BASIC GUIDE TO INSTALLATION AND PREPARATION OF FOOTBALL FIELDS

MODULE 2

-CONMEBOL-
EVOLUCIÓN

Unit 1

Renovation of old courts

Situation of the field to be renovated

There are some field conditions with good general infrastructure that only need to be adapted in some aspects.

Generally, when the field has a good leveling and a quality turf installed, with an adequate variety of grass and without significant contaminants, a reform for the installation of irrigation or new drainage is justified due to the reduction of the cost to obtain a good result. Otherwise, if we have a field with a good drainage base, but a poor-quality turf, we can choose to successfully replace only the turf, taking the opportunity to redo the surface leveling, preferably with a laser grader.

However, there are aspects to consider that can compromise the result or raise the cost too much in a partial renovation. For example, when we have severe deficiencies in some structural aspects, such as soil with a very clayey texture or severe irregularities in the surface, we should consider the possibility of redoing the ground from the base.

Deadlines for execution

Timelines should be considered according to the times of use of the turf and the complexity of the renovations to be carried out. Renovations cannot be planned for execution during the rainy season, especially in regions where this period is well defined.

It should be sought to hire companies that use modern implementation methods to optimize the time available. Today there are technologies that allow quick execution of works, such as changing the lawn, in a few days or even a few hours, and quick installation of irrigation and drainage systems.

Renovation budget

Another relevant factor is the cost comparison between the necessary renovation for each situation and the budget for a total reconstruction, considering the quality of the result to be achieved. A very high investment would not be justified for a partial or precarious result.

Post-reform management

It is important to foresee the necessary management after each type of renovation, estimating the time for full recovery until the resumption of use with safety and quality. In general, these deadlines refer to the closing of the area covered with grass, rooting of the lawn to allow for games, leveling after planting grass rolls, etc. These processes can be accelerated a bit, with intensified fertilization, adequate irrigation, use of growth modification products, light and continuous leveling, etc. But there is a limit to these steps because turf is a living being, and this acceleration is closely related to the climate of the region.

Installation of all systems

When planning a job, a survey should be made of all the needs to be satisfied. Ideally, in the same renovation it is possible to install all the necessary systems. If there will be a total change of lawn, you should take the opportunity to correct or, better, redo the leveling. It would be ineffective if, only after installing a lawn, the need for further drainage is noted. It is also possible, many times, to take advantage of the same trenching operation, for example, to install part of the irrigation and drainage.

It is essential to analyze the situation of the court considering all the systems, since they can compromise the result or raise the cost of a partial renovation too much. It is necessary to be clear about the state of each system to take advantage of the renovation to be carried out.

Drainage in old courts

Today there are technologies and equipment that allow you to do a quick job, with minimal intervention in the installed turf. The use of narrow trenchers such as *Vermeer*, *Ditch - Witch* or similar equipment or even *Bob-Cat* type, allows the opening of trenches about 20 cm wide. This equipment has punctured tires, adapted for use on already installed turf, and will not damage the areas adjacent to the trenches.

- Check the condition of existing drainage: a detailed preliminary study of drainage needs should be carried out, which can range from the installation of supplementary drains at sites of moisture accumulation, to a complete project, when no drainage system is installed or when the existing drainage is not working. Look for information on installed drainage (old projects, description of employees) and check the efficiency of the system (look for drains, clean, test operation during periods of heavy rain).

To organize and choose the space between the new drains, take into account the climate of the region, the slope of the land and the type of soil (the higher the clay

content, the closer the drains should be). For drainage complements, it is important to observe the field in rainy periods, to demarcate beforehand the places with moisture accumulation, as well as to plan the water outlets for the pluvial network.

- Correct choice of materials: for drainage efficiency, in addition to the correct design and drainage of the drains, the materials that compose it must have a good drainage quality. Generally, we work with perforated pipes, suitable for drainage, with diameters between 2.5" and 6", gravel and sand. The geotextile blanket surrounding the drains is not recommended, since over the months it will fill (clog) with the fine particles of organic matter present in the soil. If the soil in which the drains are installed is unstable or easily broken, the blanket at the base and sides of the trench can be used, but never over the pipe. If placed on top, it can hinder the vertical flow of water in times of heavy rain.

In choosing suitable sand and gravel, sand with very fine particles should be avoided. Gravel should not be dusty and stones should preferably have a more rounded shape (avoid too many flat stones). For more details, there are granulometric patterns that serve as a parameter. In the laboratory, sand and gravel are passed through a set of sieves and the percentages passing through each mesh are placed on a curve.

- Installation of sod over drains: define how to remove and replace sod in drainage ditches. It can be removed beforehand for reinstallation immediately after the drainage is completed (leave the sod loaves in a shady place where they can receive irrigation and no piling). Or it can be removed by equipment while trenching. In this case it is necessary to purchase sod loaves for replanting. If there is time to create roots, it is strongly recommended to install washed sod loaves (without soil) in the drainage trenches, which will make drainage more efficient, or even fill the trenches with sand to the surface and wait for the grass to close up. It is important to remember that you do not want a clay material on top of the drains, so as not to create a barrier against surface water infiltration, nor a moisture retention layer. Always predict the time needed for the planted grass to take root on the surface.

- Work organization: it is important to work in an organized manner, with a well-coordinated work team. Provide for the removal of residues from the soil and their disposal, the protection of the adjacent lawn, with the use of tarpaulins or wood. Drains should be made obeying the planned drainage for the correct flow of water, and without starting to dig from the lowest part, next to the exit to the rain net. For this, anything from laser levels to transparent construction

hoses can be used. The important thing is that the leveling conference accompanies its execution. The lower part of the trenches must be compacted very well.

- Arrangement and transport of the materials to be used: plan the installation sites of the materials (pipes, sand, gravel) and the way they will be carried to the drains. They should not be deposited directly on the lawn. If they are transported by carts, use boards or wood to move the wheels during the trip. We must always avoid any deformation of the adjacent ground during the work. We are working on a field that already has grass.

- Trenches backfill: the bottom of the drains should be covered with a layer of approximately 1 inch of gravel, on top of which the pipe should be laid, which should be centralized and not touch the trench walls. Over the pipe, fill with gravel to about half the depth of the compact drain and, on top, add the layer of sand to the surface. Before laying the turf in the trenches, it should be well compacted and irrigated.

Irrigation in old fields

In the same manner as described for drainage, trenching for the installation of irrigation pipes should be done with narrow trenches, executed quickly, and the same type of light equipment already proposed above can be used, which does not cause damage to the existing turf.

Considering a field that has reasonable leveling and good turf coverage, and a soil with a drainage profile, it is very advantageous to invest in an irrigation system as a complement to the infrastructure.

If the base soil of the court has large stones, this material cannot be used to fill the irrigation trenches, where the pipes are installed. The stones may break the pipe. It is recommended to backfill with sand.

- Water storage and replacement: as already discussed in the irrigation installation, in Module 1, it is important to provide the reservoir for the supply and to verify the quality of the water supply.

Will it be necessary to replace all the sod when partial or total work is done on the irrigation or drainage systems? It is not necessary to replace the sod, only above the ditches.

Replanting of existing fields

It is worth redoing a turf on an existing field if the other structures are in good condition, and especially the soil profile is sandy, suitable for professional Football practice. It is necessary to harness and level the ground, preferably with a laser.

You can choose different planting methods, already discussed in Module 1. The choice will depend on your budget and the time available to perform the service.

Unit 2

Annual and end-of-season maintenance

The objective is to create a soft, evenly leveled, and dense playing surface, with strong resistance to wear and tear and extraction by the studs (of Football boots), as well as a healthy, aesthetically presentable and uniform green turf.

After the tournament season, it is important to dedicate efforts and financial resources to make a full recovery of the turf, putting it in perfect condition for next year. With the load of use, the field is getting a lot of wear and tear during the playing season. These annual renovations are intended to "zero out" the wear and tear and prepare the field for the next season.

Depending on the climatic region in which the court is located, this management should include:

Turf renovation

- Removal of excess turf cushion

The vertical mowing (*verticutting*) is an essential management to be done frequently, mainly in hybrid bermudagrass fields and other species with stoloniferous characteristics, which will have a greater tendency to the formation of grass mattress (*thatch*). When excessive, this mattress makes ball rolling more difficult, slowing down the pace of play, in addition to greatly impairing the phytosanitary aspect of the turf, making it an ideal environment for the development of fungal and insect pests.

Also, lawns located in warmer regions, with high temperatures throughout the year, will have greater mattress formation and, in these cases, it is recommended to perform several light operations throughout the warmer months, always keeping the pitch in playable condition.

Management should be done in a very aggressive way, in the summer period, in the interval between seasons, and in a softer way, before the sowing of winter seeds, to have more contact between seeds and soil.

Table 1

Removal of excess turf cushion	
Purpose	Equipment
Remove excess organic matter from the turf to improve growth, reduce fungal nuisance attacks and optimize the absorption of fertilizers and other inputs that need to be absorbed by the root system. This practice also provides better surface traction and a denser, stronger turf. The aim is to cut the stolons and side shoots. Attention should always be paid to sweep well the straw resulting from the vertical cut.	There is a wide variety of equipment, attachments, rakes, windrowers and even cylindrical scarifiers with rotating blades that cut into the surface of the lawn. Ideally, the equipment should be wide to allow the fewest number of passes within the field. Take care to adjust the equipment in such a way that it removes and cuts the stolons (grass stems), but does not penetrate the soil to avoid damaging the root system.

Source: own elaboration.

- Soil aeration

To be done after vertical cutting, using hollow or solid punching tools, with variable depth and thickness. In general, the higher the percentage of clay in the soil, the more aggressive this management needs to be. Soil compaction is cumulative, and in clay soils, and tends to worsen as field use occurs.

There are scientific studies that show that soil compaction is responsible for many injuries in players, so it is very important to adopt this management as a routine in professional Football fields.

Table 2

Soil aeration	
Purpose	Equipment
Create perforations in the court surface to improve water infiltration and air exchange.	There is a wide variety of equipment, depending on the depth of penetration required and the type of operation demanded. In the simplest case, manual forks can be used, but there is also a wide variety of

Decrease soil compaction, which favors better root development. Removing fine particulate material from the surface layer and creating holes within the court that can be filled by sandy materials. In other words, to modify the soil profile in old courts, built with clay, through successive aerations. Control the formation of excess grass mat (*thatch*). Improve the firmness characteristics of the playing surface.	motorized equipment, ranging from drum aerators, drilling machines, augers and machines that inject compressed air or water to lift and split the soil. Some of the larger and more efficient machines have lifting functionality to lift the soil and decrease compaction. The different types of corers are divided between (1) solid corers, which are usually needle-like or a type of blade/knife, which make holes into the soil without removing any material, and (2) hollow corers, which remove cylinders of soil and organic matter, which are thrown up to the surface and, thus, can be removed or broken up and reintegrated into the surface layer. Also depending on the type of equipment, it operates at an angle of penetration into the soil. Equipment with hollow points generally remains at a 90-degree angle, but solid equipment must be adjusted to enter the ground at an angle. For old courts with clay soils, the use of hollow punching tools is recommended, which will allow a change of material, incorporating sand to the soil profile.

Source: own elaboration.

- Aeration with deep vertical drainage:

Used correctly, deep vertical drainage is an excellent tool for:

(1) improve surface drainage capacity,

(2) leave the floor softer,

(3) remove minimal corrugations,

(4) incorporate sand into the soil profile.

The depth of this equipment varies from 50 to 300 mm, but much depends on the machine and the punch. In most cases, vertical drainage should only be used at least three weeks before a tournament. Lighter and faster equipment can be used

throughout tournaments. It is important to note that vertical drainage is not a replacement for the shallow bore aerator and both machines are necessary. It is important to note the following:

-Delimit and isolate the field before aerating it.

-Have a second operator walking behind the machine during adjustment to ensure that the machine is not breaking or overly damaging the floor.

-Check if all the punches are firm and have the same diameter and length.

-Check to see if no punch is jamming, as this can damage the turf.

-The machine must be wider than the tractor.

-Mark with flags all sprinklers and other structures buried in the turf to prevent damage.

-It is necessary to put a roll at the back of the machine.

-Test the aeration depth with a spare punch.

-If a punch is lost during the operation, the entire field will need to be checked until it is found, for safety reasons.

- Aeration with surface perforators:

The shallower aerators are recommended for aerating courts before and during tournaments, without affecting the presentation of the turf. The machine operates at a depth of 50 to 150 mm, although it may be less effective at greater depths. Most of the operations performed will be with 6 mm, 9 mm, or 12 mm punches, to soften the turf.

A 10 mm punch aeration in the aerator will reduce the hardness by 10 gravitational forces and the idea is to keep the turf slightly soft and remove the soil cylinders left by the aeration with the next day's mowing.

-Perform all operations on cutting rails using beads as a guide.

-Have a second operator walking behind the machine during adjustment to ensure that the machine is not breaking the ground too much.

-Check if all the punches are properly fastened, in addition to the correct diameter and length.

-Test the depth of aeration with a spare punch.

-If a punch is lost during the operation, the entire field needs to be checked until it is found, for safety reasons.

-As this management can be carried out during the playing season, it is important to check the traction of the turf before and after each operation, so that there is no risk of loss of stability.

- *Topdressing* for leveling (*topdressing*):

This management should be done at least twice a year. Once at the end of the season, after aeration, with the aeration holes open, and after sowing winter seeds, to protect the seeds and help the germination process. It is recommended to cover with sand, of medium granulometry and without stones. The material should be incorporated in the profile of the field, using brushes or metallic grids.

Table 3

Coverage for leveling	
Purpose	Equipment
Improve surface leveling. Reduce the layer of turf cushion (*thatch*) that forms on the ground. Provide a firmer playing surface. Fill the holes made by aeration, stabilizing the soil.	Among the most recommended equipment are rotary and gravity spreaders (with rotating brush for a more uniform application). It is necessary to give preference to wider equipment, to be able to apply over the entire surface of the field with the least number of strokes.

Source: own elaboration.

In colder and more humid climates, pure sand is usually used, provided that a specific granulometry to be recommended by the agronomist, the professional responsible for the field, is always respected. If it is too fine, the sand will tend to retain water and may impede drainage; if it is too coarse and/or contains stones, there may be stability problems, player complaints and possible damage to the mowing machines. It is

necessary to check the material with each truckload that is delivered to ensure that the quality of sand that has been contracted is maintained.

In warmer and drier climates, a mixture of sand and organic matter (usually *peat*) can be used because it helps in water and nutrient retention. It is very important to know the origin of the sand and peat, which may contain pathogens and weed seeds.

To perform the service, it is important to cut the grass short (low) before starting, removing the clippings.

The base of the field should be dry when sand is applied, so that there are no tire marks on the turf.

The material needs to be dry and immediately after application a brush or metal grid should be used to incorporate the input into the soil profile.

Evaluate the need for product application to prevent seed germination, after aeration and sand management, so that contaminants in the soil and sand are removed.

Weed, disease and insect control

Control requirements: Most turfgrasses can be subject to weed invasion and disease or insect damage. Choosing the right turfgrass variety and recommended management practices can help minimize problems.

It is essential to have the guidance of an agronomist specialized in sports turf, who will recommend products that will not cause damage to the turf, nor injuries to the players.

In specific cases, where the use of pesticides is necessary, it is important to emphasize that each country has its own specific legislation for the use of these products, which must be respected. Always use products that have a registered use for sports turf. Respect also the need to use the space after the application and guide the employee who will perform the application to use all the necessary protective equipment and perform the correct application.

- Weeds: any plant that is not the species of the lawn that has been planted. They are plants, in general, easy to reproduce either by seeds or stem pieces. Their seeds can be carried by birds, by wind, by mowing or other equipment or by animals, or even on shoes.

How to make the control:

- Make frequent mowings. Most weeds do not sprout after successive mowings;

- Water and fertilize adequately, preventing the grass from losing its natural density, which would favor germination;

- Hand pulling or weeding existing weeds with a hoe;

- Use quality breads, stolons and seeds;

- Perform cleaning of cutting equipment;

- Use physical barriers;

- Use clean soil or substrates;

- Through proper herbicide management.

Manual weed removal can be used to remove some larger types of weeds, but it is not totally effective, especially for those with deep roots or bulbs that may reappear in the lawn.

- Herbicides: It is important to identify very well the species to be controlled in order to choose the correct product and dosage.

Herbicides can be divided into two main groups:

- Pre-emergent: herbicides applied before weed seed germination. They promote a residual control of 60 to 75 days. It is important to know the life cycle of weeds. If the application is made after the emergence of the target plants, the pre-emergent action will not be effective. In general, the application of pre-emergent herbicides should always be made after the installation of a turfgrass, especially for those planted by vegetative propagation (seedlings, stolons - *spriggs*). Another important moment is just after the aeration of the lawn and / or after the execution of more aggressive vertical cuts (exposing the soil surface to the action of light, stimulating the germination of seeds). Also, when sand is applied, it can bring seeds of invasive plants (commonly sedges).

  When managing *ryegrass* in the winter, it is important to plan to adhere to the 60-day window after any pre-emergent herbicide application.

- Post emergent: they are active only on weeds that have already emerged. Best results occur when plants are still young. Repeated applications may be necessary for acceptable control. Many products require the use of additives such as mineral oils or wetting agents. Most will need to dry on the leaf prior to rain or irrigation.

  In general, temperatures above 29 - 32oC can cause phytotoxicity (yellowing) in turfgrass. Therefore, preference should be given to the application of post-emergent herbicides to turf in the off-season, and it is appropriate to take advantage of the summer break, where they can be applied during the field renovation period.

There are different modes of action and varying degrees of selectivity of herbicides in relation to different grass varieties. Therefore, it is important to choose products according to their prescription and use them in accordance with the indicated dosage and manner of application.

- Diseases:

As turf is maintained with low and very frequent mowing, it is subject to stress and the appearance of various diseases. In modern stadiums, with intense shading due to the roof, this problem is much more intense and difficult to manage.

The field team should receive specific training, learn to recognize the first symptoms of diseases in the field, as some diseases spread very quickly, and large areas of turf can be lost in a few days if efficient control is not carried out.

The agronomist should check the lawn very frequently, at dawn is the best time to identify visible fungal structures on the grass blades. In addition, knowing the main diseases that occur in the region, he can carry out a preventive control, according to the time of the year. Some of these preventive measures are:

- Adoption of cultural practices, such as reduction of excess turf mat and soil de-compaction.
- Use of supplemental lighting and floor ventilation on courts subject to intense shading.

- Removal of dew at dawn, so that the leaves dry. This can be done with heavy cordons, and adopt this practice throughout the winter months.
- Correct irrigation management, avoiding excess water and irrigating during the hottest times of the day, especially in the winter period.
- Insects: Most will not cause any damage, they are small in size and difficult to visualize. When you notice damage to your lawn, you should try to identify the insect that caused it. These are some of the measures to take:
- Depending on the degree of infestation, we can only treat with cultural treatments.
- Insects and other creatures that can affect the healthy development of a lawn are considered pests.
- Keep your lawn well fertilized. A healthy lawn does not prevent pests, but it is less prone to major damage and, most importantly, recovers much faster when damage does occur.

Turf bun changes

It is often necessary to make localized changes of the turf panels, especially in the areas of greater wear and tear, next to the goal and penalties. It is also necessary to make eventual changes when accidents occur with spills of products such as fuel, fertilizers or burning of lines due to the use of inadequate paint, among others. It is important to have immediate availability of grass in appropriate conditions to replant these areas, in order to be able to play immediately afterwards.

It is not always possible to count on suppliers (farms) of turf, because we depend on availability, distance and delivery time and also with the condition of the turf, which generally does not meet the appearance and technical quality to be ready to be put into use.

The ideal is to have a nursery near the field, with turf maintained in the same conditions as the main field, so that every maintenance operation performed in the field is also performed in the nursery, with the same equipment, the same mowing frequency, for applications and doses of products. It is also important that the base material is the same (same soil) and that, as far as possible, the nursery has the same condition of sun exposure. Adequate drainage

should be ensured for this area, which should be kept well leveled and the surroundings should be kept free of weeds.

In addition to providing quality turf for immediate use, it is important that the replacement be done as perfectly as possible. To remove the turf, if there is no specific equipment to remove the slabs (such as a lawn mower), shovels or other very sharp cutting equipment should be used. The area to be exchanged should be measured and the removal should be done with a large thickness (5 to 8 cm, minimum), to give stability soon after seeding, as there will not be time to rely on the rooting of the turf. Transport must be careful to maintain the integrity of the plates.

The site to be replanted, from the moment the material to be exchanged is removed, must have its sides protected with some type of wood, avoiding traffic or throwing soil on the surrounding grass.

Try to make changes in areas of regular shapes (rectangles, squares), avoiding excessive trimming, for a better finish.

The soil should be pre-leveled after the material has been removed. This leveling should be checked at the time of planting, removing or adding sand under the new sod slabs when necessary. A metal construction straightedge can be used to adjust and verify levelness. Use some type of compaction equipment prior to planting, on the soil, to avoid future settlement and do not compact the sod immediately after planting. Although it should be avoided, any slight depression that remains in the planted area can be corrected later with the addition of sand in the cover (use sand with green dye), as areas that become higher need to have the sod removed again to adjust the levelness with removal from the soil below.

At the time of installation, the joints must be perfect, with no space between them. Ideally, the need to sand these joints should be avoided, as this would be obvious. If necessary, it is preferable to make small adjustments to the joints with the same forks used to correct the post-set holes.

When it is not possible to maintain a nursery, or when, for some reason, it does not look as similar to the main turf, you can use the turf outside the four rows (around the field) to plant inside the field (then replace this removed turf with what is in the nursery). For this, it is best to use the turf that is located on the east side, not near the technical area, which is the least exposed to the cameras during the broadcast of the games.

Winter seed sowing

Run with cold weather species seed on sites where Bermuda grass is a permanent base for the field. Recommended management for areas where there is a significant temperature difference between winter and summer months.

It is generally worked with *turf-type* varieties of *Lolium perenne*, implanted on the base turf, always preserving an interval of a few days without matches for germination and establishment. This management will greatly increase the resistance to trampling and recovery of the turf during the cold months, period in which the summer base turf (generally bermudagrass) paralyzes or greatly reduces its growth. It will also imply a great aesthetic improvement in the fields, even allowing better marking of the recommended mowing strips, leaving the mowing more beautiful and with intense green coloration.

This management, which usually has a high cost within the annual budget of the field, needs to be planned together with all the other annual renovations that will be executed. Depending on the region, this seeding will occur already during the season, in the fall.

Establishment of new turf from seed

In regions with lower temperatures throughout the year, where *cool season grasses* are used as the sole species, the interval between tournaments should be used to establish the species, which is sporadically renewed.

Why is the management seen so far necessary?

Unit 3

Maintenance and regulation of machines

Sports turf maintenance equipment is extremely precise and sophisticated, the vast majority of which is not produced in South America.

This creates the need to import the equipment, with very high tax costs, depending on the country.

In addition to the purchase of equipment, it is necessary to purchase spare parts and have representatives in the country to perform maintenance and provide technical assistance and warranties.

Hence the importance of having a preventive maintenance plan that prolongs the useful life of the equipment and keeps it in perfect condition for use.

Equipment for routine use, which will be used during the playing season, needs special care, so that there are no problems that could compromise the preparation of the field for a game.

As far as possible, always have back-up equipment for emergencies, also in perfect condition.

Calibration of spraying equipment

There are situations in which it is necessary to spray products on the lawn, either in liquid fertilizations that allow the administration of macro and micronutrients through the leaves or hormones, for example, in the applications of preventive or curative phytosanitary treatments, such as fungicides, insecticides or herbicides.

When a product is applied on a Football field, especially in the case of stadiums, with frequent televising of matches, there is no margin for error. Any oversight can result in uneven coloration, compromising the appearance or even the quality of the playing surface.

In addition, it is often necessary to work with products whose recommended doses are as low as a few grams per field. Thus, it is even more important that the applications are carried out seeking excellence, without failures or overlaps, and that the equipment and operations have a perfect calibration, since this will determine that the product can have the desired action in the adequate coverage, without damaging the field by excess.

In addition to care in the application and calibration of the equipment, it is important to strictly follow the recommended dosages and to have measuring equipment available, such as volume measuring cups, graduated syringes for small volumes and small digital scales (for weighing small quantities) and scales for weighing large volumes.

Aiming at application uniformity, it is ideal to avoid the use of knapsack sprayers, which can present variability in application, since the operation is influenced by the walking speed, the capacity of the applicator or the pressure administered to the equipment. Thus, it is difficult to rely on satisfactory coverage or even to calibrate the equipment to a safe rate per area applied, resulting in most of the time, partial control, with areas of gaps or overlaps and frequently spotted turf.

A boom equipment allows you to better distribute the product. However, to optimize the application of liquid products, in order to minimize maneuvering and allow a more agile operation, it is recommended that the spraying equipment has a boom width of about one meter.5

There are agricultural sprayers that must be coupled to a tractor with balloon tires, so as not to damage the lawn or equipment with simple tanks, with engine, adapted to be stretched for example by lawn mowing tractors.

Automated equipment with sprayers attached to the coupler, such as *John Deere*'s *Gator*, Toro's *Workman* or similar, which can have varying capacities and application booms, is also available.

Both tractor-mounted and automated equipment can be equipped with foam line markers or even GPS equipment to speed up the application by marking the lines.

If these resources are not available, strings should be used as guides to mark the application or even dyes to visualize the applied area.

Whatever spraying equipment is available, application calibration must be performed prior to use. For this, some prerequisites are required:

Nozzles: Choose the appropriate nozzles, which depending on the target may have fan or cone jet. Each nozzle will have a predefined capacity, in degrees of fan application and in flow volume per second. The flow specification will be associated with a nozzle color. The vast majority of nozzles available on the market have flow rates standardized by the ISO standard. This standardization is done through colors, and there are specific tables. On a nozzle there are three pieces of information: name, angle and flow rate.

Table 4: Nozzle standardization

Color	Caudal nominal L/min
Naranja	0,4
Verde	0,6
Amarillo	0,8
Azul	1,2
Rojo	1,6
Marrón	2
Gris	2,4
Blanco	3,2

Fuente: [untitled image about nozzle standardization], 2016, https://bit.ly/3gfUYey.

Color: - Colour

Caudal Nominal L/mín: - Nominal flow rate L/min

Naranja: Orange

Verde: Green
Amarilla: Yellow
Azul: Blue
Rojo: Red
Marrón: Brown
Gris: Grey
Blanco: White

For example, a 110 02 (yellow) nozzle will apply at an application angle of 110 or at a flow rate of 02 U.S. gallons per minute, while a 110 04 (blue) nozzle will have a higher application rate of 4 gallons per minute. What is important is that all nozzles on a boom are the same or in excellent working condition.

Nozzles can be made of different materials such as plastic, ceramic or stainless steel. Their wear will vary according to the material, pressure (working within recommendations), use (abrasiveness of the products, water quality) and care. In general, the wear allowed for using a nozzle is limited to 10%, which should be replaced when the flow rate is 10% higher than the nominal flow of a new nozzle.

- Acceleration/speed: A fixed acceleration/speed must be determined for the work, being that in agricultural tractors a fixed working gear and rotation is stipulated, or in automatic equipment, a working speed can be set directly.
- Pressure: Regulate a preset application pressure (generally 2 to 4 BAR). The working pressure governs the main factors of an application, the droplet size and the application volume. The choice of the ideal working pressure for each nozzle should be consulted in tables.

Table 5: Ideal working pressure for each nozzle

Especificações					Velocidade de Trabalho Km/h								
Modelo	Malha do filtro	Pressão lbf/pol²	Vazão L/min	Tamanho de Gota (DMV)	5	7	9	10	12	14	16	18	20
ADI 11001 RG 457.788	80	20	0,28	C	67	48	37	34	28	24	21	19	17
		30	0,32	M	77	55	43	38	32	27	24	21	19
		45	0,40	M	96	69	53	48	40	34	30	27	24
		60	0,46	F	110	79	61	55	46	39	35	31	28
ADI 110015 RG 457.796	80	20	0,43	C	103	74	57	52	43	37	32	29	26
		30	0,49	M	118	84	65	59	49	42	37	33	29
		45	0,60	M	144	103	80	72	60	51	45	40	36
		60	0,69	M	166	118	92	83	69	59	52	46	41
ADI 11002 RG 457.804	50	20	0,57	C	137	98	76	68	57	49	43	38	34
		30	0,66	M	158	113	88	79	66	57	50	44	40
		45	0,80	M	192	137	107	96	80	69	60	53	48
		60	0,91	M	218	156	121	109	91	78	68	61	55
ADI 11003 RG 457.812	50	20	0,86	VC	206	147	115	103	86	74	65	57	52
		30	0,98	C	235	168	131	118	98	84	74	65	59
		45	1,20	M	288	206	160	144	120	103	90	80	72
		60	1,39	M	334	238	185	167	139	119	104	93	83
ADI 11004 RG 457.820	50	20	1,15	VC	276	197	153	138	115	99	86	77	69
		30	1,31	VC	314	225	175	157	131	112	98	87	79
		45	1,60	C	384	274	213	192	160	137	120	107	96
		60	1,85	C	444	317	247	222	185	159	139	123	111

Source: Bicos e acessorios, n. d., https://bit.ly/3xlHjwi

Spray volume for spray boom (l / ha). Nozzle spacing 0.5m

Especificacoes: - Specifications

Velocidade de trabalho km/h: - Working speed km/h

Modelo: Model

Malha do filtro: Filter mesh

Pressao lbf/pol2: Pressure lbf/inch2

Vazao L/min: Flow rate L/min

Tamanho de Gota (PMV): Drop Size (PMV)

- Calibration by means of calibrating cup:

a) the 50 meter mark on the land to be treated;

b) Choose the working gear;

c) Plug in the socket;

d) accelerate the motor to the determined speed;

e) Start the movement of the tractor at least 5 meters before the marked point;

f) Note the time the tractor takes to travel the 50 meters;

g) With the tractor stopped, at the acceleration used to travel the 50m, open the sprayer;

h) Set the nozzle volume in time equal to the time taken to travel the 50m, making the reading in the column correspond to the space between the nozzles in the calibrator, in liters per hectare;

i) Repeat the operation on several nozzles to obtain an average volume;

j) The average obtained in the samples is the volume of spray (in liters per hectare) for the speed and pressure already determined.

Observation:

- If the volume obtained is below the desired volume, increase the pressure, decrease the speed or change the nozzles to a higher flow rate;
- If the volume obtained is above the desired volume, decrease the pressure, increase the speed or change the nozzles for others with a lower flow rate.

- In the absence of a calibrator cup, the procedure is the same, but the volume flow rate is obtained by calculation, taking into account the length of the spray boom and the number of nozzles on the boom:

-Time (in seconds) measured for a 50 m run at T50

-Volume (in ml) collected in a nozzle at time T50 or V1

-Total volume (in liters) collected at time T50:Vt50o = (V1 in ml x number of nozzles)/1000

-Distance (in linear meters) to cover 1ha: Dha= 10,000 m2 / width of the bar in meters

-If it takes a time T50 to go 50m, then:

to pass through 1ha it will take a time Tha (Dha x T50)/50m

-If the time to travel 50 m (T50), all the nozzles of the spray boom spent a volume Vt50 in liters, then:

In the time it takes to pass through 1 ha (Tha), it will expend a volume flow rate in l /ha:

Flow rate =(Vt50 x Tha)/T50

Example:

For a 5.5 m boom with 50 cm between nozzles (11 nozzles on the boom):

Where:

T50 at 40 seconds (time it takes to travel 50 m)

V1 = 320 ml (Volume flow rate collected in 40 seconds)

Vt50 (320 x 11 nozzles)/1000 = 3.52 liters (total volume, in liters, of flow collected in the 11 nozzles in 40 seconds)

Dha = 10,000 m2/5.5m = 1,818 m (distance to cover 1 ha with a 5.5 m bar)

Tha = (1.818 X 40)/50m = 1454 seconds (time to cover 1ha with a 5.5 m bar)

Flow rate = (3,52 x 1454)/40 = 128 liters/ha

Or, to simplify the calculation, you can use the following formula:

Flow in liters/ha:

Flow rate = (600 x q)/(v x f)

Where:

q = volume of a nozzle in liters/minute

v = Equipment speed in km/hour

f = spacing between nozzles in meters

- Weather conditions:

Temperature, air humidity and wind speed can greatly influence the quality and efficiency of the application. In general, at temperatures above 30oC, humidity below 50% should be avoided. As for wind, ideally, work in a range of 4 to 10 km/h. Higher speeds cause excessive drift, but speeds close to zero cause droplet suspension, decreasing plant deposition and product penetration.

- Bar height:

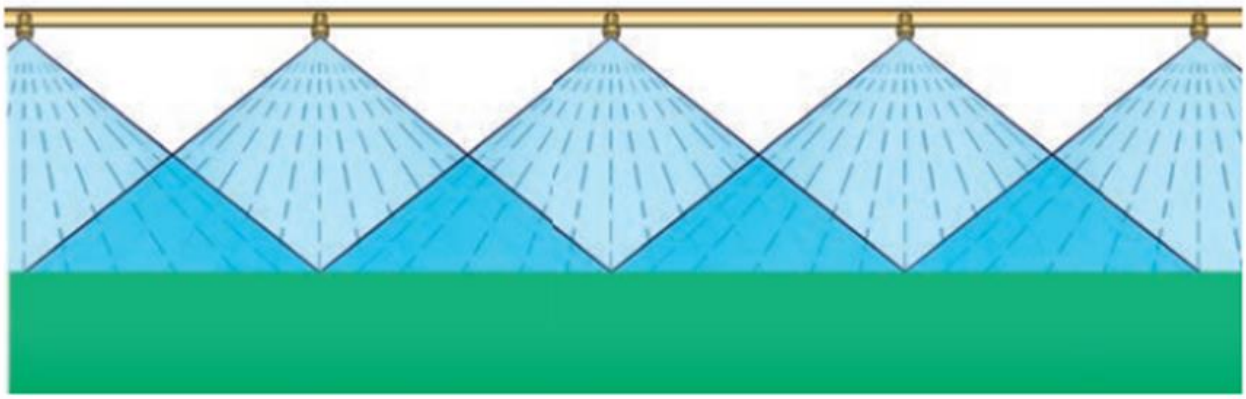
The ideal boom height is the one that allows the jets to cross (overlap) in order to homogenize the distribution of the applied volume along the boom. The minimum height depends on the nozzle angle and the spacing between the nozzles. For jets with triangular distribution, the minimum boom height should be adequate for the crossing of the jets to occur at half the height between the boom and the target (grass).

Table 6. Relationship between angle, nozzle and boom height at a nozzle spacing of 50 cm.

Relationship between angle, nozzle and boom height at a nozzle spacing of 50 cm.	
Nozzle angle	Minimum bar height
80°	60 cm
110°	35 cm

Source: own elaboration.

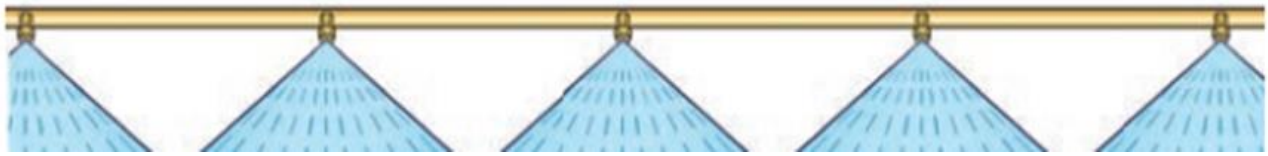
Figure 1: Correct positioning of the rod and ideal crossing of the jets



Source: own elaboration.

Excessive boom height leads to drift and evaporation losses. Already a boom positioned too low can lead to areas of application failure (lack of spray overlap) interspersed with areas of excess (high product concentration), which can lead to a streaking effect on the areas, especially when the applied product is herbicide or liquid fertilizer.

Figure 2: Very low positioning of the bar



Source: own elaboration.

Fertilizer Spreader Calibration

Special care is needed when using granular fertilizers. Fertilizer distribution should also be calibrated beforehand.

Before starting each application, it is important to check the working width and the opening of the equipment for fertilizer outlet.

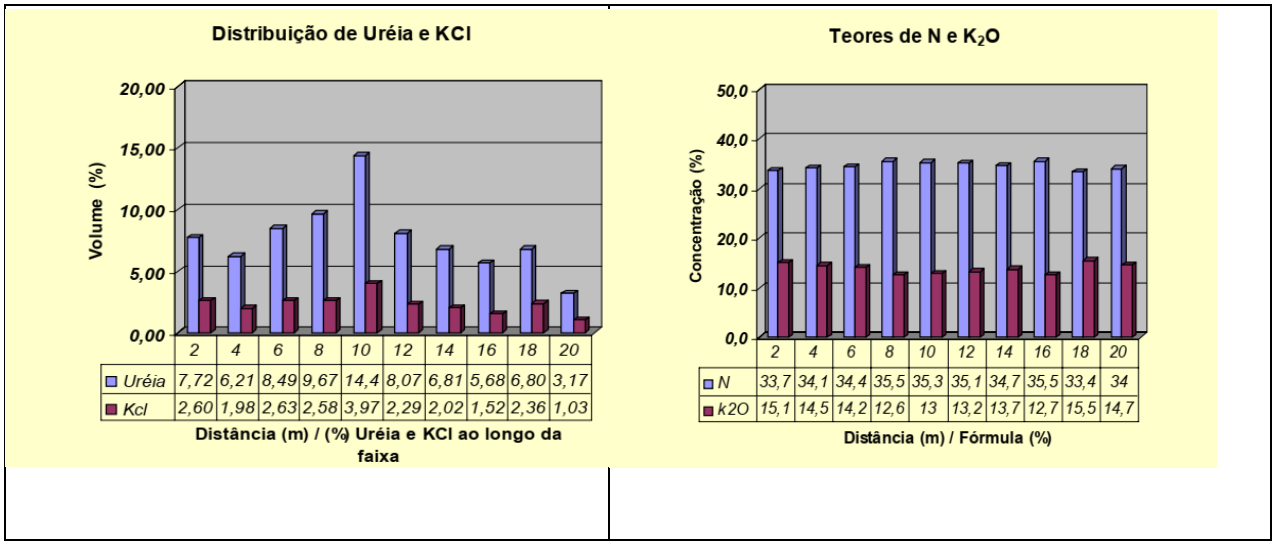
In the case of the application of granules, we must take into account that each product will have a specific granulometry that will influence both the working width and the dose released by the opening of the equipment.

Below, you can see a series of graphs that help to exemplify the distribution behavior of some fertilizers.

The graphs on the left show how the distribution curve of some different products behaves, while those on the right show the effect of nutrient distribution in the soil.

Although these are the same products (urea and potassium chloride), by comparing the upper graphs with the lower graphs, it can be seen that different grain sizes can have different effects on the distribution of the products.

Figure 3: Urea and KCl distribution

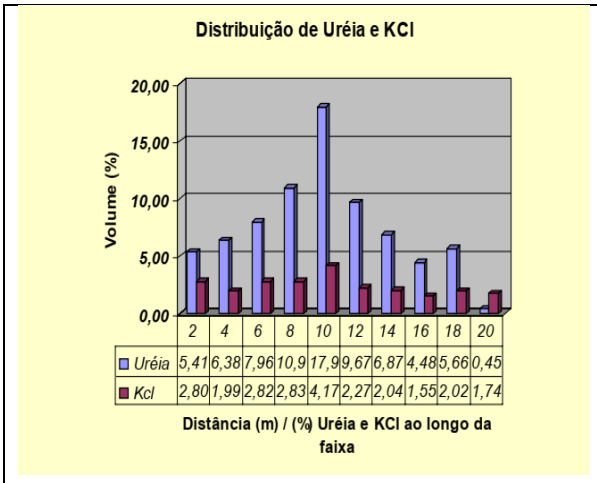


Comparison of the behavior of urea and KCl distribution curves, both with coarse particle size.

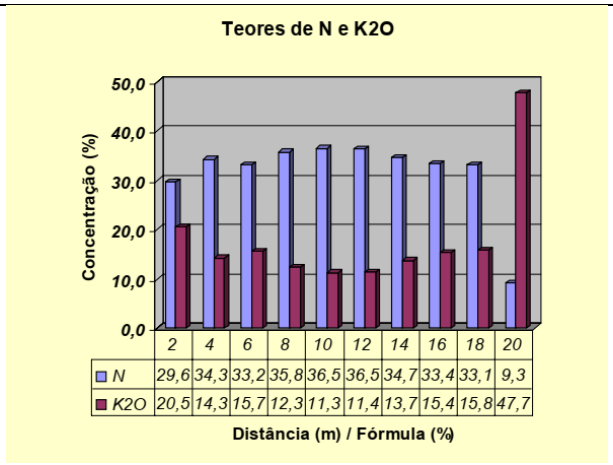
Balanced result in nitrogen and potassium content in the soil when both pure products have a similar granulometry (coarse).

Source: own elaboration.

Figure 4: N content and potassium oxide



Comparison of the behavior of the distribution curve Urea (thin) and KCl (coarse), with different granulometries.



Results in nitrogen and potassium contents in the soil when the products have different granulometry.

Distribuicao de Uréia e KCl= - Urea and KCl distribution Volume: - Volume Distancia (m): - Distance (m) (%) Uréia e KCl ao long faixa: - (%) Urea and KCl in the long range Teores de Ne K2O: - Ne K2O content Concentracao: - Concentration Distancia (m): - Distance (m) Fórmula (%):- Formula (%)

Source: own elaboration.

For this, it is recommended to choose an area outside the lawn, place the product in the fertilizer applicator and perform the displacement to determine the adjustment of the dose and the width of the application.

The fertilizer rate can be tested by marking a known measurement (such as 1 m², for example) on the ground with a tarp or a shallow plastic tray and weighing the amount of fertilizer that falls on it. From this information, the fertilizer rate obtained for the entire field can be calculated. The test should be repeated until the fertilizer rate is reached to achieve the desired dose.

We also need to predict a suitable overlap area, as there is generally a higher concentration of fertilizer in the center of the application that gradually decreases towards the sides (as illustrated in the graphs on the left, above). Ideally, you should find the optimum overlap distance where the sum of the amounts of fertilizer falling at the ends equals the amount of fertilizer falling below the center of the fertilizer applicator. In this way, you can determine the working width for each product. This can be determined by weighing given amounts of fertilizer under each area over the width of the application. Or, more empirically, by visually observing the distribution and measuring the distance, remembering to consider an overlapping range.

When changing the person operating the fertilizer, care must be taken to maintain the same application speed (which should be the speed of a normal walk, slightly accelerated). When we change the speed of application, we can throw the product at shorter and shorter distances.

After determining the working distance, ropes spaced at this distance should be used. The entire fertilization operation should be done using the string as a reference. It is possible to make fixed measurements (with pipes, for example) where the desired working width is marked, to speed up the operation, marking the places where the ropes change more quickly.

We also have to keep in mind that most fertilizer spreaders tend to pull the fertilizer more to one side, which should be taken into account when adjusting. Even with a good calibration performed, when fertilizing always in the same direction, there can be a tendency to form a distribution pattern. To make fertilization even more uniform, each fertilization should reverse the direction of application. Thus, if the previous fertilization was made from target to target, the next fertilization should be made from side to side. Also start once on the east side, the other time start on the west side.

Adjustment of lawn mowing machines

For a helical cylindrical cutter or rotary machine to operate optimally, the surface of the cutting blade must be sharpened. The benefit for a helical cutter is that the contact between the cylinder blades and the counter-blade acts as a self-sharpening agent.

However, the cutting surfaces will not maintain a sharp edge unless the counter-blade is adjusted for proper contact, which should be checked before each use. The rotary blades should be checked approximately every week for sharpness. When checking the blade edge, verify that the non-cutting side is not damaged or worn. Sharpen and balance the rotary blades as necessary.
Cutting height adjustment on helical machines.

- To adjust the cutting height, the adjustment bar can be used:

For acceptable cut quality, the rollers must be parallel to the cylinder. Before adjusting the roll parallelism, check for loose bearings, and the bearings should be adjusted or replaced as necessary. Using a feeler gauge, set the desired height of cut on the bar, adjusting the screw as necessary. After loosening the front roller adjustment screws, the adjustment bar is placed under the rear roller, attaching the screw head of the adjustment bar to the top of the lower blade. The front roller is adjusted, one side at a time, so that the adjustment bar is secured by the front roller, lower blade and rear roller. Tighten the screws and check again. This procedure should be done in exactly the same way on each cutting unit. Before making this adjustment, the counter knife and roller must be parallel to the cylinder. It must be remembered that the setting being made here (the height of cut set on the bench) is different from the actual or real height of cut on the turf. This is due to several factors, such as the fact that the turf surface is not as firm as a bench; turfs can vary in density; different models of cutting units will have different weights and the rollers will not seat on the surface in the same way; after mowing grass debris may settle under the counter-blade, among others.

- Basic requirements for good performance on helical machines:
  - The shaving heads of helical blades must be straight and sharp.

-The counter-blade must be exactly parallel to the cylinder. -The counter-blade should be positioned against the cutting cylinder with very little contact.

-All cutting units should be operated with identical settings for a uniform cut. A 0.25 mm error from one end of the cutting unit to the other may be seen in the appearance of the turf.
Operators should be properly trained in operation and periodic maintenance.

- Preventive maintenance: depending on the type of equipment used, perform a daily check for:

- Safety lockout operation;
- Braking operation;
- Engine oil level;
- Cooling system and fluid level;
- Drainage of the water/fuel separator;
- Air filter cleanliness condition;
- Radiator and screen for debris;
- Unusual engine noises;
- Cutting height;
- Hydraulic system oil level;
- Damage to the hydraulic hose;
- Liquid leakage;
- Tire pressure;
- Operating instrument;
- Leaf condition;
- Lubrication of all grease fittings;

- Cutting unit settings and adjustments: always use the operator's manual for each model being worked on.
  To maintain performance, check:

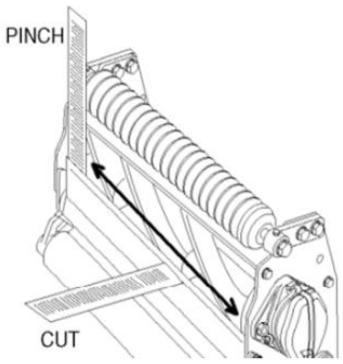
    - Daily:

- Adjustment of the counter with the cylinder;

- Sharpening;
- Cutting height;
    - Periodically:
- roller conditions;
- Cylinder bearings;
- Paper parallelism;
- General mechanical condition.

- Lubrication should also be part of the daily maintenance routine. Bearings should be lubricated after each use and after any washing. Before cutting, it is essential that the cylinder and counter-blade are adjusted and sharp. It is important to sharpen when necessary. Adjustments are necessary to bring the blade and cylinders closer together, with slight contact for free rotation of the cylinder. Different models of cutting units will have different adjustment methods for cylinder to counter-blade contact.

Figure 5: sharpening



Source: own elaboration.

Adjust the cylinder against the counter-blade to evenly compress a thickness of paper along the blade. Then, cut the paper strips to check the sharpness of the blade.

- SHARPENING OF CUTTING EQUIPMENT

Sharpening is part of the maintenance required for proper operation of a cutting unit cylinder.

Your need can be assessed if:

- The grass is not mowed properly;
- The color of the grass may have a yellowish or brownish-tipped appearance.
- Stripes.
- The cutting unit is noisy.
- You can also check the cutting edges of the cylinder and counter-blade to see if they are sluggish, cut, crooked or moving without a slight contact between them.

The cylinder blades and counter-blade edge should be checked for damage, visually and carefully by touch.
These rounded edges will cause the blades of grass to compress and break rather than cut. When light contact is not maintained, yellow edges will result.

If there is no contact (a gap between the counter-blade and the cutting cylinder is missing), this can lead to rapid wear of the cutting edges and the need for more frequent grinding.

Without contact, grass blades are pulled and shredded, rather than cut cleanly, resulting in a poor-quality cut, which accelerates the blade wear process. Deterioration of the lawn's appearance after mowing damages its long-term health.

The cutting units must be kept sharp for:

- Promote healthy leaf growth;
- Optimize the performance of the cutting units;
- Extends the life of the brush cutter;
- Maximize the time of the cutting operation;
- Promote the best possible post-cut appearance.

When the blades lose their shape and the quality of the cut deteriorates, the tendency is to want to press the counter-blade against the cylinder, resulting in excessive contact, which

can cause scratches, which appear as a grooved wear pattern on the cylinder. This condition can only be corrected by grinding the counter-blade and the cutting cylinder.

Back lapping will not correct this condition.

The counter-blade should generally be replaced rather than just ground.

A barrel-shaped cylinder (more common on units with welded rather than bolted frames), caused by bending of the cutting unit structure, will also require grinding to return the coil to a cylindrical shape. Frame flexing can cause uneven wear and eventually lead to scratches. If the roll wears unevenly, it becomes difficult to maintain parallel across the full width of the roll. When setting a cutting unit with this condition, the tendency is to squeeze the counter knife to make contact with the cylinder, resulting in excessive contact.

How can we tell if a lawn mower needs sharpening?

- Grinding and Back grinding (*BACK LAPPING*)

Grinding and *back lapping* are complementary works to sharpen the cylinder. Back lapping allows for a better fit and longer life of the counter-blade and cylindrical blades. A properly assembled and adjusted ground cutting cylinder will cut very well. However, the quality of the cut will be better if *back lapping* is performed, which will allow the removal of metal debris and high spots on the blade. The perfect fit between the cylinder blades and the counter-blade will allow a clean cut.

Back lapping is recommended after each cut, ensuring that the blades are always perfectly sharp. It takes a few minutes to back lap after each cut, which is a time often used to keep the lawn healthy.

By performing *Back lapping* regularly, the sharpness of the cutting cylinder and counter-blade can be maintained for a longer period of time. Back lapping cannot be used to sharpen a deformed cylinder or counter-blade. *Back lapping* is a maintenance practice to finish the edge of the blades.

As the cylinder blades run against the counter knife during *back lapping*, a small burr will appear on the leading-edge surface for the entire length of the counter knife, which must be removed.

Back lapping should be done after each blade is ground. This is done to establish perfect contact between the counter-blade and the cutting edge of the cutting cylinder. *Back lapping* is not intended to be a reconditioning process to correct severely damaged

blades, scratches or cones. If, after approximately 5 minutes of sharpening, the edge is not restored, it is time to regrind the cylinder and counter-blade.

Back lapping is usually a regularly scheduled maintenance process.

To sharpen the helical system it is necessary to use a sharpening paste, which can have different granulometries:

- 60 grit: for heavy duty work, e.g. sand damaged cylinders;

- Grain 80: for regular maintenance of large cylinders;

- 120 grit: for regular routine maintenance of cylinders;

- *Back lapping* process and care:

After connecting the cutting body to the sharpening equipment, the sharpener should be rotating, causing the cylinder to rotate in opposite rotation to the cutting body. Apply the sharpening paste evenly throughout the cylinder as the cylinder rotates in the opposite direction. The counter-blade should be adjusted to allow the cylinder to slide. Always use a long-handled brush to apply the sharpening paste to the rotating cylinder to avoid accidents. Keep hands, feet and clothing away from moving parts. The blades produce a grinding sound as they sharpen, but as the blades sharpen, the grinding noise becomes less until the blades run smoothly and look smoother. When the helical cut is sharp enough, you should be able to cut a piece of paper like a pair of scissors.

It is necessary to clean (wash) the cutting body to remove residues after the process.

- Rectify:

Grinding of the cutting cylinder can be performed between two and three times a year, depending on factors such as the frequency of use of the equipment, the number of sand covers made, the degree of tightness between the counter-blade and the cutting cylinder, among others.

In the turf machinery industry, making the profile of each roller blade thinner, so that there is less metal-to-metal contact between the cylinder and counter-blade, is called relief. This reduces the mechanical effort required to drive the cutting cylinder when the cylinder and counter-blade are in contact.

This relief grinding could be described as "blade thinning". The thickness and angle required to thin the blade varies from manufacturer to manufacturer (generally between 20 and 45%, with Toro, for example, adopting 30%). Excessive relief angles and thin edge relief weaken cylinder blades and make them more vulnerable to wear and damage from rocks or other objects. Relief is not about mowing. This is to make it easier for the cutter to make contact.

Before a cylinder can be properly ground, it must be cleaned and checked for loose or bent blades.

Cylinder bearings should be in good condition, with no obvious play. The cutting unit frame and roller supports should be tight and not bent or damaged by impacts. The cutting unit should be aligned so that the work is parallel to the cylinder axis. This will cause the cutting cylinder to be ground to the desired cylindrical shape.
It is important to follow the sharpening equipment manufacturer's guidelines for assembly and operation. When sharpening, care should be taken not to overheat the cylinder blades. Remove small amounts of material with each pass.
After completing the grinding process, a complete setup and adjustment procedure should be performed on each cutting unit.

There are several manufacturers of cylinder grinders (grinders). These same manufacturers also produce counter-blade grinders.

Whatever grinder is in use, it should be ground parallel to the cylinder axis. Rollers naturally wear more on one side than the other. Any conical shape of the worn cylinder should be removed. It should be checked whether the centerline of the cutting cylinder, which is its axis, is parallel to the grinding stone's displacement.

Table 7

Troubleshooting problems observed in cutting		
Problem	Possible Cause	Solution
Occasional leaves of uncut grass	Motor speed too slow. Feed speed too fast. Cutting height too high. Counter-blade incorrectly adjusted. Counter-blade cutting cylinder not cutting. Slipping drive belt.	Increase motor speed. Reduce the forward travel speed. Reduce the cutting height. Readjust the counter-blade. Sharpen/refurbish if

		necessary. Adjust belt tension.
Uncut strips of grass between adjacent mowing passes.	Overlap between very small passes	Increase the overlap between cutting passes.
Uneven cut on uneven terrain.	Irregular soil conditions.	Reduce the travel speed, change the cutting direction.
Scalping of the lawn.	Cutting height too low for the conditions. Irregular soil conditions.	Increase the cutting height. Increase the cutting height, change the cutting direction.
Marks on the blades of grass perpendicular to the direction of travel.	Cylinder speed is too low for travel speed. Very fast travel speed.	Increases motor speed. Reduces travel speed.
Grass trails in direction of travel	Counter-blade in close contact with the ground. Small cylinder adjustment with counter-blade. Worn cylinder bearings.	Increase the cutting height. Reset the counterfeit. Restore worn parts.
Excessive wear of the counter-blade.	Counter-blade in great contact with the ground. Blind blade. Cylinder in excessive contact with the counter-blade. Excessively abrasive soil conditions.	Increase the cutting height. Sharpening or grinding. Readjust the counter-blade to clean the cylinder. Increase the cutting height.
The cylinder is struck as it rotates.	Blows on the edges of the blade. Worn cylinder bearings.	Sharpening / grinding of the cylinder and counter-blade. Restore worn parts

Source: own elaboration.

- Preventive maintenance of equipment:

Preventive maintenance is that which is performed regularly on equipment or its parts to reduce the probability of failure. It is performed while the equipment is still working, so that it does not break down. Preventive maintenance is planned so that all necessary resources are available.

An equipment only generates return when it works properly. That is why preventive maintenance is essential to get the most out of your machines, being important to:

- Safety: Keep the equipment safe to operate. If worn components are not repaired, the risk of collision or injury increases.
- Availability and productivity: The work team depends on the equipment being ready to use when needed. Preventive maintenance helps maximize machine availability and increase productivity. In the case of equipment that will be used for match preparation, this element is extremely important. In addition to having back-up equipment, we need this equipment to be in perfect condition for use.
- Longer machine life: regularly scheduled maintenance helps extend the life of the equipment, which helps optimize the investment.
- Cost savings: Preventive maintenance is proactive. It helps minimize failures that require more costly unscheduled repairs. Unplanned maintenance generally costs three to nine times more than planned maintenance.

- Preventive maintenance program:

An effective preventive maintenance program includes equipment inspections, scheduled service based on manufacturer's recommendations, and parts replacement as needed. For turf equipment, maintenance intervals are generally based on operating times. When developing a preventive maintenance program, the following recommendations should be considered:

- Create checklists. Document a set of steps to follow whenever a specific preventive maintenance service is performed to ensure that nothing is missed.
- Collect operator feedback. Install a system for operators to report when they have a problem or become aware of a problem with a machine, so that it can be resolved in maintenance.
- Define maintenance intervals. Refer to the owner's manual or manufacturer's guidelines for recommended maintenance intervals for each machine.

The following issues should be especially considered when considering preventive maintenance of the equipment:

- Lubrication: The most important maintenance item on any piece of equipment is lubrication. Almost all machines have bearings or bushings that are lubricated with grease fittings, and each needs to be lubricated regularly. You can follow the manufacturer's recommendations for lubrication intervals, but a basic rule of thumb is to lubricate at least once a day. However, the more you lubricate, the less chance of bearing failure.
  The correct way to lubricate a fitting is to apply two or three pumps of grease from a grease gun to the fitting. This is sufficient to provide the proper amount of lubrication without damaging the bearing with excessive hydraulic pressure. It also limits the mess caused by old grease that will be blown out.
  The best time to apply grease is right after flushing. No excessive lubrication. Lubrication after flushing is important because it purges water entering the bearing. When cold water hits a hot mower, the metal expands and allows water to be sucked through the rubber seals and into the bearing. If the water is not purged, it will rust the bearing, causing premature bearing failure.
- Greases: The type of grease used is critical. For most applications, it is recommended to spend a little more on a better kind of high-temperature grease that does not dissipate as quickly as a less expensive multi-purpose grease. In addition, gearboxes for portable

equipment, such as string trimmers and edgers, generally need special greases.

- Washing: it is recommended to routinely wash equipment well after each use, especially equipment used for the application of corrosive materials such as fertilizers and pesticides. But other equipment should also be considered, both to remove soil and turf residues, as well as salts left on the turf after fertilization, for example. This practice will prevent oxidation of components, prolonging the life of the equipment.

- Oil and filter changes: Oil and filter changes are another essential maintenance item. Lack of lubrication can result in equipment repair needs that can be quite costly. Oil is generally changed within the first 10 hours of use and then every 50 to 100 hours. Oil filters can be changed at any other oil change. However, oil checks should be completed daily. Manufacturer's recommendations should be followed for the appropriate interval, but shorter intervals are always better than delayed intervals. Take advantage of rainy days or days off to change the oil. Remind operators to check and top off fluid levels daily. Checking fluid levels is not only important for equipment maintenance, but can also provide an indication of a fluid leak. Hot oils can damage turf, so finding a leak early can save time and money on repairs.

It is advisable to pay close attention to the fuel and air filters. In extremely dry or dusty conditions, an air filter gets dirty very quickly. The dirtier the filter, the less air enters the engine, which can cause hard starting and poor fuel economy. In addition, poor quality fuel or a microbial infection in diesel fuel can block a fuel filter, which can also stall an engine. Air filters should be checked weekly or daily in dry, dusty conditions. Test your diesel supply frequently and replace fuel filters according to the manufacturer's recommendations or when clogged.

- Belts: Belts can cause costly downtime. Consideration should be given to keeping additional belts in stock.

- Tire pressure: Pay attention to tire pressure. Keeping tire pressure at the correct levels will increase performance and efficiency, as well as minimize wear and the occurrence of a flat tire.

When it comes to lawn mowers, properly calibrated tires improve the quality of cut. Tire pressure is important to verify the levelness of the machine. A lower tire on one side directly affects the level of cut and quality.

Lawn mowers:

Lawn mowers have the greatest impact on the appearance of the lawn. They are also used regularly and this level of regularity requires precision. Sharp, balanced blades are also critical to the life of the machines. Sharp blades cause unnecessary stress on pulleys, shafts, belts, motors, gearboxes, and clutches. In addition, unbalanced blades can cause abnormal vibrations, resulting in damage to the shaft or gearbox, not to mention long-term damage to cutter deck components.

Helical cutting equipment:

Helical cutting devices require many adjustments, especially when the cutting height decreases. The two main adjustments are the height of cut and the contact with the counter-blade. The cutting height setting of a helical cylinder should not change much from the time it was initially set, but it is best to check it once a week. This is more important on equipment with multiple cutting units, as you will notice variations in the height of cut setting in the turf. The counter-blade contact will change with each use as the blade wears against the cylinder during operation. It should always be checked and adjusted after each use. Consult the operator or service manual for adjustment specifications and individual adjustment procedures.

Rotary equipment:

Rotary mowers are less labor intensive to maintain. The disadvantage is that a rotary mower cannot cut as low as a helical mower. Rotators do not require much adjustment, which means less time will be required for maintenance than with helical equipment. As long as the belts are tight (if belt-driven) and the blades are sharp, a rotary mower should be ready to work any day you need it.

Aerators:

Aerators are generally only used for a limited period of time. An aerator, depending on the number of fields, may be used for a week or two in early spring and also early fall, and that's it for the season. Even if it is only used for a short period of time, it will spend many hours of

heavy work when in service. Because of this, breakdowns can severely affect the aeration schedule.

The best thing you can do to make sure an aerator goes through its scheduled use is to check it before it stops because of a problem. It should not be assumed that because it worked fine the last time it went out, it will work fine this time. Verify that routine maintenance is up to date. Check with the last operator to see if there was a problem. Take it somewhere out of the field and test the aeration. Check for loose screws and fasteners. Then, when the aeration is finished, check with the operator to see if you have noticed a problem. Do not postpone any repairs; do it before the machine is ready for the next time.

Another thing to keep in mind about aeration is that pins break and break frequently. Order several pins and keep them in stock before starting work. Aeration follows a tight schedule, and equipment technicians should be prepared to stop, if necessary, to replace one or more pins.

Sprayers:
If a mower or aerator breaks, turf may be affected, but is unlikely to be damaged. If a sprayer breaks, the health of the lawn may be at risk.

- Clogging/pre-mixing: Clogging can stop a sprayer. Most equipment has some type of filter to prevent larger particles from leaving the tank and entering the precision parts of the spray system. If there are too many large particles trapped in the filter, the flow will be blocked. The best way to avoid this is to pre-mix the chemicals outside the spray tank. This is especially important when using powdered chemicals. Mix them with water in a 10-20 liter bucket and pour into the spray tank. Always follow the chemical manufacturer's mixing instructions. It is a good idea to do the same with chemicals in soluble bags. The bags do not always dissolve completely and the plastic may end up in your filter. After the spray technician has completed the application, spray three tanks full of clean water to flush the system.

- Nozzle cleaning: after use, nozzles and nozzle filters should be removed and washed. Never use abrasive materials to clean nozzles; to clean or unclog nozzles, keep a soft bristle toothbrush handy. Always try to have spare nozzles (as well as the other nozzles used on the bar) for possible quick changes during operation.

- Flow check: Any sprayer, electronic or manual, should be calibrated regularly to ensure that the actual application rate equals the intended application rate. This is accomplished by running a nozzle capture test. A nozzle capture test shows what the sprayer is actually applying to the turf. It will also indicate if a nozzle is not

meeting specifications. To perform a nozzle capture test, fill the spray tank approximately half full with water. Extend all booms and activate the sprayer at the desired application rate, as if applying chemicals. Place a measuring bottle under a nozzle for one minute. Compare the results with the specifications provided by the nozzle manufacturer. Repeat the procedure for all nozzles on each bar. A variation of more than 5% is considered unacceptable. Replace nozzles that do not meet their specifications. If all nozzles are out of specification, but are consistent with each other, there may be a problem with one of the sprayer components.

References

[Untitled image about nozzle standardization]. (2016). Retrieved from https://bit.ly/3gfUYey.