BASIC GUIDE TO INSTALLATION AND PREPARATION OF FOOTBALL FIELDS

MODULE 1

- CONMEBOL -
EVOLUCIÓN

Introduction

CONMEBOL expects to hold football events on excellent quality fields comparable, in terms of appearance and performance, to other facilities considered of international standard.

The objective of this document is to provide technical information for the improvement of stadium turf that will host matches of the main competitions of the continent, such as CONMEBOL Libertadores, CONMEBOL Sudamericana, RECOPA and Copa América.

This document was designed to be able to always opt for the best method that will confer the highest quality to the turf, both for remodeling and construction of new fields. In addition, it should serve as a guide for the preparation of all the fields that will be used in other CONMEBOL-sanctioned competitions. Also included in this manual is a breakdown of the annual maintenance and operation of the field during tournaments.

Main characteristics of the playing surface we need to obtain

- Adequate leveling, without holes or unevenness
- Good drainage
- Good coverage with grass of the most suitable species, grass suitable for sports practice.
- Firmness and stability to ensure good player performance
- Appropriate court markings for better visual appearance

The methods used in the construction of the field, in the selection of the turf and in the management after seeding will directly influence the final quality to be obtained. It is important to have a clear idea about the type of installation to be implemented and about the main climatic constraints of the region.

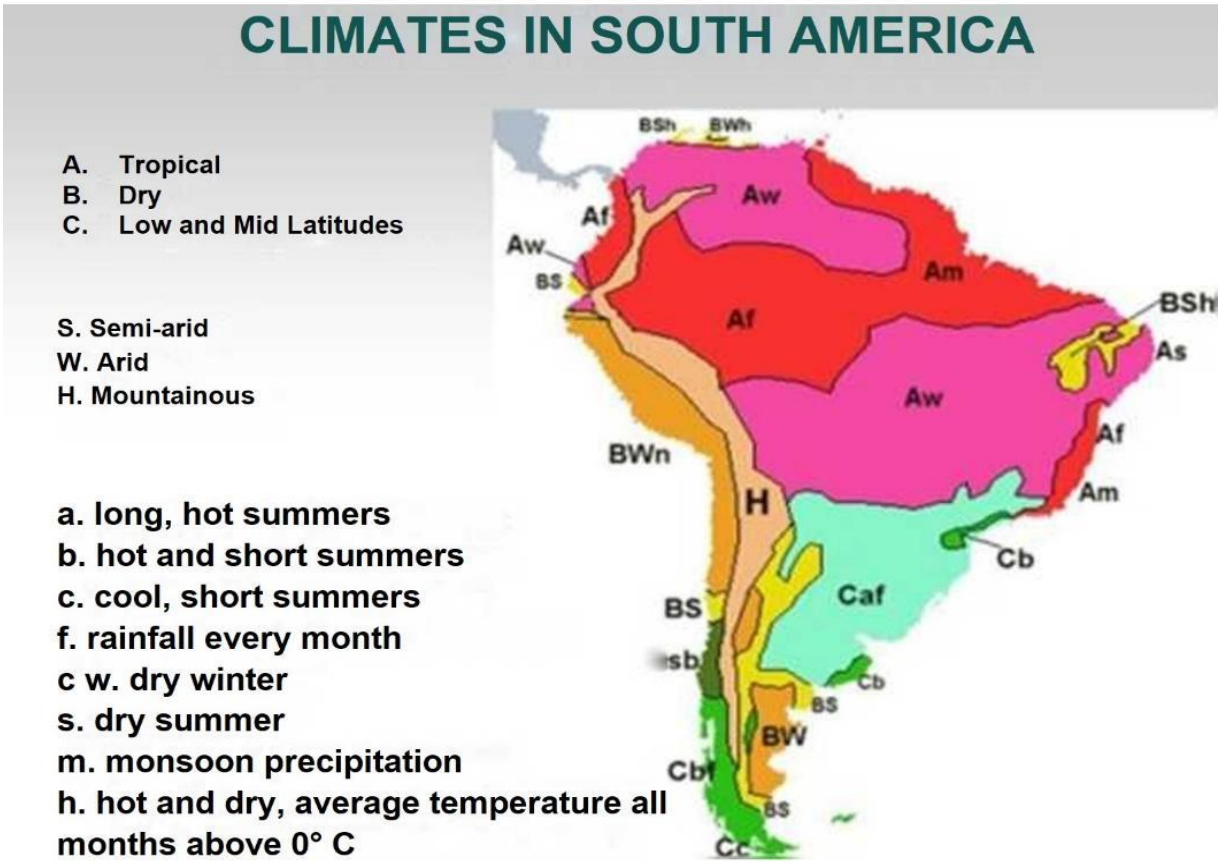
Unit 1

Climatic Regions of South America

South America encompasses enormous climatic variations throughout the continent. These differences will directly influence the choice of turf species to be implemented for sports practice.

They also indirectly influence all the characteristics and construction details of a pitch. A project to be installed in extremely rainy areas, for example, will need a well dimensioned drainage system as well as special attention in the choice of the substrate that will form the base of the turf. Fields to be built in arid regions, on the other hand, will need an oversized irrigation system, reservoirs, and water supply. The thermal amplitude in mountainous regions, where temperatures will be lower, must also be considered. Another very important factor is the microclimate and shading of covered stadiums, which will greatly influence the design of the stadium structures.

Figure 1. Map of climates of South America



Source: [untitled image about climates in south America], n. d., https://bit.ly/30cPPyD

With this diverse climate and conditions, we will have different grass species forming the playing fields, from tropical species, with accelerated growth due to the high temperatures, to permanently cold weather all year round. Due to these very heterogeneous characteristics, the great challenge is to develop and manage the playing surfaces in the whole South American continent in the most professional way, and to offer playing surfaces that are the most like each other, with all the desirable agronomic characteristics. This is what we will discuss in this paper.

Specialized consulting

It is very important to evaluate all the variables before the installation of a high-performance sports field, in the development phase of the project and in the definition of the maintenance that will be necessary in this field. Consider rainfall, altitude, temperature

throughout the year, the type of soil and drainage to be installed, and the coverage of the stadium (shade on the field).

The guidance of a sports turf consultant or expert and agronomist is essential to:

- determine the construction requirements,
- ensure that the construction work is carried out according to the appropriate standards using the indicated materials
- provide a quality court maintenance program.

For routine services throughout the year, the service of a sports turf agronomist is essential. He will prescribe chemical products, calculate fertilizer doses, identify fungal diseases, and control them quickly, regulate equipment and train personnel to perform these tasks. The engineer will also be the technician responsible for the field before the official control bodies.

Unit 2

Construction of the court

Installation standard

The quality of the court to be installed depends very much on the resources available, both for construction and maintenance. We can consider two different levels of playing surface:

(1) Intermediate standard courts. These are courts of good to intermediate quality, used primarily for smaller clubs, recreational matches, and training facilities.

(2) High standard courts. Courts where a very high standard of playing surface is required, mainly for professional and international competitions such as the tournaments mentioned in the introduction of this document. In such circumstances, it is important to eliminate the risks of further playing conditions or match cancellation, especially associated with weather conditions.

Intermediate standard fields are usually constructed using the existing soil on site. Priority should be given to drainage and surface leveling, as well as maintenance equipment, fertilizers, agricultural defensives, etc., in addition to ensuring that there are sufficient and knowledgeable court personnel to perform proper management.

High standard courts will normally have a construction profile consisting of layers of sand and gravel, with very effective drainage.

To facilitate reading comprehension, review the glossary and return to it whenever necessary.

Construction planning

A well-constructed court will have the ability to withstand much higher usage loads, allowing more matches to be played without significant damage to the playing surface.

Items to be considered in the construction:

- Define the base of the court - whether it will be made with natural soil or with substrate to be brought to the installation site.

- To know the topography of the terrain, to define the level quotas to be adopted, and to define the appropriate drainage discharge for the municipality's pluvial network. To know if there is a need to build ditches, to have access to the public drainage system and, thus, to define the final project of the court (for the planning of new facilities, authorizations and licenses from the competent bodies may be necessary).
- Identify the presence of existing infrastructure facilities on the site. This will include electricity supply, irrigation water supply, identification of existing old drainage pipes.
- The design of the court in relation to the stadium project and the correct alignment of the court is necessary to reduce the problems of low sunlight incidence and to avoid sun incidence that can affect the game, mainly at dusk.
- The potential budget available for the construction of the court must be considered to define the final project.
- Timelines for construction or drainage work, determination of turf establishment period and probable time before availability for use.
- Resources in terms of personnel and equipment available to maintain the facility.
- Predominant climate of the region where the court will be built.
- Many stadium fields used for professional football practice need to be developed within the context of an existing facility, and this must be considered in project development.
- In larger and taller stadiums, there may be more shading and less ventilation, both of which will have a significant impact on turf quality. Assessment of the environmental effects of the stadium structure is necessary during the design stage and this should normally include analysis of shading standards at different times of the year, in addition to assessment of the potential for air displacement.
- In regions where frost may occur, the effects of shade within a stadium mean that shade will dissipate more slowly, and this site will be more susceptible to turf damage.
- Most stadium events occur at pre-scheduled times for televised events. The risk of cancellation due to adverse weather must be taken into consideration. The budget for stadium construction and subsequent maintenance should be determined in relation to these risks.
- Laser leveling is the only guaranteed method to ensure perfect levels.

The topography of the site, the intended use of the court, the climate, the resources, the drainage and irrigation system are part of the basic aspects to be taken into account for both a new facility and a remodeling.

Construction Methods

In many stadiums, when redevelopment is planned, the existing topsoil levels may not be adequate to provide a good quality football field.

Minimal adjustments of up to +/- 50 mm can be obtained by harrowing and cultivating the soil and leveling using a laser leveler. Major alterations in levels may need to be resolved by removal of the arable soil and leveling of the base with cutting and burial, prior to the return of soil suitable for court installation.

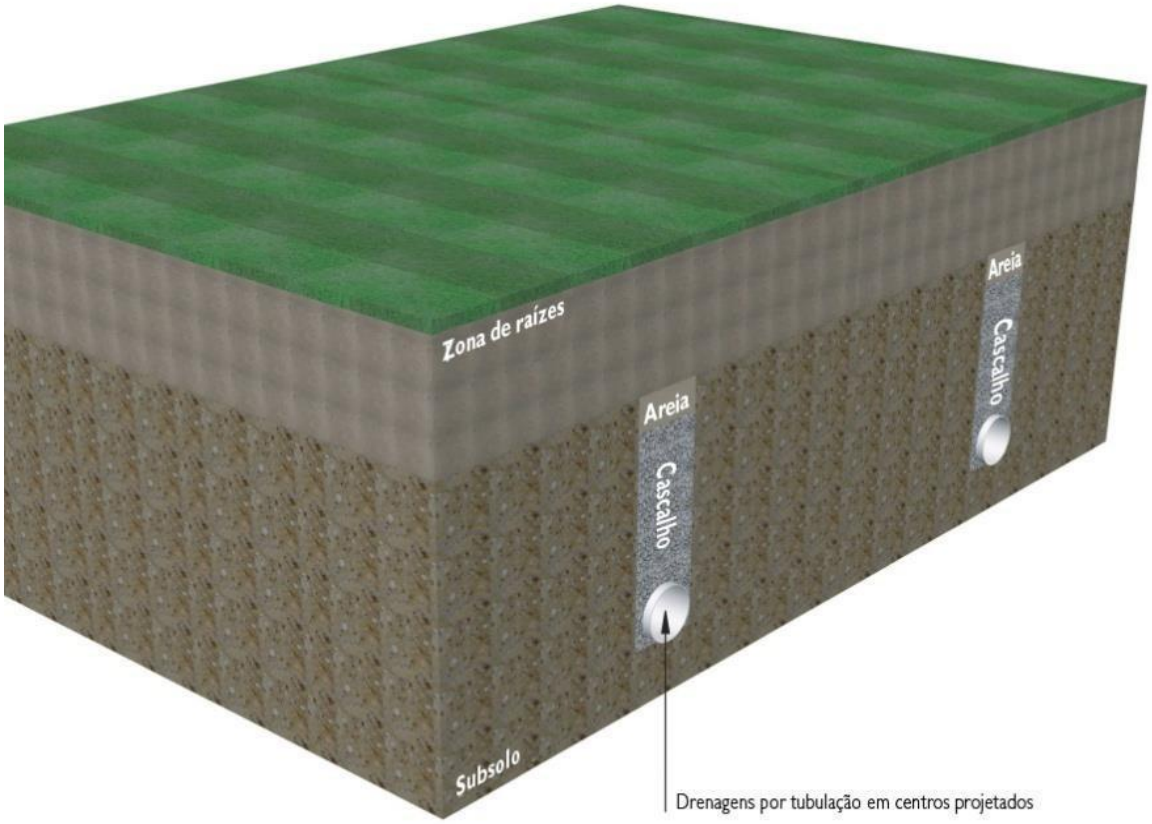
It is essential that the base be adequately consolidated to ensure that subsidence and irregularities in the soil profile will not occur in the future.

The selected construction method must take into consideration the local climate and soils, as well as the expected levels of use and especially the quality of the desired court. Logically, this definition will have an impact on the final cost of the project.

- Court with piped drainage system and natural soil:
  In this system, drainage trenches are usually dug to a depth of approximately 600 mm, which may vary according to the circumstances of the site. A pipe is placed at the base of the trench, covered with gravel or other suitable aggregate and then with sand and a mixture of organic matter suitable for the lawn.

  This system is still widely used in older courts, when the choice is made to remodel using the existing installation.

Figure 2: Profile of a field with drainage pipe in natural soil



Source: FIFA, 2013, https://bit.ly/2XaqgMy

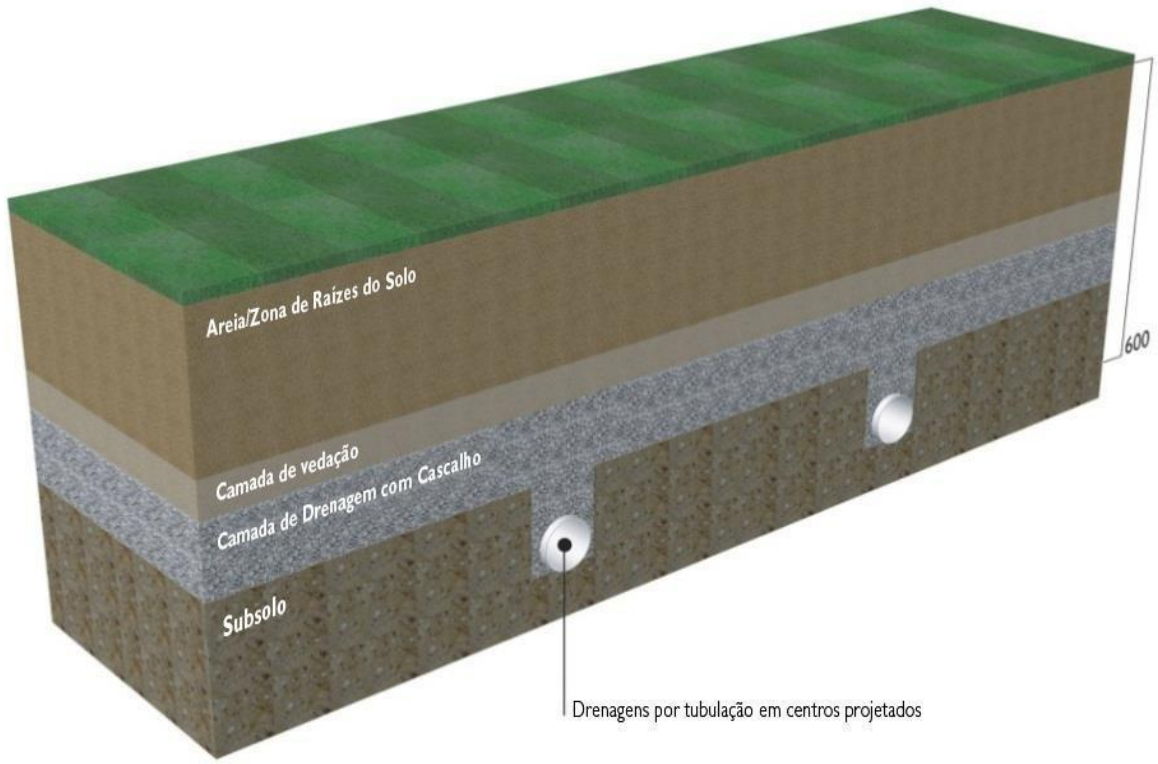
Zona de Raices: Root Zone Areia: Sand Cascalho: Gravel Subsolo: Subsoil Drenagens por tubulacao em centros projetados: Piping drains on designed centers

- Court with sandy layer on a draining gravel mattress:

  This construction model is usually used when good drainage is essential, although it can also be useful in dry climates because water tends to be retained in the root

zone layer and not run off through the gravel unless there is heavy rainfall or excessive irrigation. The correct choice of materials used in the layers is critical to the success of this type of construction.

Figure 3: Profile of a court with a sandy layer on a draining gravel mattress



FIFA, 2013, https://bit.ly/2XaqgMy

Areia/zona de raices do solo: - Sand/soil root zone Camada de vedacao: Sealing layer Camada de drenagem com calcalho: Drainage Layer with Gravel Subsolo: Subsoil Drenagens por tubulacao em centros projectados: Piping drains on designed centers

Irrigation installation and management

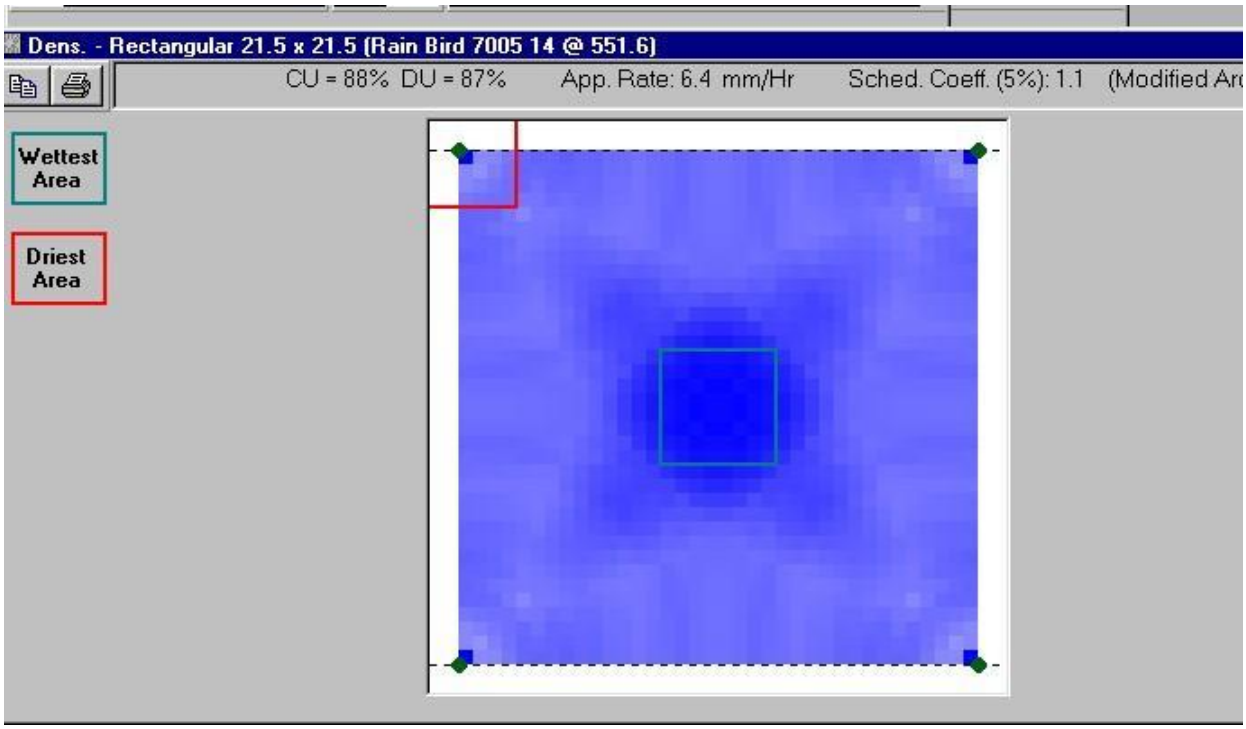
A fully automatic irrigation system will ensure the correct volume of water at the desired location and achieve the overall objectives of turf growth and vigor.

It is also essential to have irrigation available when preparing the playing surface for performance during matches. The system should be designed and specified by a specialized irrigation engineer to ensure even water coverage, avoiding any possibility of localized dry spots.

The engineer will take into consideration the field design and drainage characteristics as well as the local climate and geography, rainfall rates, prevailing winds, water storage and replenishment capacity, as well as the sizing of pumping, piping requirements and the selection of appropriate sprinklers to provide the necessary volume of water within the time frame available.

The study of sprinkler spacing is the starting point and the most important in the realization of the project. A schedule coefficient of 1.2 SC (*Schedule coefficient*) is required. This is the recommended parameter for irrigating football fields. To carry out this study, sprinkler databases and simulation programs are required. This program provides the "x-ray" of sprinkler water application. Incorrect spacing generates waste of water, electricity and can cause turf problems such as diseases and pests.

Figure 4: Example of an overlay study using the program *Space*



Source: own elaboration based on software Space screenshot.

It is highly recommended to install the *valve-in-head* system on new fields, which allows for variation and flexibility in irrigation usage throughout the year. Especially in stadiums subject to shading in one part of the field due to roofs, this system is essential. If this is not possible, it is necessary to at least provide irrigation lines that allow watering only the playing area, without watering the entire TV structure that is set up around the field for these events. In this way, it is possible to comply with the irrigation protocols planned for the day of the game. Design errors or savings will be very difficult to correct later, as it would require reworking all the piping, if placed in an inadequate space to allow for the correct coverage.

Correct sizing of the irrigation system is critical. The distance between lines and sprinklers should provide an ideal overlap. The jet from one sprinkler should touch the base of the neighboring sprinkler.

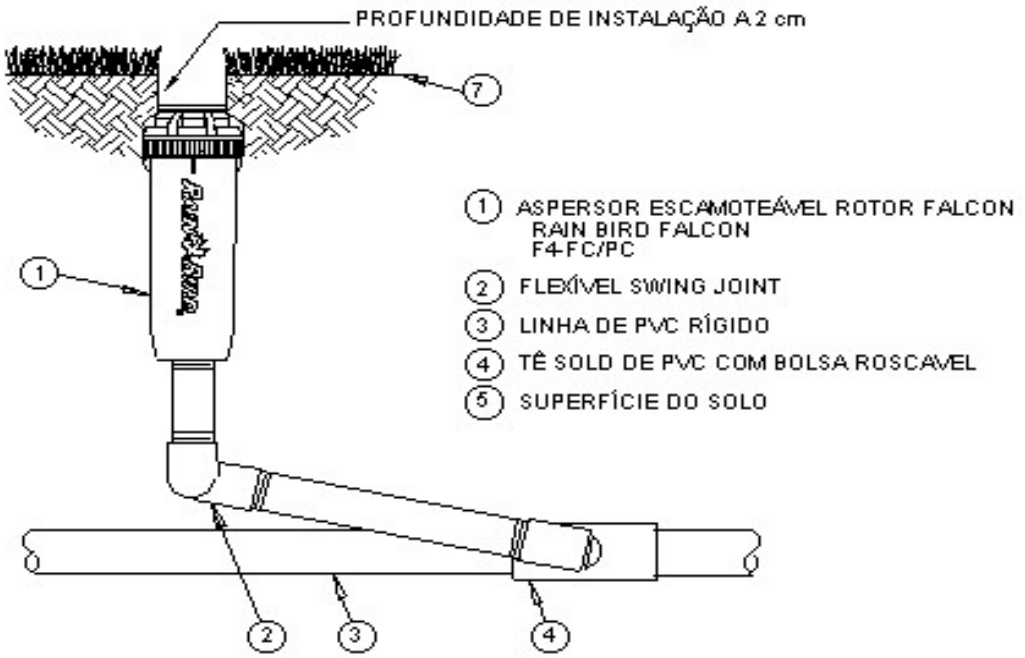
Installation

Pipes should be installed at least 35 cm deep. This is of utmost importance as shallow installation leads to constant damage to the system in the face of surface management, such as mechanical aeration that perforates the entire field at an average depth of 30 cm. Sprinklers should be installed at an average depth of 1.5 - 2.0 cm in relation to the soil surface. Installation in this manner is intended not only to protect the system but also the player. If installed too high, there may be a risk of damage from routine operations such as cutting. However, they should not be too deep, so that the water outlet nozzles do not malfunction.

In new fields made with sandy substrate it is normal for sprinklers to move during the first year after installation. This happens because the soil is loose and soft and must be fixed immediately as they lose their working angle and can cause dry spots in the field. It is necessary to always keep the sprinklers at 90 degrees to the ground.

Long-range sprinklers must be connected to the hydraulic network through a flexible system. This system is called "*swing-joint*", which is a joint sized for this purpose. Unfortunately, we see in our market the use of homemade solutions that only cause wear and tear to the customer and the questioning of the efficiency of the system due to the famous "economy of the nut".

Figure 5: Details of the correct installation of a rotor sprinkler with *swing joint*



Source: [untitled image about correct installation of a rotor sprinkler with swing joint], n. d., https://bit.ly/2Xaj2s0

Profundidade de intalacao a 2 cm: Installation depth at 2 cm Aspersor escamateavel rotor falcon rain bird falcon F4 – FC/PC: falcon rain bird falcon F4 rotor scaleable sprinkler - FC/PC Flexíbel swing joint = Flexible swivel joint Linha de PVC Rígido = - Rigid PVC Line Te sold de PVC com bolsa roscavel = - PVC solder tee with threadable bag Superficie do solo = - Soil surface

Irrigation water quality

Depending on the source of the water, especially when it comes to natural watercourses, water reuse or artesian wells, it is very important to test the water quality before defining its use.

Irrigation water quality is becoming an important issue for sports field managers. Since water quality can influence soil quality and turf performance, it is recommended that

irrigation water be tested periodically for factors that may compromise the turf/soil system. Almost all water contains dissolved salts and trace elements. In addition, drainage water from irrigated lands and industrial and urban effluents can affect water quality. In most irrigation situations, the main concern with water quality is salinity levels, as salts can affect soil structure and crop yields. However, several elements are found in water, which can limit its use in irrigation.

The most important parameters for turfgrass management are total soluble salt concentration (salinity); sodium (Na) content; relative ratio of sodium to calcium (Ca) and magnesium (Mg) (sodium adsorption ratio or SAR); chloride (Cl), boron (B), bicarbonate (HCO3) and carbonate (CO3) content; and pH. Other parameters generally found in a water test report that should be checked are nutrient content (nitrogen, phosphorus, and potassium, among others) and chloride content. Irrigation water contains plant nutrients in varying concentrations. Depending on the concentrations, nutrients can influence fertility programs and have an environmental impact on groundwater and surface water. Nitrogen has a significant influence on plant growth and can pose a risk to drinking water sources if nitrate levels are 10 mg/l or higher, although turfgrass will tolerate much higher levels. Phosphorus concentrations should be as low as possible (less than 1.0 mg/l) to avoid algal blooms in holding tanks and phosphorus loading to surface streams and lakes.

Table 1: Maximum tolerated levels of some elements in irrigation water

	Unit	Maximum concentration in irrigation water
Salinity	ds/m	3,0
	mg/l	2000
Sodium	mg/l	70
Chloride	mg/l	355
Bicarbonate	mg/l	500

Adapted from D. W. Westcot and R. S. Ayers. 1984. Irrigation water quality criteria. In G. S. Pettygrove and T. Asano (eds.) Irrigation with reclaimed municipal wastewater: guidance manual.

Report No. 841-1wr. California State Water. Resources Control Board, Sacramento, CA; and from D. S. Farnham et al. 1985. Water quality: its effects on ornamentals.

Plants University of California Division of Agriculture and Natural Resources Publication 2995(a).

Table2: Maximum tolerated levels of some elements in irrigation water

	MACRONUTRIENTS	
	Unit	Maximum concentration in irrigation water
Nitrogen	ml/l	22,6
Nitrate (MO3-)	mg/l	100
Ammonia (NH4+)	mg/l	100
Phosphorus (P)	mg/l	0,8
Potassium (K)	mg/l	30
Calcium (Ca)	mg/l	30
Magnesium (Mg)	mg/l	35
Sulfur (S)		60
	MICRONUTRIENTS	
Iron (Fe)	ml/l	5
Manganese (MN)	mg/l	0,2
Copper (Cu)	mg/l	0,2
Molybdenum (Mo)	mg/l	0,1
Zinc (Zn)	mg/l	2,0
Boron (Bo)	mg/l	2,0

Based on suggestions from Duncan, R. R. R., R. N. Carrow, and M. Huck.2000. Understanding water quality and guidelines for management. USGA Green Section Record. September -October, pp. 14-
24.

However, tolerance to the elements may vary depending on soil conditions, installed drainage, level of management and local climate.

Even with acceptable sodium limits for plants of 70 mg/l, no sodium damage is considered to occur with good management in light soils with good infiltration and drainage and no impermeable layers. Although at maximum tolerated levels, elements such as iron are not considered toxic to plants in aerated soils but can acidify the soil with loss of phosphorus. In addition, although the maximum suggested concentration for iron is 5 mg/l in irrigation water, levels above 1.5 mg/l can cause damage by clogging the irrigation system. In case of high salt concentration, for example, the water source should be alternated. In this case, it is important to have alternative water sources, to alternate irrigation supply (flushing/flushing), such as municipal water supply, or to invest in an efficient filtration system. Regions with a regular rainfall regime and aerated soils are unlikely to have a problem with the concentration of salts or other elements. In periods of prolonged drought, there may be an increase in the concentration in the soil, if there are no alternative sources of water to exchange for irrigation (and leaching of excess elements).

Irrigation system maintenance

Irrigation components have a finite life span. A good preventive maintenance program can extend the life of your irrigation equipment and keep it operating efficiently. Specific preventive maintenance procedures and intervals vary depending on the type of irrigation equipment and water quality. In general, a preventive maintenance program for irrigation systems involves observation, adjustment, and maintenance at regular intervals of sprinklers, valves, controllers, and other components. The following activities generally form the basis of a preventive maintenance program:

- Daily maintenance involves checking wet and dry areas, monitoring the pumping system, and checking the central controller to make sure it is programmed correctly. Cleaning of filters and other components.
- Weekly maintenance generally includes observing the operation of the sprinklers to ensure that they are rotating properly and that there are no leaks or clogged nozzles.
- Less frequent but important work includes maintenance of the pumping system every six months and raising and leveling the sprinklers.
- An annual cleaning of the water tank helps prevent future problems.

It is also interesting to create an inventory of all spare parts, keeping them available in sufficient quantities, especially when suppliers are distant. Also try to keep employees

properly trained to maintain irrigation systems. The important thing is that maintenance tasks are assigned to someone responsible for completing them. In addition, all employees should be trained to look for and report problems such as dry areas or broken equipment.

Water storage and replacement

As a safety measure, a reservoir capacity of 180 m3 is recommended, which makes three days of full irrigation, using a water depth of 8 mm/day over the entire surface of the field. In addition, it is important to calculate the water replacement capacity so that there is a constant supply of replenishment to maintain the reservoirs. The lower the replacement capacity and rate, the larger the reservoir should be.

The goal here is to reduce the risk that a big game is scheduled in two days, for example, and the stadium's supply system is interrupted.

Stadium irrigation projects

In the *power point* presentation, you will find examples of the designs used to install irrigation systems. It is important that it is properly planned for the correct functioning of the court. In addition to turf maintenance, it is necessary to lower the temperature and should be as efficient as possible.

Dry areas can generate problems of ball rolling and stability on the ground. The player can have accidents and knee damage in a lap.

To make the design of the irrigation project efficient, special attention must be paid to its correct installation, to plan the periodic analysis of water quality and to carry out preventive maintenance of the system.

Floor leveling

The most superficial layer of the field, ideally formed by good quality sand, but finally formed by the local soil, must receive a final leveling finish, generally in the form of two or four waters (envelope format), or even with a zero adjustment. This leveling must respect the overall design of the field and is generally associated with all drainage planning.

Grading is the process of flattening the surface, cutting, filling, and smoothing the ground. In sports field construction, laser grading works by moving the ground from higher points to lower locations using equipment that has an automated blade control system guided by a laser. This work will be carried out continuously until the field exactly meets the desired slope tolerances. On sloping fields, this leveling is necessary to give a shallow lateral drop to the water. In general, on sports fields, minimal slopes are designed so as not to affect play or leave standing water on the field. This slope contributes to surface drainage.

Laser leveling is highly recommended for using machine-controlled equipment to establish tighter tolerances for slope or final finish grade. The use of laser levelers, especially smaller equipment, allows for greater accuracy in this finish. Operator skill and training will also directly influence the quality of the result. It is important to always keep in mind that topsoil tends to settle over time, forming deformations, which impairs leveling the field surface. Settlement will exist in any soil but tends to occur differently depending on the type of material. There are cohesive materials, with finer granulometry, such as clay and silt, and soil cohesion increases with the increase in the content of these components. And there are granular materials, with larger particles, such as sand and gravel. Cohesive soil has water retention, while granular soil has more free drainage, which is a desirable feature on a sports field. It is essential during the leveling process to gradually compact the soil (using roller compactors) in layers. Compaction acts by filling the spaces (voids) in a layer, through densification of the soil, increasing its support. When building a field from the base, it is essential to do this compaction from the lower layers. If the compaction is not performed well, all the layers built above can be compromised with future falls and deformations of the soil.

The compaction operation is as important as the leveling itself. Common mistakes in this process are under- or over-compaction and improper speed. Insufficient roller passes will result in insufficient settlement because, if there are too many passes, the soil may begin to disintegrate. As for the speed, if it is high, impacts are not continuously applied to the soil, with gaps not receiving adequate compaction. The ideal compaction speed is approximately 4 km/h.

To allow compaction, the soil must be close to its optimum moisture content. That is, neither too dry nor too wet. If it is too dry, the friction between the internal particles acts as forces against soil thickening. For this, a small amount of moisture is necessary to "lubricate" these internal frictions and promote compaction. But if the soil is excessively

wet, the presence of excess water in the voids between the particles also acts as a force against compaction.

Therefore, a very important resource during compaction is the use of irrigation. Often, automated irrigation will be installed only for the final stages of leveling the surface finish. Therefore, providing other forms of water supply will be indispensable to assist in the accommodation of the subsurface layers, such as cannon irrigation and external piping. The occurrence of rainfall during the process is highly efficient, as long as the ideal humidity is expected to restart the work. In the case of sand, even heavy rains do not get in the way of the work.

Leveling should also be done from the initial layers. When constructing a field with a mattress drainage system, for example, the gravel and sand layers should follow the same shape and surface cut (zero cut, one or two waters).

Leveling should also be done from the initial layers and should follow the same shape and cut of the surface. The compaction operation is as important as the leveling since it will avoid deformations or subsidence

Lawn

Choice of turf

The grass species chosen for a court must be adapted to the region in which the court is built, to form a resistant turf and be able to offer the necessary performance in a match, in addition to the aesthetic presentation.

There are two main groups of grasses that vary considerably in terms of biological characteristics and climatic adaptation, which should be adopted.
And a possibility to combine them.

Table 3

Warm season grasses (*warm season grasses*)	*Cool season grasses* (*cool season grasses*)	*Overseeding* warm weather turf (*overseeding*)
Tropical Regions	Cold regions	Regions with climatic variation

Bermuda (*Cynodon sp.*)	Perennial ryegrass (*Lolium perenne*)	Bermuda Base autumn over sowing of ryegrass
Established by stolon, with attestation of genetic stability or grass rolls, preferably washed.	Introduced with seeds of proven quality and always using varieties developed for sports use.	It will confer an aesthetic value as well as greatly increase resistance to trampling and cold during the winter months. This management should be adopted in certain fields. The strategy is to minimize the risk of an unsatisfactory field by multistage seeding of ryegrass on a consistent bermudagrass base.

Source: own elaboration.

- *Warm season grasses* are adapted for tropical areas and among the species and cultivars are Bermuda grasses (*Cynodon sp.* varieties), established by means of stolon, with crowded genetic stability or turf rolls, preferably washed (without soil).

- *Cool season grasses* are adapted, as the name suggests, for colder climatic regions and, among the examples regularly used on football fields, are perennial ryegrass (*Lolium perenne*), introduced with proven quality seeds and always using varieties developed for *turf type* use.

- In some parts of South America, where there is a relatively large temperature variation between summer and winter, overseeding of winter seed is used. This seeding is done in the fall, over the base turf, usually bermudagrass. This management will confer a great aesthetic value to the field, in addition to greatly increasing the resistance to trampling and cold during the winter months. This management should be adopted in certain fields. The strategy is to minimize the risk of an unsatisfactory field by multistage seeding of ryegrass on a consistent bermudagrass base. The base sod (usually bermudagrass) will need to be refined with cultivation practices prior to seeding.

The altitude should also be considered, since in South America there are regions of high altitude, which are very close to Ecuador. In these places there are important cities that have large games, such as Quito (Ecuador) and La Paz (Bolivia), among others. In these places, often the first species chosen may be a bermudagrass hybrid, which over the years shows little adaptation and ends up losing space to other varieties not developed for sports practice. This happens either because of the great thermal amplitude during the whole day, with cold nights, or because of the little sunlight due to the altitude; and the infestation of other species occurs, especially Kikuio (*Pennisetum clandestinum*). The great challenge for professionals who manage this type of turf, is to obtain a good quality standard, often using broad-leaved species, with other growth habits, and which tend to develop an excess thatch mattress that is inappropriate for football practice. There are some new bermudagrass cultivars, such as *Latitude* 36, which are noticeably more adapted to cold weather and are already being used in high altitude regions, such as Mexico. These more adapted varieties show good growth at lower temperatures, while the others remain "still". This is evident from early spring greening, while the other varieties remain colorless.

Each type of grass has particular characteristics that make it more appropriate for certain climatic areas, for example, heat or cold tolerance, drought, or disease resistance.

Sod installation methods

After defining the ideal variety to be installed, it is necessary to choose the best installation method, which will consider the term and the financial resources available.

- Sod installation methods
- Stolon
- Sod loaves
- Seeds
- Rolls with floor
- Rolls without floor
- INSTANT PLAY rolls
- Hybrid system

- By stolon: This method will allow the highest purity of the field, avoiding any contamination with soil coming from the grass production fields. There are already equipment that make the sowing of grass stolon in a few hours. The soil needs to

be perfectly leveled and unpacked. It is the most economical method of turf installation per planted area. It allows the use of materials of high varietal purity, certified, that even imported from other countries will have a reduced cost. It adds as advantages the fact that the turf can be more easily and economically transported, even over long distances, where there are alternatives of refrigerated ground transportation. In addition, it does not bring soil contaminants. If used in an adequate amount, and with a favorable climate and if properly managed after planting, it can close in up to 60 days and allow for playing conditions between 90 and 120 days, or even less. The stolon planting method only exists for warm climate species, which are generally improved hybrid varieties and do not produce fertile seed.

It is very important to buy live material from certified producers, who will guarantee the purity of the material, without mixtures with other varieties or weeds. When stolon is obtained with mixtures of varieties, the result is very stained fields, with compromised aesthetic quality. These stains are not reduced with the use of fertilizers.

Among the Bermuda grasses developed for sport (*Tifway* 419, *Celebration*, *Tifgrand*, etc.), which are the main representatives of this group in South America, there is a great variation in color and density among them, hence the great care in avoiding mixtures of varieties. Despite all the advantages listed above, stolon require intensive management after planting, which starts with the demand for continuous use of pre-emergent herbicides until complete closure and, eventually, post-emergent herbicides, in addition to very frequent fertilization and irrigation. In the first two weeks after planting, the amount of irrigation required is very large, and a frequency of several times a day is needed, so as not to lose material.
This cost must be considered when implementing this system

- By sod loaves: It is a system that allows the immediate closing of the soil surface but requires a lot of time and labor for its installation. In addition, it needs approximately 45 days for complete rooting and consent to securely set. There are various sizes of sod loaves that can be supplied, depending on the harvesting equipment available in the field. In general, 61 X 41 cm slabs are produced. This system is most recommended for minor turf renovations and replanting of worn areas throughout the season. For replanting an official football field, the use of small loaves is not recommended for the sake of having many amendments, which hinders the final leveling of the field.

- By seeds: For winter grass variety, which will have the implantation by seeds. It is necessary to choose the right time of the year to make this implantation. It is also necessary to have 120 days for intensive use of the field.

  There are different seeds available for sale in South America, generally from growers in the United States. These seeds offered are generally a "mix" of several cultivars, and one should pay close attention before choosing, to have one that is adapted to the climate of the location to be installed. Many regions of South America will have mild winters, with weeks of high temperatures, and this can be a challenge for the use of winter seeds that do not support these climatic variations.

- By rolls with soil: Rolls of turf with a width of 0.70 to 1.20 meters by 10 to 30 meters long, installed with appropriate equipment that does not interfere with the leveling of the field. It is a more expensive method; however, it allows the realization of a match after two weeks from its installation, because of its dimension, which is well fixed on the ground. It is very important to know well the turf producer who will supply the material and to make a previous inspection of the field to make sure that the material to be delivered corresponds to the desired quality standard.

- Soilless (washed) rolls: This is a system that allows you to quickly plant a field, with 0.7 m wide by 10 to 30 m long rolls, which are completely washed under pressure, just after harvest to eliminate the soil. It is a unique product, produced by specialized turf fields, and must be ordered in advance, as the turf must be very mature and rooted to be supplied in this way.

  It is possible to plant a field quickly, obtaining immediate coverage, without compromising the original drainage of the field with the soil of the turf production farm. It requires cultural treatments after planting, such as continuous sand covers, but allows games to be played approximately 30 days after installation. However, for success, it should be planted in a favorable climate, with high temperatures, where there is rapid rooting of the turf, and should be avoided in the near-winter months, when the goal is to establish quickly.

- By INSTANT-PLAY rolls: This is the same system of large rolls, but with turf produced on the farm in a condition very similar to that which will be used on the sports field. In other words, the turf is already "ready to play" from the farm. With the same

mowing height, maintained without excess matting and with similar levels of fertilization, but harvested at a greater thickness. In this way, there is a safety and appearance suitable for playing games right after planting. A large investment is made in leveling this crop, which should be perfect at harvest date.

In Brazil, this process was carried out for the first time in the 2016 Olympic Games, when in the inaugural Maracana stadium, the entire field was changed in 3 days, and the game occurred 72 hours later. After that, a record of total planting of the field in 23 hours was already achieved, which made it possible to play the next day. With this method, it is possible to hold large events, such as concerts in sequence, using the turf for many days. Despite the need to completely change the field, we were able to maintain the schedule with games a few days later. As very thick rolls are used, it is necessary that this material has a percentage of organic compounds and clay, which can compromise the drainage of the surface.

It is also necessary to evaluate the cost, which allows dilution between several events that are carried out in sequence.

The transport of this material from the field to the stadium must be very fast, so that no discoloration or fermentation occurs, as this method allows immediate use of the field.

- By hybrid system: It consists of the installation of rolls of synthetic turf suitable for this system, directly on the sandy base of the field. These rolls are joined together, perfectly leveled. Then, a cover is made with organic material mixed with sandy substrate, and grass seed is sown on the surface. The grass will germinate, and the roots will intertwine in this profile of carpet and synthetic fibers. This system is advantageous to promote better traction and stability.

After installing a field, regardless of the method used, there is an essential period before the field is ready for use. This is the post-planting phase - SET-UP/GROWN-IN.

establishment (*grown-in)* stage is the period necessary for the turf to complete its development, which may involve simple finishing operations or other more complex demands such as rooting, surface coverage and, especially, "maturation" with the

formation of resistance structures such as rhizomes and stolon that will provide greater durability and the ability to recover from trampling.

This period will vary in time and management demand, according to the planting method adopted, and may last a few days (or even hours) in the case of plantings of coarse grass rolls in the ready-to-play system (which would involve only the finished management, such as rolling the cover for leveling and light sand liners), spend a few weeks when planting with normal large rolls, up to several weeks when planting with slabs and even a few months when planting with seedlings (twigs).

The time required to complete the growth stage, in any chosen planting method, will depend on factors such as the climate of the region at the time chosen and the level of management and resources available for its execution, but in general can be understood in a comparative in the table below.

Table 4

Planting methods	Weeks																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Large rolls																								
Washed rolls																								
Bread																								
*Stolon (sprigs)																								

Source: own elaboration.

In this table, we do not consider the *INSTANT PLAY* system as it allows almost immediate playing conditions. The cells marked in gray show the time in which the growing period can be extended, under intermediate conditions of climate and management (which can be even longer when these conditions are not satisfactory, or even less when under optimal conditions).

- Establishment (*Grown-in)* in the stolon system: In the stolon system the estimated time in the table is the time of grass closure. Although in this period it could be played with safety and quality, we must consider that more time is needed for the field to show a proper "maturation", with a better development and densification of resistance structures such as rhizomes or stolon, to present more strength and endurance. A lawn just after "closed" has the risk of damaging its few newly formed structures more easily.

  On the fields for the 2014 World Cup, for example, several fields were seeded with stolon of Bermuda grass hybrids a year before they were put into play, so that the root system was fully formed. As you can see, the growing season is especially important in the stolon seeding system. In this system, three phases are essential: the "setting", "seeding" and "maturing" of the turf prior to use.

  o Fixation: the "fixation" period consists of the initial two weeks, in which the seedlings need to start rooting. At this stage, the most important operation is the watering of the lawn. As we now have the soil surface exposed, there is no protection and water losses are higher. It is necessary to foresee several watering cycles per day (depending on the composition of the soil and its water retention capacity). The important thing is to maintain surface soil moisture (up to 5 cm deep). Even the time of planting needs to be analyzed, because the soil can reach high temperatures in the summer, during the day. Therefore, it is often necessary to cool the soil with light watering and / or planting at night. The first 24 hours after planting are crucial to the success of this method. Seedlings cannot dry out due to lack of water. On sandy soils more watering per day will be required, usually of shorter duration, as any excess water will drain quickly. Soils with a higher clay content may be irrigated less frequently. Success in this period will be all the more effective the better the planting (with correct burial of seedlings, neither too deep nor too shallow) and the correct water management.

  - Closure: The "closure" period of the lawn will be followed by rooting. The turf will also need to form rhizomes and stolon, which will result in the formation of new seedlings, until they cover the soil surface. Here, various managements are important, but the most successful determinants are maintaining the frequency of watering and fertilizing. The more intensive these operations are, the faster the lawn will close. According to the budget and the schedule established for the beginning of the sports use of the turf, fertilizers, for example, can be applied

regularly, with a frequency that can range from twice a week (usually at lower doses) to biweekly. Prefer NPK fertilizers with complete formulas, with ratios such as 1: 1: 1: 1 or 2: 1: 2, or 3: 1: 2, or 4: 1: 2. The use of rooting products can help during this period. As the soil surface remains exposed, it is important to avoid weed seed germination, to avoid competition with the lawn. Ideally, after planting, apply a preemergent herbicide with a less aggressive active ingredient to the seedlings. Since these products are generally active for 60 days, it should be provided for reapplication until turf closure. The correct timing of application of these products is crucial to the success of the final product, which is a clean lawn free of invasive plants. It is in this period that mowing operations begin, which may start with rotary mowing, but should evolve to helical mowing with turf closure. In addition, mainly due to the intensity of fertilization, it will be necessary to maintain the frequency of vertical mowing so that the grass grows with a buffer under control. Sand applications should also be practiced with a view to the final leveling of the surface.

- Maturation: is the period that elapses after the total closure of the surface, until it creates its own stability to better resist and recover from trampling damage. The time required for this period is difficult to estimate, but the longer the better the results. At this point, it is important to keep the turf under a program with twice weekly helical mowing, fertilization every 21 days and vertical mowing at least every 15 days. Do not confuse turf closure (total ground cover) with release for field use. The turf may be closed and vigorous, but the root system is not yet ready. Pull tests can help define the correct time to release a field made with stolon for use.

- Establishment (*Grown-in*) in the system of planting by rolls of grass: here we can say that the phases are "settlement" and "maturation".

  - Settling: in the first fifteen days watering is essential, as the grass is not yet rooted. However, with the soil surface covered, the demand will be less than when planting stolon.

  - Maturation: at this stage, the grass should complete its rooting, to give firmness and stability to the game. But since the grass has already formed, this time it will be much shorter than when sown with seedlings. Also compared to slabs,

depending on their size, the rollers will stabilize faster. After the turf has been established, and as soon as the turf is stabilized (firm) on the ground, mowing management can begin, which will take place first on the lawn planted by large rollers. The first mowing should be done with a rotary machine, to reduce the cutting height of the lawn well, helping to level the surface, which should conclude with the application of a sand cover. While turf planted in large rolls will already have faster stability, smaller loaves will require more time to be safely put into play, as well as generally requiring more operations and time for satisfactory leveling and appearance.

- Establishment (*Grown-in)* in the system of plantation by rolls of washed turf.
  o Settling: in this method, the lawn is more sensitive to lack of water because it has no soil to retain moisture. Thus, the frequency of watering required is generally higher than in turf with soil methods.

  - After "fixing", here there will be a greater demand for handling, in relation to the method of rollers with soil, both in the continuity for more frequent watering and in the need for sand and fertilizer coating operations to achieve stability and quality of the final finish. In plate or roller methods, with or without soil, the labor demand and time for final finishing will also be related to the quality of turf delivery from the field. When a turf is received with excessive matting, for example, it will require more care to achieve final quality.

Whichever method is chosen, it is essential that management operations in the post-planting periods, especially those with higher soil moisture due to high irrigation frequency, be carried out carefully, with light equipment so as not to damage the surface leveling and the turf.

Suitable planting period: As you can see, there are several different demands for each planting method. We can adapt to the existing game calendar, choosing the most appropriate method, or we have to plan this calendar according to the most convenient planting method to be adopted, either by cost or quality.

It is important to remember that time limitation also occurs due to weather. In winter we can install grass in soil-based methods, whether large slabs or rolls, but we will be restricted for other techniques. Both washed-grass roll planting and stolon planting will require higher temperatures to complete their establishment period more quickly.

In shaded locations, these time windows will be even more restrictive, as satisfactory turfgrass development results are not achieved under shaded conditions.

For planting in stolon, the ideal is to plant in spring, when we will have the warmest periods for its initial establishment. It is possible to plant in winter (except for very harsh winters, where seedlings that have not yet formed rhizomes may die), but we have to consider that closure will take much longer to occur.

However, lack of sunlight will be a limiting factor for planting in seedlings or in soilless grass, as this may perish before rooting is complete.

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