SOLINHO IN THE CAATINGA

Halt Soil Salinization, Boost Soil Productivity

Introduction

This booklet tells the story of the Brazilian Caatinga, the only biome exclusive to this country, which means that most of the natural habitats and history cannot be found anywhere else on the planet.

Most of the Caatinga is found in the Northeast region of Brazil,and has a wide variety of organisms living there due to the characteristically dry climate. However, a dry climate can also cause salt to build up in the soil in some places, in a process called salinization, which can affect how the organisms in these environments live.

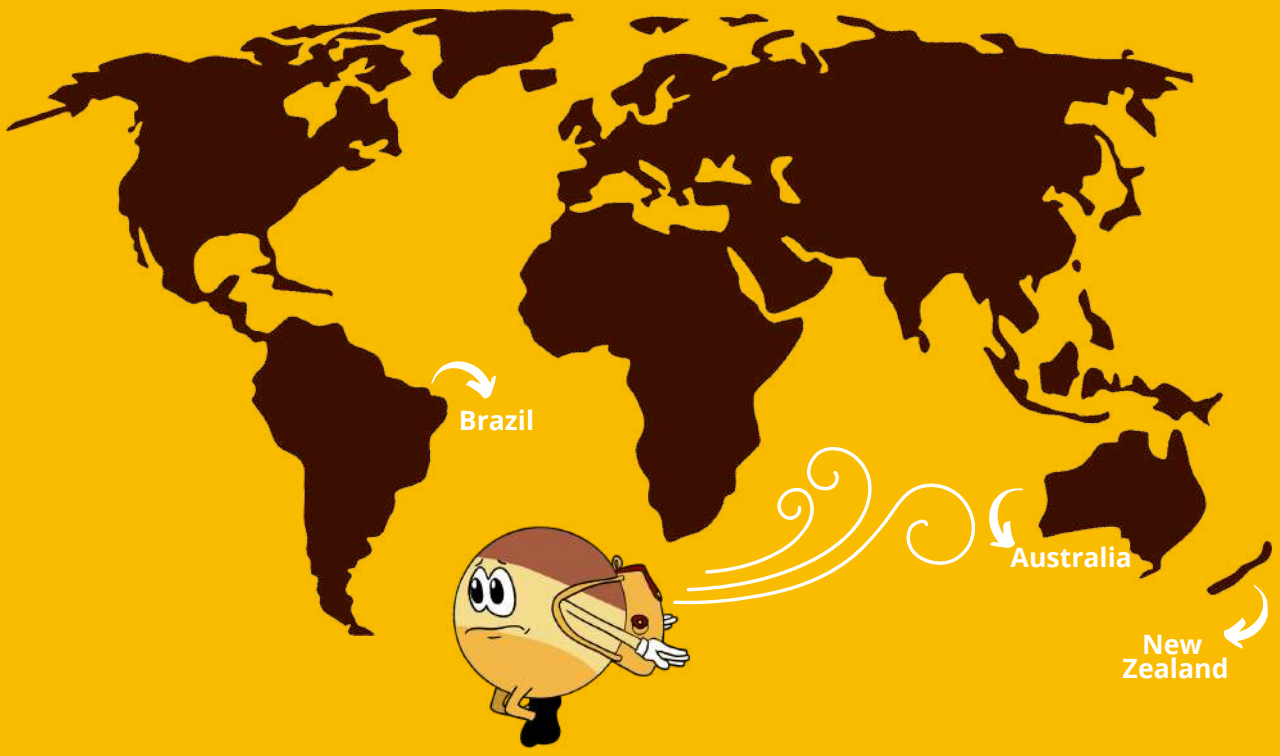
Salinization can worsen by human actions, and so people need to come together to stop the problem, since it takes a long time for these areas to recover once the salt builds up, and often costs more money than people want to spend.

Thus, with a little poetic license, we are bringing together stories and science to explore solutions that, although not always possible in the real world, are being studied to solve the problem of salinization.

Solinho, after his adventure in the Amazon, was called to a place in New Zealand that needed his help. Only a few organisms were left and most of them were dehydrated, the animals thirsty and the plants wilting in the soil. Soon after arriving, Solinho got another report that an area in Australia had a similar problem.

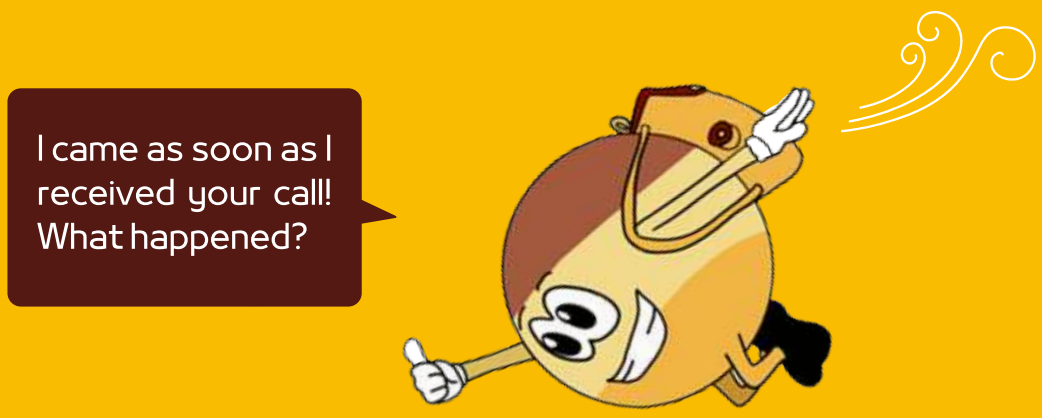
As the two problems were very similar, the communities worked together and swapped ideas and information in search of a solution. It took much work, but eventually the soils and organisms in those places began to recover. Solinho's mission was complete! His friends would continue to work, restoring the soil, but they were now on the right track. However, before Solinho could even say goodbye, he received a new call for help, this time from Brazil.

He immediately hitched a ride with the Wind Current towards Brazil.



Solinho arrived to where the call had come from and he saw a lush green landscape and an imposing dam. However, just by the side of this was a large desert-like area that caught his attention. The place looked bleak and desolate.

There was only a solitary ant waiting for Solinho, visibly relieved to see him.



I don't know exactly, but things here haven't been going well for a while now. This entire region was once beautiful and full of life, and there were large corn plantations. When harvest time came, the São João festival made everyone happy. But, little by little, many of the organisms started to die, the plants withered and some didn't start growing at all. The animals that did survive had to move away to find food, so I called you because I don't want to leave my land. I believe that you, as a scientist, can help us.

The Ant continued, "However, for some time now life has been difficult, even with all of this water."

Although the area was mostly deserted, the irrigation system had continued to be maintained in an attempt to bring back life to the arid soil.

Solinho already had an idea of what the problem might be. To confirm his suspicions, he pulled out a conductivity meter from his ever-present backpack and analysed the water coming out of the pipes. Now he knew for sure.

An irrigation system is a technique that has been used since the Persian Empire. It works by channelling water to make it available to the soil in a controlled way, and it is often used in agriculture.

Note:

A conductivity meter measures the amount of salt in a water sample by measuring how quickly electricity passes through it. The more salt there is, the higher the electrical current!

"Dear Ant, I know what the problem is," Solinho said. "I have just come from places that had a similar problem and, after a lot of work, they were able to start making the soil better again."

Solinho pulled out his notebook, as well as other things he needed for a demonstration.

Salinization is a worldwide problem that has been occurring in different regions all over the planet. It has many different causes, which means that each region has to be investigated by researchers to help understand the process.

You can also do experiments to find out what happens when there is too much salt in the soil, as the University staff explains on the next page!

To understand what is happening, Solinho and Ant set up an experiment using table salt (Sodium chloride, NaCl)

$Na^+ + Cl^- \longleftrightarrow NaCl$

Na^+ = sodium (ion)

Cl^- = chlorine (ion)

NaCl = Sodium chloride (salt)

What you need

- 2 containers
- soil
- marker (pen)
- labels
- seeds (your choice)
- water
- table salt

Example:

What to do

- Fill 2/3 of the two containers with soil;
- With the marker/labels, label the containers with "salt" and "no salt";
- Put the same amount of seeds in each container (for beans, three are enough, for smaller seeds, it can be more)
- Cover the seeds with soil;
- In the container labelled as "no salt", add tap water (without drowning the soil);
- Make a saline solution by adding two pinches of salt to a cup of water and mix well. Add this to the container labelled as "salt" (without drowning the soil);
- Place the two containers in a sunny spot;
- Observe the experiment for a week. If the soil dries out during the week, water it again with tap water for "no salt" and the saline solution for "salt".

What happened?

1.Carefully remove the seeds/seedlings from the containers, being careful to keep them separate.

2.Describe how the seeds/ seedlings are:

No salt: _____

Salt: _____

3.Was there germination?

No salt: yes ( ) no ( )

Salt: yes ( ) no ( )

In the table to the side, you can find some examples of plant responses to lots of salt in the soil.

Some can grow when the Exchangeable Sodium Percentage (ESP) is above 40, so they are more tolerant and thrive in a saline soil.

Others cannot tolerate this and are therefore considered sensitive to excess salt.

Note:

Germination is the first stage of a plant growing. The seed splits open and small shoots and roots start to come out. Can you see this happening with your seeds?

Table 1. Relative tolerance of cultures* to exchangeable sodium (Ayers; Westcot, 1999)

Sensitive (ESP<15)	Semi-tolerantes (ESP de 15 a 40)	Tolerantes (ESP>40)
Cowpea	Wheat	Rhodes Grass
Chickpea	Tomato	Angola Grass
Peanut	Spinach	Cotton
Lentil	Sorghum	Bermuda Grass
Tangerine	Rye	Sugar Beet
Peach	Rice	Beetroot
Orange	Radish	Barley
Grapefruit	Onion	Alfalfa
Pea	Oat	
Corn	Mustard	
Cotton (germination)	Clover	
	Sugar cane	
Bean	Millet	
Nut	Lettuce	
Deciduous fruits	Fetusca	
Avocado	Carrot	

* Listed in ascending order of tolerance

Adaptaded from: Ayers & Westcot (1999 apud DIAS et al. 2016, p. 156; available on: https://www.ars.usda.gov/arsuserfiles/20361500/pdf_pubs/P2542.pdf)

SALINIZATION

Natural causes

Global factors can cause the accumulation of salts in the soil:

- Transport of salt particles by the winds that blow from the sea to the continents;
- Transport of salts by wind in areas next to mineral exploration zones, such as mines.

Local factors can also cause salinization:

- Types of rocks in the local area which give rise to different soil types;
- Seasons of prolonged droughts;
- Fluctuation of the water table.

Human action

Some human practices can accelerate the salinization process or make it worse. One example is the use of saline water in irrigation systems.

Salinization in Brazil

Although salinization can be seen in different areas all over Brazil, it is more common in the Northeast, due to the natural conditions of this region.

Water can turn into a gas easily, in a process called evaporation, but the salt in that water does not. This means the salt from evaporated water is left behind in the soil, causing salinization. When there is not much rain, there is no water to "wash" the concentrated salt out of the soil.

Some areas in the Northeast have high average temperatures, which leads to high levels of evaporation. This combined with little rain to replace this water means the areas are highly salinized.

The soil in the Northeast region of Brazil is formed through the dry climate and flat landscape. The combination of these factors leads to a soil more susceptible to salinization.

Date: No:

Consequences of Salinization

- Loss of soil porosity due to the physical effect of salts;
- Loss of flora and fauna, as many organisms cannot tolerate lots of salt in the soil.

What happens to plants when they are planted in soil with an excess of salt?

When seeds are placed in soils with accumulated salt, where the elemental concentration is higher in the soil than in the seed, the water in the seed will leave to go into the soil to balance the salt concentration. The loss of water can cause the seed to wither and die.

With salt

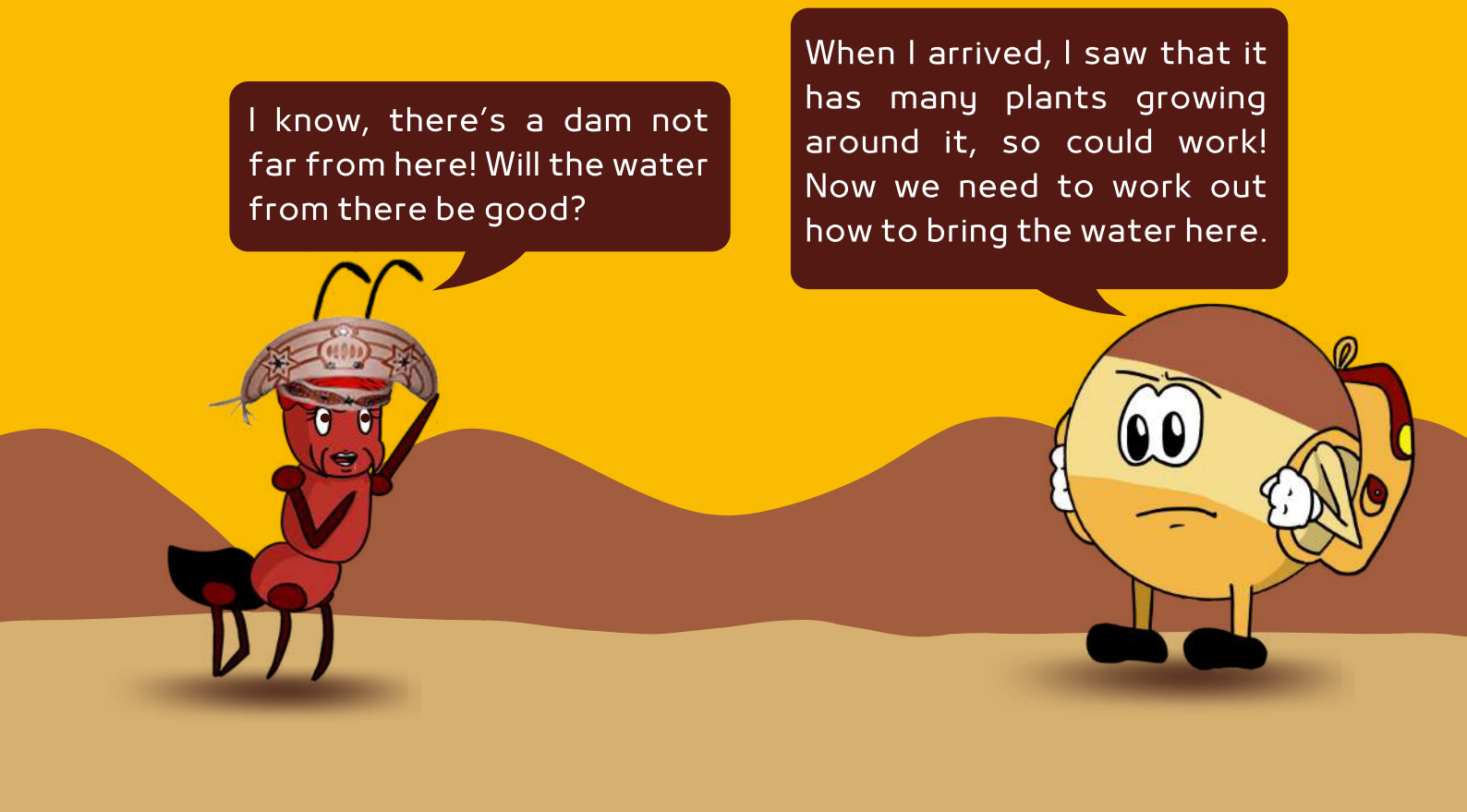
What happens to plants when they are planted in soil without excess of salt?

In soils without excess salt, the seeds can absorb water from the soil because they have a higher concentration of elements in the seed than in the soil. This water makes them germinate and develop.

Without salt

Osmosis is the movement of water from a less concentrated solution to a more concentrated one through a **semipermeable membrane**, one that lets gases and liquids pass through, until the concentration is equal on each side.

After Solinho studied the site's conditions, he talked to Ant. They would need lots of unsalted water. He warned her the process would be long and hard.



Thus they went on a long and exhausting journey in search of water. When they got there, Ant was pleasantly surprised to find her earthworm friends, who were soil engineers.

Feeling encouraged by Aguinha's confirmation, Solinho and Ant explained their idea. The Earthworms were excited at the idea of finally going home and volunteered to help.

Soon, several organisms started to help transport fresh water to the area with too much salt in the soil. They were hoping to create and maintain a layer of water that would withstand evapotranspiration.

Evapotranspiration is the loss of water to the atmosphere through evaporation from the soil and movement through plants, which is called transpiration.

Before removing the salt from the soil, Aguinha said that washing the soil would not be enough, as the process would generate a lot brackish water that would need to be disposed of properly.

Solinho was a little discouraged, but Aguinha knew what to do, because she had already done some research.

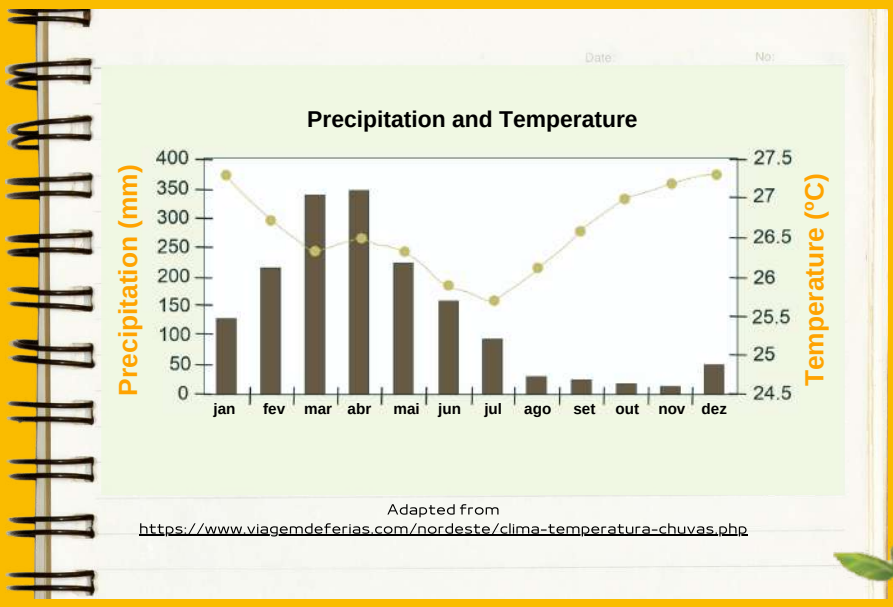
After a lot of work, and washing the soil made brackish water, Aguinha decided it was time to put the second part of her plan into action. She asked the wind to bring her *Atriplex nummularia* seeds and spread them all over the affected region.

Atriplex nummularia (from the Chenopodiacea family), is a halophyte plant (a saline tolerant plant) used in the Northeast region of Brazil since the 1930s by its ability to accumulate significant amounts of salts in its leaves.

While they waited for soil to recover, Ant showed Solinho a collection of seeds that she had kept, hoping that one day she would be able to plant them and grow corn again.

As Solinho had warned, it was neither quick nor easy, but, finally, Aguinha and the halophyte plants managed to reduce the excess salt accumulated in the soil and other plants began to grow.

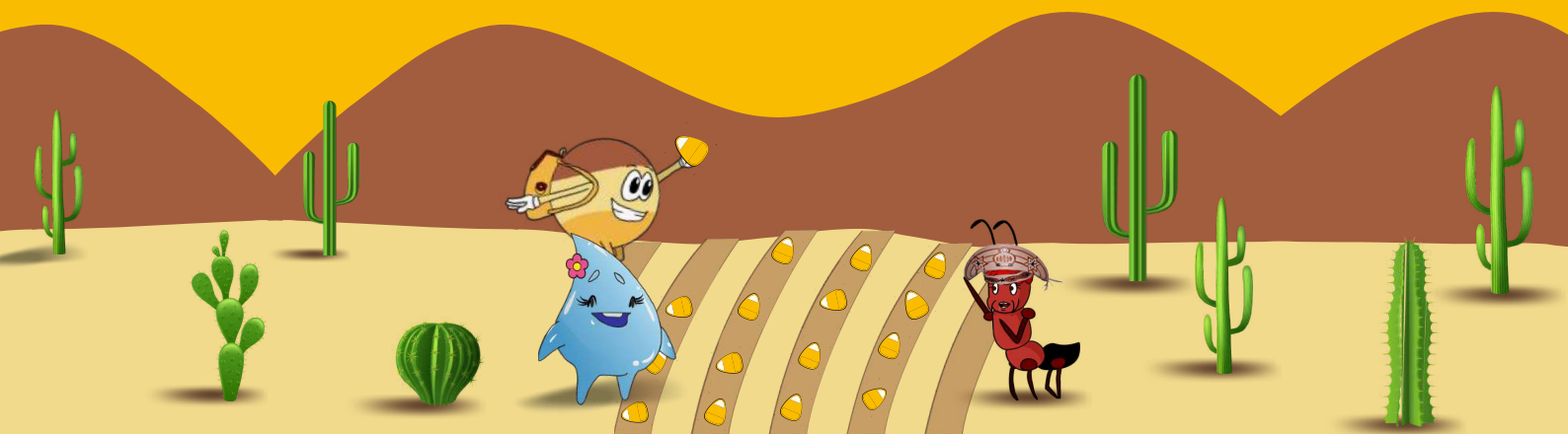
Finally, a very special day arrived, one that Ant had long awaited.



Adapted from
https://www.viagemdeferias.com/nordeste/clima-temperatura-chuvas.php

In the graph to the side, the grey bars show the amount of rain in a month and the orange points show the temperature for a part of the Northeast region of Brazil.
The first months of the year are rainier; therefore, it is the best time to sow seeds.

Carefully, Ant and Solinho planted the corn seeds in the soil. Aguinha helped by watering the soil, and everyone eagerly awaited for them to germinate.

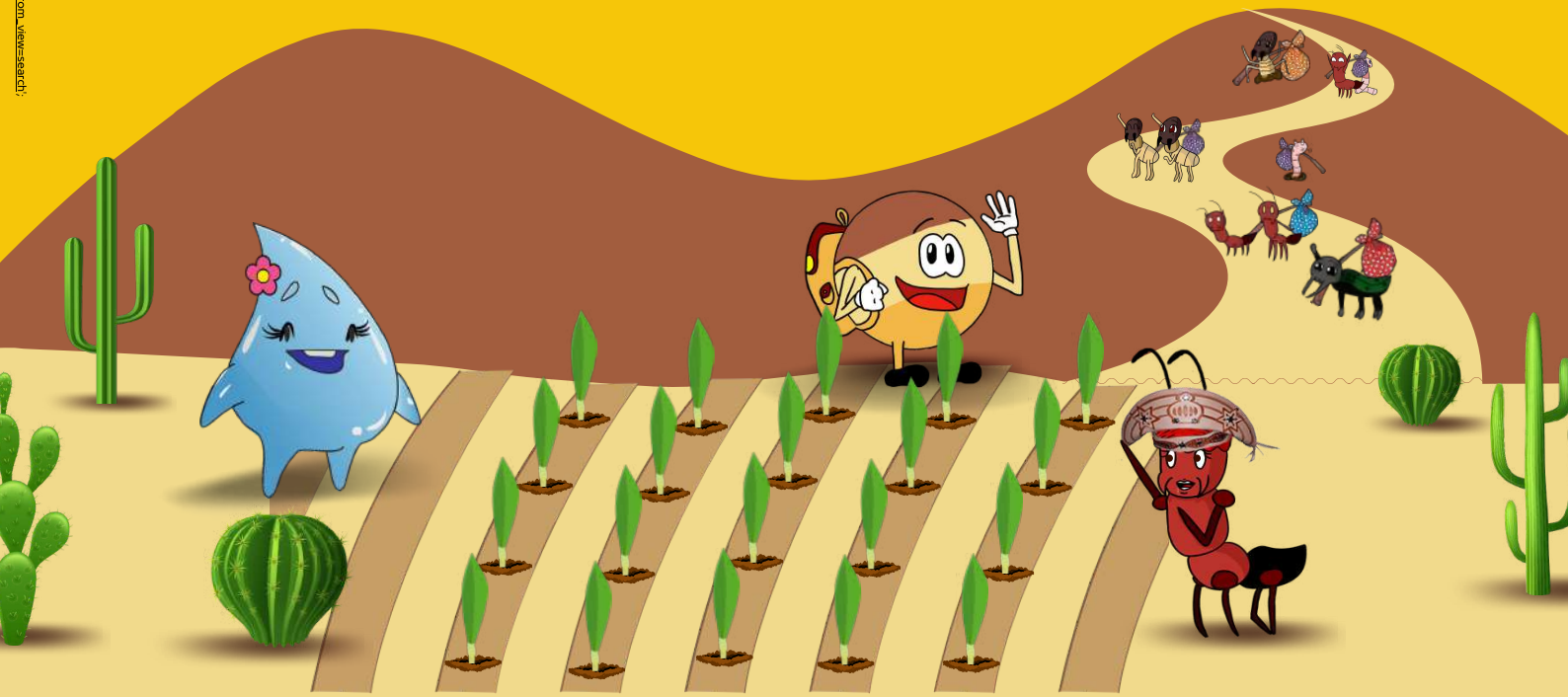


In time, the roots of many plants began to grow and to spread the good news by reaching out to the organisms that lived in unaffected regions.

Click here to learn more about plant communication.

When they received the message, Ant's friends began to return to their homeland.

With everyone back and the corn growing beautifully, everyone was just waiting for the most important time of all: the corn harvest in June and the São João festival.



Cactus vector: https://www.freepik.com/free-vector/different-types-cactus-plants-realistic-decorative-icons-set_3817855.htm#page=1&query=cactos&position=16&from_view=search;

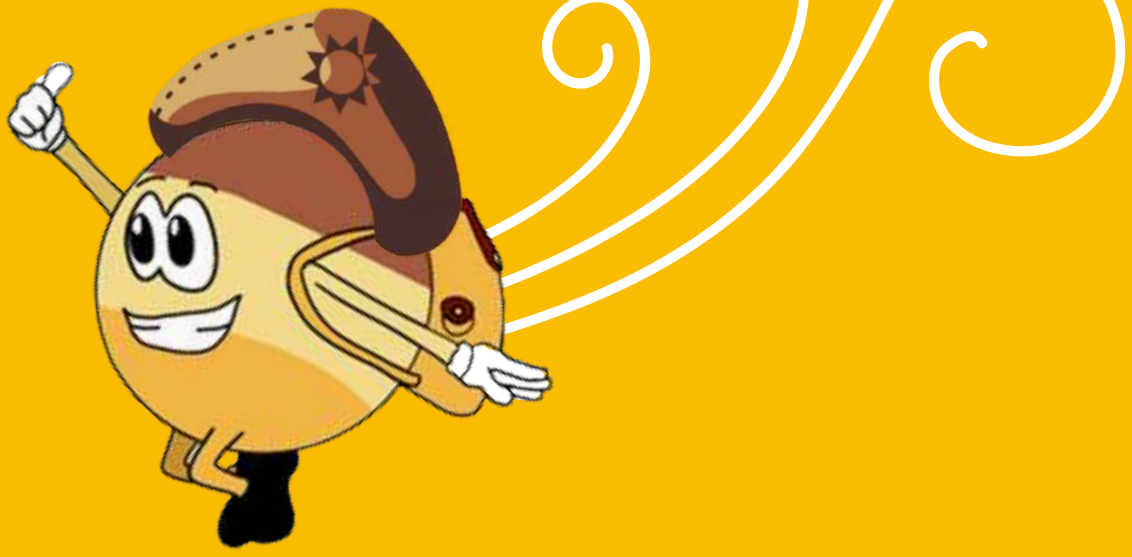
The São João festival in Brazil is celebrated in June. In the Northeast region, it is combined with the corn harvest, which gives rise to many delicious recipes.

Note:

Initially, leather hats were mainly used to protect the cowboy's head from the thorny weeds of the Caatinga, as well as from the sun and rain. But later it became a tradition due to Luiz Gonzaga, a singer-songwriter, who used several models of leather hat in his performances in the Southeast, to represent his northeastern origin.

Click here to listen to traditional music from Brazilian Northeast, written and performed by Luis Gonzaga.

When the festival was over, Solinho knew his mission was complete and that his friends would continue to look after the soil when he was gone.



Cactus vector, https://www.freepik.com/free-vector/different-types-cactus-plants-realistic-decorative-icons-set_3817855.htm#page=1&query=cactus&position=16&from_view=search,