according to the manual for pesticides use.

- Tractors used for pesticide spraying should have a closed cabin for the driver.
- Nozzles, hoses and valves should not be cleaned using the mouth.
- Never use leaking, uncalibrated or defective equipment to spray pesticide.
- Minors should not be permitted to work with pesticides.
- Pesticide application should be done in the cooler periods of the day and when relative humidity is lower than 60%.
- Pesticides should not be applied when winds blow at speeds higher than 8 km/hour to avoid jet deflection.
- Pesticides should not be used close to watercourses or deposits.
- Post-emergent herbicides should not be sprayed on wet plants by irrigation or other cause or if weeds and crops are under dry stress.
- Application equipment and IPE should be cleaned and washed in appropriate places far from any watercourse or reservoir.
- Operators should bathe immediately after finishing their chores.

In case of intoxication with pesticides the victim should be taken to a cool and ventilated place, undressed, taken to a hospital or medical doctor, together with the pesticide label. The victim should not drink milk because it increases the retention of the pesticide in the human body.

Storage and destination of empty pesticide containers

- Pesticides should be stored in ventilated rooms, safely locked, distant from residences, protected from rain, off limits to children and untrained persons.
- Safety rules and pertinent legislation should be strictly observed.

- Never store pesticide container close to human or animal food and close to fire sources.
- Empty pesticide containers should be washed three times (triple washing method), and sent to appropriate destruction or recycling centers.
- Never wash empty pesticide containers or equipment in water wells, streams, rivers or lakes.
- Never reuse the empty pesticide containers for other purposes.
- Never leave, store or empty pesticide containers or pesticide remains near cultivated areas or water wells, streams, rivers or lakes.

Human health and environmental quality can be seriously affected when empty pesticide containers are not discarded according to technical and legal rules.

Crop protection

Integrated pest, diseases and weed management should be preferred, utilizing cultural and biological methods whenever possible, in place of chemical methods (pesticides). Reeducation in this respect reduces costs of production, avoids contamination of people and other environmental impacts.

- Use integrated pest and disease management.
- Prefer the use of natural, biological and biotechnological methods.

Pests and diseases should be strictly monitored during the entire cropping cycle. Efficient control of weeds, pests and diseases minimizes the use of pesticides. The adoption of correct procedures assures worker health, satisfactory yields and environmental preservation.

Weed control

- Herbicides should be used only when necessary and with legal agronomic prescription.
- Maintain records of pesticide application.
- Workers involved in pesticide handling and application should be trained and use IPE.
- Herbicides should be selected based on the characterization of the weeds to be controlled, of the production site, taking into account the requirements of the market.
- Spraying equipment should be calibrated before use.
- Used containers must be disposed of in especially designated places, according to the law.
- Equipment must be cleaned after use and when moved to other cultivation fields.

- Use certified seeds with low level of impurities.
- Applications should be made in cooler periods of the day and when relative humidity is lower than 60%.
- Evaluate the efficiency of the different control methods (manual or mechanic; chemical on non-chemical)
- Whenever possible, avoid the use of highly soluble products, with high vapor pressure and with high adsorption coefficients and long half-life.

Correct weed management is important for environmental protection and for the economic feasibility of the crop.

Pest control

- Establish educational and legal mechanisms to oblige operators to follow strictly legal rules in pest control and observe IPM principles.
- Utilize only pesticides and biological products legally registered for vegetables, observing selectivity, environmental impact, food safety and Maximum Residue Limit (MRL).
- Constantly monitor the incidence and population density of both pest and beneficial insects.
- Establish an effective registration system of all activities involving the use of pesticides and other pest management procedures.
- Install a structure to monitor the climatic conditions to help in the preventive control of insect pests.
- Organize a process of continuous education of all personnel involved in IPM.
- Use only registered pesticides, legally prescribed by an agronomist.

Consult local technicians or extension agents when deciding about pest control strategies and do not use unregistered pesticides.

Disease control

- Integrate all recommendations with emphasis on cultural control.
- Use crop rotation.
- Leave intensively cultivated areas fallow for one or more growing cycles.
- Use exclusion and destruction as the first control method of any disease.
- Eliminate all infected plants during field inspection.
- Organize a process of continuous education of all personnel involved in disease control.
- Utilize only pesticides and biological products legally registered for vegetables, observing selectivity, environmental impact, food safety and Maximum Residue Limit (MRL) determined by the particular import markets.
- Establish an effective registration system of all activities involving the use of pesticides and other disease management procedures.

Preventive measures should be preferred to avoid vegetables crop diseases. Chemical control should be used only if technically necessary.

Pre-harvest treatments

The contamination of vegetables by physical, chemical or biological factors endangers the health of consumers and affects the final quality of the products.

- Respect pre-harvest intervals established for agricultural chemicals applied during cultivation.
- Clean and sanitize all installations, equipment and packing-house facilities, harvest instruments, containers and vehicles.
- Inspect the packing-house and the sites of storage for the presence of rats, birds and insects.
- Discard damaged containers.
- Waste containers should be made of adequate materials and properly labeled; if necessary, they should be constructed with impermeable materials.

Good pre-harvest practices contribute for better quality vegetable products.

Harvest

Good harvest practices contribute to wholesome vegetable produce, favor market acceptance, minimize dissemination of chemical, physical and biological contaminants, reducing health hazards for workers and consumers, and preserving the environment.

- Vegetables should be harvested in cool periods of the day.
- Clean harvest tools with chlorinated water at 100 ppm of free chlorine, before and after harvest operations.
- Remove and destroy all crop residues in the field.
- Containers and wagons should be used exclusively for vegetable produce transportation.
- Discard damaged containers.
- Use appropriate tools to cut off the fruits. Never pull off the vegetables.
- Keep 3 cm of the stalk after harvest.
- Use only containers or appropriate wagons to transport vegetables.
- Identify the loading by registering all information about the harvested area, date, time, people in charge etc.
- Do not harvest unripe vegetables.
- Remove all the visible ground and other plant residues on the vegetable before loading.
- Avoid damage to the plants.
- Prevent the direct contact of the harvest containers with the ground and avoid contamination by manure.
- Prevent direct contact of container bottom with the vegetables of the container below, when pilling up.
- Wagons used in harvest transport must be lined with rubber fabric or other materials that cushion impacts and are easy to clean with chlorinated water.

- Never transport vegetables in containers or vehicles previously used to transport pesticides, manure or garbage.
- Always keep vegetables under shade before transportation to the packing-house.

Good harvest practices contribute to better quality of vegetables and hence to success in the market.

Post-harvest

Post-harvest procedures, particularly in transport and storage of vegetables depend on the requirements of the particular market, and are essential to assure good hygiene and sanitization of the vegetable and therefore improve overall quality of the produce.

- Exclude domestic animals and pests from the packing-house and adjacent areas.
- Build all post-harvest installations in safe distance from feedlots, manure storage and other animal holding places.
- Control pests inside the packing-house.
- Isolate the area of vegetable reception in the packing-house to prevent from the circulation of unauthorized people and animals.
- Keep the area around the packing-house clean and free of contamination sources.
- Establish a program of maintenance and cleanliness for tools and installations of the packing house, registering all products, procedures and frequency of use and people in charge.
- Clean tools and other parts that have direct contact with produce.
- Use only non-toxic products like those used in the food industry. Follow the recommended dilutions.
- Implement waste handling programs.
- Wash the floor after each work day.
- Store packing materials in a clean, dry and ventilated place, above the floor.
- Promote continuous maintenance of the refrigeration equipment.
- Inspect vehicles and containers for cleanliness and disinfect before shipment.
- Monitor the cold chain from storage and transport to final destination.
- Keep samples of vegetables packed, for chemical and microbiological analyses.

- Maintain internal pedestrian walks and roadways clean and in good traffic condition.
- Systematically clean plastic containers after use.
- Install properly dimensioned packing tables for worker comfort.

Water

- Use only potable water.
- Monitor the chemical and biological quality of water.
- Maintain the level of chlorine over 100 ppm in water used for washing and sanitizing of vegetables.
- Maintain pH between 6,0 and 9,0.
- Substitute the water used every day and in shorter periods if a large volume of vegetables is being treated.
- Install countercurrent devices in water faucets.
- Install drainage system in the packing-house.

Cooling

- Periodically clean cooling systems used for the storage of fresh vegetables.
- Condensed and defrost water from evaporator type cooling systems shall not drip over fresh produce.
- Control and monitor water quality in hydro-cooling systems or systems that use crushed ice.
- Periodically clean the fans and covers used in forced air cooling systems.
- Install countercurrent devices in water faucets.

The equipments should be given proper maintenance to reduce costs and to assure good working conditions and to protect the health and the well-being of the workers.

Hygiene, safety and workers' well-being

It is fundamental to train employees to reduce the risk of chemical, physical and biological contamination of people, the produce and the work environment. The observance of the pertinent legislation avoids problems and penalties and assures a healthy workplace.

- Demand the use of long gloves, impermeable apron and mask, by those in contact with any chemical product in the packing-house.
- Store the chemical products in places specially designated for this purpose and adequately labeled.
- Keep a register of health and safety occurrences in specific files.
- Train the workers for correct handling of chemicals and for the obedience of rules of personal hygiene.
- Install a hygienic place for worker meals.
- Maintain a program for constant cleaning and assurance of sanitary supplies in hygienic toilets.
- Train the employees in good hygienic personal practices and in manipulation of fresh vegetables.
- Install appropriated places for water drinking and hand washing, inside the packing-house.
- Require observance of work safety rules.
- Require hand washing before vegetable manipulation.
- Provide all legal benefits for workers including adequate work schedule, salaries and other monetary benefits, vacations, housing, meals and transportation.
- Establish mechanisms to facilitate education for the children of rural workers according to the legislation.
- Provide periodical medical examinations to check employee health.

Cleanliness habits and adequate working conditions avoid produce contamination and reduce the incidence of health problems for personnel and consumers.

Environmental management

Environmental management in agricultural enterprises is fundamental for the maintenance of soil and water quality, for the conservation of biological resources and for the quality of life of the local population.

- Perform all activities during all phases of the work, according to the regional ecological characteristics.
- Develop activities that promote sustainable development.
- Monitor constantly the execution of plans devised to preserve the environment or correct eventual problems during the operations.
- Do not use areas of permanent legal preservation for agricultural purposes.
- Preserve watercourses, springs, lakes and other water bodies, maintaining and restoring natural vegetation with appropriate species.
- Always consult with local extension agents or research scientists to decide on best solutions for vegetable production.

Vegetable production in Brazil can provide supplementary benefits for the farmer if GAPs are used assuring better quality produce.

Technical assistance and cooperative initiatives

The adoption of GAPs with competent technical assistance and with the association of farmers in cooperatives helps regional socioeconomic development and contributes to the preservation of natural resources.

- A professional should be hired to supervise the vegetables crop from planning to marketing.
- The association of farmers in cooperatives should be stimulated mainly for machinery sharing, collective input purchase and produce sale, packing operations and management activities.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Milk
production



Author: José Renaldi Feitosa Brito, Embrapa Gado de Leite, Juiz de Fora, MG.
jrfbrito@cnpagl.embrapa.br

Co-authors: Maria Aparecida V. Paiva Brito, Embrapa Gado de Leite, Juiz de Fora, MG.
mavpaiva@cnpagl.embrapa.br

José Ladeira da Costa, Embrapa Gado de Leite, Juiz de Fora, MG.
ladeira@cnpagl.embrapa.br

Luciano Patto Novaes, Embrapa Gado de Leite, Juiz de Fora, MG.
novaes@cnpagl.embrapa.br

Aluizio Torres Campos, Embrapa Gado de Leite, Juiz de Fora, MG.
atcampos@cnpagl.embrapa.br

John Furlong, Embrapa Gado de Leite, Juiz de Fora, MG.
john@cnpagl.embrapa.br

Edna Froeder Arcuri, Embrapa Gado de Leite, Juiz de Fora, MG.
edna@cnpagl.embrapa.br

Antônio Cândido C. Leite Ribeiro, Embrapa Gado de Leite, Juiz de Fora, MG.
candido@cnpagl.embrapa.br

Rodolpho Almeida Torres, Embrapa Gado de Leite, Juiz de Fora, MG.
rotores@cnpagl.embrapa.br

Carlos Renato Tavares de Casto, Emater-MG.
crtcasto@zipmail.com.br

Introduction

The success of the dairy industry depends on the eating habits of the population. These habits are influenced by the favorable image of dairy products usually associated with safety, quality and flavor. Dairy products must be palatable and appetizing, packaged and merchandised in an attractive manner, and sold at an attractive price.

Milk and milk products are rich in protein, calcium, vitamins, and milk sugar and they provide these nutrients in proper balance and at a reasonable price. These nutrients are usually not entirely available from other sources and if so, they are usually more expensive. At the same time, milk and milk products are perishable foods, being easily contaminated by microorganisms that can alter their nutritional, sensorial and technological characteristics. In addition, some microorganisms may pose a threat to human health. Milk can also be contaminated on the farm, intentionally or not, with water, veterinary drugs like antibiotics and disinfectants, pesticides and mycotoxins, among others.

The concern to meet quality demands by dairy product consumers must begin on the farm. The dairy farmer plays an important role on the quality of raw milk, which is fundamental for the industrial processing and shelf life of the products.

Dairy cattle are kept on nearly 1.2 million farms in Brazil. Production on a commercial scale involves approximately 400,000 dairy herds. Small herds, with crossbred cows, which are usually milked by hand, characterize most of these farms. However, the major part of the milk production is originated from larger herds, with a predominance of specialized milking herds, intensive use of inputs, milking parlor with mechanical milking, cooling system for storage and transport from the farm to the dairy plants. It is estimated that the whole dairy industry is responsible for approximately six million jobs.

This document has been prepared having in mind the production of milk predominantly based on pasture utilization, supplemental feeding when necessary, use of mechanical or hand milking, from crossbred or purebred cows.

The Good Agricultural Practices (GAP) here presented are a set of activities to be performed on dairy farm, including activities associated to the health, well-being and safety of the farm workers. They favor the processing of healthy products, a sustainable environment, besides adding value to the milk produced by small, medium and large dairy farms. These practices are the basis for other incentive programs aimed at improving the quality of products, sponsored on a global scale like Hazard Analysis and Critical Control Points (HACCP). GAPs support programs to promote agricultural certification. The adoption of GAPs is crucial to maintain the acceptance of dairy products by the market and to assure the success of each farmer and therefore of the whole industry.

The GAP here recommended consider the different dairy farming systems adopted in Brazil, from subsistence farming to the most technically sophisticated ones. Those GAP should respect the environmental and labor legislation as well as the Children and Adolescent Statute, and the ethical principle of equal opportunity pay for all types of rural labor.

Selection of the production area

Milk is produced in any point of the Brazilian territory, as long as environmental laws (legal reserves) are respected. This includes the exclusion for productive purposes of the legal ecological reserve area in each farm and the areas of permanent preservation designated by the government. The adequate selection of the area is essential for the success of milk production. Planning is essential and mistakes in this selection bring forth economic losses, environmental damages and will negatively affect final product quality.

- Observe current legislation concerning legal area reservations.
- Observe minimum required distances from watercourses, to preserve fringe forests.
- Protect flora and fauna.
- Preserve the forests next to watercourses.
- Observe agricultural zoning maps.

Soils

- Survey the physical, chemical and topographical conditions of the land.
- Use areas according to their agricultural aptitude.
- Maintain or improve the soil organic matter using pasture rotation and appropriate equipment and conservation practices, with emphasis to zero-tillage.
- Maintain the soil cover to minimize the erosion losses by runoff and other causes.
- Apply pesticides and organic or inorganic fertilizers when necessary, in doses recommended by the specialists or the Extension Service Agent.

Water

- Survey the water resources, their spatial distribution in the farm and their suitability for use in cattle and crop production.
- Protect water ponds and lakes.
- Protect against pollutants in rivers, water tables and springs.
- Monitor water quality periodically.

Animals

The selection of the animals is crucial for the success of the dairy enterprise. Animals in production should be supplied with quality food and water, a comfortable and safe environment, freedom of movement, protection against stress, diseases and unnecessary injuries. Neglecting these principles can result in production losses, yield reduction, health problems and economical losses.

- Use bulls and cows with acceptable genetic merit for your production standards.
- If buying animals, do it from herds with good records of management and sanitary control, adapted to the particular production system and fitted to market requirements.
- Use only animals from genetically selected herds with strict sanitary control.
- Keep good records registering all acquisitions and sales of animals, acquisitions of food, semen, breeding programs, losses and discards, feeding plans.

Facilities and equipment

Facilities should be planned according to the particular production system adopted (extensive, semi-extensive and intensive), the size of the herd, the expected yield, the climate, the feeding system, the type of facilities, meet official regulatory laws and the specific demand of the dairy processing plant. Non-observance of these principles can affect the economic feasibility of the enterprise and increase vulnerability for sustainability.

Planning the housing system, equipment and other resources

- Consider the need for the following facilities: barns, covered feed bunks, milking parlor, milk room, cleaning/washing system, one or more feeding areas, storage shed, transportation system between storage and feeding areas, manure and other effluent treatment system, corrals and rest paddocks, maternity and treatment areas, artificial insemination area and calf and heifer management facilities.
- Evaluate the infrastructure of the farm considering the natural resources and the watershed where it will be located.
- Consider water quality and plan to use 100 to 200 liters/cow/day.
- Economic feasibility should be assessed on the market basis for inputs and sales.
- Evaluate the production system considering the availability of feed, animal comfort and health of the animals.
- Housing should be planned according to herd size, feeding system, housing type, manure handling type and the working conditions, which traffic and feeding alleys to promote quick and easy movement of cattle materials, and consider future expansion plans.
- The production system should be compatible with the management capacity of the farmer.

- Availability and qualified working force (labor) is an important factor.
- Health legislation and official specifications related to production, housing and disposable wastes must be observed.
- Assure sufficient feed bunk space to avoid competition of the animals for feed.
- Feed troughs for mineral feeding located in pastures should be covered to avoid losses caused by rain, and located in a place where animals go through at least once a day.
- The working environment should be adequate to satisfy the needs of workers to enhance productivity and allow proper equipment performance.
- Traffic and feed alleys should be designed to promote quick and easy movement of cattle and materials.
- Avoid funneled and narrow alleys, steps and slippery floors, to prevent accidents that may cause serious injuries to animals.
- Housing should assure enough space for animal, easy access and good ventilation for animal comfort.
- Electricity should be available to attend the total farm needs.

It is essential to observe the official sanitary code.

- Water tanks should be located in high places for distribution through gravity.
- Assure properly localized drinking water facility (tanks or automatic water bowls), in safe and clean places, surrounded by compacted gravel.
- Localize water supplies in different pastures preferably in the crossings of fences, to serve various pasture divisions.
- Design adequate structures for storage and/or feed processing based on the adopted feed management scheme (silage, hay or concentrate feed).

- Silos should be located close to the feeding place.
- Design the manure handling system (treatment and storage) complying with the environmental legislation.
- Consult a specialist about the choice of the best manure management system with minimum environmental risk.
- Manure should be managed to reduce odors, control flies and assure the safety of people and animals.
- Water and cleaning agents from the milking parlor and milk room should not be mixed with manure and the organic matter.
- Follow the soil support capacity in relation to nutrient absorption and to the rate of decomposition of organic matter.
- Assure maximum thermal comfort for three cows inside the buildings. Under tropical and subtropical conditions, locate the building in an east-west direction.

Animals should be provided with comfortable conditions, space and protection; a clean, dry, ventilated area to avoid diseases. Promote the hygienic milk production assuring consumer health and environmental safety improving the competitiveness of dairy products.

Calf housing

- House calves in individual pens or stalls during the first six to eight weeks.
- Provide a clean, dry, draft-free environment for the newborn calf.
- Design facilities for easy cleaning and sanitizing, and follow a regular and frequent cleaning up schedule.
- Provide plenty of feed and fresh water.
- Handle weaned calves in groups, with a minimum of 2.50 m² per animal.

Pens and paddocks for bulls

- Construct solid sheds, with internal divisions, fences and reinforced feed bunks allowing easy feeding, cleaning and access to cows in heat.
- Design the pen to conduct all managing operations from the outside, avoiding the risk of being injured by the bull.
- Use well-bedded pens with bedding such as sand, straw or other material, and change it frequently.
- Have an exercise paddock (80 to 100 m²) adjacent to the pen.
- Install an electric fence around the exercise paddock to increase herdsman safety when managing bulls.

Adequately designed bull pens are a factor of worker safety.

Corrals

- Locate the corral in a central position as related to farmstead and pastures, on firm, dry land.
- A layer of compacted gravel helps to keep cleanliness and cow comfort (prevent mud or dust formation).
- Area per cow should be of 6 m², and may vary from 2 to 10 m², depending on the size of the animals and on how long they will remain in the corral.
- Divisions should be constructed of boards and wooden posts, steel cables or galvanized tubes.
- Avoid slippery floors, splinters in wood structures, protruding hardware, or any hazardous element that may hurt the animals.

- Pasture fences should be in sections of about 200 m (maximum of 300 m) and electrically grounded, to reduce risk to people and animals of accidents by lightning.

Corrals should be maintained clean and dry to avoid health hazards for animals.

Holding area

- Provide an adequate area for keeping cows clean and dry before milking.
- Allow an area of 1.25 to 1.70 m² per cow, depending on the breed and size of the animals.
- Use concrete floor or other durable nonskid material with a slope of 2% to 3% for good drainage and easy cleaning.
- Maintain the cows in the holding area for a maximum of 60 minutes before milking.
- The holding area should be shaded and well-ventilated.

Less stressed animals, comfort, convenience and safety for workers in a farm, will guarantee better productivity.

Milking parlor

- Design a milking parlor for maximum efficiency without overlooking comfort of milkers and good milking practices (easy access to the udder to facilitate the cleaning and sanitizing operation of the teats, and to the milking equipment).

- Consult a specialist to design the parlor to fit needs but allow for possible expansion.
- Consider initial and maintenance costs, number of cows to be milked, speed of milking and technical assistance for maintenance.
- Training of employees will increase labor efficiency and increase profits.

Milk center

- Observe official regulations.
- Design the building with adequate lighting, ventilation, waste disposal and water supply, with floor, walls and ceiling made of impermeable materials for easy cleaning.
- Have windows with ventilation flaps and insect screens.
- Keep place clean and dry.
- Have hot and cold water supply available for cleaning, sanitizing and disinfecting milking machinery and all equipment.
- Locate the milk center close to the milking parlor with enough space considering that size and type of milk tank, compression location, and kind of washing and milk handling equipment affect milk house dimensions.
- Space should be sufficient to accommodate all milking utensils and equipment, which should not have direct contact with the floor.
- A sink should be available to wash the utensils and milking equipment and a larger tank to clean bulky items.

Cleanliness in the milking center is fundamental for the quality and wholesomeness of the final product.

Other facilities

- Include an area for treating sick cows or other special care, considering the proportion of one pen holding three animals (3.60 x 4.20 m) for 100 lactating cows, with easy to clean feeding trough and water fountain.
- Include an area for artificial insemination, pregnancy check and other exams.
- Separate a maternity area away from the young calf housing. Plan one pen of 3.60 x 3.60 m or 3.40 x 4.20m for each 25 cows.
- Maternity area should have a bedded area, feed bunks and fresh water supply. Paved floor should not be slippery.
- Provide a loading chute for receiving, holding and shipping cows.
- Provide a loose housing resting area for heifers and dry cows with an area of 5 to 6 m² per animal.

Buildings and equipment for dairy production must be designed and planned to prevent damages to the environment and to assure animal and human well-being.

Forage production

Pastures are the main source of feed for dairy cattle. Adequate establishment and/or renovation procedures are a determinant factor for profitability and environmental preservation. Conserved forages as silage, hay or haylage are important for a twelve month dairying plan.

Establishment and recuperation/renovation

- Establish pastures preserving the soil, water springs and water courses, bird and other wildlife.
- All farms need to have preserved natural vegetation according to current environmental regulations.
- If necessary to eliminate native vegetation, do it according to environmental legislation.
- Keep trees and wooded areas to provide shade for the animals.
- Control weeds, ants and termites.
- Use adequate soil conservation procedures.
- Renovate degraded pastures with grass or legumes species adapted to local soil conditions (fertility, texture and moisture), to the topography, climate and system of management.
- Use species with higher forage production potential which suits your management level.
- Choose forage species adapted to the local environment, to soil differences in the farm, to promote diversification of pastures and forage crops.
- Use fertilizers according to physical-chemical analyses of the soil and demands of the forage species.
- Prepare the soil adequately and use soil conservation practices, according to the topographical characteristics.

- Use only certified seed in quantities recommended by specialists.
- Use grass-legume associations whenever possible.
- Plant according to technical recommendations.
- Whenever possible, integrate cropping activities with animal production (agro-pastoral systems).
- Annual maintenance fertilization should be done during the rainy period (split in at least three parcels), after the animals have been moved from the particular pasture.
- Soil analyses defines the fertilizer dosage for a particular forage specie.
- Monitor pasture productivity considering the carrying capacity (heads per hectare), forage yield and land productivity (kg milk/ha/year).

Consult local technicians for the definition of the most suitable practices for pasture establishment and management.

Pasture management

- Use rotational or alternate grazing allowing periods of resting and utilization.
- Adjust grazing pressure to carrying capacity of the pastures, avoiding over or undergrazing, soil exposure and poor use of the dry matter produced.
- Supplemental forage is needed for normal practice of pasture management.
- Whenever using chemical weed control, it must be carried out observing the manufacturer's recommendations, and use of Individual Protection Equipment (IPE).
- Clean out weeds from the pastures and replenish nutrients periodically.
- Use agro-pastoral systems whenever possible.

- Fire should not be used as a continuous management tool and without a good control plan.
- Be sure that pesticides and their containers do not contaminate soil and watercourses.
- Follow legal prescriptions to handle, apply and disposal of empty pesticides containers, including the triple washing method.
- Only well-trained workers using IPE should be allowed to handle and apply pesticides.
- Pesticide application equipment should comply with safety and maintenance recommendations.

Human health and environmental quality may be negatively affected by pesticide containers discarded without observance of the pertinent technical recommendations

Pasture division

- Pastures should be divided according to the number of categories of animals in the herd and to the management system.
- Keep different categories of animals in different pastures.
- The number of paddocks is dependent on grazing time and pasture resting period, and is calculated by the formula: $\text{number of paddocks} = \text{resting period} / \text{grazing time} + 1$.
- Electric fences are recommended whenever possible.
- High yielding species should be used for lactating cows and other categories with high nutrient requirements.
- Management practices like carrying capacity, available forage will assure adequate soil cover, species persistence, land and animal yielding.
- Irrigation will improve forage production and pasture use in specific situations.

Supplemental pasture feeding program should be planned based on the local soil and climate conditions, and in accordance with a twelve months forage use.

Feeding the herd

An inadequate feeding program affects the whole milk production system and impair animal performance as concerns growth and/or milk production reducing the competitiveness of the business.

- Design a feeding program to assure enough forage and concentrate supply to meet the animals' requirements for maintenance and production.
- Keep updated records of the feeding program.
- Supervise animals regularly to be sure of their well being both in pastures and in the corrals.
- Provide clean and fresh water all times.
- Provide mineral salts in weather protected troughs (covered feed mangers).
- Forage crops like sugarcane, elephant grass, maize, sorghum and others grass species for cut-and-carry forage or making silage, hay or haylage to supplement pasture deficits in the critical seasons.
- Herd size, daily consumption, supplemental period, and forage yield will determine the needed area to produce the total forage.
- Use protein and energy feed supplements to optimize animal performance.
- Provide animals with mineral supplement *ad libitum*, at all times.
- Use only ingredients approved by the Ministry of Agriculture, Livestock and Food Supply to prepare concentrate mixtures.
- Use good quality (free of fungi and pesticides residues) ingredients to mix concentrate feeds supplements.

Shelter, space, food and water are essential elements for yield and profitability of dairy herds.

- Store supplements protected from humidity, rodents and possible contaminants.
- Do not use products of animal origin as feed.
- Do not use antibiotics, hormones, additives or any other chemical products as feed without technical assistance.
- Use ionophores and other growth promoting substances observing legal and technical recommendations.
- Manage pastures during the rainy season in order to get good yields from forage and animal performance.
- Stockpiling grass (*Brachiaria spp*) species should help in some regions.
- The amount of forage to be deferred should be 2.0 to 3.5 times of the expected intake.
- Choose forages based on their ability to retain leaves.

The use of ionophores and other growth promoting substances must observe governmental regulation.

Herd health and production management

Animal health is maintained by permanent attention to herd management and to housing conditions, by the immediate identification and treatment of diseases, by following a strict schedule of vaccination and other preventive health care procedures. The neglect of these requirements results in deterioration of the well-being of the animals, reducing yields, causing economic losses and environmental hazards.

General management of the dairy herd

- Identify and record the origin of all animals introduced in the production system.
- Supervise regularly the productive and reproductive performance of all animals.
- Learn to recognize the symptoms of prevalent diseases in the region to be able to adopt prompt measures of control.
- Observe the animals in lots to facilitate the identification of those which present signs of debilitation or sickness.
- Get familiar with the use of a thermometer to evaluate the temperature of the animals, which is normally between 38.5 and 39.5°C.
- Maintain all medicines and vaccines under the conditions recommended by the manufacturer, especially in relation to temperature, expiration date and mode of administration.
- Strictly observe the vaccination schedule, de-worming, tick treatment and other strategic treatments as recommended by technical assistance.
- Test the herd yearly for tuberculosis and discard sick animals.
- The introduction of any animal in the herd should be conditional to negative results in the tuberculosis and brucellosis test.

- Newly purchased animals should be maintained in quarantine, before contact with the rest of the herd.
- Deworm young animals up to two years of age.
- Deworm adult animals only if surges of infestation occur.
- Consider climate variations when planning worm prevention programs.
- Concentrate deworming in the period of low worm population in pastures, which varies between regions and seasons.
- Do at least three consecutive deworming applications in the selected period preferring the beginning, the middle and the end of the period of low worm population, repeating one application in the middle of the subsequent period (high population period).
- Consult the local veterinarian to define the product, the use and the most efficient and economic dosage of anti-parasitic medicine.

The veterinarian plays an important role in the definition of health programs for the herds.

- Avoid the contact of animals with remnants of anti-tick chemicals or from other treatments, and prevent the contamination of the water table, springs, rivers and lakes.
- Ask the local veterinarian for specific information on the strategy to be used.
- Wet completely the animal body when using contact products.
- Use only chemical products of the same family or chemical group during a minimum period of two years. After two years change to a different chemical group.
- Conduct tick sensibility tests when choosing a new product.
- Control grubs in highly infected animals by spraying specific chemical drug on the site of the grubs.

- Ask the local veterinarian for specific strategic control measures.
- Adopt measures of self-protection using protection equipment.
- Dispose of all recipients and the chemical leftovers of antibiotics, antihelmintics, tick and grub control products, together with their packages, syringes and needles in a proper manner, following the official norms and the manufacturers recommendations.
- Avoid the accumulation of feces and urine in the entrance of stables, cleaning these areas frequently.
- Observe animals regularly to identify early cases of foot rot for prompt treatment.
- Prevent the disease by using a box deep filled with five percent copper sulfate and formalin placed where the cows will be forced to walk through it at milking time.
- Treat infected animals by scraping the sore and saturating the foot with proper medication.
- Keep infected animals in dry places until they are cured.
- Perform yearly feet monitoring to detect abnormal processes.

An efficient milk production system requires the maintenance of the animals in good health during all phases of production.

Calf management

- Feed the newborn calf within 15 to 30 minutes after birth with 1.5 liters of colostrum milk.
- Disinfect and squeeze out the navel cord and paint the navel with iodine or other suitable antiseptic to avoid infection, within two hours after birth. Repeat this 12 to 18 hours later.
- Tie the navel off with a piece of cotton or linen thread, if it is bleeding. Dip the thread in 70% alcohol before use.

- Leave the newborn calf with the dam during the first 24 hours, or feed it by bottle.
- Milk out the colostrum and feed the newborn by bottle after 24 hours.
- Give colostrum or transition milk after two or three days.
- Apply fly repellent in the navel area, if there is high incidence of flies.
- Dehorn using chemical paste, until 30 days of age.
- Raise calves in individual pens, or group pens, or free in an adequate paddock.
- Keep pens clean, dry, well-illuminated, adequately bedded and well-ventilated.
- Clean and disinfect calf pens at regular intervals, using officially recommended products.
- Wash all utensils used to feed calves after each feeding.
- Avoid food competition at the group pens, by providing sufficient feed bunk space.
- Wean abruptly at 56 days, when the calves are consuming more than 800g/day of concentrate.
- Transfer calves from pens to paddocks at 70 days of age.

The improper use of chemical products can contaminate soil and water, causing environmental hazards to animals, workers and consumers.

Heifer feeding

- Group animals according to age and size to avoid competition and for ease of handling. Form a group with those of 2 to 4 months and another with those of 4 to 6 months, the younger group in paddocks close to the barn.
- Reserve at least two paddocks for each group. Rotate between them.

- Assure that each paddock has good quality pasture and facilities for feeding concentrate and forage.
- Provide hay for the calves until 4 months of age.
- Provide covered feedboxes for the supply of concentrate and roughage, located at the fence line each serving two paddocks.
- Supply concentrate (1 to 2 kg/animal/day), according to the quality and availability of pasture and the daily weight gain.
- Maintain females from 6 to 12 months in pastures until they reach 330 kg, supplementing with concentrate (1 kg/animal/day). In the dry season provide a supplement of sugar cane with 1% urea and ammonium sulfate in addition to the concentrate.
- Transfer females that reached 330 kg to the group of pregnant heifers, in paddocks near the barn or, if in small numbers, near lactating cows to facilitate observation of heat and insemination.
- Inseminate heifers with good quality semen, following technical recommendations.
- After pregnancy is confirmed, transfer them to the group of dry cows and pregnant heifers.

Dry cows and pregnant heifers

- Keep dry cows and pregnant heifers on pasture.
- In the dry season, provide roughage (cane + urea) in feedboxes located at the pasture, depending on the condition of pastures and the state of development of the animals.
- Transfer cows two months before calving to a maternity paddock, located near the barn to facilitate assistance during delivery.
- Maintain the maternity paddock always clean and dry.

Lactating cows

- Separate lactating cows in three or four groups, with an equivalent quantity of animals, according to lactation stage and with their milk output (low, medium low, medium high and high).

- Feed primiparous cows until 90 days after calving the same ration given to the higher production group.
- Feed all other fresh cows the same ration given to the higher producers, until 30 days after calving.
- Reserve the best pasture to the most productive cows.
- Allow the access of cows to pasture all year long; during the dry season, provide corn silage (to cows of medium and high production) or sugar cane plus urea for the remainder. Cows should stay in pastures during the night between milking times.
- Feed cows in groups (3 or 4) based on the lactation period and milk production, or individually, according to the herd size.
- Feed concentrate immediately after milking to assure that cows remain standing as long as possible.
- Feed concentrate in groups, according to the individual milk production at 1 kg of concentrate for each 3 liters, approximately.
- Give a mixture of concentrate and roughage, after milking, in the dry season.

Planning timely the feed supplementation during the dry season assures additional income in dairy farming.

Care of the cow at calving time

- Provide a safe, dry and comfortable environment and adequate feed for the female at calving time.
- Place cows on a maternity paddock near the barn to facilitate daily observation, two months before calving.
- Provide good pasture and easily accessible clean drinking water.
- Do not allow other animals near the pregnant females at calving time.

- Vaccinate against pneumoenteritis one month before calving.
- Provide supplementary feed to assure adequate production of colostrum and milk and the return of heat shortly after delivery.
- Observe the udder to detect abnormalities like edema. Milk the cow in case of severe swelling of the udder before calving. Save (freeze) the colostrum to feed the newborn calf or use it to feed other calves.
- Observe the cows closely in the maternity paddock, at least twice a day, in the morning and in the afternoon to allow emergency assistance if necessary.
- Help carefully the cow if it has difficulty to deliver. Wash and disinfect hands before.
- Utilize only clean and disinfected instruments.
- The delivery should take place in a dry and clean environment (maternity pen).
- Clean and disinfect the place after delivery.

Constantly monitor the incidence of diseases in the region and adopt the protection measures for the herd.

Milking and after milking management

The adoption of good milking practices contributes to improve milk quality, yield and competitiveness.

Cleaning and sanitizing of the milking parlor

- The milking parlor should be properly built and kept clean and dry.
- Adequate volume of good quality water should be provided.
- Walls should be smooth for easy cleaning and disinfection.
- Clean the milking parlor after milking, by removing organic matter (feces, urine, milk) and paper towels used to dry the teats and hands.
- Wash floors and walls using pressurized water and a broom or brush.
- Disinfect the milking parlor monthly. If a disease occurs disinfection must be done immediately. Before applying the disinfectant clean the room, wash and drain the water carefully.

Milking

- Conduct cows to the milking room calmly and without routine changes.
- Perform milking in a clean and dry room.
- Organize the milking line in order to always first milk heifers and the healthy cows, and last the older cows and the ones that have had mastitis or the ones that present sub-clinical mastitis.
- Clean and dry cow teats before milking.
- Check for observable abnormalities in the udder (pain, with little or no heat or swelling) and the foremilk.
- Strip out foremilk (first three jets) and look for the presence of flakes, clots, or watery appearance. If the milk presents such signs it is a sign of clinical mastitis.

- The altered milk must be discarded.
- Separate and treat sick cows according to a veterinarian prescription.
- Make sure that milkers are in good health, have good hygienic habits and are well-trained.
- Clean and wash the teats if necessary. Pay special attention to teat ends to assure they are clean. Use a hose with low pressure.
- Dip teats in a safe and effective disinfectant before milking (optional). The disinfectant must contact the entire teat surface for 30 seconds.
- Dry teats thoroughly, using one disposable paper towel per cow.
- Start milking within one minute after udder preparation and finish milking in about 5 minutes.
- Milk each cow calmly, completely and without interruptions.
- Attach the milking unit to the teats with minimal entrance of air.
- In case of hand milking, protect the milking bucket from dust coming into the milk.
- Check milk flow and adjust milking unit as needed. Do not leave a milking unit squawking. Do not over-milk.
- Shut off the vacuum in the milking unit before detaching the teat cups from the teats.
- Dip teats immediately after milking in a safe and effective disinfectant. The disinfectant must contact the entire teat surface.
- Discard residual teat dip solution and wash the teat dip applicator after every milking.
- Keep the cows standing up right after milking by providing fresh feed.
- Clean utensils and equipment after each milking, following the manufacturer recommendations.
- Clean the milking parlor after each milking.

Mechanical milking

- Perform equipment maintenance following the manufacturer recommendations for daily, weekly, monthly and annual maintenance.
- Train the milker on hygienic practices and how to use the milking machine.
- Circulate good quality warm water, at temperatures of 40 °C to 45°C immediately after milking the last cow, in order to eliminate all the remaining milk.
- Circulate alkaline detergent in hot water (70°C to 80°C). Rinse the equipment with warm water (40°C).
- Wash with acid solution (35°C to 45°C) for five minutes. Rinse with warm water allowing a complete drainage of the system.
- Use only chemical products specific to clean and sanitizing milking machines, following technical cleaning recommendations.
- Visually inspect the equipment to detect any residue or deposit on the surfaces.
- Verify if the exit valve is clean and if all water has been drained, repeating the cleaning operation if necessary.
- Sanitize the equipment 30 minutes before milking, with an appropriate product for about three minutes. Allow the sanitizing agent to drain.

Hand milking

- Follow the same recommendations given above, relative to milking parlor cleanness, hygiene and management of the animals.
- Use stainless steel semi-covered buckets for milking.
- Milk cans should be in good keeping, clean and sanitized
- Filter milk with stainless steel or plastic filters. The filter must be clean and sanitized.

- Clean buckets and cans immediately after finishing milking as follows:

- Rinse with warm water.
- Brush the surfaces with a detergent solution.
- Rinse with water. Drain well.

- Wash all utensils with acid solution once a week.

- Keep the buckets upside down on a clean and dry place.
- Keep the cans clean and closed when not in use.
- Wash cans and buckets with hot water (minimum of 80°C) or use a sanitizing solution (as sodium hypochloride at 200 ppm) just before using the utensils again. Allow the sanitizer to drain.

In mechanical as well as in hand milking, hygiene and cleanliness are essential factors for quality milk and to minimize health hazards to the consumer.

Milk storage in the farm

- Perform the bulk tank maintenance following the manufacturer's recommendations.
- Use only chemical products specific to clean and sanitizing the bulk tank following the manufacturer's recommendation.
- Cool milk immediately after milking to temperatures below 4°C.
- If the milk is sent to a common bulk tank, the existing regulations for time and procedures must be followed.
- Clean the bulk tank as soon as milk is collected, following the steps bellow. These steps may be altered to fit the manufacturer's recommendations.
- Rinse with warm water at 40°C to 45°C until the runoff water is clean.

- Wash with alkaline detergent solution with a minimum temperature of 50°C and maximum of 75°C for ten minutes. The total volume of water to be used must be sufficient to ensure contact between the detergent solution and the equipment. Scrub all the surfaces, the mixer, the lid and all components with a specific brush.
- Rinse with warm water.
- Check that the valve is clean and that all water is drained.
- Wash with acid solution once a week.
- Sanitize the equipment before using it with an appropriate sanitizer 30 minutes before milking, for at least 3 minutes. Allow the sanitizer to drain.

Preventing milk contamination by veterinary drugs and other chemicals

Precautions about the sanitary quality of milk are foremost in any dairy production.

- Use only drugs recommended by a veterinarian.
- Read the label instructions carefully before the drug administration.
- Follow the label directions and use the drug only for what it is allowed.
- Observe the withdrawal times stated on the drug labels.
- Use the correct dosage for each animal.
- Do not use antibiotics recommended for the dry period on lactating cows.
- Identify all treated cows with ribbons, bracelets or collars and milk them separately.
- Discard milk from all four quarters of a treated cow even if drug has been used only in one quarter.
- Establish a treatment schedule for lactating cows.
- Avoid the use of more than one antibiotic in the same treatment unless recommended by a veterinarian.
- Do not treat subclinical mastitis during lactation, unless prescribed by a veterinarian, and discard the milk.
- Establish a preventive mastitis control program.
- Keep a written record of all treatments, including date of treatment, why cow was treated, drug used, withholding times, and who administered the treatment.
- Follow rigorous hygiene precautions in intramammary use of antibiotics adopting following steps:

- Clean, dry and disinfect teat ends before administering the drug.
- Insert the cannula tip into the teat end by approximately 3 mm.
- Discard used cannulas in a safe place preventing their reutilization.

The dairy farmer should observe sanitary legislation and the recommendations of the veterinarian.

Hygiene, safety and workers' well-being

Satisfaction of all personnel involved in the management of the property, their welfare and of their families are fundamental for maintaining the competitiveness of the production system. All principles, laws and regulations regarding hygiene and safety during any operation related to dairy production must be followed, in order to avoid any health hazard to the workers or to consumers.

- Treat employees with respect and dignity.
- Offer befitting housing to employees.
- Observe work legislation.
- Observe social obligations including the provision of schooling for all children.
- Provide periodical training to employees.
- Build safe facilities.
- Supply protection equipment and wear to assure safety to all employees.
- Pay just and satisfactory salaries to promote the well-being of workers and their families.
- Reward deserving employees with a percentage of profits.
- Do not employ child labor.
- Employ only well-trained staff and operators and retrain them as required.
- Make sure all safety rules are observed during the operations.
- Monitor frequently the health status of all workers involved with agricultural and processing operations.
- Keep records related to health and safety properly filed.

- Workers involved in the manipulation of pesticides should be adequately trained and use IPE, strictly observing all hygienic and safety rules.
- Provide safe transportation and adequate installations for feeding and for personal hygiene for staff and operators.
- Observe the Brazilian labor laws, including wages and fringe benefits, housing, education, nutrition, school, transportation, holidays and other rights.
- Qualify the employees in good practices of personal hygiene.
- Guarantee compatible work schedules for agricultural activities and workers' well-being.

The human element is the most important factor in the animal production system. Hygiene habits and good work conditions minimize health problems for workers and for consumers.

Environmental management

All environmental protection legislation should be strictly observed in all stages of dairy production.

- Respect the Brazilian legislation regarding protection of springs, and watercourses such as rivers, creeks, lakes and similar.
- Develop agricultural activities according to the regional ecology parameters.
- Production activities should always promote sustainable development.
- Planning should have in mind the prevention and correction of environmental non-conformities in any stage of production or processing.

Dairy production in Brazil can guarantee supplemental income to farmers if good agricultural practices are followed contributing to better quality products.

Technical assistance and associative initiatives

It is important to integrate efforts of the different actors either governmental or private, in order to improve social organization (associations, cooperates, experiences groups) of small and medium dairy farmers for an adequate insertion in the market.

- Technical assistance is important in dairy farming, from planning to commercialization.
- Farmers should be stimulated to organize cooperatives, to benefit from larger scale of common operations, specially input purchase, sale of the production, technical assistance and business management.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Mango production



Author: *Joston Simão de Assis, Embrapa Semi-Árido, Petrolina, PE.*
joston@cpatsa.embrapa.br

Co-authors: *Maria Auxiliadora Coelho Lima, Embrapa Semi-Árido, Petrolina, PE.*
maclima@cpatsa.embrapa.br
Guy Self, CIRAD — FLHOR.
guyself@cpatsa.embrapa.br

Introduction

Brazil is the seventh world mango producer. In 1996 total volume of production was of 763 thousand tons in an area of 63.000 hectares. The Northeast provides 51% of the total production. 82% of the exported fruit is produced in the Petrolina/PE — Juazeiro/BA area, generating an income of US\$ 28.6 million. The most important problems of mango production are the inadequate use of pesticides, low technology level among small and medium size producers, insufficient training of laborers in all aspects, from production technology, to harvest and post-harvest procedures as well as in personal hygiene, safety and labor rights.

Good Agricultural Practices are procedures that improve conventional methods of production, beginning with the choice of the cultivation areas reaching until post-harvest procedures with emphasis in the health, well-being and safety of workers. They aim at healthy products and at the preservation of the environment promoting the addition of value to the products of small, medium and large farmers. These practices are the basis for other programs of stimulus to quality improvement, like the Hazards Analysis and Critical Control Points (HACCP) or for programs of promotion of agricultural certification such as Integrated Fruit Production and other international protocols for quality certification.

The topics presented in this outline of Good Agricultural Practices (GAPs) such as choice of the cultivation area and soils, fertilization, irrigation, soil and water conservation practices, integrated pest and disease management, pre and post-harvest procedures, hygiene and safety, are a combination of theoretical principles and practical procedures that constitute important information to mango producers of any scale, about forms to improve environmental conditions (social, economic and ecological) in the productive sector to attain adequate standards of sustainable production, worker well-being and consumer safety. The described practices help the environmental planning and management of farms and may be rapidly incorporated into the existing production routines.

The GAPs here recommended consider the different cropping systems adopted in Brazil, from subsistence farming to the most technically sophisticated ones. Those GAPs should respect the environmental and labor legislation as well as the Children and Adolescent Statute, and the principle of equal pay for all types of labor.

Selection of the cropping area

Mango may be planted in any point of the Brazilian territory, as long as environmental laws are respected. The legal ecological reserve area in each farm and the areas of permanent preservation designated by the government should not be used for productive purposes. The adequate selection of the area is essential for the success of mango production. Mistakes in this selection bring forth economic losses, environmental damages and will negatively affect final product quality.

When selecting the cropping area, the mango producer shall be assured of the existence of appropriate infrastructure (electricity, water supply, roads etc.), compatibility of soil and climate for the mango crop and the market, as well as availability of labor.

A business plan should be prepared beforehand to provide elements for a realistic preview of the intended business.

Selection of the cultivation site

The selection of the cultivation site is an important phase in the establishment of a mango crop. Planting in inadequate sites will affect costs, cause environmental damages and negatively affect the quality of the final product.

- Deep soils, not subject to soaking, with a sandy to medium texture with low content of soluble salts should be preferred.
- Avoid areas subject to flooding (hydromorphic and poorly drained alluvial soils) unless preliminary drainage is made.
- Soils should be of a close to neutral pH and base saturation near 80%.
- Do not cultivate mango in soils with slopes of more than 8%.

Mango cropping in soils with good fertility and adequate physical characteristics favor the development of a healthy crop, facilitates cultivation and minimizes the risk of soil degradation.

Seeds and seedlings

It is essential to choose seeds and seedlings well adapted to the region and to the objectives of the plantation. Inadequate seeds or seedlings increase the risk of mal-development of plants and the attack of pests and diseases. This affects input costs and loss of productivity, reducing potential economic gains, environmental preservation and the wholesomeness of the final product.

- Prefer hybrids well adapted to the regional conditions.
- Seeds should be certified for adequate levels of germination, vigor and purity, in addition to sanitary certification.
- Pest tolerance/resistance, market acceptance, resistance to transport and longer shelf life are important characteristics.
- Seedlings should be acquired from officially certified nurseries, free from pests, diseases and malnutrition symptoms.
- Transportation of seedlings requires proper authorization.
- Use healthy material, adapted to the area, with certificate of origin and sanitary registration.
- Purchase and transportation invoices of seedlings and sanitary certification should be kept in the farm.
- Choose varieties adapted to climate, market and cropping system.
- In irrigated systems, prefer genetically improved monoembryonic varieties.
- In non-irrigated systems, use polyembryonic varieties because of their rusticity and lower production cost.

Use of seedlings of controlled origin, well adapted to local conditions reduces the incidence of pests and diseases. Consequently, there is a reduction of pesticide use, less expenditure with other inputs, resulting in environmental protection and reduced hazards to workers and consumers.

Soil use and management

Good soil and water management and conservation practices favor plant coverage, stimulate biological activity, reduce compaction and soil and nutrient losses, minimize silting of water bodies and the contamination of adjacent areas. The neglect of these precautions causes yield reduction and financial losses and environmental degradation.

- Control erosion and promote improvement of the biological conditions of the soil, using contour planting and constructing terraces and strip cropping according to technical recommendation.
- Consider the soil's capacity of use.
- Use mulching to protect against high temperatures and moisture losses.
- Use leaching reducing practices.
- Do not allow water soaking and water logging in the cultivation areas.
- Adopt integrated weed management.
- Maintain the diversity of plant species, favoring ecological stability and minimizing the use of herbicides.
- In already producing orchards, maintain a mulch strip for natural weed control and use manual weed control methods.
- Do not stockpile manure or maintain compost heaps in or near the orchards.
- Composting and manure treatment areas should be installed far away from water bodies.
- Plant wind breaks around the orchard.

Soil preparation

- Physical, chemical and biological analyses of the soil before planting are essential for good crop planning.

- Determine the contents of organic matter, pH, available phosphorus, calcium, magnesium, potassium, sodium, sulfur, electric conductivity of the saturated extract, boron, copper, iron, manganese and zinc, in the first soil layer of 20 cm.
- Minimize mechanical soil intervention.
- Use a system of soil preparation that favors root development.
- Do sub-soiling in compacted soils only when other methods are not efficient or when technically recommended.
- Prepare the soil when humidity is right.

Orchard installation

- Stake plants right after planting to avoid wind damage.
- Observe a planting density, compatible with pest management practices, traffic of equipment, expected yields and quality of the product, as well as equipment to be used in the production process.
- The mango trees should be conducted to obtain plants with adequate height according to the selected management system.
- Reduced plant density allows better orchard ventilation, intercropping with annual crops mainly at the initial stages, and easy moving of materials and equipment.
- At least one soil test should be done before the orchard installation and subsequently every five years.
- Keep records of all the analyses performed in the orchard.
- Harmonize the orchard site, the rootstock variety, the cultivar and the planting system, to meet market requirements, with minimum use of pesticides and using low environmental impact practices.
- The pollinating cultivar should not occupy more than 49% of the area.
- Utilize several cultivars for pollination purposes, as required by the mango crop.

Fertilization

Adequate levels of available nutrients in the soil are essential for sustainability of the mango cropping system, because it contributes to good plant development, to better fruit quality and to crop productivity. The inadequate use of fertilizer and lime causes soil and water contamination, erosion, compaction causing economic losses.

- In the pre-planting phase, if liming is necessary, apply in the planting holes at least 90 days before planting.
- Use approved and registered fertilizers free of toxic substances, especially free of heavy metals.
- Adopt protection procedures in order to prevent ground water contamination, mainly by nitrates.
- Make soil tests to verify levels of fertility.
- Register the cropping history in relation to liming and fertilizing.
- Establish the fertilization program based on technical recommendation and the results of soil and leaf analysis.
- Define the source and amount of fertilizers at planting time, based on soil test and expected nutrient removal by the crop. Especially with nitrogen, take in account the leaf analysis.
- Evaluate the nutrient losses due to leaching in sandy soils.
- Split the applications of potassium and nitrogen to minimize losses by leaching.
- Use soil fertilization; foliar fertilization should only be used if technically recommended.
- Whenever feasible, substitute chemical nitrogen fertilization by an organic alternative, calculating the nitrogen equivalence based on the content of each kind of fertilizer.
- Apply fertilizers in the area corresponding to the projection of the tree canopy.

Liming

- Liming should be done 60 days before planting based on soil test.
- Use adjusted methods to quantify the correct amount of lime maintaining pH below neutral (7.0).
- New lime application should be done only if base saturation is below 80%.
- The lime must be well incorporated at 20 cm depth.
- Only dolomitic lime should be used, if the exchangeable magnesium is below 8 mmol_c dm³.

Organic fertilization

- Use well fermented organic material of known origin.
- Livestock manure should be used as fertilizer only after a rest period of 90 to 120 days.
- Minimize organic fertilization close to harvest time.
- Manure piles and compost heaps should be placed distant from water courses and water reservoirs.

Organic fertilization, when correctly performed, reduces the use of chemical fertilizers, minimizes environmental problems, avoids soil pollution and contamination of fruits (especially by coliforms, salmonella and others) and contributes to the improvement of fruit quality.

Irrigation

The improper management of irrigation may cause salification and waste of water and energy. Pertinent legislation should be observed.

- When using fertigation microbiological quality of the water used to dissolve the fertilizers and its pH stability should be monitored.
- Calculate the amount of water according to the water balance, water-holding capacity of the soil and the crop requirements.
- Control the salinity level and the presence of pollutants by periodical chemical, physical and biological analysis of the water.
- Calculate the need of water to irrigate the planned orchards and compare with the availability of water on the farm.
- Irrigation should be planned considering its environmental impacts.
- Do not use irrigation water, which does not meet the technical requirements of the mango crop.
- When systematic water quality control is not possible, the farmer should follow Good Agricultural Practices to minimize the risks of fruit contamination.
- If underground water is used, consumption should be matched with the extraction potential.
- Use localized irrigation and fertigation according to the requirements of the mango crop.
- Apply a water amount based on the regional reference evapotranspiration (E_t) and the crop coefficient (K_c) and soil humidity.
- Irrigation water should have electrical conductivity lower than 2.0 dSm^{-1} .
- Adopt a periodic and systematic filter maintenance program.
- The water should be of adequate and appropriate quality for its use.
- Localized irrigation systems such as dripping and micro-sprinkler irrigation should be used to save water.

- Avoid the access of domestic or wild animals to water reservoirs to be used for irrigation and for the other pre and post-harvest practices.
- Fertigation should observe the mango crop requirements.
- Adopt high frequency of fertigation with small amounts and low concentration of fertilizer solution.
- At the moment of application of fertilizers split fertigation in three periods.
- Split fertigation according to soil texture, nutrient availability, phenological phases of the crop, soil conservation and cost of the operation.
- In fertigation use non-corrosive, water soluble fertilizers, safe for handling in the field, that do not clog the equipment, easy to use, pure, and non-reactive with the chemical components of the water.
- In non-irrigated areas, do not allow the formation of soaked areas and waterlogging in the proximity of the cultivation areas to avoid sources of contamination.

The adoption of good irrigation practices minimizes losses (nutrients, inputs, soil erosion), reduces silting and contamination of water courses, the accumulation of salts in the soil (salinization), prevents frequent maintenance of equipment and assures better water quality.

Precautions in the use of pesticides

Pesticide regulations should be strictly observed to prevent environmental pollution and human health hazards.

Selection and handling of pesticides

- Only legally registered pesticides should be used.
- The legal rules of agronomic prescription should be followed strictly.
- Spraying should be used exclusively in areas under epidemic risk and/or when the target species reach the critical level (economic threshold level).
- Personnel in charge of pesticide application should be well trained and use Individual Protection Equipment (IPE).
- Only adults should be allowed to perform pesticide application.
- Children, domestic animals and people not directly involved should be excluded from the area where pesticides are being used or prepared.
- Pesticides should be prepared and handled only in specially designated, safe and ventilated places.
- It is forbidden to eat, drink or smoke while handling and applying pesticides.
- Pesticides should not be applied close to water sources (streams, lakes, wells etc.) to avoid contamination.
- The water used to clean the pesticide recipient should be returned to the tank to be mixed with the next batch of pesticide.
- The handling of pesticide should follow all rules recommended by law.
- Pesticide spraying should be avoided during windy periods to reduce jet deflection.

- The product label should be read carefully and all recommendations should be followed regarding the procedure, care, interval before harvest and the pesticide container destination.
- Specific doses for mango should be used according to the prescription of each pesticide.
- Do not manipulate or carry around damaged pesticide containers.
- Avoid direct manual contact with pesticides using always the original container to store or transport the chemicals.
- Avoid spillage when handling pesticides.
- After work is finished, clothing should be removed and the operators should bathe immediately with abundant water and soap use.
- Medical assistance should be sought immediately if there is suspicion of intoxication.
- Workers involved in the use of pesticides should be submitted to periodical health check-up.

Care in pesticide use is a serious matter of human security because they can cause long term ecosystems contamination affecting the health of human beings.

Pesticide application

- Children, domestic animals and people not directly involved should be kept out of the area where pesticides are being used or prepared.
- The equipment should receive periodical maintenance and calibration using recommended method and technology.
- The maintenance and use of equipment should be well planned to be available when needed.
- The operators should be well trained and use Individual Protection Equipment (IPE) like gloves, mask, protection glasses, waterproof coat, hat and boots, according to the manual for pesticides use.

- Tractors used for pesticide spraying should have a closed cabin for the driver.
- Nozzles, hoses and valves should not be cleaned using the mouth.
- Never use leaking, uncalibrated or defective equipment to spray pesticide.
- Minors should not be permitted to work with pesticides.
- Pesticide application should be made in the cooler periods of the day and when relative humidity is below 60%.
- Pesticides should not be applied when winds blow at speeds higher than 8 km/hour to avoid jet deflection.
- Pesticides should not be used close to watercourses or deposits.
- Post-emergent herbicides should not be sprayed on wet plants by irrigation or other cause or if weeds and crops are under dry stress.
- Application equipment and IPE should be cleaned and washed in appropriate places far from any watercourse or reservoir.
- Operators should bathe immediately after finishing their chores.

In case of intoxication with pesticides the victim should be taken to a cool and ventilated place, undressed, taken to a hospital or medical doctor, together with the pesticide label. The victim should not drink milk because it increases the retention of the pesticide in the human body.

Storage and destination of empty pesticide containers

- Changes in the pesticide stock should be recorded periodically.
- Pesticides should be stored in ventilated rooms, safely locked, distant from residences, protected from rain, off limits to children and untrained persons, strictly observing safety rules and pertinent legislation.
- Never store animal or human food near pesticide containers.
- Empty pesticide containers should be washed 3 times, depending on the kind of material, and sent to appropriate destruction or recycling centers.
- Never wash empty pesticide containers or equipment in water wells, streams, rivers or lakes.
- Never reuse the empty pesticide containers for other purposes.
- Never leave or store or empty pesticide containers or pesticide leftovers near cultivated areas or water wells, streams, rivers or lakes.

Human health and environmental quality can be seriously affected when empty pesticide containers are not discarded according to technical recommendations.

Crop protection

Integrated pest, diseases and weed management should be preferred, utilizing cultural and biological methods whenever possible, in place of chemical methods (pesticides). Reeducation in this respect reduces costs of production, avoids contamination of people and other environmental impacts.

- Use integrated pest and disease management
- Natural, biological and biotechnological methods should be preferred.

Pests and diseases should be strictly monitored during the entire cropping cycle. Efficient control of weeds, pests and diseases minimizes the use of pesticides. The adoption of correct procedures assures worker health, satisfactory yields and environmental preservation.

Weed control

- Herbicides should be used only when necessary and with legal agronomic prescription.
- Maintain records of pesticide application.
- Workers involved in pesticide handling and application should be trained and use IPE.
- Herbicides should be selected according to the characterization of the weeds to be controlled, to the production site, considering the requirements of the market.
- Spraying equipment should be calibrated before use.
- Used containers must be disposed of in especially designated places, according to the law.
- The equipment must be cleaned after use and when moved to other cultivation fields.

- Use certified seeds with low level of impurities.
- Applications should be made in cooler periods of the day and when relative humidity is lower than 60%.
- Evaluate the efficiency of the different control methods (manual or mechanic; chemical or non-chemical)
- Whenever possible, avoid the use of highly soluble products, with high vapor pressure and with high adsorption coefficients and long half-life.

Correct weed management is important for environmental sustainability and for the economic feasibility of the crop.

Pest control

- Utilize only pesticides and biological products legally registered for mango, and observing selectivity, environmental impact, food safety and Maximum Residue Limit (MRL).
- Constantly monitor the incidence and population density of both pest and beneficial insects.
- Establish an effective registration system of all activities involving the use of pesticides and other pest management procedures.
- Install a structure to monitor the climatic conditions to help in the preventive control of insect pests.
- Organize a process of continuous education of all personnel involved in IPM.
- Use only registered pesticides, legally prescribed by an agronomist.

Consult local technicians or extension agents when deciding about pest control strategies and do not use unregistered pesticides.

Disease control

- Integrate all recommendations with emphasis on cultural control.
- Adopt crop rotation.
- Adopt exclusion and destruction as the first control method of any disease.
- Eliminate all infected plants during field inspection.
- Organize a process of continuous education of all personnel involved in disease control.
- Utilize only pesticides and biological products legally registered for mango, observing selectivity, environmental impact, food safety and Maximum Residue Limit (MRL).
- Establish an effective registration system of all activities involving the use of pesticides and other disease management procedures.

Preventive measures should be preferred to avoid mango crop diseases. Chemical control should be used only if technically necessary.

Crop management

Crop management is fundamental to assure good yields and good quality products. When followed correctly, crop management procedures contribute to environmental protection, to economic feasibility of the crop and to the good health of workers and consumers.

Pruning

- Prune the plants to attain balance between the vegetative activity and the regular yield, according to the requirements of the mango crop.
- Use a pruning method compatible with the objectives of the crop, forming the support structure, obtaining compact plants, avoiding branch breaking, and favoring plant balance.
- The production pruning should reduce plant growth, to be compatible with the row spacing.
- Pruning for interrupting bud dormancy should be made whenever necessary for removal of immature branches.
- Maximum plant height should not exceed 60% of the row spacing and the canopy should not project to more than 45% of row spacing, to avoid plant interlacing.

Removal of crop residues

- After fruit bearing, clean the panicles to remove floral remains, overlapped leaves, leaves that are too close to the fruits, unproductive panicles, and sick or malformed fruits.
- Discard damaged fruits and those not conforming to technical quality specifications.
- Remove leaves and panicle remains to avoid frictions, which cause mechanical damages to fruits, to expose them to sunlight and for pest control.

Growth regulators

- Growth regulators should be used only if other management practices fail.
- Use registered chemical products according to technical recommendations to and the legislation.
- Do not employ workers without technical training.
- Avoid growth regulators for both control of plant growth and fruit development.
- Always observe technical recommendations.

Flowering induction

- Avoid the use of growth regulators for flowering induction.
- When the use of Paclobutrazol (PBZ) is absolutely necessary, limit its use to once a year.
- Paclobutrazol (PBZ) can be used at the maximum dose of 1.5g of active principle/linear meter of canopy tree crown for the mango cultivar Tommy Atkins.
- Apply PBZ in the soil.
- Only apply PBZ after the 2nd vegetative growth flow soon after the post-harvest pruning.
- To break bud dormancy, the maximum dose of the products should not be higher than 4% for potassium nitrate, 2% for calcium nitrate and 1.5% for ammonia.
- In areas with high organic matter and moisture levels, or with other cultivars, the product can be used at a dose that is 30% higher than the recommended dose for Tommy Atkins, which is equal to 1.9g of the active principle per linear meter of tree canopy.
- When using flowering induction through water stress, maintain control of the water status of the plants in order to avoid excessive stress, which makes plants more susceptible to pathogens.

Branch maturation

- Induce branch maturation only with technical supervision.
- Etephon should be applied via leaves.
- Maximum dose of Etephon should be 400 ppm.
- Use Etephon until 75 days after the PBZ application.

Bud dormancy breaking

- Only induce branch maturation under technical supervision.
- The practice of bud dormancy breaking should happen after the period of growth interruption for fruit ripening, aiming at floral panicle formation.
- Nitrates can be used to break bud dormancy.
- Nitrates should be used only 90 days after PBZ application.
- Maximum acceptable doses are potassium nitrate: 5%; calcium nitrate: 2%; ammonia: 1.5%.

Techniques for fruit thinning

- Thin the fruits in order to optimize fruit weight and fruit quality, according to mango crop needs.

The use of chemical products for floral induction, fruit ripening and bud dormancy breaking, should be made under technical supervision and strict observance of recommendations

Pre-harvest procedures

Contamination of fruits with physical, chemical or biological contaminants, causes health problems to consumers and affect final quality of the products. The adoption of pre-harvest precautions improves quality, price and reduces health hazards.

- Observe the withdrawal period for pesticides applied to the crop.
- All facilities, equipment, vehicles, instruments and containers, should be cleaned and sanitized with chlorinated water.
- All equipment, instruments and containers that come in contact with fruit should be made of nontoxic materials and easy to clean.
- Inspect the packing-house and the storage places for rodents, birds and insects.
- Maintain the packing-house and the storage facilities clean.
- Eliminate damaged containers.
- Properly identify containers for garbage, sub-products, non-edible parts and dangerous substances, which should be made of appropriate materials.

The packing house, storage buildings, harvest equipment, vehicles and all materials that come in touch with fruit should be well cleaned and sanitized to assure product quality and competitive prices.

Harvest

Good harvest practices avoid disease inocule dissemination on the farm and chemical, physical and biological contaminations that cause health problems to the worker, the environment and the consumer.

- Follow specific technical regulations for the mango crop.
- Establish the harvest point using, preferably, non-destructive techniques.
- When using destructive techniques, place the remains of the sampled fruits in an appropriate container, removing it immediately from the growing area.
- Establish the best harvest point for each market and take representative samples to know the right harvest time.
- Pre-select the fruits, according to the mango crop patterns.
- Use a cutting instrument to separate the fruit from the plant, sterilizing it with chlorinated water, whenever you move from one plant to another.
- The harvest containers must be previously washed and sterilized with chlorinated water.
- Always keep the containers with the harvested fruits under shade before sending them to the packing-house.
- Protect the fruits against bruises and injuries, lining the containers with soft materials (polyethylene foam or newspaper).
- Use plastic containers without edges that accumulate dirt.
- During harvest, do not allow direct contact of the bottom of containers with the ground, to avoid contamination of the fruit of another container in the stacking process.
- Before and after harvest, clean harvest instruments with chlorinated water, with at least 100 ppm of chlorine.
- Transport fruits in containers and vehicles used exclusively for this purpose.

- Identify each load informing harvest site, date, time and person responsible.
- Only fruit at the correct ripeness should be harvested.
- Use several ripeness indicators to determine the best harvest moment.
- Container bottom should not touch the fruit in the container right below.
- Never use equipment previously used for transportation of pesticides, garbage or manure.

Good harvest practices contribute to the competitiveness and quality of fruit produce.

Post-harvest

Post-harvest procedures, particularly in transport and storage of fruits depend on the requirements of the particular market, and are essential to assure good hygiene and sanitization of the fruit and therefore improve overall quality of the produce.

- Exclude domestic animals and pests from the packing-house and adjacent areas.
- Build all post-harvest installations in safe distance from feedlots, manure storage and other animal holding places.
- Control pests inside the packing-house.
- Isolate the area of fruit reception in the packing-house in order to prevent circulation of unauthorized people and animals.
- Keep the area around the packing-house clean and free from contamination sources.
- Establish a program of maintenance and cleanliness for tools and installations of the packing-house, recording all products, procedures and frequency of use and people in charge.
- Clean tools and other parts that have direct contact with fruits.
- Use only non-toxic products like those used in the food industry. Follow the recommended dilutions.
- Implement waste handling programs.
- Wash the floor after each workday.
- Store packing materials in a clean, dry and ventilated place, above the floor.
- Promote continuous maintenance of the refrigeration equipment.
- Make sure all vehicles and containers are clean and disinfected, before shipment.

- Monitor the cold chain from storage, transportation to final destination.
- Keep samples of fruits packed, for chemical and microbiological analyses.
- Maintain internal pedestrian walks and roadways clean and in good traffic condition.
- Systematically clean plastic containers and vehicles after use.
- Install properly dimensioned packing tables for worker comfort.
- Keep records of all processed lots informing parcel, name of the farmer, the person in charge, harvest point, treatments and procedures.
- Do not use containers previously used to transport fish, raw meat, eggs and other products which are sources of food borne pathogens.
- Check odors that indicate microbiological contamination or inadequate cleaning.
- Vehicles should be kept dry, without any water condensation.
- Utilize tightly closed containers to avoid contamination from the environment during transportation.
- Check the refrigeration equipment for its proper operation during transport.
- Use only potable water monitoring its chemical and biological quality submitting it to treatment if necessary.
- Maintain the level of chlorine over 100 ppm in water used for washing and sanitizing of vegetables.
- Maintain pH between 6.0 and 9.0.
- Substitute the water used every day and in shorter periods if a large volume of fruit is being treated.
- Install countercurrent devices in water faucets.
- Install drainage system in the packing-house.
- Monitor systematically and treat all water to be used.

- Clean periodically cold rooms' cooling systems used for the storage of fresh fruit.
- Condensed and defrost water from evaporator type cooling systems shall not drip over fresh produce.
- Utilize only potable water in hydro-cooling systems or systems that use crushed ice.
- Control and monitor water quality in hydro-cooling systems or systems that use crushed ice.
- Periodically clean the fans and covers used in forced air-cooling systems.

Hygiene, safety and workers' well-being

It is fundamental to train employees to reduce risk of chemical, physical and biological contamination of people, the produce and the work environment. The observance of the pertinent legislation avoids problems and penalties and assures a healthy workplace.

- Demand the use of long gloves, impermeable apron and mask, by those in contact with any chemical product in the packing house.
- Store the chemical products in places specifically designated for this purpose, adequately labeled.
- Keep a register of health and safety occurrences in specific files.
- Train the workers for correct handling of chemicals, good personal hygiene practices and in manipulation of fresh fruits.
- Install a hygienic place for worker meals.
- Maintain a program for constant cleaning and supply of sanitary materials in hygienic toilets.
- Install drinking fountains and hand washing taps, inside the packing house.
- Enforce observance of work safety rules.
- Provide all legal benefits for workers including adequate work schedule, salaries and other monetary benefits, vacations, housing, meals and transportation.
- Establish mechanisms to facilitate education for the children of rural workers according to legislation.
- Provide periodical medical examinations to check employee health.

Cleanliness habits and adequate working conditions avoid fruit contamination and reduce the incidence of health problems for personnel and consumers.

Environmental management

Environmental management in agricultural enterprises is fundamental for the maintenance of soil and water quality, for the conservation of biological resources and for the quality of life of the local population.

- Perform all activities during all phases of the work, according to the regional ecological characteristics.
- Develop activities that promote sustainable development.
- Monitor constantly the execution of plans devised to preserve the environment or correct eventual problems during operations.
- Do not use areas of permanent legal preservation for agricultural purposes.
- Preserve water courses, springs, lakes and other water bodies, maintaining and restoring natural vegetation with appropriate species.
- Always consult with local extension agents or research scientists to decide on best solutions for mango production.

Mango production in Brazil can provide supplementary benefits for the farmer if GAPs are used assuring better quality fruit.

Technical assistance and cooperative initiatives

The adoption of GAPs with competent technical assistance and with the association of farmers in cooperatives helps regional socioeconomic development and contributes to the preservation of natural resources.

- A professional should be hired to supervise the mango crop from planning to marketing.
- The association of farmers in cooperatives should be stimulated mainly for machinery sharing, collective input purchase and produce sale, packing operations and management activities.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Melon production



Author: *Vitor Hugo de Oliveira, Embrapa Agroindústria Tropical, Fortaleza, CE.*
vitor@cnpat.embrapa.br

Co-authors: *Levi de Moura Barros, Embrapa Agroindústria Tropical, Fortaleza, CE.*
levi@cnpat.embrapa.br

Clódion Torres Bandeira, Embrapa Agroindústria Tropical, Fortaleza, CE.
clodion@cnpat.embrapa.br

Raimundo Braga Sobrinho, Embrapa Agroindústria Tropical, Fortaleza, CE.
braga@cnpat.embrapa.br

Francisco das Chagas de Oliveira Freire, Embrapa Agroindústria Tropical, Fortaleza, CE.
freire@cnpat.embrapa.br

José de Arimatéia Duarte de Freitas, Embrapa Agroindústria Tropical, Fortaleza, CE.
ari@cnpat.embrapa.br

Francisco José de Seixas Santos, Embrapa Agroindústria Tropical, Fortaleza, CE.
seixas@cnpat.embrapa.br

Ricardo Elesbão Alves, Embrapa Agroindústria Tropical, Fortaleza, CE.
elesbao@cnpat.embrapa.br

Introduction

Melon production in Brazil is concentrated in the Northeast region. Almost all exported melons are produced in the Assu-Mossoró corridor, in Rio Grande do Norte State, and in the Jaguaribe-Apodi Upland, in the Ceara State, and the main market is the European Union (ca 90% of the Brazilian exports). The cultivated area is of 12,000 hectares with a total annual production of 180 thousand tons, generating 29,000 direct jobs and 15,000 indirect ones. Major problems in melon production are the improper use of pesticides, lack of adequate training of workers, bad sanitary condition, inappropriate harvesting and inadequate post-harvest procedures.

Good Agricultural Practices are procedures that improve conventional methods of production, beginning with the choice of the cultivation areas reaching post-harvest procedures, emphasizing worker health, well-being and safety. They aim at healthy products and at the preservation of the environment promoting value addition to the products of small, medium and large farmers. These practices are the basis for other incentive programs for quality improvement, like the Hazards Analysis and Critical Control Points (HACCP) or for agricultural certification such as Integrated Fruit Production and other international protocols for quality certification.

The topics presented in this outline of Good Agricultural Practices (GAPs), such as choice of the cultivation area and soils, fertilization, irrigation, soil and water conservation practices, integrated pest and disease management, pre- and post-harvest procedures, hygiene and safety, are a combination of theoretical principles and practical procedures that constitute important information to melon producers of any scale. They deal with forms to improve environmental conditions (social, economic and ecological) in the productive sector to attain adequate standards of sustainable production, worker well-being and consumer safety. The described practices help the environmental planning and management of farms and may be rapidly incorporated into the existing production routines.

The GAPs here recommended consider the different cropping systems adopted in Brazil, from subsistence farming to the most technically sophisticated ones. These GAPs should respect the environmental and labor legislation as well as the Children and Adolescent Statute, and the principle of equal pay for all types of labor.

Selection of the cropping area

Melon may be planted in any point of the Brazilian territory, as long as environmental laws are respected. This includes the exclusion for productive purposes of the legal ecological reserve area in each farm and the areas of permanent preservation designated by the government. The adequate selection of the area is essential for the success of melon production. Mistakes in this selection bring forth economic losses, environmental damages and will negatively affect final product quality.

- When selecting the cropping area, the melon producer must be assured of the existence of appropriate infrastructure (electricity, water supply, roads etc.) the compatibility of soil and climate for the melon crop and the market, as well as availability of labor. The minimization of environmental risks and the offer of working opportunities to the local community are important goals to be considered.

A business plan should be prepared beforehand to provide elements for a realistic preview of the intended business.

Cultivation site

The selection of the cultivation site is an important phase in the establishment of a melon crop. Planting in inadequate sites will affect costs, environmental conservation and the quality of the final product.

- Deep soils, not subject to soaking, with a sandy to medium texture with low content of soluble salts should be preferred.
- Avoid areas subject to flooding (hydromorphic and poorly drained alluvial soils) unless preliminary drainage is made.
- Prefer level or slightly sloping fields, not exceeding 8% to facilitate erosion control and mechanization.

Melon cropping in soils with adequate physical characteristics favors the development of a healthy crop, facilitates cultivation and minimizes the risk of soil degradation.

Seeds

It is essential to choose seeds and seedlings well adapted to the region and to the objectives of the plantation. Inadequate seeds or seedlings increase the risk of mal-development of plants and the attack of pests and diseases. This affects input costs and loss of productivity, reducing potential economic gains, endangers the environment and the quality of the final product.

- Prefer hybrids well adapted to the regional conditions.
- Seeds should be certified for adequate levels of germination, vigor and purity, in addition to sanitary certification.
- The production potential and uniformity should be higher than local varieties.
- Pest tolerance/resistance, market acceptance, resistance to transport and longer shelf life are important characteristics.

The use of hybrids of controlled origin and well adapted to local conditions reduces the incidence of pests and diseases. Consequently, there is less pesticide use, less expenditure with other inputs, resulting in environmental protection and reduced hazards to workers and consumers.

Soil preparation

Improper soil preparation results in chemical, biological and physical degradation (destructuring and compaction), increases input costs (energy and fertilizers) and water deficit and causes erosion.

- Physical, chemical and biological analyses should be made, before soil preparation and planting.
- Important determinations are organic matter content, available phosphorous, calcium, magnesium, potassium, sodium, sulfur, boron, copper, iron, manganese, zinc, pH and electric conductivity of the saturated extract in the 0 to 20 cm depth layer.
- Avoid the repetitive use of plow and disk harrow.
- Adopt soil management practices that favor the development of the root system.
- The furrow should be prepared in a way that facilitates the organic and foundation fertilizing.
- The dimensions of the nurseries should be: 1.0 to 1.5 m width and 15 to 25 cm height.
- The seedbeds must be higher than normal in both the rainy period and in soils with deficient drainage.
- Tilling should be used when other methods are not efficient.
- The soil should be prepared when the moisture level is favorable.
- Crop rotation should be used to control pests and weeds and improve the soil fertility.
- Plowing should be done at a depth of about 30 cm and harrowing at about 20 cm deep but tilling and harrowing depth should vary every planting season.
- The nursery location should alternate.

The ideal humidity is when the soil preparation machinery operates with minimum effort. When the soil is excessively humid, there is an increase in compaction. When the soil is too dry, successive harrowing is necessary to break soil lumps, using more fuel.

Planting

Planting is a fundamental operation that, if not performed correctly, brings about increased erosion, reduced efficiency of pest, disease and weed control and general operations, including harvest and final quality of the produce, affecting the potential economic gains of the crop.

- Spacing should follow regional recommendation.
- Leave only one plant per hill if larger fruits are wanted or 2 to 3 plants if the objective is to produce small fruits.
- Do not use a high density planting system.

Higher density increases competition between plants for water, light and nutrients.

Fertilization

Adequate levels of available nutrients in the soil are essential for the sustainability of the melon cropping system because it contributes for good plant development, for better fruit quality and for crop productivity. Inadequate use of fertilizer and lime causes soil and water contamination, erosion and compaction, causing economic losses.

- Use approved and registered fertilizers free of toxic substances, especially heavy metals.
- Adopt protection procedures to prevent chemical contamination of ground water, mainly by nitrates.
- Make soil tests to verify levels of fertility.
- Register the cropping history in relation to liming and fertilizing.
- Determine the nutrient amount necessary at seeding time based on soil analysis and on the quantity removed by the plants.
- Observe the source and amount of fertilizers. Nitrogen dosage should be based on leaf analysis.
- Evaluate the nutrient losses due to leaching in sandy soils.
- Evaluate the effect of other agronomic factors such as hybrids, spacing, plant density, plant sanity, water availability etc.
- Apply phosphorus and micronutrients on top of the well-fermented organic matter before incorporating it in the soil.

Liming

- Use adjusted methods to quantify the correct amount of lime, maintaining pH below neutral (7.0).
- New lime application should be done only if base saturation is below 80%.
- The lime must be well incorporated at 20 cm depth. One half before plowing and the other half before harrowing.

- Base saturation should be raised to 80 % through liming to guarantee a minimum level of magnesium in the soil.
- Only dolomitic lime should be used, if the exchangeable magnesium is below 8 mmol_cdm³.

Soil acidity correction is essential for the economic feasibility of the melon crop.

Organic fertilization

- Use well-fermented organic material of known origin.
- Utilize livestock manure after a rest period of 90 to 120 days, for use as fertilizer.
- Minimize organic fertilization close to harvest time.
- Manure piles and compost heaps should be placed far from watercourses and water reservoirs.

Organic fertilization, when correctly performed, reduces the use of chemical fertilizers, minimizes environmental problems, avoids soil pollution and contamination of fruits (especially by coliforms, salmonella and others) and contributes to the improvement of fruit quality.

Sidedress fertilization

- Split nitrogen and potassium application to avoid soil and water contamination, nitrification, salification and eutrophication of lakes and reservoirs.

Irrigation and fertigation

Inadequate management of irrigation and fertigation can cause salification, excessive water and energy consumption, enhancing the need for equipment maintenance. It is necessary to observe pertinent legislation and avoid water losses.

- Systematically perform chemical and physicalchemical analyses of the water to monitor pollutants and salt content.
- Monitor the correct amount of water based on the hydric balance, soil water retention capacity and plant requirements.
- Optimize the water usage in order to minimize negative environmental impacts.
- Monitor the soil moisture and the crop evapotranspiration.
- Control both soil salt content and pollutant substances.
- Use only water with electric conductivity below 2.0 dS/m.
- Adopt high frequency of fertigation with small amount and low concentration of fertilization solution.
- When applying fertilizers, irrigation must be done in three-time intervals.
- Soil texture, nutrient physical state, split of application in accordance with the phenological phase of the crop, soil conservation and fertilizer costs, should be constantly evaluated.
- To avoid trapping in the irrigation system and operational safety improvement, use non-corrosive, water-soluble fertilizers that do not react with salts and other chemicals present in the water.
- Use preferentially drip irrigation.
- Fix the irrigation system in a way that the lateral pipes cross the major land slope.
- Space the drippers at 25 to 50 cm according to the soil type.
- Use both reference evapotranspiration (ET_o) and the crop coefficient (K_c) to calculate the water amount. It shall be done daily.

- Keep the soil moisture in a level that does not block the plant transpiration.
- Before seeding, raise the soil moisture up to the field capacity through irrigation and keep close to this level during the crop cycle.
- Keep wild and domestic animals away from reservoirs and other sources of water used for irrigation and for other pre- or post-harvest operations.
- Perform systematic and periodical filter maintenance.
- Avoid flooded or water soaked areas close to melon fields to avoid sources of contamination.
- If impossible to monitor water quality, the farmer should use GAPs to minimize fruit contamination.

Good irrigation practices reduce losses, silting, pollution of watercourses, salification, demanding less maintenance and improving water quality.

Soil and water conservation practices

Water and soil conservation practices improve plant cover and diversity, reduce erosion losses and minimize silting. When they are neglected, environmental and economic losses will occur.

- Use the soil in accordance with its use capacity.
- Control the erosion process and promote the improvement of biological conditions of the soil.
- Use correct mechanical practices of soil conservation, with contour cropping, terraces and strip cropping.
- Use mulching to reduce erosion, increase infiltration, reduce evaporation, and reduce thermal and hydric differentials.
- Promote crop rotation.
- Maintain the plant diversity in order to keep the ecological stability.
- Use practices to prevent water logging around the field crop.
- Use strip cropping where land declivity is higher than 8%.
- Livestock manure must be stored far from streams, water reservoirs and crop fields.
- Adopt techniques to minimize nutrient losses by leaching.
- In fertigation, monitor the quality of the fertilizer dissolution water as well as the pH stability during fertigation.
- Prevent hydric stress by water excess.

Local technicians should be consulted to plan conservation practices.

Precautions in the use of pesticides

Pesticide regulations should be strictly observed to prevent environmental pollution and human health hazards.

Selection and handling of pesticides

- Only legally registered pesticides should be used.
- The legal rules of agronomic prescription should be followed strictly.
- Spraying should be used exclusively in areas under epidemic risk and/or when the target species reach the critical level (economic threshold level).
- Personnel in charge of pesticide application should be well trained and use Individual Protection Equipment (IPE).
- Only adults should be allowed to perform pesticide application.
- Children, domestic animals and people not directly involved should be excluded from the area where pesticides are being handled.
- Pesticides should be prepared and handled only in specially designated, safe and ventilated places.
- It is forbidden to eat, drink or smoke while handling and applying pesticides.
- Pesticides should not be applied close to watersources (streams, lakes, wells etc.) to avoid contamination.
- The water used to clean the pesticide recipient should be returned to the tank to be mixed with the next batch of pesticide (triple washing method).
- The handling of pesticides should follow all technical and legal rules.
- Pesticide spraying should be avoided during windy periods to reduce jet deflection.
- The product label should be read carefully and all recommendations should be followed regarding the procedure, care, withdrawal period before harvest and the pesticide container destination.

- Specific doses for melon should be used according to the prescription of each pesticide.
- Do not manipulate or carry around damaged pesticide containers.
- Avoid direct manual contact with pesticides using always the original container to store or transport the chemicals.
- Avoid spillage when handling pesticides.
- After work is finished, operators should undress and bathe immediately with abundant water and soap.
- Medical assistance should be sought immediately if there is suspicion of intoxication.
- Workers involved in the use of pesticides should be submitted to periodical health check-up.

Care in pesticide use is a serious matter of human security because they can cause long-term ecosystems contamination endangering human health.

Pesticide application

- Children, animals and people not directly involved should be kept out of the area where pesticides are being used or prepared.
- Equipment should receive periodical maintenance and calibration using recommended method and technology.
- Maintenance and use of equipment should be well planned to be available when needed.
- Operators should be well-trained and use Individual Protection Equipment (IPE) like gloves, mask, protection glasses, waterproof coat, hat and boots, according to the manual for pesticides use.
- Tractors used for pesticide spraying should have a closed cabin for the driver.

- Nozzles, hoses and valves should not be cleaned using the mouth.
- Never use leaking, uncalibrated or defective equipment to spray pesticide.
- Minors should not be permitted to work with pesticides.
- Pesticide application should be made in the cooler periods of the day and when relative humidity is below 60%.
- Pesticides should not be applied when winds blow at speeds higher than 8 km/hour to avoid jet deflection.
- Pesticides should not be used close to watercourses or deposits.
- Post-emergent herbicides should not be sprayed on wet plants by irrigation or other cause or if weeds and crops are under dry stress.
- Application equipment and IPE should be cleaned and washed in appropriate places far from any watercourse or reservoir.
- Operators should bathe immediately after finishing their chores.

In case of intoxication with pesticides the victim should be taken to a cool and ventilated place, undressed, taken to a hospital or medical doctor, together with the pesticide label. The victim should not drink milk because it increases the retention of the pesticide in the human body.

Storage and destination of empty pesticide containers

- Changes in the pesticide stock should be recorded periodically.
- Pesticides should be stored in ventilated rooms, safely locked, distant from residences, protected from rain, off limits to children and untrained persons, strictly observing safety rules and pertinent legislation.
- Never store animal or human food near pesticide containers.

- Empty pesticide containers should be washed three times (triple washing method) and sent to appropriate destruction or recycling centers.
- Never wash empty pesticide containers or equipment in water wells, streams, rivers or lakes.
- Never reuse the empty pesticide containers for other purposes.
- Never leave or store empty pesticide containers or dispose of pesticide remains near cultivated areas or water wells, streams, rivers or lakes.

Human health and environmental quality can be seriously affected when empty pesticide containers are not discarded according to technical and legal requirements.

Crop protection

Integrated pest, diseases and weed management should be preferred, utilizing cultural and biological methods whenever possible, in place of chemical methods (pesticides). Reeducation in this respect reduces costs of production, avoids contamination of people and other environmental impacts.

- Use integrated pest and disease management.
- Prefer the use of natural, biological and biotechnological methods.

Pests and diseases should be strictly monitored during the entire cropping cycle. Efficient control of weeds, pests and diseases minimizes the use of pesticides. The adoption of correct procedures assures worker health, satisfactory yields and environmental preservation.

Weed control

- Herbicides should be used only when necessary and with legal agronomic prescription.
- Maintain records of pesticide application.
- Workers involved in pesticide handling and application should be trained and use IPE.
- Herbicides should be selected according to the characterization of the weeds to be controlled, of the production site, taking into account the requirements of the market.
- Spraying equipment should be calibrated before use.
- Used containers must be disposed of in especially designated places, according to the law.
- The equipment must be cleaned after use and when moved to other cultivation fields.

- Use certified seeds with low the level of impurities.
- Applications should be made in cooler periods of the day and when relative humidity is lower than 60%.
- Evaluate the efficiency of the different control methods (manual or mechanic; chemical or non-chemical).
- Whenever possible, avoid the use of highly soluble products, with high vapor pressure and with high adsorption coefficients and long half-life.

Correct weed management is important for environmental sustainability and for the economic feasibility of the crop.

Pest control

- Utilize only pesticides and biological products legally registered for melon, and observing selectivity, environmental impact, food security and Maximum Residue Limit (MRL).
- Constantly monitor the incidence and population density of both pest and beneficial insects.
- Establish an effective registration system of all activities involving the use of pesticides and other pest management procedures.
- Install a structure to monitor the climatic conditions to help in the preventive control of insect pests.
- Organize a process of continuous education of all personnel involved in IPM.
- Use only registered pesticides, legally prescribed by an agronomist.

Consult local technicians or extension agents when deciding about pest control strategies and do not use unregistered pesticides.

Disease control

- Integrate all recommendations with emphasis on cultural control.
- Adopt crop rotation.
- Adopt exclusion and destruction as the first control method of any disease.
- Eliminate all infected plants during field inspection.
- Organize a process of continuous education of all personnel involved in disease control.
- Utilize only pesticides and biological products legally registered for melon, observing selectivity, environmental impact, food safety and Maximum Residue Limit (MRL).
- Establish an effective registration system of all activities involving the use of pesticides and other disease management procedures.

Preventive measures should be preferred to avoid melon crop diseases. Chemical control should be used only if technically necessary.

Harvest

Good harvest practices avoid the dissemination of disease inoculants, and of chemical, physical and biological contaminants, that represent hazards to the personnel, the environment and to consumers.

- Observe specific technical recommendations regarding harvest timing.
- Use more than one maturity criterion in the decision to harvest.
- Inspect, clean and sanitize the packing-house, the harvest equipment, the containers and the vehicles.
- Clean harvest tools with chlorinated water at 100 ppm of free chlorine, before and after harvest operations.
- Remove and destroy all crop residues in the field.
- Containers and wagons used for harvest transportation should be exclusive for this purpose.
- Discard damaged containers.
- Use appropriate tools to cut off the fruits. Never pull off the fruits.
- Keep 3 cm of the stalk after harvest.
- Use only containers or appropriate wagons to transport fruits
- Identify each loading by registering all information about the harvested area, date, time, people in charge etc.
- Do not harvest unripe fruits.
- Remove all the visible ground and other plant residues on the fruit before loading.
- Avoid damage to the plants.
- Prevent direct contact of the harvest containers with the ground and avoid contamination by manure.
- Prevent direct contact of the container bottom with the fruits of the other container below, when pilling up.

- Wagons used in harvest transport must be lined with rubber fabric or other materials that cushion impacts and are easy to clean with chlorinated water.
- Never use containers or vehicles previously used to transport pesticides, manure or garbage.
- Always keep fruits under shade before transportation to the packing-house.

Good harvest practices contribute to better quality of fruits and hence to success in the market.

Post-harvest

Post-harvest procedures, particularly in transport and storage of melon depend on the requirements of the particular market, and are essential to assure good hygiene and sanitization of the fruit and therefore improve overall quality of the produce.

- Build all post harvest installations at a safe distance from feedlots, manure storage and other animal holding places.
- Control pests inside the packing-house.
- Isolate the area of fruit reception in the packing-house to prevent circulation of unauthorized people and animals.
- Keep the area around the packing-house clean and free of contamination sources.
- Establish a program of maintenance and cleanliness for tools and installations of the packing-house, registering all products, procedures and frequency of use and people in charge.
- Clean tools and other parts that have direct contact with fruits.
- Use only non-toxic products like those used in the food industry. Follow the recommended dilutions.
- Implement waste handling programs.
- Wash the floor after each workday.
- Store packing materials in a clean, dry and ventilated place, above the floor.
- Promote continuous maintenance of the refrigeration equipment.
- Inspect vehicles and containers for cleanliness and disinfect them before shipment.
- Monitor the cold chain from storage, transportation to final destination.
- Keep samples of fruits packed, for chemical and microbiological analyses.

- Use only potable water, maintaining the pH below 7,0 and the level of active chlorine above 100 ppm for fruit washing.
- Identify the lot to be processed registering all information about the harvested area, date, time, people in charge etc.
- Do not allow condensation water from refrigeration equipment to drip on the fruit and make sure wagons and containers are dry when in use.
- Install temperature-monitoring instrument.
- Do not use containers previously used for fish, meat, eggs or other animal products because they are an important source of pathogens transmitted by food.
- Conduct thorough inspections and cleaning of instruments, containers and places when suspicious odors indicate microbiological contamination and unsatisfactory cleaning.
- Containers should be tightly sealed to avoid contamination during transport.
- Keep records of all procedures applied to the fruit during harvest and post-harvest until the moment of final shipment.
- Packing tables must have the right dimensions to facilitate fruit handling and avoid worker fatigue.
- Establish a program of maintenance and cleanness of the installations and external areas.
- Establish a permanent system to wash and disinfect of the plastic containers after use.
- Change the water after each workday or more frequently, depending on the volume of treated fruits.
- Install countercurrent flow devices in the water points.
- Install a draining system in the packing-house.

Equipment should be carefully maintained to avoid unnecessary expenses and assure good working conditions, contributing to the good health and well-being of workers.

Hygiene, safety and workers' well-being

It is fundamental to train employees about risks of chemical, physical and biological contamination of people, the produce and the work environment. The observance of the pertinent legislation avoids problems and penalties and assures a healthy workplace.

- Demand the use of long gloves, impermeable apron and mask, by those in contact with any chemical product in the packing-house.
- Store the chemical products in specific places for this purpose, adequately labeled.
- Keep a register of health and safety occurrences in specific files.
- Train the workers for correct handling of chemicals and for the obedience of rules of personal hygiene.
- Install a hygienic place for worker meals.
- Maintain a program for constant cleaning and assurance of sanitary supplies in hygienic toilets.
- Train the employees in good personal hygiene practices and in manipulation of fresh fruits.
- Install drinking water fountains and sinks for hand washing, inside the packing-house.
- Require observance of work safety rules.
- Require hand washing before fruit manipulation.
- Provide all legal benefits for workers including adequate work schedule, salaries and other monetary benefits, vacations, housing, meals and transportation.
- Establish mechanisms to facilitate education for the children of rural workers according to legislation.
- Provide periodical medical examinations to check employee health.

Cleanliness habits and adequate working conditions avoid fruit contamination and reduce the incidence of health problems for personnel and consumers.

Environmental management

Environmental management in agricultural enterprises is fundamental for the maintenance of soil and water quality, for the conservation of biological resources and for the quality of life of the local population.

- Perform all activities during all phases of the work, according to the regional ecological characteristics.
- Develop activities that promote sustainable development.
- Monitor constantly the execution of plans devised to preserve the environment or correct eventual problems during operations.
- Do not use areas of permanent legal preservation for agricultural purposes.
- Preserve watercourses, springs, lakes and other water bodies, maintaining and restoring natural vegetation with appropriate species.
- Always consult with local extension agents or research scientists to decide on best solutions for melon production.

Melon production in Brazil can provide supplementary benefits for the farmer if GAPs are used assuring better quality fruit.

Technical assistance and cooperative initiatives

The adoption of GAPs with competent technical assistance and with the association of farmers in cooperatives helps regional socioeconomic development and contributes for the preservation of natural resources.

- A professional should be hired to supervise the melon crop from planning to marketing.
- The association of farmers in cooperatives should be stimulated mainly for machinery sharing, collective input purchase and produce sale, packing operations and management activities.

Appendix

Main melon insect pests

White fly (*Bemisia argentifolii*), melon stem borer (*Diaphania sp*), aphids (*Aphis gossypii*), leaf miner (*Liriomyza sp*), leaf feeder (*Trichoplusia ni*), cucurbits fruit fly (*Anastrepha grandis*) and cutworm (*Agrotis ipsilon*).

Main melon diseases

Anthracnosis (*Colletotrichum gloeosporioides f. sp. cucurbitae*)

- Use certified seeds.
- Control irrigation to prevent moisture excess.
- Eradicate wild cucurbits.
- Apply only two products in mixture: benomyl and mancozeb, if the disease is present in more than 10% of the area.
- Rotate crops every two years.

Gummy stem blight (*Didymella bryoniae*)

- Remove all young fruits resulting from self thinning and parts of pruned plants.
- Only two products can be mixed: benomyl and methylic thiophanat.
- Prevent plant injury mainly in the beginning stages of crop development.
- Prevent waterlogging, irrigating at minimum levels, increasing frequency and reducing water quantity. Locate the dripper at 5 cm from the plant

Downy Mildew (*Pseudoperonospora cubensis*)

- Limit water to minimum levels avoiding excess during irrigation.
- Do not plant in humid areas especially those subject to waterlogging and poor crop aeration.
- Cultivate resistant varieties.
- Apply metalaxyl or metalaxyl + mancozeb in case of epidemic attacks.

Powdery Mildew (*Sphaeroteca fuliginea*; *Erysiphe cichoracearum*)

- Use resistant varieties.
- If infestation occurs apply fenarimol, wettable sulphur, methylic tiofanato and triadimefon.

Fusarium wilt (*Fusarium oxysporum f. sp. melonis*)

- Use certified seeds.
- Use resistant varieties.
- Rotate crops in periods over 3 years.
- Control weeds regularly.
- Use drip irrigation.

Bacterial fruit blotch (*Acidovorax avenae subsp. citrulli*)

- Use certified seeds.
- Avoid seeding in rainy periods.
- Avoid excess water during irrigation.
- Raise the frequency of irrigation reducing the amount of water.

**Papaya ring spot virus (*Papaya ringspot*
virus type watermelon. PRSV-W)**

- Control aphids to avoid its dissemination over the fields.
- Cultivate tolerant or resistant hybrids.
- Avoid areas previously planted with cucurbits where aphids have been spotted.
- Eliminate aphid host plants around the cultivation fields.

Nematodes

- Avoid more than two applications of fungicide for crop cycle.
- Rotate with grassy species.
- Eliminate all previous crop residues.
- Revolve the soil to expose lower layers to sunlight.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Maize production



Author: *José Carlos Cruz, Embrapa Milho e Sorgo, Sete Lagoas, MG.*
zecarlos@cnpms.embrapa.br

Co-authors: *Antônio Marcos Coelho, Embrapa Milho e Sorgo, Sete Lagoas, MG.*
ancoelho@cnpms.embrapa.br

Carlos Roberto Casela, Embrapa Milho e Sorgo, Sete Lagoas, MG.
casela@cnpms.embrapa.br

Décio Karam, Embrapa Milho e Sorgo, Sete Lagoas, MG.
karam@cnpms.embrapa.br

Derli Prudente Santana, Embrapa Milho e Sorgo, Sete Lagoas, MG.
derli@cnpms.embrapa.br

Evandro Chartuni Montovani, Embrapa Milho e Sorgo, Sete Lagoas, MG.
evandro@cnpms.embrapa.br

Fernando Tavares Fernandes, Embrapa Milho e Sorgo, Sete Lagoas, MG.
tavares@cnpms.embrapa.br

Israel Alexandre Pereira Filho, Embrapa Milho e Sorgo, Sete Lagoas, MG.
israel@cnpms.embrapa.br

Jamilton Pereira dos Santos, Embrapa Milho e Sorgo, Sete Lagoas, MG.
jamilton@cnpms.embrapa.br

José Eustáquio Loureiro, Emater-MG
emdtsetl@mrnet.com.br

José Magid Waquil, Embrapa Milho e Sorgo, Sete Lagoas, MG.
waquil@cnpms.embrapa.br

Luiz Marcelo Aguiar Sans, Embrapa Milho e Sorgo, Sete Lagoas, MG.
lsans@cnpms.embrapa.br

Nicésio F. J. de Almeida Pinto, Embrapa Milho e Sorgo, Sete Lagoas, MG.
nicésio@cnpms.embrapa.br

Paulo Emílio P. de Albuquerque, Embrapa Milho e Sorgo, Sete Lagoas, MG.
emilio@cnpms.embrapa.br

Ramon Costa Aarenga, Embrapa Milho e Sorgo, Sete Lagoas, MG.
ramon@cnpms.embrapa.br

Ricardo A. Lopes Brito, Embrapa Milho e Sorgo, Sete Lagoas, MG.
rbrito@cnpms.embrapa.br

Introduction

Maize in Brazil is produced in about 3.6 million farms, and occupied about 13 million hectares in the 2000/01 growing season. Total production reached a record of 41.5 million tons of grain and average yield was 3,272 kg/ha (IBGE, 2001).

Brazil's maize production is distributed over all regions. In the growing season 2000/01, 74% of the planted area and 92% of the production were concentrated in the South, Southeast and Midwest regions. 20% of the maize fields are located in the Northeast region, corresponding to 4.5% of the national production; the North represents 6% of the planted area and 3.5% of the grain production. In the nineties, the substitution of maize by soybean production has been intensified.

Part of the maize production has been transferred to a second-crop harvest in the same growing season, known as "safrinha". This is done in sequence after the early soybean harvest, from January to April, in the Center-South. This second-crop has expanded lately mostly in the States of Mato Grosso and Mato Grosso do Sul, where the "safrinha" area is larger than the maize area in the normal period. Nowadays it represents about 2.6 million hectares.

The maize production systems in Brazil vary remarkably from subsistence cropping with yields sometimes as low as 1 ton/ha to highly technical production systems that may reach yields of 10 ton/ha. In the subsistence systems it is common to plant maize in association with other crops. Crop rotation, and no-tillage as well as genetically improved seed and the control of leaf cutting worms (in about 60% to 80% of the total area) are among the most utilized practices in technically advanced systems.

Varieties, double-cross and three-way cross hybrids are available in the genetically improved seed market. It is estimated that chemical weed control and seed treatment with insecticides are used in 4 million hectares. The use of fertilizer based on soil testing is still deficient. It is estimated that with a present average consumption of 95 kg/ha of nitrogen, P_2O_5 and K_2O , this crop will be the chief fertilizer consumer in the near future.

The GAPs for maize production are oriented towards: a) assurance of good quality to agricultural products and the safety, health and well-being of the rural laborer; b) preservation of the environment; c) add value to the produce of small, medium and big farmers.

The GAPs here recommended consider the different cropping systems adopted in Brazil, from subsistence farming to technically sophisticated cropping. These GAPs should respect the environmental and labor legislation as well as the Children and Adolescent Statute, and the principle of equal pay for all types of labor.

Selection of the cultivation area

Maize may be planted in any point of the Brazilian territory, as long as environmental laws are respected. The adequate selection of the area is essential for the success of maize production. Mistakes in this selection bring forth economic losses, environmental damages and negatively affect final product quality.

Climate

- Temperatures of 10°C; 25°C to 30°C and 42°C are the minimum, best and maximum for maize cultivation.
- A rainfall of 350 to 500 mm is the lower limit for maize production without irrigation.
- Water requirement for the entire cycle is of 500 to 800 mm.

Soils and topography

- The effective soil depth for adequate root development should be at least 50 cm.
- Shallow soils affect root development, and present lower stored soil water.
- Soil and climate aptitude, the requirements of maize cultivation and of the market should be observed.
- To successfully reduce erosion and to facilitate mechanical operations, maize should be planted on land with slopes of less than 12%.
- Maize must not be planted in areas subject to flooding (hidromorphic and poorly drained alluial soils) unless a good drainage system is prepared.

Maize can be severely damaged by excess water. It does not tolerate flooding even for short periods.

Practices of soil and water conservation.

Soil and water conservation practices contribute to improve the plant coverage and diminish erosion and silting.

- Land should be used within its use capacity.
- Good soil erosion control practices associate adequate conservation techniques such as vegetative and mechanical practices.
- Good soil management practices should reduce water erosion and improve biological conditions:
 - Use mulch, cover crop or crop residues to protect the soil against erosion, increase infiltration, reduce evaporation, reduce thermal and humidity range.

- Use contour cultivation.
- Establish compatible crop rotation systems.
- Maintain the vegetal species diversity to increase the ecological stability.
- Animal manure should not be stored and compost should not be prepared in the cultivation area.
- Animal manure and the composting area should be kept as distant as possible from surface water resources.

Local technicians should be consulted for advice on the best conservation measures.

Soil preparation

Inadequate practices of soil preparation cause chemical, physical and biological degradation of soils in addition to unnecessary expenditures with inputs (fertilizers and energy) increasing the water deficit and its effects.

- Adequate techniques of tillage to preserve the chemical, physical and biological soil conditions. To prepare an ideal seedbed the following goals should be set:
 - Alternate the plowing depth annually.
 - Seedbed preparation should be done at the right moisture content.
 - The last harrowing (secondary tillage) should be done immediately before planting, to control weeds.

The ideal moisture content requires minimum effort for mechanical operations, allowing better results. Excess humidity provokes soil compaction. If the soil is excessively dry, it requires several harrowing operations, increasing fuel consumption.

- No-tillage or conservation tillage should be used whenever possible.
- No-tillage systems should be used with adequate residue cover over the soil surface (about 6 t.ha⁻¹ of residue from previous crops).
- Use crop rotation or double crop systems.

The no-tillage system has many peculiarities and involves many crops; all recommendations of the No-till Manual should be followed. This cropping system promotes energy saving expands the viable planting period, reduced fixed costs and permits better use of available machinery.

Planting

The planting operation is essential for good results in production. The consequences of deficiencies in this respect will negatively affect the whole cultivation process from erosion control, to pest management, harvest, yield, product quality and profits.

Cultivars

- Cultivars should be selected considering the type of cropping system, soil and climate conditions, and the objective of the crop (maize for *in natura* consumption, forage or grain).
- Genetically improved seed with adequate germination, purity, and vigor indices/percentages, should be purchased from reliable seed dealers.
- Maize cultivars should be well adapted to the region, resistant to common diseases, show good agronomic characteristics, such as stalk and root strength, have a crop cycle that is suitable for the type of exploitation, and present good grain characteristics, in accordance to market requirements.
- The maize seeds may be hybrids or improved open pollinated varieties. To choose the right seed for his crop, the farmer should consider the following facts:
 - Hybrids present higher potential yields, but the price of the seed is higher.
 - Open pollinated varieties can be planted in more than one crop season without losing its yield potential, if some special care is taken to provide a high degree of genetic purity. Farmers that still use the traditional seed saved from the last crop, are those that can't afford to purchase improved seed.
 - Maize seeds are classified according to their sizes and shapes (round or flat), and based on width, thickness and length.
 - The size and the shape of the seeds do not affect the crop yield.

- Smaller seeds may provide savings of up to 44 percent in comparison with bigger seeds.

Planting date

- For non-irrigated maize, the planting date is determined by the beginning of the rainfall season.
- The planting date should allow the tasseling, silking and pollination stages to coincide with the rainy period, and the harvest to coincide with a dry period.
- Irrigated maize may be planted in any date around the year in the regions where there is no frost hazard.
- Planting of maize in cooler periods determines a longer cycle which may affect subsequent crops.
- Where possible, as in some Brazilian regions, farmers should use Agricultural Zoning information to decide about the best planting date.

Planting depth

- In heavy soils, or when growing conditions are unfavorable to the emergence, or during the cold season, the planting depth should be 3 to 5 cm.
- When growing conditions are favorable, as in light or sandy soils, the planting depth should be 5 to 7 cm.
- If the soil is too cold, too wet, or too dry, germination may be slow or the young seedling may die before it becomes established.

Plant population

- Maize population for maximum economic yield of grain varies with hybrid or genetic material, row spacing, soil fertility, soil water and climatic conditions.

- Optimum population varies from about 40,000 to 70,000 plants per hectare.
- Under favorable moisture conditions, a higher plant population is recommended.
- Early maturity cultivars, with shorter plant height, can stand a larger plant population than late maturity cultivars of higher plant height.
- Mechanical harvesting will not be affected by narrow row spacing.
- There is general agreement that maize yields increase as row width decreases, if plant populations are relatively high. Yields are greater for narrow row spacing than for wider spacing. This results from greater solar energy interception, greater efficiency in water and fertilizer use, and better weed control, due to faster canopy coverage of the soil surface, which also contributes to reduce erosion.
- Rows about 100 cm wide are used in subsistence cultivation of maize, where field operations are manual or by animal traction. In this situation weed competition is greater.
- The adjustment of the maize planter should be made carefully. Special sowing discs are often necessary.
- Under average conditions, it is wise to overplant by 20 to 25 percent to compensate for crop mortality due to lack of germination, mechanical or cultivation damage, and soil pests and diseases.
- Adequately gauge the planter using special disks whenever necessary.
- Use 20% to 25% more seeds than required by the intended stand.
- Recommended stand varies from 40,000 to 70,000 plants per hectare.
- In irrigated crops, the planting density should be of no less than 60,000 plants per hectare.
- In intercropping systems, the plant population should not exceed 40,000 plants per hectare.

- Row spacing for maize production may vary considerably: from about 100 cm in the low technology subsistence cultivation to about 70 cm, where modern technology is adopted.
- In subsistence cropping row spacing should be wider because of manual and animal traction operations.
- In manual sowing, row spacing should be between 90 and 100 cm and hill spacing 40 to 50 cm with 2 to 3 kernels per hill. Row spacing should match harvester dimensions if mechanical harvesting will be used.
- Planting speed should account for terrain characteristics and machine specifications
- Narrower rows are mainly used with modern maize cultivars, which are of smaller plant height and erect plant architecture.

Whenever possible use narrower spacing.

Soil fertility

Adequate and balanced level of nutrients is essential for sustainable maize cropping. Improper use of fertilizer and amendments may cause contamination of soil and water, besides erosion and soil compaction.

- Soil analysis is essential for better management of fertilizer and limestone use.
- Record the liming and fertilization history of the areas.
- Use only legally registered fertilizers.
- Fertilizers that contain toxic chemicals should be avoided, especially heavy metals that can cause soil contamination.
- Contamination of the water table by chemicals, especially nitrates, should be avoided.

Preparation of a business plan is recommended for better management.

Liming

- Quantify rates of lime to use with proper methods, observing research recommendations for any particular region.
- Doses of limestone up to 2 t/ha should be applied in two times: half before and half after plowing.
- Check the need of new application of limestone using the base saturation method.
- Do not apply limestone when base saturation is equal or above 50%.
- Add limestone to about 20 cm soil depth.
- Limestone should be well-mixed with the soil.

- In consolidated no-tillage systems with more than 4 years, limestone should be applied on the soil surface, without soil disturbances (plowing or harrowing).

Gypsum application

- Apply gypsum based on chemical characteristics and texture of the soil layer from 20 to 40 cm and from 40 to 60 cm.
- Apply gypsum at the same time as limestone.

Apply gypsum only under strict technical recommendation and if absolutely necessary.

Fertilizer application at planting time

- Define nutrient needs at planting time based on soil analysis and the nutrient removal by the crop (34 kg/ha of phosphorus, 143 kg/ha of potassium for a yield of 9 t per hectare).
- If the objective is to produce maize for silage or forage, removal of phosphorus will be smaller and of potassium will be larger (23 kg/ha of phosphorus and 143 kg/ha of potassium for a yield of 17 t dry matter per hectare).
- Prepare the fertilizer formulation according to needs or use a commercial formula that has similar nutrient content.
- Check response to micronutrient fertilization mainly in sandy soils with low levels of organic matter and irrigated crops with high yield.
- In some regions, where zinc is deficient, it is necessary to use fertilizer containing this element.
- Fertilizer application with zinc: 2 kg of Zn/ha in soils with zinc (DTPA) of 0.6 to 1.2 mg/dm³ and 4 Kg of Zn/ha in soils with zinc (DTPA) lower than 0.6 mg/dm³.

- Application methods: in the soil, on the plant (foliar application), on the seeds and by fertigation.
- Granulated fertilizers should be preferred due to the simplicity and uniformity of application.
- Split nitrogen application: apply 10 to 20 kg/ha of nitrogen at planting time and the complement in one or two times later (sidedress application).
- In no-tillage systems, increase nitrogen application at planting time to 30kg/ha.

Sidedress application

- Check needs of nitrogen application considering soil and climate conditions, in no-till or conventional system, planting time (normal or “safrinha”): response of the cultivar; crop rotation; time and method of application of the fertilizer; sources of nitrogen; and economic and operational aspects.
 - In double cropping or crop rotation (maize-soybean) reduce 20 kg of nitrogen per hectare in the sidedress application.
 - Two sidedress applications should be done if high nitrogen rates (> 120kg ha) are required; in sandy soils; and areas with high probability of heavy rains.
 - Only one sidedress application is necessary if rates of nitrogen are low or medium (< 120kg/ha); if the soils are of medium or clay texture, if there is no irrigation, and fertilizer is applied mechanically.
 - A single sidedress should be applied in the initial period of crop development, when the plants present 4 to 6 fully developed leaves, independently of the rain intensity.
 - When sidedress application of nitrogen is split in two, the first should be done when maize plants have 4 to 5 leaves and the second when plants have 6 to 7 leaves.
 - When nitrogen fertilizer is urea, application should be done in wet soil incorporating to about 5 cm depth or via irrigation water (fertigation).

- Sidedress application of potassium is necessary for forage maize if soil is highly deficient in potassium; this application should be made no later than 30 days after planting.

Organic fertilization

- For organic amendment, always use decomposed material of known origin.
- Liquid swine manure should be stabilized during a period of 90 to 120 days.
- The economic rates of liquid swine manure are from 50 to 100 m³/ha.
- Rates of fertilizer and lime should be calculated on the basis of soil test results and on the expected yield.
- Sidedress fertilization is needed because nitrogen is a very important nutrient for maize yield.
- Follow strictly the technical recommendations for doses, methods and timing of fertilizing and liming.

Irrigation

Inadequate irrigation management can cause salification, wastage of water and energy. Pertinent legislation should be observed.

- Local climatic conditions during the growing period and the expected economic return of the activity are essential factors in the definition of whether to use irrigation.
- Irrigation is necessary if the cropping period coincides with long drought periods, or in semi-arid or arid regions.
- The selection of the most suitable (or well adapted) irrigation method for maize should consider: available water discharge in the farm; topography; water quality and cost; soil characteristics (water holding capacity, intake rate, natural fertility and the spatial variability of these characteristics); climate conditions (rainfall, wind and the evaporative demand of the atmosphere); crop characteristics (farming system and crop density, effective root depth, and economic value).
- Surface, subsurface irrigation or sprinkle irrigation methods should be used.
- Localized (trickle, micro-sprays) irrigation systems should be avoided, because they are not well adapted and not economically feasible for maize crop.
- The application of irrigation water and the distribution uniformity of the system should be measured and controlled.
- The definition of the amount and depth of water to be applied should be based on the water balance, soil water holding capacity and the crop water requirements.
- The water should be used in a rational and efficient way, without damaging the environment.
- Soil moisture and the crop evapotranspiration should be monitored.
- Water salinity and the presence of polluting substances should be controlled.

- Irrigation and water quality regarding chemical, physical and biological aspects should be monitored.
- The following lab analyses are needed to evaluate water quality for irrigation:
 - Electrical conductivity (EC) or total dissolved salts (TDS); concentration of calcium, magnesium, sodium, carbonates, bicarbonates, chlorides and sulfates for the determination of the Sodium Adsorption Ratio (SAR); and the presence/concentration of toxic elements, especially boron.
- The EC of the water (EC_w) should not exceed 1.1 dS/m, at 25° C, nor should the EC of the soil saturation extract (EC_e) exceed 1.7 dS/m, at 25° C.
- Boron concentration in the water should be in the range of 2.0 to 4.0 mg/L, in the irrigation water and in the saturation extract.
- Irrigation water that does not conform to these technical standards should not be used for maize.
- A maize crop needs 400 to 700 mm of water, not including losses.
- If groundwater is used for irrigation, correct design and calculation of its use is necessary to match the crop water needs with the limits of extraction.

Irrigation is a recommend practice when the growth cycle coincides with long dry periods or in arid or semi-arid regions, but it is essential that the water be of good quality and that pertaining legislation is observed.

Integrated pest management - IPM

Weed control

Inadequate chemical weed management can affect crops subsequently planted in the same area, develop resistance in weeds, pollute ground water, increase costs, and cause environmental damage to adjacent areas with eventual impacts on human health.

- Prevent weed seed production or the introduction of new weed species in the planting area.
- Clean the equipment when there is traffic between areas.
- Control weeds in irrigation and drainage canals to avoid weed seed production.
- Always use certified crop seed with low level of weed seed contamination.
- Keep recently acquired animals in quarantine before the introduction in the farm to avoid dissemination of weed seeds present in the animal gastrointestinal system.
- Whenever possible, instead of chemical weed control, use cultural methods such as: manual or mechanical cultivation; well adapted cultivars; appropriate plant density and spacing, to speed up crop canopy development, thus promoting timely shading; adoption of no-tillage.
- Manual or mechanical weed control should be done between 14 and 21 days after maize emergence.
- Repeat manual or mechanical weed control between 28 and 35 days after emergence.
- Do not use deep (> 5 to 6 cm) manual or mechanical late weed control to avoid mechanical root damage to maize.
- Whenever possible, reduce herbicide use to prevent environmental contamination.
- Check legislation and registration before using herbicides.
- Personnel involved in herbicide application should be properly trained and individual protection equipment (IPE) and clothing should be used.

- Use chemical weed control when expected yield is above 4,000 kg/ha⁻¹.
- Herbicides should be selected considering the weeds as well as the location where the herbicide will be sprayed; also the application mode (pre-emergence or post-emergence) should be taken into account.
- Chemical and physical characteristics of the herbicide should be known (water solubility, vapor pressure, adsorption coefficient and half-life) to evaluate the probability of environmental contamination.
- Whenever possible, avoid chemical products with the following characteristics:
 - High water solubility (high risk of ground water contamination).
 - High vapor pressure.
 - High adsorption coefficient
 - Products with long half-life.
- Pre-emergence herbicides should be applied in wet soil.
- Post-emergence herbicides should be applied at the weed growth stage recommended by the chemical manufacturers.
- Herbicides should be applied in cool periods when the humidity of the air is below 60%.
- Sprayers should be calibrated adequately to obtain uniform herbicide distribution.
- All applications of pesticides must be done by trained persons using IPEs to avoid intoxication.
- The equipment must be cleaned after application.
- Dispose of the empty containers in places previously designated for that purpose.
- Constantly check the efficacy of the weed control independently of the method used (manual, mechanical or chemical).

Precautions in weed management are important for environmental and economic sustainability of any agricultural production enterprise.

Insect pest control

The inadequate use of pesticides to control insect pests can cause development of resistance and contaminate soil, water and produce, cause environmental damages in adjacent areas, affect wild and domestic animals and cause economic losses, besides affecting human health.

- Natural pest control methods such as biological and biotechnological should be preferred.
- Periodical surveys and records of pest outbreaks and population density of natural pest predators should be performed.
- Control actions should be taken only when the target pest density reaches the control threshold level. Take no action when population density of the natural enemies is above the expected level to keep the target pest density below the economic threshold level.
- Appropriate instruments should be installed to monitor the climate conditions to aid the preventive control of target pests.
- Personnel should be adequately trained.
- Only legally registered chemical products for each crop and pest species should be used.

Soil pests

- Soil insect pests should be controlled.
- Soil should be well drained and never keep water excess in clay soils or soils under irrigation to avoid *Diabrotica* damage and to provide good environmental conditions for the action of entomopathogenic fungi.
- Under no-tillage system, the incidence of white grubs, wireworm, termites, and ants, should be monitored.
- Under conventional tillage system, it is recommended to monitor the lesser maize-stalk-borer, which causes the death of seedlings by opening galleries in the stem.

- Seed (FW) or soil (granular) treatment with systemic insecticide are recommended to control the lesser maize stalk borer.
- When treating soil with granular insecticides utilize only the row treatment.

Control of aerial pests

- To avoid unbalancing the agro-ecosystem it is recommended to monitor and control, beginning at plant emergence, with selective insecticides, the following pests: fall armyworm (FAW) – *Spodoptera frugiperda* (Smith) and sugarcane borer - *Diatraea saccharalis* (F).
- Seed treatment is recommended for the control of soil and foliar pests (it protects seedlings until 15 to 17 days after sowing).
- Fall armyworm (FAW) control is recommended only when the surveys indicate pest incidence above 20% of infested plants.
- Physiological pesticides should be preferred for the control of fall armyworm (FAW), because they are selective, protecting the natural enemies of the target pest in the field.
- Nonselective insecticides like organophosphate or carbamate for the control of fall armyworm (FAW), should be avoided at the beginning of crop development to protect the natural enemies of the pests.
- Not more than two insecticide applications per crop season should be used.
- Priority should be given to the preservation of earweeegs (*Doru luteipes*) and Chrysopa (*Chrysoperla externa*), the two main natural enemies of many pest species, always present in the maize fields.
- For late planting season or continuous planting under irrigation, intensive monitoring should be done for the virus and mollicutes vector, and for the maize leafhopper (*Dalbulus maidis*). In areas where the leafhopper occurs, seed or soil treatment should be done with a systemic insecticide (imidacloprid or thiamethoxan).
- Insecticide application by airplane or via irrigation water, to control fall armyworm, maize earworm and sugarcane borer should be

avoided since these treatments are ineffective and can cause strong environmental impacts.

Local technicians and extension agents should be consulted in the definition of the pest management strategy and to avoid the use of illegal pesticides.

Disease control

The use of resistant cultivars and of cultural practices to control the most common diseases, avoids yield losses and positively influences final product quality, besides preserving human health.

Following plant disease prevention measures should be taken:

- Use genetic resistant varieties.
- Late planting should be avoided.
- Continuous disease monitoring and diagnosis.
- Crop rotation with non-host species.
- Suppression of volunteer maize plants and alternation among susceptible hosts to reduce the inoculum potential in the area.
- Adequate irrigation management avoiding excessive use of water.
- Use of adequate crop management practices including adequate fertilization, avoiding plants under nutritional stress and, consequently, more susceptible to diseases.
- Chemical control of diseases is not recommended for maize disease management in Brazil, except in special situations, in seed production areas.

Preventive management of diseases in maize should be preferred. Chemical control should be used only in seed production.

Precautions in the handling and application of pesticides

Pesticide use legislation must be strictly observed to prevent damages to the environment

Preparation and application of pesticides

- Only legally registered pesticides should be used.
- The legal rules of agronomic prescription should be followed strictly.
- Spraying should be used exclusively in areas under epidemic risk and/or when the target species reach the critical level (economic threshold level).
- Personnel in charge of pesticide application should be well trained and use Individual Protection Equipment (IPE).
- Only adults should be allowed to handle pesticides.
- Children, domestic animals and people not directly involved should be excluded from the area where pesticides are being used or prepared.
- Pesticides should be prepared and handled only in specially designated, safe and ventilated places.
- It is forbidden to eat, drink or smoke while handling and applying pesticides.
- Pesticides should not be applied close to water sources (streams, lakes, wells etc.) to avoid contamination.
- The water used to clean the pesticide container should be returned to the tank to be mixed with the next batch of pesticide.
- The handling of pesticide should follow all rules recommended by the law.
- Pesticide spraying should be avoided during windy periods to reduce jet deflection.

- The product label should be read carefully and all recommendations should be followed regarding the procedure, care, interval before harvest and the pesticide container destination.
- Specific doses for maize should be used according to the prescription of each pesticide.
- Do not manipulate or carry around damaged pesticide containers.
- Avoid direct manual contact with pesticides using always the original container to store or transport the chemicals.
- Avoid spillage when handling pesticides.
- After work is finished, clothing should be removed and the operators should bathe immediately with abundant water and soap use.
- Medical assistance should be sought immediately if there is suspicion of intoxication.
- Workers involved in the use of pesticides should be submitted to periodical health check-up.

Care in pesticide use is a serious matter of human security because they can cause long-term ecosystems contamination affecting the health of human beings.

Equipment used in pesticide application

- Children, domestic animals and people not directly involved should be kept out of the area where pesticides are being used or prepared.
- The equipment should receive periodical maintenance and calibration using recommended method and technology.
- The maintenance and use of equipment should be well planned to be available when needed.
- The operators should be well trained and use Individual Protection Equipment (IPE) like gloves, mask, protection glasses, waterproof coat, hat and boots, according to the manual for pesticides use.

- Tractors used for pesticide spraying should have a closed cabin for the driver.
- Nozzles, hoses and valves should not be cleaned using the mouth.
- Never use leaking, uncalibrated or defective equipment to spray pesticide.
- Minors should not be permitted to work with pesticides.
- Pesticide application should be made in the cooler periods of the day and when relative humidity is below 60%.
- Pesticides should not be applied when winds blow at speeds higher than 8 km/hour to avoid jet deflection.
- Pesticides should not be used close to watercourses or reservoirs.
- Post-emergent herbicides should not be sprayed on wet plants by irrigation or other cause or if weeds and crops are under dry stress.
- Application equipment and IPE should be cleaned and washed in appropriate places far from any watercourse or reservoir.
- Operators should bathe immediately after finishing their chores.

In case of intoxication with pesticides, the victim should be taken to a cool and ventilated place, undressed, taken to a hospital or medical doctor, together with the pesticide label. The victim should not drink milk because it increases the retention of the pesticide in the human body.

Storage and destination of empty pesticide containers

- Changes in the pesticide stock should be recorded periodically.
- Pesticides should be stored in ventilated rooms, safely locked, distant from residences, protected from rain, off limits to children and untrained people.

- Safety rules and pertinent legislation should be strictly observed.
- Never store animal or human food near pesticide containers.
- Empty pesticide containers should be washed three times, depending on the kind of material, and sent to appropriate destruction or recycling centers.
- Never wash empty pesticide containers or equipment in water wells, streams, rivers or lakes.
- Never reuse the empty pesticide containers for other purposes.
- Never leave or store or empty pesticide containers or pesticide remains near cultivated areas or water wells, streams, rivers or lakes.
- Lime should be used to neutralize noxious chemicals in empty pesticide container deposit.

Human health and environmental quality can be seriously affected when empty pesticide containers are not discarded according to technical recommendations.

Quality assurance

- Preventive maize grain treatment should be applied against toxicogenic fungi and/or mycotoxin contamination.
- Only seeds with high physiological and sanitary quality should be used.
- Maize cultivars with good ear sanity and resistant to toxicogenic fungi and maize cultivars with decumbent ears should be used.
- The right plant population should be used avoiding excessively high densities.
- Mono-cropping system should be alternated by rotation with other crops not susceptible to *Aspergillus*, *Fusarium* and *Diplodia* species.
- Weed plants which host *Aspergillus*, *Fusarium* and *Diplodia* should be eliminated.
- The objective of these practices, before harvesting¹, is to keep micotoxins within prescribed limits.

To obtain maize with acceptable sanitary quality the adequate practices must be adopted from soil preparation and selection of varieties to post-harvest operations and storage.

¹The maize grain can be damaged by fungi before harvesting, which produces burned grains and during storage period producing grain molds. These toxigenic fungi produce toxic substances called mycotoxins, which are highly harmful to human and animal health (swine, poultry, equine, bovine etc.), producing diseases named mycotoxicosis. The mycotoxins are carcinogenic (cancer promoter), teratogenics (physical deformation promoter) and mutagenic (mutation promoter).

Harvest and post-harvest

Inadequate harvest and post-harvest practices harm grain quality and consequently the quality of the food for animals and humans, affecting the price and the marketing of the crop.

- Maize should be harvested with 16% humidity.
- Harvest should not be delayed to avoid increased attack of fungi, insects and rodents in the field.
- Maize ears from lodged (fallen) plants should not be harvested to avoid contamination by soil fungi like *Fusarium*, or should be separated if harvested.
- When infrastructure for artificial drying is not available, maize should dry naturally in the field.

Mechanical harvesting

- Cultural practices should be scheduled to provide favorable conditions for mechanical harvest.
- The planters should have row numbers equal or multiple of the maize head of a combine, to match the same row spacing of maize planting with harvesting.
- Maize cultivars of short to medium plant height and resistant to broken plant and root and stalk lodging should be used.
- Good cultural practices should be adopted to secure an adequate soil preparation and good seed germination.
- Grain harvest should start with moisture content range from 18% to 22% to reduce grain and energy losses with artificial drying.
- The combine and its components have to be properly operated and maintained.
- The combine operators should be trained to reduce losses.
- Prescribed maintenance procedures on the equipment should be observed.

- Equipment should be adequately adjusted and gauged, according to the combine manual.
- Choose the best work speed.

A good maize harvest depends on good planting.

Post-harvest

- A maximum of 6% of burned grain should be accepted in commercial lots of maize.
- Maximum limit of aflatoxin in maize grain for human and animal consumption is 20 ppb (20 micrograms of aflatoxin/kg).

Drying temperature

- Clean grains before drying.
- Drying temperatures should be set as follows:
 - Below 44°C is best for seed quality
 - Below 55°C is best for human food grain quality.
 - Below 82°C is best for animal feed grain quality.

Drying temperature is very important for product quality and depends on the destination of the grain (seeds, human food of animal (feed)).

Grain storage

- Store grain following the official manuals for grain classification (Ministry of Agriculture, Livestock and Food Supply).
- Instruments for temperature and humidity monitoring and aeration equipment should be installed in storage structures.
- Moisture content below 14.5%.
- Mass grain temperature below 25° C during storage.
- Avoid: bulks of grain infected by fungi; storage structures infested by fungi; presence of impurities adult insects and its body parts, excrements in the grain mass.
- Rodents in the storage structures and infestation in stored grain by weevils (*Sitophilus zeamais*) and moths (*Citrotroga cerealella*) should be controlled.

Shelled Grain Storage

- Whenever possible, grains should be stored in structures with temperature and aeration monitoring system.
- Silos should be built of steel or concrete and tightly sealed.
- Grain mass should be maintained clean, dried, ventilated and free of insects.
- Fumigation with phosphine gas should be made to control insects during storage, observing following precautions:
 - Use phosphine gas at the recommended dose.
 - Use only trained personnel.
 - Use only sealed grain storage.
 - Repeat fumigation every three months.

Grain storage in bags

- Maintain grain stored with moisture below 13% to 13.5% in a well-ventilated structure.

- Bags stored on concrete and cemented floor with perfect roof structure and anti-rodent protection.
- Bags piled on wood platforms away from the walls.
- Phosphine gas applied to control insects periodically, at the recommended dose.

Unhusked ears storage in woodbins

- Woodbins made of materials existing on the farm.
- Ventilated woodbins.
- Maize harvested with moisture content below 16%.
- Control insects. Use deltamethrin 0,2% powder, as an option, for insect control.
- Separate the well-covered ears from the open tips.
- Build physical barriers against rodent invasion.

There are different storage structures for maize. The choice should be based on the location and available resources. In any case, hygiene is fundamental.

Hygiene, safety and workers' well-being

It is essential to train employers to avoid chemical, physical and biological contamination, of laborers, of the product and of the environment. The observance of pertinent legislation avoids problems and sanctions and assures a healthy environment.

- Personnel should be trained for each specific activity.
- Regulations and work safety rules should be respected.
- Worker health in all areas should be monitored.
- A record on health and work safety procedures should be maintained.
- All personnel who manipulate pesticides should be trained on the use of IPE and for obedience of personal hygiene procedures.
- Labor legislation including salaries, lodging, transport and other legal rights should be respected.
- Education facilities for the children of laborers should be provided according to legislation.
- Adequate facilities for meals and personal hygiene should be offered.

Cleanliness habits and adequate working conditions minimize health problems of laborers and consumers.

Environmental management

Environmental management of the agricultural enterprise is basic for the maintenance of soil and water quality, for the preservations of biological resources and for the quality of life of the local population.

- Ecological precautions should be observed during all operations, having sustainability in mind.
- Contingency plans should be prepared for prevention and/or correction of environmental problems (ground, water, plants and human being) during all operations.
- Areas of mandatory preservation should not be used for agriculture and legislation pertaining to the legal ecological reservation on farms should be observed.
- Preserve watercourses and springs maintaining the natural plant cover contributing for the restoration of the natural vegetation.
- Always consult extension agents or research scientists to decide about best technical and ecological solutions for maize production.

Maize production in Brazil can provide a supplementary income to farmers provided that good agricultural practices are used to obtain better quality products.

Technical assistance and associative initiatives

The adoption of Good Agricultural Practices, with technical assistance and cooperative organization of farmers, contributes for the regional socioeconomic development and for the conservation of natural resources.

- A professional should be available for the supervision of the maize production from initial planning up to the marketing phase.
- Organization of farmers in cooperatives should be stimulated for cooperative use of machines, purchase of inputs, marketing of produce, grain storage and management activities.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Soybean production



Author: *Décio Luiz Gazzoni, Embrapa Soja, Londrina, PR.*
dgazzoni@cnpso.embrapa.br

Co-authors: *Ademir Assis Henning, Embrapa Soja, Londrina, PR.*
henning@cnpso.embrapa.br

Antonio Garcia, Embrapa Soja, Londrina, PR.
garcia@cnpso.embrapa.br

Áureo Lantmann, Embrapa Soja, Londrina, PR.
aureo@cnpso.embrapa.br

Introduction

This document reflects technical recommendations composing a set of Good Agricultural Practices for soybeans in Brazil. The most important aspects for the sustainability of the soybean cultivation were considered, especially environmental, social, economic and commercial considerations.

Good Agricultural Practices are a set of sound concepts, supported by good science, tested and validated not only on small plots studies but also under different Brazilian soybean production conditions. It is understood that details of the practices regarding specific recommendations are subject to frequent modifications, and consultations should be made to the official soybean cultivation recommendations, issued yearly by the research organizations.

It must also be understood that this ideal set of Good Agricultural Practices does not represent a unique rule for all the situations of soybean production in Brazil, whose geographical distribution ranges from latitudes of 5° N up to 33° S. Consequently, this document provides a set of the best available concepts that might not be applicable to all areas and conditions where soybeans are cultivated in Brazil.

Soybeans in Brazil are spread almost all over the country, except in the eastern part of the country, due to topographic restrictions, and on the Amazon and Pantanal regions, due to legal environmental restrictions. During the 2002/03 season it is estimated that ca. 17 million hectares of soybeans will be planted with an overall production of ca. 48 million metric tons. There are approximately 2 million people involved with soybean production, including farm administrators, rural workers, machine operators and similar occupations.

The destination of the Brazilian soybeans is about 50% for internal consumption, as oil, flour, meal either for human food or for animal feed and for seed production; the rest of the production is traded in

the international market mainly as grain, but also as meal and a minor part as oil or other processed products.

The GAPs here recommended consider the different cropping systems adopted in Brazil, from subsistence farming to the most technically sophisticated ones. These GAPs should respect the environmental and labor legislation as well as the Children and Adolescent Statute, and the principle of equal pay for all types of labor.

Climate and soil requirements

Soybeans can be planted in almost all Brazilian arable area, exception made to the Amazon and Pantanal areas, protected by Brazilian laws due to environmental restrictions. The available technology allow soybean cultivation on the different climate and soil conditions of the several regions, exception to the Northeastern Semi-Arid and the mountains along the eastern part of the country. Area selection is critical for the competitiveness of the crop and for the protection of the environment.

Climate

- Soybeans can be cultivated in regions with mean temperatures ranging from 20° to 30° C, during the planting season. The ideal average is 30° C. Vegetative growth of the crop is null or strongly reduced in temperatures lower than 10° C or higher than 40° C.
- The crop requires, during its growing season, from 450 to 800 mm of rain, depending upon general climatic conditions, crop management and the cycle length of the variety.
- When scheduling the planting operations a factor to be considered is that senescence and harvesting must coincide with low rainfalls periods, to avoid harvest troubles, reduced yield and low grain quality.

Soil selection

Preference should be given to soils of medium texture (clay content from 30 % to 35%) or heavy but well drained soils, with adequate water retention capacity and effective soil depth above 1 m. Soils with clay content of less than 15% should be avoided.

- Soybeans should not be sowed in soils with declivity over 8%, when using conventional cropping systems, or over 15% when using the no-till system.
- Soybeans should not be sowed in soils with any major physical problem, like rocky outcrops, presence of stones or salty soils.

- The soils must have adequate standards of fertility or provide the conditions for its correction, according to crop requirements.

Soybeans must be planted in well drained soils with adequate water retention capacity and adequate standards of fertility.

Soil and water conservations practices

The adoption of adequate soil and water conservation practices is critical for the sustainability of the soybean cultivation. Inadequate practices will cause chemical, physical and biological degradation of the soil, unnecessary waste of inputs like fertilizers, seeds and also energy, soil and water contamination, and water stress.

- Soil use capacity must be taken into consideration, specially regarding its declivity, depth and texture.
- Prevent any erosion process by building terraces, retention strips, using no-tillage and contour cropping.
- Promote the enhancement of the biological conditions of the soil, by rotating crops and using organic fertilization whenever possible.
- Use mulching to protect the soil against high temperatures and loss of humidity.
- The soil should be covered either with green vegetation or debris from past crops, to avoid erosion caused by water runoff or by the wind.
- Use practices to avoid nutrient lixiviation from the soil.
- Avoid water stress caused by excess water, as continuous flooding contributes to the development of pathogenic microorganisms, loss of soil nutrients or salification.
- Manure deposits and compost heaps should be located in places distant from the cultivation fields.
- Water bodies should be protected, and permanent vegetation should be implanted and kept along them.
- Use pest management practices that avoid or mitigate soil contamination and the pollution of the surrounding environment.

Local technicians should be consulted to plan conservation practices.

Soil management

Soil Management Practices are crucial for the sustainability of soybean cultivation along the time, for the expression of the plant yield potential and for soil and water conservation. No-tillage practices are well suited to soybean cultivation, considering the plant and environmental requirements, reduce susceptibility to water stress, allow longer sowing periods and require less rain for germination. No-till allows better management of the machinery complex, reducing fixed costs.

- There are three major systems of soil management for soybean cultivation; selection should observe the following order of priority:
 - No-tillage.
 - Minimum tillage.
 - Conventional tillage, with ploughing and deep harrowing as primary practice, followed by one or two light disk harrowings.
- No-tillage should be used on soils without compacted layer, or when decompaction was performed and where soil fertility is adequate on the first 20 cm of the soil.
- In no-tillage, crop rotation should be reinforced, in order to produce enough mulch for adequate soil cover.
- In minimum tillage or conventional system, the operations should provide the minimum soil disturbance, maintaining the maximum amount of crop debris on the soil surface; the tillage equipment should operate below the compacted layer of the soil. It is recommended to alternate soil management systems, the depth of the operation and the type of implements.

No-till favors fuel saving, amplifies the planting period, reduces fixed costs and allows a better use of the machinery.

Crop rotation

Crop rotation is essential for avoiding the same pattern of nutrients uptake, root development, biomass production and specially to reduce the amount of inoculum sources of soybean pests.

- In crop rotation, crops of economic importance and species that provide adequate soil coverage, with high biomass production should be used. Species of different botanic families, with priority for the combination of Gramineae and Leguminosae should be preferred.
- Preference should be given to species or varieties that are not primary or alternative hosts of plant pathogens or insect pests, and that favor the reduction of the weed population.
- To recover degraded soils, species with abundant root growth are indicated.
- When planning crop rotation, the summer crop should be of high intrinsic economic value such as soybeans, corn and cotton, and the winter crop may be wheat, rye and barley or other species with restricted economic importance such as sunflower, beans, pigeon pea, millet or wild turnip species.

Soil fertility and acidity correction

Adequate and balanced levels of available macro and micronutrients in the soil are essential for the sustainability of soybean production and for the best relation between inputs and soybean yield. The inadequate use of fertilizers can contaminate soil and watercourses and also compact the soil and provoke its erosion.

- Decision on liming or fertilizer use should be based on the history of the area and on soil tests (made each 1 to 3 years), performed by a certified laboratory and based on soil samples that actually represent the area.
- Use brands of lime and fertilizers that conform to the Brazilian legislation.
- Fertilizers containing residues of toxic substances, like heavy metals, should not be used, to avoid soil contamination.
- On sandy soils preference should be given to practices that mitigate nutrient leaching, such as mulching, application of potassium fertilizers on the soil surface and that promote the enhancement of the organic matter content of the soil, to increase the pH-dependent Cation Exchange Capacity of the soil.
- Whenever possible, use manure and green manure.

Correction of the soil pH

- Liming should be performed when necessary to keep the soil pH in the range 5.0 to 5.5, as determined by the CaCl_2 method or 5.5 to 6.0 when determined by H_2O .
- Define the lime rates according to the following methods:
 - Exchangeable aluminum neutralization or increasing content of calcium and magnesium.
 - Increasing base saturation.
 - SMP solution, following regional technical recommendation.
- Preference should be given to lime with Total Relative Neutralization Power around 100%.

- Lime rates over 2 t/ha should be split into two applications, the first applied before plowing and the second after.
- Lime should be incorporated in the first 20 cm of the soil, with thorough mixing of soil and lime.
- On soils with a long history of no-tillage (more than 4 years), liming should be performed by surface deposition with maximum rates of 2 ton/ha.
- Gypsum can be used for pH correction when high acidity indices are detected in layers deeper than 20 cm; the gypsum can be applied on the soil surface.

Macronutrient fertilization

- Soil contents of phosphorus and potassium should correspond to the availability of, at least, 20 kg of P_2O_5 and K_2O for each ton of estimated grain harvest.
- Macronutrient fertilization can be performed during sowing (in less fertile soils) or on the soil surface (in more fertile soils).
- Applications of potassium fertilizers can be made on the soil surface according to the Cation Exchange Capacity, soil texture or the K availability in the soil.
- Sulfur is normally provided to soybeans through fertilizers containing this element; supplementary rates of sulphur are only necessary when indicated by soil and leaf tissue analysis.
- Soils with deficiency of calcium and magnesium, but with adequate pH, might receive a surface application of gypsum.
- Leaf tissue analyses are convenient indicators for future needs of macronutrient fertilization.

Nitrogen supply

- The supply of nitrogen should be made exclusively through Biological N_2 Fixation by bacteria from the *Bradyrhizobium* genus.

- The inoculants containing the nitrogen fixing bacteria, either in solid or liquid formulation, should contain a minimum population of 1×10^8 cells/g or ml. The minimum rate of the inoculant should provide 160,000 cells/soybean seed.
- Seed inoculation should be made in shadowed environments, on the same day the seeds will be sowed; seeds should be humidified with 300 ml of sacharose (10% to 15%) for each 50 kg of soybean seeds.
- The validity of the inoculants and adequate storing conditions should be strictly observed.

Micronutrient fertilization

- Leaf tissue analysis should be used to plan the use and evaluate the plant reaction to micronutrient fertilization.
- The micronutrients, whenever necessary, can be applied yearly, during sowing, by using fertilizers containing both macro and micronutrients.
- Optionally it is feasible to apply micronutrients on the soil surface, with a residual effect of 5 years.
- The rates of micronutrients to be applied are defined by regional recommendations, according to critical levels of micronutrients established by the soil and leaf tissue analysis.
- The micronutrients molybdenum and cobalt can be applied as seed-coating or through foliar spraying, according to the regional technical recommendations.

Foliar fertilization

- Only the micronutrients manganese, molybdenum and cobalt can be applied through spraying over the plant. This practice is not recommend for any other nutrient.

Organic fertilization

- Only well composted materials of known origin should be use for organic fertilization.
- Animal dejects used as fertilizers must be previously stabilized during a period of 90 to 120 days.

Fertilizing and liming should be calculated on the basis of soil test result, considering also the expected yield.

Selection of varieties and seeds

Varieties must be adapted to local conditions, like soil and climate and also should be resistant/tolerant to the most important soybean pests occurring in the region. Only high quality certified seeds should be used and seed treatment must only be considered when recommended.

Varieties

- Use only varieties recommended for each state or region, registered at the Ministry of Agriculture, Livestock and Food Supply and conforming to the Agricultural Zoning, as informed in the official technical recommendations for soybeans.
- Among the recommended varieties, preference should be given to the genotypes resistant to the prevalent soybean diseases for the region, with suitable plant height for mechanical harvesting and plant cycle compatible with the dominant climatic conditions and with the crop rotation plan.
- The use of a single variety, all over the area, should be avoided; preference should be given to 2 to 3 different varieties, with different maturity cycles, especially in larger areas, in order to improve production stability along the years.
- The use of the same variety, in the same area, in subsequent years should be avoided, to reduce the inoculum of plant pathogens. However it is not recommended to substitute all known and tested varieties at the same time, by new varieties even though they are recommended for the region.
- Preference should be given to inspected or certified seeds, with documented guarantee by the seed producer.
- When using self produced seed, all aspects of seed quality must be observed.

Seed quality

- When purchasing seeds, consider the technical quality information mainly germination, purity and sanitary inocuity.
- Only seeds with germination index of 80% or higher should be used.
- Previously to sowing, a germination test on sand or soil should be performed, according to technical recommendations.
- Seeds should be always stored in well ventilated environments, with bags arranged at a convenient distance from walls, without any contact with fertilizers, lime or pesticides, assuring the absence of any pests, in temperature below 25°C and relative air humidity below 70%.
- Seed property and intellectual rights must be observed and the grower should assure that the seed was produced and marketed in observance of property rights.

Seed treatment

- Seed treatment with fungicide should be made to assure the required plant population, when one or more of the following conditions apply:
 - Dry soil condition during sowing.
 - Seeds with inadequate sanitary condition.
 - Low soil temperature during sowing.
- The selection of the fungicides for seed treatment must consider its impact upon the nitrogen fixating bacteria (*Bradyrhizobium* spp), according to regional recommendations.

Sowing period

Sowing soybean earlier or later than the recommended period will cause reduction of the yield and the quality of the grains or seeds and increase the risk of exposure to climatic stresses.

- Soybean should be planted from mid October to mid December, in almost all Brazilian regions, except in micro regions, where soybean can be planted in early October or in late December.
- In the North and Northeastern regions there are significant variations among locations. Technical assistance institutions should be consulted for more detailed recommendations.
- Private and public breeding organizations can provide detailed information regarding the requirements for its varieties.
- Sowing should be performed when the soil moisture is sufficient for seed embedding and germination. In regions where the interval between rains is short and regular, sowing can be made even in dry soils, but the seed treatment with fungicides is recommended.

Plant population and row spacing

Optimum plant population and row spacing are linked to local conditions, mainly soil texture and fertility, climatic conditions and prevalence of soybean pests. Non-observance of the right parameters may lead to reduction of the soybean yield and quality and also harvesting difficulties.

- A seed rate of 220 to 320 thousand plants/ha should be used to obtain a satisfactory plant population.
- Higher plant populations should be selected in less favorable conditions (in soils with low fertility rate or when planting occurs out of the recommended periods) or if the variety is of the low height kind.
- Lower plant densities are indicated when environmental conditions allow more intense vegetative growth, with high lodging risk.
- Soybean rows should be kept from 0.4 to 0.5 m apart. Reduced row spacing can be used if total plant population is observed.

Planting depth

Planting depth of more than 5 cm result in difficulties for soybean germination and the opposite situation may provoke excessive exposure to water stress and high soil surface temperature.

- Soybeans should be planted from 3 to 5 cm deep. Using deeper sowing may difficult germination and the opposite may face the lack of enough soil moisture for germination.

Precautions in the use of pesticides

Pesticide use legislation must be strictly observed, including package disposal, to prevent damages to the environment. and human health hazards.

Selection and handling of pesticides

- Only legally registered pesticides should be used.
- The legal rules of agronomic prescription should be followed strictly.
- Spraying should be used exclusively in areas under epidemic risk and/or when the target species reach the critical level (economic threshold level).
- Personnel in charge of pesticide application should be well trained and use Individual Protection Equipment (IPE).
- Only adults should be allowed to handle pesticides.
- Children, domestic animals and people not directly involved should be excluded from the area where pesticides are being used or prepared.
- Pesticides should be prepared and handled only in especially designated, safe and ventilated places.
- It is forbidden to eat, drink or smoke while handling and applying pesticides.
- Pesticides should not be applied close to watersources (streams, lakes, wells etc.) to avoid contamination.
- The water used to clean the pesticide recipient should be returned to the tank to be mixed with the next batch of pesticide.
- The handling of pesticide should follow all rules recommended by the law.
- Pesticide spraying should be avoided during windy periods to reduce jet deflection.

- The product label should be read carefully and all recommendations should be followed regarding the procedure, care, interval before harvest and the pesticide container destination.
- Specific doses for maize should be used according to the prescription of each pesticide.
- Do not manipulate or carry around damaged pesticide containers.
- Avoid direct manual contact with pesticides using always the original container to store or transport the chemicals.
- Avoid spillage when handling pesticides.
- After work is finished, clothing should be removed and the operators should bathe immediately with abundant water and soap use.
- Medical assistance should be sought immediately if there is suspicion of intoxication.
- Workers involved in the use of pesticides should be submitted to periodical health check-up.

Care in pesticide use is a serious matter of human security because they can cause long-term ecosystems contamination affecting the health of human beings.

Pesticide application

- The tractors for pesticide application must be equipped with a cabin.
- Pesticide application should be only made by well-trained and skilled operators, protected with Individual Protection Equipment and observing all rules regarding operator and environmental safety.
- After pesticide application all the people involved with the operation should take a shower with abundant use of water and all the Individual Protection Equipment must also be carefully cleaned for future use.

- Pesticide should not be applied when the wind speed is over 8 km/h.
- Nozzles should never be cleaned using the mouth or unprotected hands.
- Sprayers leaking or with any type of defect, or out of calibration, should never be used to deliver pesticides.
- Preventive maintenance and periodic calibration of the sprayer, using the appropriated techniques are required.
- Post-emergence herbicides must not be applied if the plants are wet or when the soybeans and weeds are under stress caused by soil drought.
- The maintenance and use of the pesticide application equipment should be well planned in order to have them ready to be used when necessary.

In case of intoxication with pesticides, the victim should be taken to a cool and ventilated place, undressed, taken to a hospital or medical doctor, together with the pesticide label. The victim should not drink milk because it increases the retention of the pesticide in the human body.

Storing pesticides and disposing of packages

- Pesticides must be stored in ventilated warehouses, far from homes, protected from rain showers, inaccessible to children and other people not authorized to handle pesticides, in accordance with all safety rules and pesticide legislation.
- Packing materials should not be washed on or close to lakes, watercourses or reservoirs, rivers and creeks.
- Dispose pesticide packages after washing them according to the triple washing method, according to legal determination, and never using pesticide containers for other purposes.

- Do not store empty pesticide containers or pesticide remains close to watercourses or reservoirs.
- Keep systematic records of pesticide stocks to control its use.

Human health and environmental quality can be seriously endangered when empty pesticide containers are not discarded according to technical recommendations.

Integrated Pest Management - IPM

Integrated Pest Management practices must be strictly observed from the planning stage to post-harvest. Failure to use the IPM practices will lead to economic losses and environmental impacts as well as increase of human health hazards associated with pesticide application.

- Apply the concepts of Integrated Pest Management to prevent yield losses, and grain or seed quality degradation.
- Utilize all possible and available resources to minimize the use of chemical products.
- If there is need to use chemical products, request a technical prescription, according to the law.
- Avoid the continuous use of products with the same mode of action, to reduce the possibility of pest resistance to chemical products.

Weed Control

- Keep the crop free from weeds during the first 45 to 50 days after emergence.
- The methods normally employed to control weeds are: mechanical, chemical and cultural practices. A combination of one or more control methods may also be used according to the needs and the available conditions.

Cultural practices: Use cultivars adapted to the region, adequate plant population (density of plants) and row spacing to reduce the time needed to attain good ground coverage. Planting at the proper time and no-tillage help to reduce weed emergence. Crop rotation favors the diversification of weed species preventing the dominance of a determined species in the area.

Mechanical control: In the conventional cropping system, use a hoe or field cultivator, especially in hot and dry days to

improve weed control efficiency; this operation must be shallow to avoid damage to soybean roots and must be done before flowering; this method can be easily applied in no-till systems.

Chemical control: Make applications on soils with sufficient moisture content to allow the herbicide to act appropriately (in pre-emergence); in post-emergence applications be aware of the stage of weed plant development recommended for best performance of each product.

- In chemical control, avoid as much as possible, products with the following characteristics:
 - High solubility, capable of leaching and contaminating ground water.
 - High vapor pressure (too volatile), to prevent drift and damage to the neighboring crops and human and animal intoxication.
 - High adsorption coefficient, to prevent surface movement of impregnated soil particles that may contaminate surface water.
 - Long half-life, because of persistence in the soil, causing possible damage to subsequent crops.

Weed control practices are important in the assurance of environmental sustainability and economic feasibility of soybean crops.

Insect pest control

- Follow all IPM recommendations, especially those described below:
 - Perform regular sampling of the insect population with a shake cloth.
 - Adopt control measures only when insect species density, or level of damage is above economic loss thresholds.

- Preferably employ natural or biological control methods.
- Apply only chemical products that are selective to natural enemies.
- Reduce by 50% the doses of insecticides for the control of stinkbugs through the addition of NaCl at 0,5% concentration in the application tank.
- Recommendations for the control of underground pests:
 - Keep the soils well drained.
 - Avoid soil compaction.
 - Correct soil fertility and acidity to favor root development and to enhance tolerance to the rhizophagous insects.
 - In areas infested with beetle grubs, planting should take place earlier. Plowing should be carried out during the warmer hours of the day to reduce the larvae's population. It is not recommended to plow the soil in no-till areas.

Disease control

- To prevent and reduce the incidence of soybean diseases, the following precautionary measures should be adopted:
 - Regular field inspections to record the occurrence of diseases and the level of damage.
 - Use of resistant or tolerant cultivars, if they are available.
 - Crop rotation with non-host species.
 - Seed treatment with a mixture of systemic and contact fungicides, as indicated.
 - Adequate soil management: pH correction and fertilization (K^+).
 - Adequate crop management: spacing, planting density, with adapted cultivars and certified or registered seeds.

Soilborne Fungi (Damping off, Root rots)

- Keep soils well drained.
- Avoid soil compaction, correct soil fertility and acidity to allow better root development.
- Do not plant soybean in compacted soils.
- In areas with white mold (*S. sclerotiorum*) occurrence, the plant population should be as low as possible.
- Employ the correct flow of machines during seed processing (air screen cleaner, spiral separator and density table) to eliminate the sclerotia mixed with the seeds.
- Treat all seeds produced in fields where white mold occurred with a mixture of contact and systemic fungicides, as indicated, before planting.

Foliar diseases

- Whenever available, use resistant or tolerant cultivars to the prevailing diseases.
- Use only certified or registered seeds, free from seed-borne pathogens.
- Whenever indicated, treat seeds with the recommended mixture of fungicides.
- Control of fungal diseases should be based on technical recommendations.
- Apply preventive measures to control insect vectors, whenever recommended.

Adopt preventive practices to avoid pests and diseases in soybean crops and utilize chemical control only when strictly necessary and when the objective is seed production.

Nematodes

Perform a survey of the nematode occurrence and identify the species and physiological races occurring.

- Avoid introducing contaminated seed lots (seeds contaminated with soil and pods infested with cysts), farm machinery, vehicles, running water, wind etc.
- Avoid the movement of farm machinery, equipment and vehicles from contaminated (infested) areas to disease-free areas, without previous cleaning of the parts that may transport soil particles.
- Use crop rotation/succession with nonhost species.
- Use resistant cultivars, with adequate management practices.
- Seed production in areas infested with the soybean cyst nematode should follow the technical and legal prescriptions.
- Adequate soil management (high organic matter levels, base saturation within the limits indicated for the region, potassium split-application in sandy soils, balanced fertilization, micronutrient supplementation and absence of compacted layers) help soybean tolerate cyst nematode.

Consult local technician to decide about the best pest control tactics and do not use pesticides banned by plant protection authorities.

Harvest

Harvest should start when soybeans are at the optimum stage, and climatic conditions are right, specially temperature and humidity. The machinery must be calibrated and fine-tuned frequently during the operation. Bad harvesting practices will result in yield losses, leaving an excess of soybean grains in the field, and increase the incidence of damage in the harvested grains.

- Begin harvesting when the plants in the field reach R_8 stage of development (harvesting maturity) and the moisture content of the seed (grain) is between 13% and 15%.
- Adjust and clean the harvesting machine previously (to avoid introducing soil particles and crops residues). When adjusting the combine, special attention should be given to the harmonic work of the pick up reel, cutting bar, ground speed, cylinder and screens, as basic conditions to avoid yield losses.
- The ground speed of the combine should be between 4 and 6 km/h and the peripheral speed of the pick up reel 25% superior to the ground speed of the combine.
- Perform periodic evaluations of the harvest losses, using a specific kit, to detect the areas of the major losses and make the necessary corrections immediately. During harvesting a maximum loss of 60 kg/ha is tolerated.

A good soybean harvest begins with a good planting procedure.

Drying

Soybean drying is crucial when the grains were harvested with moisture content over 16%, and should be performed as soon as possible to avoid grain deterioration and the attack of pests.

- Avoid delay in drying the grain. If soybean is harvested with moisture content above 16%, keep the grain ventilated until the beginning of the drying process, avoiding storage in big bags or silos without ventilation (aeration) during this waiting period.
- Keep the drying temperature below 40°C for seeds and below 90°C for industrial grain.

Drying temperature is very important for final product quality and depends on the destination of the grain (seeds or industrial processing).

Bulk storage

Inappropriate storage conditions cause economic losses, deterioration of grains and seeds, that may become worthless.

- Store soybeans in adequate storage facilities, with thermometry and aeration equipment.
- Keep the moisture of stored grains below 12.5%.
- Keep the temperature of the grain below 25°C and the relative humidity of the air below 70% during the storage period.
- Control insects and rodents and clean the storage facilities before storing soybean.
- Store soybeans according to the legal requirements.
- Do not store soybeans with a moldy appearance and/or in process of fermentation, with a strange smell of any kind, since it will have negative effects on its normal utilization.

Hygiene is a fundamental aspect in soybean storage.

Hygiene, safety and workers' well-being

All principles, laws and regulations regarding hygiene and safety during any operation related to soybean cultivation must be followed, in order to avoid any health hazard to workers or to soybean consumers.

- Employ only well trained staff and operators and develop skills for new operations as required.
- Make sure all safety rules are observed.
- Monitor frequently the health status of all workers involved with agricultural and processing operations.
- Keep records related to health and safety properly filed.
- For the manipulation, preparation and application of pesticides all operators must use the appropriated Individual Protection Equipments and strictly observe all hygienic and safety rules.
- Provide personnel with safe transportation, sanitary facilities and adequate installations for meals.
- Observe the Brazilian labor legislation, including wages and fringe benefits, housing, education, nutrition, school transportation, holidays and other rights.
- Train employees about personal hygiene habits.
- Maintain working hours compatible with agricultural activities and with the well-being of the workers.

Hygiene habits and adequate working conditions minimize health hazards for workers and consumers.

Environmental management

All legislation regarding the protection of the environment should be strictly observed during all stages of soybean cultivation.

- Respect the Brazilian legislation regarding protection of water resources like reservoirs of water rivers, creeks, lakes and similars, specially the ciliar vegetation.
- Develop or agricultural activities according to the regional ecology parameters and sustainable development principles.
- Execute, control and evaluate plans to prevent or correct environmental non-conformities in any step of the production or processing.

Technical assistance and associative initiatives

It is important to promote interaction among different actors governmental and private, in order to organize (associations, cooperates, experiences groups) small and medium farmers to facilitate their insertion in the market.

- A professional should supervise soybean production from planning to commercialization.
- Producers and partners should be stimulated to organize themselves in cooperatives to benefit from larger scale of common operations, especially buying inputs, selling the production, technical assistance and management skills.

Soybean production in Brazil can provide supplemental income to farmers when Good Agricultural Practices are used.



FAO/Embrapa

**Guidelines for
Good Agricultural Practices**

Swine production complete cycle



Author: *Jerônimo Antônio Fávero, Embrapa Suínos e Aves, Concórdia, SC.*
favero@cnpsa.embrapa.br

Co-authors: *Nelson Morés, Embrapa Suínos e Aves, Concórdia, SC.*
mores@cnpsa.embrapa.br

Gustavo J. M. Monteiro de Lima, Embrapa Suínos e Aves, Concórdia, SC.
gustavo@cnpsa.embrapa.br

Paulo Roberto Souza da Silveira, Embrapa Suínos e Aves, Concórdia, SC.
silveira@cnpsa.embrapa.br

Carlos Cláudio Perdomo, Embrapa Suínos e Aves, Concórdia, SC.
perdomo@uncnet.com.br

Clênio Nailto Pillon, Embrapa Suínos e Aves, Concórdia, SC.
pillon@cnpsa.embrapa.br

Flávio Bello Fialho, Embrapa Suínos e Aves, Concórdia, SC.
bello@cnpsa.embrapa.br

Janice Reis Ciacci Zanella, Embrapa Suínos e Aves, Concórdia, SC.
janice@cnpsa.embrapa.br

Armando Lopes do Amaral, Embrapa Suínos e Aves, Concórdia, SC.
armando@cnpsa.embrapa.br

Nilson Woloszyn, Embrapa Suínos e Aves, Concórdia, SC.
woloszyn@cnpsa.embrapa.br

*Alderí Miguel Crestani, Cooperativa Central Oeste Catarinense Ltda.,
Concórdia, SC*
agro@frigorifico-aurora.com.br

Introduction

Pork is the most abundant kind of meat worldwide and Brazil was responsible, in 2001, for 2.5% of the world production, with 2,216 million tons. This corresponds to the fourth position in the world production rank, after China, the European Union and the United States of America. This production comes from all Brazilian States, but 49.7% is concentrated in the Southern region. The yield of the Brazilian hog production varies among regions and systems of production. As a maximum the yield of the State of Santa Catarina can be mentioned, which is of 170% the herd yield rate.

Brazilian exports are growing steadily, mostly in the last three years (1999 to 2001), when sales to the external markets grew from 4.74% to 11.96% of the total production. Presently, the opening of new markets will stimulate further growths. In the internal market, the consumption will surpass the present 12kg/inhabitant/year, intensifying the demand for pork production.

This production, however, must be compatible with the requirements of the markets and of society, for a sustainable mode of production in contrast with the present mode that is centered strictly in the concept of high physical and economic productivity. It is therefore fundamental to produce meat with a reliable and constant quality, with traceable origin, wholesome and that satisfies consumer expectations.

Based on these principles, the Good Agricultural Practices here recommended emphasize the pursuit of higher yields to assure the economic feasibility of swine production without losing sight of the need to preserve the environment and to promote social justice. Good Agricultural Practices improve the production system when compared with the conventional methods, from the selection of the production site until the marketing stage, emphasizing questions related to the health, the well-being and the safety of workers. They aim at obtaining healthy products, the environmental preservation and the addition of value to the produce of small, medium and large farmers. These practices are the basis for other incentive programs for quality improvement, like the Hazards Analysis and Critical Control

Points (HACCP) and other international protocols for quality certification.

Good Agricultural Practices in pork production can aid presently adopted complete cycle systems of production and aid their expansion, or can be used as reference for the development of new systems. Because they contemplate all phases of the production process – from the acquisition of genetically improved matrixes until the delivery of the hogs to the processing plant, GAPs apply also to systems that contemplate only parts of the cycle, like the Piglet Producing Unit, that produces piglets until their exit from the nursery, and the Finishing Unit that receives the piglets from a PPU and manages the growth and termination process. The intensive system of swine production, grown in open areas, is not contemplated in GAPs and should be established, because of its peculiarities, in consultation with specialists. In the same manner, the systems of production with more than 200 matrixes must be established with the constant supervision of specialists, with intensive use of artificial insemination, large scale feed production, automated feeding and computerized information and control systems.

The most critical stages, like the maintenance of facilities and equipment, feed formulation and preparation, the sanitary supervision need the assistance of specialized professionals to assure optimum performance.

The GAPs here recommended consider the peculiarities of the commercial systems adopted in Brazil, and can also contribute to the improvement of the subsistence systems. The GAPs presuppose respect to the environmental and labor legislation as well as the Children and Adolescent Statute, and the ethical principle of equal pay for all types of rural labor.

Planning the activity

The establishment of a new activity requires planning with estimation of costs, of the technologies to be used, of production goals, of input availability and prices, of market demand, to allow the estimation of return on investments. Good planning contributes to sustainability, to environmental preservation, to comfort for people and animals, and facilitates the management of the operation.

Environment

- Consider the availability of natural resources on the farm and the watershed, planning the environmental monitoring activities.
- Obtain the environmental license to establish and operate the production activity from the corresponding agency.
- Observe the Federal Forest Code (Ref. 15.2) and the State environmental legislation that define among other mandatory requirements, the minimum distance of facilities and excrement treating installations, in relation to roads, homes, property divisions and water bodies.

Planning the recycling of all excrements, using them preferentially as fertilizers on the same farm, in annual or permanent crops, pastures and reforested areas contributes to an environmentally sound and sustainable operation.

Technical Project

- Perform a feasibility study, involving the input market and the absorption of the products by the market.
- The site of the facilities should be well drained and compatible with the number of animals to be handled.

- Water of adequate quality should be available in a quantity equivalent to 150 liters/animal/day.
- Prepare a complete technical project (civil, hydraulic and electrical), including operational goals and flows, facility layout, equipment, production management, descriptive memorial, budget, and deadlines.
- Planning (Reference 15.15) should consider the following details:
 - The area needed for any phase of the production process.
 - Details of the buildings (such as type of maternity, delivery cells, nursery, the roof/ceiling, the kind of tile, the walls, the floor, the windows and curtains), based on the requirement of the animals, the climate characteristics and the established production goals.
 - The size of buildings, the number of rooms to be built in each stage, according to the number of animals.
 - The types of water and feeding troughs adequately dimensioned to meet the demands of the animals without causing wastage.
 - The adequate thermal insulation and ventilation of the buildings.
 - The best layout to facilitate working routines, to improve efficiency and efficacy of operations, and avoid risks to workers.
- Use compatible technologies with the scale and objectives of the enterprise.
- Consider the feasibility to use the swine management system on bedding, which requires special facilities and specific handling of excrements (Ref. 15.12).

An efficient manual or computerized system for the control of productivity and costs should be maintained.

Site selection and preparation

- The area to install the production site should be level or slightly sloped (up to 6% declivity) based on the requirements of the project and possible expansions.
- Construct the buildings in the east-west direction or with a slight deviation, to take advantage of the predominant winds to improve the comfort of the animals and reduce the incidence of solar radiation.
- Choose a location that facilitates the flow of people, animals and materials, with good traffic conditions all year around.
- Maintain proper distance among buildings to facilitate ventilation.
- Plant a lawn around all buildings and maintain the lawn constantly mowed.

Biosecurity

A rigid control of all disease transmission risk factors and all sources of food contamination is fundamental to assure good indices of productivity and quality of the final product. When this control is incomplete or inexistent, the quality will be negatively affected, there will be yield reduction, health hazards to the animals and environmental impacts.

- A veterinarian should inspect all aspects of the production system at least once a year.
- If a disease of mandatory notification occurs, the official animal health agency should be notified and the official recommendations will be issued (Ref. 15.11).

The production system should be installed and maintained in an isolated area, with strict control of the access of people, animals, feed and food.

Isolation

- Avoid the proximity to other animal production installations especially of hogs.
- Fence the perimeter and install a control booth at the farm entrance to avoid unauthorized access of people, animals, vehicles, food and feed.
- Install a loading/unloading chute.
- Restrict visits to the production facilities and if necessary demand that visitors bathe and change clothes.
- Any object or product suspect of contamination should be disinfected before introduction in the production facilities.

Introduction of animals in the farm

- Reproduction animals should be purchased at Certified Swine Breeder Farms, certified according to legislation of the Animal Sanitary Department of the Ministry of Agriculture, Livestock and Food Supply (Ref. 15.8).
- Quarantine quarters should be available for the necessary sanitary procedures before introducing recently acquired animals in the production area.
- Separate the recently arrived female piglets, housing them in pens with six to ten animals, with a minimum space of 2 m² per animal.
- House all recently arrived males in individual pens with a minimum space of 6 m².
- Adopt procedures for the adaptation of recently arrived animals to the microbial flora of the farm.
- Females should be adapted from 5.5 months on.
- Put mummified fetoes (black fetoes) in the pens of young sows that have not started to be covered.
- Start vaccination immediately after animals are adapted to the farm.

The introduction of animals from Certified Swine Breeder Farms increases sanitary security and contributes to improve the productivity of the plot, the economy of the production system and the quality of the final product.

Vaccines

- Adopt a minimum program of vaccination in each production phase for the prevention of the most important diseases in swine raising (Ref. 15.1), observing the official instructions of the Ministry of Agriculture, Livestock and Food Supply for each disease, for instance the Classic Hog Cholera and the Aujeszki Disease, that can only be used with official authorization of the Animal Sanitary Department.

- Preserve vaccines in the refrigerator under temperatures between 4°C and 8°C.
- Do not freeze vaccines.
- When vaccinating, observe following procedures:
 - Use a Styrofoam box with ice, to maintain the vaccine flasks refrigerated when vaccinating a group of sows or piglets.
 - Use a needle to withdraw the vaccine from the flask and another to apply the vaccine to the animals.
 - Disinfect the place of vaccination.
 - Use appropriate needles for each type of animal and for each mode of application (intramuscular or intradermal), according to the manufacturer's recommendation.
 - Disinfect the lid of the flasks containing remains of the vaccine and return them immediately to the refrigerator after use.
 - Apply vaccines calmly, following technical orientations to avoid flaws in the process and the formation of abscesses in the place of vaccination.
 - Do not use veterinary drugs without the recommendation of a veterinarian.

Cleaning and disinfection of rooms after the removal of each lot of animals

- Use Individual Protection Equipment to execute all cleaning, washing and disinfection of rooms and pens.
- Start with dry cleaning procedures, with broom and shovel, immediately after the withdrawal of animals.
- Empty drains and sludge/waste boxes.
- Disassemble and wash all equipments in the rooms.
- Start the cleaning operation not later than three hours after the withdrawal of the animals, firstly wetting the floor and walls with a

detergent solution to facilitate the removal of all organic matter adhered.

- Wash the rooms or pens with a high pressure cleaning machine (1,000 to 2,000 pounds).
- Apply a disinfectant the day after washing, when the place is completely dry, using 400 mL of solution per m² of surface.
- Use strictly the dilution recommended by the manufacturer.
- Make a second disinfection with a flame thrower in maternity rooms, as auxiliary measure in the control of coccidiosis.
- Leave the toilet empty and locked for a minimum of five days.
- Assemble the equipment and whitewash the rooms and pens on the day before introducing a new lot of animals.

Control of rodents and flies

- Avoid the proliferation of rodents by constantly cleaning and organizing the installations, and using rat-killing products.
- Control flies by adequately managing manure and other residues.
- Utilize mechanical means of fly control, avoiding the accumulation of any kind of deject inside and around the installations, and restricting the use of chemical and biological methods of control.

It is mandatory to follow a vaccination schedule against the most important diseases, in addition to rigid fly and rodent control and the cleanliness of all production installations.

Reproductive matrixes

The base of any animal husbandry operation is the genetics of the animals, and this is why much attention must be devoted to its selection. The productive performance of the operation starts with the reproductive matrixes, which should be capable of responding positively to the production environment, generating animals that produce pork that meets market requirements.

- Piglets should be purchased from Certified Swine Breeder Farms (Ref. 15.8), observing closely the genetic records of the animals.
- Utilize purebred, synthetic or crossed males, with percentage of meat above 60% of the carcass.
- The synthetic or crossed males must be of different races or lineages from the females.
- The first males to be acquired should be of 7 to 8 months of age.
- Males should be two months older than females.
- Maintain a minimum of two males in the farm.
- Maintain a proportion of 1 male to 20 females (piglets and sows).
- When using artificial insemination the proportion can be widened, maintaining only the number of males necessary to detect the heat and to perform some natural mountings in the days when artificial insemination is impossible.
- Substitute males at a rate of 80% per year (with approximately 24 months of age).
- Utilize crosses or F1 females, preferably of white races, with a potential to deliver many litters.
- Acquire females within 5 and 6 months of age, in lots equivalent to the gestation groups, with an excess of 20% to compensate reproductive problems.
- Substitute females at a rate of 40% per year (with approximately 36 months of age).

Pre-mounting

When pre-mounting practices are not used, there will be a reduction in reproductive performance and of the useful life of breeders, which may negatively affect the yield of the operation and reduce economic performance of the enterprise.

Management of males

- Provide 2 to 2.5 kg of growth feed per day, depending on their body development until they start their reproductive activity.
- A minimum adaptation period of four weeks is necessary before the first mount.
- Males with between 7 and 8 months of age should be trained using a docile female with strong heat that already had several gestations with a size similar to the size of the male.
- First mount should be allowed when the male reached a minimum weight of 150 kg.
- Mounting frequency should be according to the age of the animal: maximum of two mounts per week with age between 7 and 9 months, 4 mounts per week with age between 10 and 12 months and up to 6 mounts per week with age above one year.
- After the start of reproductive activity, males should receive 2 kg of gestation feed per day.

Management of females

- Furnish a daily ration of 2.5 kg of growth feed in two meals, until two weeks before mounts.
- Do not allow direct or indirect contact of females with males before five months of age.
- Start heat stimulation after five months of age, using a male with strong sexual drive, above 10 months of age, docile and not too heavy.

- Rotate males in the heat stimulation and detection process.
- Stimulate the heat allowing the male to stay for 10 minutes in the females' pen two times a day, with a minimum of eight hours interval, one hour after feeding.
- Do not house the male that is used to stimulate the heat in places that allow constant contact with the females or in places where females can constantly feel his presence and smell.
- Register the moment of heat detection in a card to calculate the date of mounting.
- Two weeks after the probable date of mounting, feed the females abundantly with lactation feed.

Management of sows

- Group weaned sows in lots of five to ten sows, in pre-mounting pens, located close to the males.
- Provide a space of 3 m² per sow.
- Group sows by size and wash them with a solution of water and creosote to reduce stress and aggressiveness.
- Stimulate the heat of sows at least two times a day, with a minimum interval of eight hours, putting them in contact with the male.
- Provide lactation feed freely, from weaning to mounting.

Management of pre-mounting, specific for boars, females and sows must be made with care, because the reproductive performance and longevity of breeders depends on this stage.

Mounting and pregnancy

Manage the reproductive activity to assure that the mounting occurs in the proper moment, allow a clean and ventilated environment, provide adequate feeding. These are factors that contribute to the improvement of the productive and economic performance of the swine raising activity.

- Manage the mounting and gestation facilities for continuous use.
- Clean daily with broom and shovel.
- Disinfect weekly the mounting and male pens.
- Yearly perform a thorough disinfection.
- Maintain internal temperature close to 16°C, by correct management of windows, shades and doors, monitoring it through a thermometer installed in the center of the building, at a height of 1.5 m to facilitate readings.
- Perform the mounting in specific pens, with compact dirt floor or concrete floor that is neither coarse nor slippery.
- Conduct females and males calmly to the mounting pen without any aggression using a management board.
- Mounting should happen always after feeding and in fresh hours of the day at the beginning or at the end of the workday.
- Females should have a minimum weight of 130 kg, minimum age of seven months and in the third or fourth heat.
- Mounting should consider the recommended interval between weaning and heat.
- Perform artificial insemination in the presence of the male, during at least 4 minutes, assuring that the female sucks the semen and that it's not forced into the her body.
- Adopt two mounts or inseminations per female, with an interval of 24 hours.
- House females in individual pens for mounting.

Mounting management and the precautions during pregnancy have a decisive influence on the offspring, because the fecundation of ovules and the formation and fixation of embryos occur in these phases.

- Maintain females in a calm environment with a minimum of movement during the first 30 days of gestation.
- Males in reproductive activity should receive 2 kg per day of pregnancy feed.
- Pregnant females should be fed daily according to the phase of gestation.
- After mounting, three pregnancy diagnoses should be made in the following intervals:

At 21 days in the presence of the male.

Between 30 and 50 days, using ultra-sound.

Visually at 90 days of pregnancy.

- Provide females with abundant good quality water, with temperature below 26°C, stimulating them to drink.
- Promote vaccinations as recommended for this phase.
- Discard females that present reproductive problems.
- Transfer females to the maternity, without any stress, seven days before the expected date of delivery, after careful washing and cleaning.

Water must be available abundantly during pregnancy, because normal consumption is of 18 to 20 liters per day in this phase.

Maternity ward

All efforts made in the previous phases may be lost if newborn piglets do not receive special care. The best environment that may be provided after the delivery will never be better than the mother's womb. The maternity, therefore, is a critical phase in the swine production and represents an important challenge to the farmer.

- Manage the maternity wards based on the all in and "all out system", or entrance and exit of complete lots of sows.
- Control the internal temperature of the maternity ward as near as possible to 18°C with a thermometer.
- Suspend feeding in the day of delivery, providing only water.
- Be sure that all necessary instruments and products are available.
- Do not interfere with the delivery unless the female cannot eliminate the piglets; in this case they should be removed with the hand protected by gloves.
- Dispense special attention to the newborn, cleaning and drying the nostrils and the mouth, massaging the loin region, cutting the umbilical cord and directing them to suck the colostrum.
- Clean the udder of the sow with a cloth moistened with iodine disinfectant solution before allowing the piglets to nurse.
- Remove the placenta and the dead piglets, immediately after the delivery, throwing them in a composting chamber.
- Observe the following procedures with the day old piglets: cut their teeth and the final third of the tail; weigh; identify; apply iron dextrane.
- Eliminate piglets with less than 700 g.
- Maintain the internal temperature of the buildings according to the age of the piglets, controlling it with a thermostat.
- In maternities with a compact floor, use a layer of wooden chips in the pen, at least for one week after the delivery, to provide comfort to the piglets, avoid knee bruises and facilitated cleaning.

- Equalize and homogenize the litter, as to the number and the weight of the piglets, in the second day of life.
- Introduce the older piglets, with low development, until two days after delivery.

Cleanliness, hygiene and feeding are essential in the phase of maternity.

- Furnish 3 kg per day of delivery feed, in two meals, during the three days after the delivery.
- Furnish free quantities of feed in the fourth and fifth day after delivery.
- Furnish lactation feed from the sixth day on, according to the number of piglets in the litter.
- Furnish pre-initial feed in a trough from the eighth day on, preventing the feed to become humid.
- Vaccinate the sows according to schedule.
- Clean the maternity rooms two times daily with broom and shovel.
- Use a specific set of broom, shovel and boots for each maternity room to prevent diarrhea.
- Castrate the piglets, following the recommend method, before they reach 12 days of age.
- Wean the piglets between 21 and 28 days of age, abruptly and always in the same day of the week.
- Weigh the piglets at weaning, before transferring them to the nursery.

Nursery

The move from maternity to nursery is a shock for the piglets because they leave the mother and substitute completely the mother milk for feed. Because of this, especial care should be given to the piglets, mainly in the first days of nursery, to avoid losses and the reduction in performance because of environmental and feeding problems, which frequently cause diarrheas.

- Manage the maternity and nursery rooms according to the “all in all out method” or by moving complete lots of piglets in and out.
- House the piglets in the nursery in the day of weaning, forming groups according to age and sex.
- Provide sufficient room for the piglets, according to the type of pen (2/m² in suspended pens and 2.5/m² in the other types).
- Maintain the internal temperature close to 26°C during the first 14 days and close to 24°C until the removal from the nursery.
- Provide unlimited amount of feed according to the following criteria:
 - Pre-initial feed: from day 1 to day 35.
 - Pre-initial 2: from day 36 to day 45.
 - Initial: from 45 days until exit from the nursery.
- Provide feed daily, removing any food leftover from previous days.
- In case of surges of diarrhea or of edema, remove the feed immediately from the troughs and start a program of gradual food furnishing until the problem is solved. If symptoms persist, call for veterinarian help.
- Water should be easily available to the piglets; care should be taken in setting height, flow and pressure of the water troughs.
- Vaccinate piglets when leaving the nursery according to schedule.
- Monitor the nursery rooms at least three times in the morning and three times in the afternoon to check the conditions of the piglets, the state of drinking troughs, feed troughs, feed and temperature.

- Clean the nursery rooms daily with broom and shovel.
- Wash the nursery rooms with suspended pens, preferably with high pressure and low volume washer, at least every three days in the winter and every two days in the other seasons.
- Implement corrective actions immediately when any anomaly is detected especially sanitary problems.
- Register medication used individually or in groups of animals.
- Weigh and transfer to the growing pens, the piglets with 56 to 63 days of age.

The care in the nursery and the adoption of corrective measures as soon as they are detected avoid unnecessary costs and contribute the efficiency and profitability of the system of production.

Growing and finishing

The success of the growing and finishing phases depends on a good performance in the maternity and in the nursery.

- Manage the growing and finishing rooms according to the “all in and all out method”, by moving complete lots in and out of the facility.
- House the pigs in the growing and finishing pens in the same day they leave the nursery, maintaining the same groups or reorganizing the lots by size and sex.
- Provide maximum room of 1 animal/m².
- Monitor the temperature of the rooms and maintain it between 16°C and 18°C, according to the phase of development of the animals.
- Provide growing feed freely to the animals until 105 days of age, finishing one feed from 105 to 120 days and finishing two, from 120 days until slaughter.
- Water troughs should be easily accessible to the animals, with adequate height, flow and pressure.
- Monitor each room at least two times in the morning and two times in the afternoon, to observe the condition of the animals, of feed and water troughs and the temperature.
- Clean the growing and finishing pens daily with broom and shovel.
- Empty and wash, weekly, the excrement collector drains. After washing, maintain 5 cm of water at the bottom.
- Take corrective actions as soon as some anomaly is detected, especially sanitary problems.
- Sell the animals for slaughter in lots, based on their weight.
- Eliminate all discarded animals.

When animals leave the nursery in good health condition and with the weight compatible with their age, the growing and finishing phases present no problem.

Preparation of the animals for transportation to the slaughter house

Cleanliness, hygiene, health and well-being of the animals during all phases of production until unloading in the slaughter-house prevent pre-slaughter mortality, which causes serious losses to the farmer.

- Suspend the feeding of the animals to be slaughtered, 12 hours before shipping, maintaining the supply of water.
- Conduct the animals to the loading area calmly, avoiding stress and using management boards.
- Never use electric shock devices.
- The loading chute should have an inclination of no more than 20% and non-skid floor.
- Use a sanitized truck, with a maximum of two layers, to transport the animals.
- Animals should be loaded at a proportion of 2.5 pigs of 100 kg per square meter, in trips of eight hours.
- Transport during the night, in cooler hours.
- Be sure to obtain a sanitary permit for transportation

The management of animals before slaughter has a direct influence on the quality of the carcass and the meat.

Handling and disposal of excrements and other residues

The environmental protection, which must be a basic concern in any system of production, should be considered in every single activity, especially in the handling and disposal of dejects and parts of dead animals. Priority should be given to the use as organic fertilizer, observing the limits imposed by soil, water and the plants.

- Establish a program of collection, storage, treatment, transportation and disposal of effluents according to the characteristics of the farm.
- Observe legal requirements about reject handling and processing installations.
- Adopt a system of stages in the process of excrement treatment combined with natural lagoons.
- Retain the manure for at least 120 days in the manure piles, if they are destined to organic fertilization.
- Observe the limits of quantities to be used, according to the results of soil tests, topography, crop requirement, soil permeability and the season of application (ref 15.13).
- Place dead animals and delivery residues (placenta, dead newborns) in covered sanitary tanks, keeping any animals from approaching it.
- Store used medicine flasks and chemical containers in appropriate covered boxes, sending them to regional and local collection posts.
- All garbage resulting from the production operations should be disposed of, having environmental protection in mind.

If it is impossible to use excrements as organic fertilizer, it is necessary to treat them appropriately, to prevent environmental pollution that causes economic losses and health problem to animals and humans.

Feed and feeding

The quality of the ingredients used in feed preparation, as well as the correct formulation of diets, to meet the needs of the animals and of the production process, is essential for acceptable levels of productivity and to avoid losses.

- Observe the regulations of the Ministry of Agriculture, Livestock and Food Supply about minimum standards for different feed ingredients (Ref. 15.3 and 15.4).
- Use only gram-positive growth regulators approved by the Ministry of Agriculture, Livestock and Food Supply (Ref. 15.5, 15.6 and 15.7).
- Use gram-negative antimicrobials only when prescribed by a veterinarian.
- Do not use Chlorafenicol, 3-nitric Acid and Nitrofuranes, because their use is unlawful.
- Be sure of the availability of chosen feed ingredients and estimate their cost.
- Use only good quality ingredients in the composition of feed, mainly from the nutritional point of view and purity (free from mycotoxins and contaminants) (Ref. 15.9).
- Monitor their quality and preservation.
- Acquire concentrated, pre-mixed feed and other products, only at dealers authorized by the Ministry of Agriculture, Livestock and Food Supply to be assured of their quality.
- Decide about diets with the aid of a nutritionist and if this is not possible, follow the instructions of the feed manufacturer.
- Calculate formulas based on the ingredients and the requirements of the animals, recalculating whenever necessary (Ref. 15.10 and 15.14).
- Weigh the ingredients and prepare diets in feed mixing machines.
- Maintain the prepared diets for a maximum of three weeks, in silos or in bags, in clean dry and ventilated places.

- Observe the withdrawal times to avoid residues of additives and medication in the carcasses.

The current legislation, that regulates the use of additives and drugs and feed preparation, must be observed strictly to assure a final product without any contamination.

Water

Water quality should be preserved in all aspects, not only because it is essential for the animals, but also because it is a limiting factor in the survival of the next generations. The springs and water bodies must, therefore, be naturally protected from any contamination.

- Protect water fountains and any other source of water.
- Provide clean, fresh, odorless and colorless water to the animals, free from any microbiological contamination.
- Monitor the water quality every 6 months through laboratory analysis.
- Treat water when necessary.
- Maintain a maximum water temperature of 20°C.
- Avoid water wastage.

To prevent water waste, to maintain its quality and provide it abundantly to the animals are responsibilities that the farmer must not forget.

Hygiene, safety and workers' well-being

Good work relations begin with mutual respect. Workers must perform their duties efficiently and timely and, in compensation, receive adequate and just salaries that assure the well-being of their families. The compliance with the labor laws prevents penalties and promotes a healthy social climate in the workplace.

- Treat employees with respect and dignity.
- Offer befitting housing to employees.
- Observe work legislation.
- Observe social obligations including the provision of schooling for all children.
- Provide periodical training to employees.
- Build safe facilities.
- Supply protection equipment and wear to assure safety to all employees.
- Pay just and satisfactory salaries to promote the well-being of workers and their families.
- Reward deserving employees with a percentage of profits.
- Do not employ child labor.
- Employ only well trained staff and operators and retrain them as required.
- Make sure all safety rules are observed during the operations.
- Monitor frequently the health status of all workers involved with agricultural and processing operations.
- Keep records related to health and safety properly filed.
- Workers involved in the manipulation of pesticides should be adequately trained and use IPE, and strictly observe all hygienic and safety rules.

- Provide safe transportation and adequate installations for meals and for personal hygiene for staff and operators.
- Observe the Brazilian labor laws, including wages and fringe benefits, housing, education, nutrition, school transportation, holidays and other rights.
- Train employees in good practices of personal hygiene.
- Guarantee compatible work schedules for agricultural activities and workers' well-being.

The human element is the most important factor in the animal production system. Hygiene habits and good work conditions minimize health problems for workers and the consumers.

Environmental management

All environmental protection legislation should be strictly followed in all stages of beef cattle production.

- Respect the Brazilian legislation regarding protection of springs, water courses and reservoirs like rivers, creeks, lakes and similar, especially the ciliar vegetation.
- Develop the agricultural activities according to the regional ecology parameters.
- Production activities should always promote sustainable development.
- Execute, control and evaluate plans having in mind the prevention and correction of environmental non-conformities in any stage of production or processing.

Technical assistance and associative initiatives

It is important to integrate efforts of the different actors either governmental or private, in order to improve social organization (associations, cooperatives and experience groups) of small and medium farmers for an adequate insertion in the beef market.

- A professional must supervise beef cattle production from the planning to the commercialization.
- Producers shall be stimulated to organize cooperative organizations to benefit from larger scale of common operations, especially input purchase, sale of the production, technical assistance and business management.

Swine production in Brazil can guarantee supplemental income to farmers if Good Agricultural Practices are followed contributing to better quality products.