RIZOMA AGRO

IMPACT REPORT

An Immersion in Regenerative Agriculture

2022 IMPACT REPORT

Rizoma Agro's positive impact on the environment and its contribution to a paradigm shift in agricultural production.

RIZOMA AGRO

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A MESSAGE FROM THE FOUNDERS

Dear friends,

It is with great satisfaction that we present our 2022 RIZOMA AGRO IMPACT REPORT. This is a regeneration study that began in 2017 and has now matured, with reliable and consistent results. The conclusions we have reached about the regenerative capacity of our agricultural systems – all of which sequester carbon, increase biodiversity, and improve the water cycle – are striking. When we founded Rizoma Agro, our mission was to prove that regenerative organic agriculture can feed the world and regenerate the land. That was the thesis, but at that time there were many questions unanswered. The decision was then made to invest to find out.

Proving the economic viability of our business model is easy – today we are the largest producer of organic grain in Brazil, and our numbers speak for themselves – but in impact assessment, we felt there was a lack of robust, scientifically validated methodology.

Our R&D team did the research, and we contacted institutions in Brazil, the USA, and Europe.

As organic regenerative operations have the potential to address a lot of environmental issues, we felt we still had to do several studies to fully understand this impact.

The methodological framework established seemed to us somewhat lacking because it was a legacy of the "sustainable" era, when the objective was to show good practices, and it was derived from analysis done in a temperate environment, unlike Brazil.

But regeneration is a newer, more comprehensive concept. It is not enough to be better than average. The bar has been set higher, and we need to prove that we are leaving the soil, biodiversity, water, and atmosphere better than we find them.

This is why we decided to create a new regeneration analysis protocol, combined with the organic production system based on a lot of studies, and the potential application by any farmers or parties interested in these measurements – they are the results of simple collection, analysis that can be outsourced, at a feasible cost.

Sharing our vision of what the key indicators are to validate the concept of Regenerative Agriculture is one of the most rewarding contributions we can make.

We are very pleased to see the growing interest in this new paradigm of food production, but we need to make sure that Regenerative Agriculture does not become an empty term, appropriated for greenwashing, as we have seen in the past.

We hope that these meaningful metrics show you that we can regenerate while producing food in a competitive and profitable manner.

Pedro Paulo Diniz
Founding partner

Fábio Sakamoto
Founding partner

EXECUTIVE SUMMARY

A FOOD PRODUCTION MODEL ALLIED TO NATURE

This 2022 RIZOMA AGRO IMPACT REPORT is the result of a thorough analysis of systematized regeneration metrics over the last three years, and clearly demonstrates, from various perspectives, the significant improvement in a series of environmental indicators, especially regarding three major axes: Carbon Sequestration, Biodiversity, and Water Retention.

This is pure regeneration, combined with productivity and gains in scale and efficiency.

The data and information presented in this report represent a watershed in the understanding of regenerative agricultural systems. We have moved on from hypothesis testing to proven results, which makes us confident in declaring the viability and high regeneration capacity of our business model.

This report contributes to a more accurate view of the real positive impact of regenerative agriculture.

And we could not be more pleased - after all, many of the discoveries described here exceeded our own expectations, in a clear demonstration that when we make an ally of nature, it repays us generously.

Sharing our results excites us because we see ourselves opening up a range of opportunities and a positive outlook at a time when we need to re-signify our relationship with the planet.

In this regard, there is no shortage of reasons for optimism because we have seen many changes for the better in the world, starting with consumer relations, one of the most powerful factors of economic transformation.

Consumers are increasingly aware of what they take home. It is not just about buying a product, it is about having a critical attitude about how it was produced. Under what conditions? What are the impacts? Were people working in dignified conditions? Were the animals treated well? Questions like this now weigh on purchasing decisions.

People are increasingly intolerant of products from environmentally harmful production systems, or which cause degrading situations for people or animals. Euromonitor's 10 Main Global Consumer Trends Survey 2022 shows that 67% of consumers tried to make a positive impact on the environment through their day-to-day actions last year. "They make more sustainable choices while requiring action and transparency of brands," as the study says.

The planet is definitely at the top of the agenda, which turns the wheel for a new, regenerative economy. Also, according to Euromonitor, companies are positioning themselves accordingly, "by adjusting their portfolios to meet consumer demand for products with a smaller planetary and ecological footprint."

This new economy that is being designed is already prosperous. Between 1999 and 2020, global sales of organic food increased from $15.2 billion to $120 billion. In Brazil, the segment more than quadrupled in a decade. That is, if anyone had any doubt, the data speaks for itself and show clearly that the organic segment has become an excellent business.

We are therefore facing a new historical moment and are on the threshold of an era of regeneration, which will create more opportunities to consolidate production and consumption models consistent with the planet. That is what we are going to be talking about throughout this report.

EXECUTIVE SUMMARY

CO_2

45 TONS

CO_2 EQ/HA/YEAR

Our systems sequester up to these levels of carbon from the atmosphere. If all national agricultural production were converted to regenerative organic models based on our figures, we would neutralize 1/2 of China's emissions. At a global level, according to the Rodale Institute, if agriculture at large followed this protocol, we would offset all the carbon emissions on the planet.

3X MORE

We have tripled the number of pollinator species and natural enemies in the areas - and this greatly increases our resilience.

49.000 LITERS

The extra volume of water our soil retains per hectare because of the organic matter added by our management.

SNAPSHOT OF OUR RESULTS IN REGENERATION

Regenerative agriculture has enormous potential to address environmental issues of great importance today – and we will offer the perspective of a virtuous cycle of carbon, biodiversity, and water as the forerunner of operations in harmony with nature.

The Rodale Institute, a major reference in organic regenerative agriculture, provides significant, quantitative, concepts based on the results of this production system. Citing some benefits of this management, it is possible to increase soil health and add organic matter over time, emit 40% less carbon, and achieve three to six-fold increases in profit for farmers.

These figures, along with the indicators obtained by Rizoma Agro, show us that the potential is enormous – the improvement is having an impact worldwide for all living beings, since farming permeates a sector with high economic, environmental, and social impacts.

Achieving carbon sequestration to offset emissions from the entire existing fleet of vehicles, ensuring the diversity of fauna and flora to maintain the ecological balance of species, and using water much more efficiently, being less susceptible to climate change that has already happened? Yes, we can have profitable farming that offers high-impact environmental solutions.

GOOD PRACTICES ADOPTED

1

Use of biological inputs to maximize crop health and soil biodiversity.

2

Use of cover crops in crop rotations, boosting soil biology and reducing the need for inputs.

3

Adoption of soil conservation practices and the minimum possible soil replacement.

4

Use of technology to optimize farm resources, such as smart irrigation systems, georeferenced vehicle control, and soil analysis.

5

Diversity of plant species in perennial systems to increase resilience, carbon sequestration capacity, biodiversity in fauna, and improve the use of water resources.

6

Integration between livestock and arable farming, allowing greater richness and optimization of systems - including by the economic perspective of maximized use of the areas.

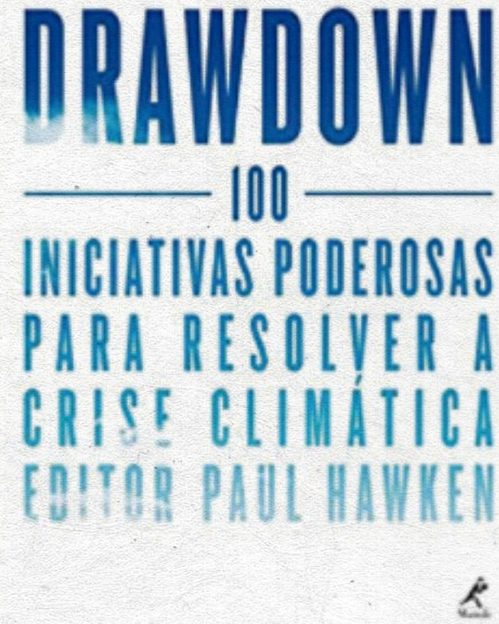
AGRICULTURE AND ITS REGENERATIVE POWER

How often recently have you seen fires destroying wildlife and forests, rivers that turn into trickles, prolonged droughts that end crops, and floods that destroy entire cities? Hard to count, isn't it? After all, this is the most visible face of climate change, the consequences of which are already being felt in all parts of the world.

But the purpose here is not to bang the drum about the gravity of the global environmental crisis, but to offer a workable solution.

One of the oldest human activities, agriculture has put us on a new level of evolution for 12,000 years. And now, again, it may be the key to another evolutionary leap in our species' journey, this time to ensure its perpetuation on the planet.

How can regenerative agriculture address this challenge to the point of being considered one of the most powerful initiatives to solve the climate crisis? This is the question we asked ourselves more than a decade ago when



A reference in climate change

we started developing this production model. And we now have enough experience, data, indicators, and results to support the answers.

Many of us grew up hearing that food production and environmental conservation are incompatible.

Rizoma's agroforest system is a case study

Fortunately, today we know that this alliance is not only possible, it can also be a highly profitable business. After these years investing, developing management in the field, improving processes and opening markets, we can say that, yes, it is possible to produce food in abundance and at the same time regenerate natural resources. There is a new paradigm in agricultural production that makes us more hopeful and optimistic about the future.

This set of deliveries – promoting biodiversity, improving environmental indicators, financial return, high productivity and efficiency – makes regenerative agriculture one of the best businesses that humanity can run today, as Pedro Paulo Diniz, a founding partner of Rizoma Agro, says.

Fortunately, we are facing a time that is especially conducive to its flourishing. In this Decade of Restoration 2021 – 2030, instituted by the UN as a call to protect and revitalize natural ecosystems, we have seen unprecedented engagement around the environmental and climate issue.

More than ever, the topic is in the spotlight for companies, governments, the press and society in general.

BRAZIL

AND THE SIZE OF ITS AGRICULTURAL AREA

TOTAL AREA
851
MILLION HECTARES

PRODUCTION AREA
280
MILLION HECTARES

GRAIN
SOY AND CORN
40
MILLION HECTARES

PASTURELAND
170
MILLION HECTARES

FRUIT GROWING
2,1
MILLION HECTARES

COMPARATIVE CARBON BALANCE DATA

CONVENTIONAL SYSTEM

ORGANIC REGENERATIVE SYSTEM

Data from regenerative organic operation obtained through our internal measurements, verified by third part (Imaflora), in a twenty-year projection based on IPCC.

IMAGINE IF THE WHOLE WORLD FOLLOWED OUR MODEL OF ORGANIC REGENERATIVE AGRICULTURE...

TO REACH THESE CALCULATIONS, WE ARE STILL USING OUR WORK DONE IN PARTNERSHIP WITH IMAFLORA FOLLOWING THE IPCC METHODOLOGY, THROUGH THE GHG PROTOCOL TO AGRICULTURE.

If the entire global fruit production were converted into agroforestry systems, it would be possible to offset all the emissions from the global fleet of cars, trucks, and buses.[1]

If global grain production were regenerative like ours, it would be possible to zero emissions related to electrical energy by more than 280 million households, double the number of homes in the USA.[2]

If Brazilian pastures were occupied by silvopastoral systems, each production year would offset two years of the country's total emissions (base 2020). [3]

[1] The world has more than 65 million hectares of fruit-growing area (FAO), and the vehicle fleet is 1.32 billion (Ward Intelligence). Each hectare of agroforestry system could offset 22.4 cars (Green Initiative).

[2] The global grain production area is almost 730 million hectares (World Bank), which would sequester the equivalent of electricity emissions mentioned (US-EPA).

[3] Brazil emitted 2.1 gigatons (2,160,663,755 tons) of CO2e in 2020 (Seeg).

SOIL: THE BASIS OF LIFE

What does healthy, regenerated soil have to do with this? Despite what you might imagine, cropland is the trigger for so many other factors that interfere with the productive potential of crops, flocks, and herds.

This is down to the fact that the characteristics of the soil dictate its ability to optimize water resources, maintain macro and active microbiology in the soil working together with the plants and, consequently, the speed at which natural cycles occur and the accumulation of total organic carbon – which is the focal point of analysis as to how much we can improve soil health over time.

And can we change these soil characteristics so that they are better suited to their purpose? The answer is yes, we can. Each type of soil has its particularities – both in the proportion of clay and sand, which influences the amount of macro and micropores in the soil and so its ability to retain water, and in the window to work to avoid compacting and erosion, as well as the effective elemental composition and chemical attributes available for plant nutrition.

However, as we increase organic matter in the soil, we also see a marked evolution in the active microbiota in the soil, the ability of the roots to permeate surface and subsurface layers because of greater porosity, better water retention, and so on. So, the main regeneration indicators adopted by Rizoma Agro set out by measuring the levels of organic matter in the cultivated areas so that we understand the forecast trends for everything else – carbon sequestration, increased biodiversity, and better use of water resources.

Healthy, living soil is the board we need for the game. The agronomic and zootechnical sides of the game, if well placed throughout the harvests, produce a victory for both sides – the environment becomes resilient to adversities, and crops benefit from this resilience, needing fewer external inputs and reducing operational costs while boosting production levels.

Farming production systems can be managed in numerous ways, meaning that choices are made at the different stages, from soil preparation and planting to fertilization, plant control, harvesting, and land use in the off-season.

Some practices are recognized as positive for the maintenance or improvement of environmental indicators, such as the use of plant cover for maintenance of the soil, no-tillage and spraying with biological controls, but others are still open to question, such as soil revolving compared with the use of herbicides for integral soil health in terms of carbon sequestration and in maintaining

life on earth. However, the rule is clear: for what is not known, monitoring through solid indicators is the best tool for these decisions – and this is what Rizoma Agro is proposing, adding knowledge to the agricultural sector on best practices that help in the recovery process of degraded areas and in the maintenance and improvement of environmental attributes of newly implemented areas.

In addition to the productive aspect, there is also the aspect of social regeneration. In addition to people's wish for healthy, nutritious food with a better environmental impact, biosecurity and working conditions are also very important and cannot be overlooked.

Regenerative production environments tend to use fewer inputs that are harmful to nature and workers, which ensures a significant improvement in this area.

The starting point of this game, then, is to understand the current condition of various productive systems and monitor how they behave according to the different soil uses, types, and management systems adopted.

The triad accompanied from the 2018/2019 harvest has been focused on carbon, biodiversity, and water aspects, which will be better described in the following chapters.

REGENERATION: A SYSTEMIC PROCESS

If someone came to you with two handfuls of dirt, as in the image above, which one would you choose for your favorite plants? Easy question, isn't it? You don't have to be an expert to realize that the earth on the right is better. The choice would be intuitive based just on how alive it looks, while the other one looks more like sand from a desert.

But these two types of soil are just a few steps away from each other. Number one was taken from a road that cuts through the farm where no regeneration technique is applied. And number two is in an agroforestry system, on Fazenda da Toca, which has been under regenerative management for three years.

If today they are so different, before the agroforestry system they were similar, looking degraded.

So, what happened over these three years to bring about this transformation in the agroforestry system soil?

The phenomenon that engendered this metamorphosis is what we call regeneration.

This is a visible part of it, but it is only a fraction of the whole. The regenerative process in its completeness concerns the soil and land, but also promotes the availability of water, an abundance of biodiversity, and an environmental and climate balance. Everything that is fundamental to human life and all species. We used this image above to illustrate what we are saying, but to really understand how regeneration operates in all its complexity, you must open your eyes to consider the invisible.

Everything begins with microbiology. It is from there that the regenerative process unfolds to the macro sphere, influencing the carbon balance, the reversal of climate change, the revitalization of natural resources, and the production of healthier food. In summary, a better planet to live in that can maintain itself over the decades.

OUR HISTORY

RIZOMA AGRO

ABOUT RIZOMA AGRO

We are driven by regeneration. The company was founded in 2008, when almost no one was talking about regeneration, which is now in vogue. One of the inspirations behind it was Al Gore's documentary 'An Inconvenient Truth,' released two years earlier to international acclaim. The film pinpoints the catastrophic consequences of climate change and the global environmental crisis.

In the year of its launch, the eldest son of entrepreneur Pedro Paulo Diniz - who had retired from motor racing and become a supporter of organic food and the environment – was born. As Pedro watched 'An Inconvenient Truth,' he was perturbed: global destruction and catastrophe were not what he wanted to leave for his children.

He started out on mission to regenerate the planet, investing in businesses with a socio-environmental impact. In 2008 he made the decision to transform Toca's Farm (in Itirapina, São Paulo state), a 2,300-hectare farm belonging to his family, into a large-scale organic production center and a model of sustainability in agribusiness.

Over the years, Toca has become a benchmark in organic farming and a laboratory for the development of regenerative agricultural systems. But its mission to change the farming paradigm demanded larger investments, a robust R&D structure, and total focus on the field.

In making the decision to move forward and put all his energy into this challenge, Pedro partnered with Fabio Sakamoto, who had spent 15 years in management and finance before focusing on purpose-driven projects. Together, they created Rizoma Agro, a new company offering solutions and scaling regenerative, highly productive and profitable agriculture.

So it was that Fazenda da Toca began to specialize in egg production, becoming the largest producer of organic eggs in Latin America, while Rizoma Agro established itself as an organic, regenerative producer focused on the expansion of highly productive, technology-based crops with a positive socio-environmental impact.

Our company was officially opened in 2018 and today owns more than 2,000 hectares on three properties: Toca's Farm (Itirapina/SP), Takaoka Farm (Iaras/SP) and a partner unit (Paracatu/MG).

That same year, we developed large-scale organic regenerative protocols for corn, soybeans, oats, beans, livestock, and other crops in the research phase. We also transformed four hectares of an agroforestry system inherited from Fazenda da Toca into more than 60 hectares of an agroforestry consortium made up of citrus, trees, and annual crops.

By 2019, we had become the largest producers of organic legumes and grain in Brazil, supplying multinational food companies and exporting to the USA and Europe.

Rizoma Agro now has a team of professionals dedicated to the technological development of regenerative agriculture with productivity and costs equivalent to those of conventional agriculture. This has made organic regenerative food more competitive and accessible to growing numbers of people.

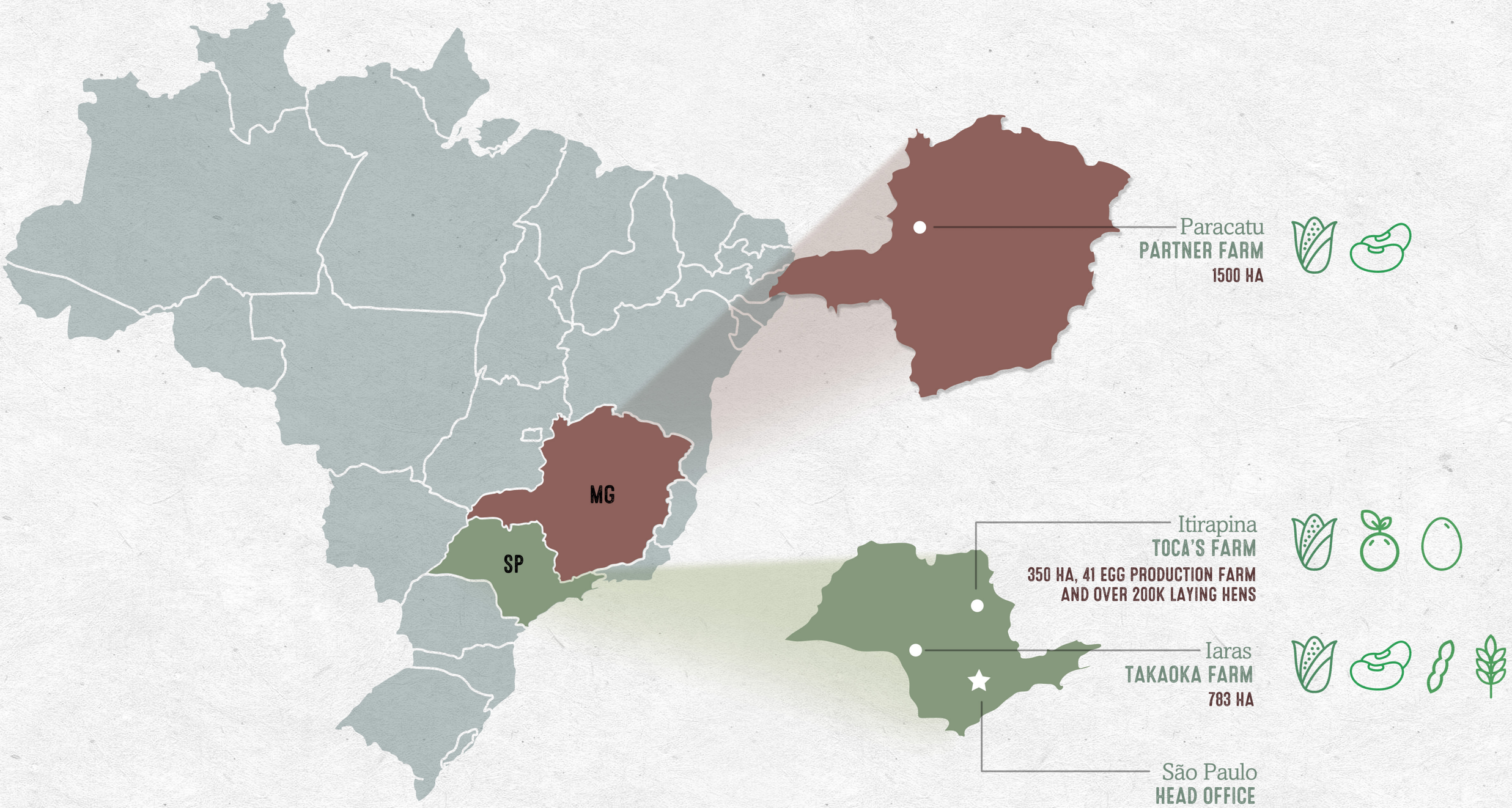
To achieve this and scale organic regenerative food, from the outset we based our experiments on the pillars of increased productivity, reduced costs, and the regeneration of our crops.

The secret is nature itself – biomimetics and the use of human technologies helping natural balance are the key to the success of these processes. Along with the maintenance of life and biodiversity, we use biological inputs to control pests and diseases in crops, which is good for the productive environment and good for the health of all beings on the planet.

There is a long history of evolution in organic regenerative agriculture, which we at Rizoma Agro want to be part of. This involves the development of an organic no-tillage system, avoiding soil revolving and maximizing carbon accumulation in tropical soils, robots that can weed crops, and many other disruptive technologies to come.

Everyone involved can be a catalyst of technological progress and usher in the high-efficiency, large-scale approach to regenerative and organic systems.

OUR OPERATIONS



AGROFORESTRY SYSTEMS

Agroforestry systems with an emphasis on tahiti lime and sicilian lemon are designed for high carbon sequestration, elevated biodiversity, and water maintenance – ecosystem services of paramount importance for the regeneration of agricultural landscapes. Other species make up the biodiversity:

- Tree species - managed for felling and sale.

- Service species - also called biomass species, serving as live recyclers of organic matter above the ground and, consequently, nutrients, micro and microbiota.

- Annual species - fast cycle crops for early returns and optimization of the system with food production early on.

GRAIN

Crop rotation keeps the soil covered for almost the whole year. Irrigated and dryland areas rotate among:

IRRIGATED	Corn and beans
IRRIGATED	Corn, soybeans and beans
IRRIGATED	Soybeans and corn
DRYLAND	Soybeans and oats
DRYLAND	Corn and oats

SELF-SUFFICIENT SYSTEMS ARE THE KEY TO RESILIENCE

Agriculture, as it is practiced, is being directly impacted by Russia invading Ukraine and the disruption of supply chains during the Covid pandemic – showing how fragile it is to heavily rely on external inputs. High prices, shortages, and uncertainties.

Here we provide the perspective of self-sufficiency and the circularity of agricultural chains as a benefit directly related to business resilience. And we will refer to two examples here: grain nutrition from poultry manure and the use of biological products.

Each chicken consumes a certain amount of corn – and production of this corn requires the use of nitrogen in crops. In organic agriculture, the main input used for nitrogen fertilization is poultry manure, and this closes the cycle harmoniously, as each hen produces enough manure to feed the corn it eats. *

Another highly streamlined process, with economic and environmental relevance, is the use of biological inputs produced within the farm itself in place of chemical pesticides.

Rizoma Agro has been studying for years protocols that lead to good results from bacteria and fungi in the field, and we are benefiting from this work which also moves towards self-reliance and working in harmony with nature.

CASE STUDY - INTEGRATION WITH THE TOCA'S FARM AGRO-ECO SYSTEM

The largest producer of organic eggs in Latin America, Toca's Farm is in Itirapina, Sao Paulo state, which also has Rizoma Agro agroforestry and grain systems.

This integration between poultry manure and corn production for feed is in place – 100% of the manure is used in grain production, with two direct benefits: less dependence on external inputs, making annual crop production more autonomous, and less of a financial and environmental impact of the logistics operations for this nitrogen-rich input.

*considering fertilization in the summer soybean crop and the winter corn crop.

OTHER HIGHLIGHTS

GREEN BOND

It is not only consumers and producers who have been changing their attitudes. The financial market and investors are also changing their approaches. One example comes from the issuance of Green Bonds by Rizoma Agro, in partnership with Ecoagro.

It was the first time an agricultural company has issued Agribusiness Receivable Certificates certified by the Climate Bonds Initiative to raise funds to sustainability projects and climate change mitigation.

Rizoma Agro raised R$ 25 million in the market, and the demand for green bonds was six times higher than the offer, which shows the appetite among investors for projects that have positive environmental and social impacts.

B CORPORATION

Soon after the founding of Rizoma Agro, one of the first measures taken was the effort to get System B certification. As part of a global network of companies that promote positive environmental and social impacts, we were able to improve our understanding of regeneration, from an environmental and socio-community perspective.

With a more accurate look at Environmental, Social and Governance (ESG) best practices, we are committed to improving our processes in the Environment, Workers, Governance, Community and Consumers spheres.

Our System B score was 62.59, which assures us we have achieved pending B certification. We are proud to be part of this group of companies that make their business a force for the good of the planet.

CARBON NEGATIVE LIVESTOCK FARMING

From low-performance, greenhouse gas-producing livestock farming, to a highly productive, carbon-sequestering system, contributing to the reversal of climate change. This inversion is one of the paradigm shifts in livestock farming that we brought about at Rizoma Agro in the first three years in business.

With a cattle breeding system integrated with forests, intercropping with grazing grass, and integration at certain times of the year with grain crops, we increased productivity nine-fold compared with the national average

From an environmental point of view, not only do we neutralize livestock emissions, but we sequester 24.3 tons of carbon per hectare per year, compared with the emission of 1.2 tons/CO2/year in conventional systems. All this while complying with Certified Humane animal welfare standards (see more in Appendix I).

Among the different experiments carried out, integration with trees and Leucaena leucocephala for grazing were the best from economic and environmental standpoints. The project was discontinued at Takaoka Farm because of its small experimental scale (44 ha), giving way to grain and convincing the company that a larger scale can be adopted.

THE PURPOSE THAT UNITES US

Close your eyes. Take a couple of deep breaths. Feel the fresh air entering your lungs. Imagine you going into a preserved forest. How does it feel? Look up; how many colors, how many shapes, how many sensations are there? How does it smell? Can you feel the shade?

Now start walking. Listen to the dry leaves underfoot. Can you see the rays of light shining on you?

Take another deep breath, now in the undergrowth. The air is fresh, the sounds are clearer. There are a lot of birds singing.

Do you feel a part of all this? That's good because you are a part of that whole - Mother Nature. Wisdom and balance are inherent in natural cycles, and we are not excluded from it. To think that our choices are ours alone is a mistake. Human beings are - or should be – a part of this sense of well-being.

Now open your eyes. What's changed? Not much, has it? The difference is that now you're in your chair, inside, but life out there goes on. And it has to. And to do so, we need to feed ourselves.

But how can we feed humanity without feeding nature, which is capable of providing us with everything we eat?

We are, in fact, part of a great solution - to maintain that balance and restore some of what has been lost over many, many years of short-sightedness. You know the dry leaves on the ground, the freshness, the whole perfect cycle? It is precisely this intelligence that we need, to care for preserved forests, since they have survived after years of evolution.

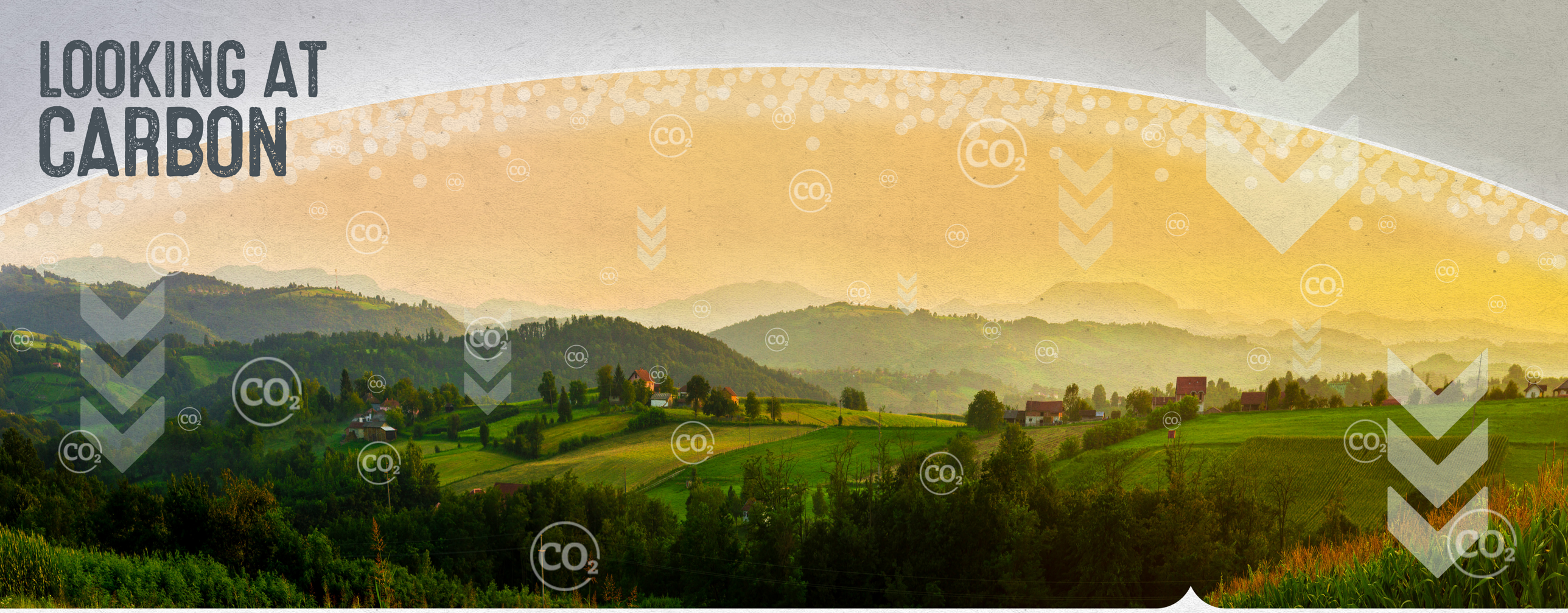
How can we do this? By creating highly efficient agricultural and livestock farming systems that produce food in abundance, and perfect integration biodiversity. Human ingenuity can help complex systems that restore fundamental parameters for everything to function.

Human action can range from the choice of plants and their spatial arrangement to the practices adopted to manage them. And this is what Rizoma Agro proposes: to build scalable, productive, and competitive systems that enable the migration of agriculture to this scenario of regeneration, in harmony with nature.

And it all begins with mobilizing people, who drive the execution of this mission that demands skill, engagement, and persistence.

CONTEXTUALIZING OUR INDICATORS

LOOKING AT CARBON



Climate change is in the spotlight now, with the focus on greenhouse gas emissions and initiatives to mitigate them.

This has made analysis of the carbon balance on farms more common, as it identifies how much each farming activity contributes to the increase or decrease of greenhouse gas emissions.

Organic matter is the starting point for soil recovery and carbon sequestration. This is because the positive impact caused by the accumulation of this organic matter involves chemical and physical improvements for soil and crops. In addition, the carbon in organic matter is a nutrient and energy source for de-composer microorganisms, which feeds a virtuous cycle, improving the quality and biological health of soil and plants.

These plants then fix CO2 and the systems become more sustainable and able to remove carbon from atmospheric air, helping convert systems to a negative carbon balance concept.

Knowing about the organic matter in the soil, analysis of root and stem carbon stock, and inputs and practices used on the property, allows an understanding of the carbon balance for each system, which guides potential improvement and adaptation for each productive context.

To clarify, the goal is to create a production logic that sequesters the largest possible amount of carbon equivalent per hectare per year, and this should become currency for carbon credit negotiations in the near future.

CARBON INDICATORS ANALYZED:

Soil organic matter

SOM

Total organic carbon

TOC

LOOKING AT BIODIVERSITY

On a handful of soil there are more living beings than the entire human population on Earth. All of them, be they bacteria, fungi, protozoa, or other microorganisms, perform a specific function.

But when soil is 'disturbed' – a technical term used to explain it is in unfavorable or very poor condition – this microbiology does what it can to adapt in extreme conditions and there is no energy left to perform vital functions for us, such as cycling nutrients and making them available for plants.

The first step in a regenerative agricultural system is to balance this 'disturbed' soil, helping the life that inhabits it. There are a number of techniques used, such as soil cover, the availability of biomass, the planting of green fertilization, minimum rotation, avoidance of aggressive procedures, such as watering and, of course, management free of pesticides, which eliminate microbiota in the soil and water bodies.

With this re-balancing, microorganisms resume activity in their functional groups – rather than just taking care of their own survival – boosting the decomposition of matter and the availability of plant nutrients, such as phosphorus, potassium, and everything else they need to develop and then feed us.

As microbiology is the link between the soil and plants and the main promoter of availability, ensuring the passage of nutrients, we make it the basis of regeneration.

From the invisible to visible, systems capable of regenerating offer the huge benefit of reconciling the intelligence of nature with several important ecosystem services for productive systems.

BIODIVERSITY INDICATORS ANALYZED:

- **Beta-glucosidase**
- **Arylsulfatase**
- **Acid phosphatase**
- **Microbial biomass carbon**
- **Edaphic surface fauna**
- **Pollinators**
- **Natural enemies**

ROBERVAL ALVES, TRACTOR DRIVER AT TOCA'S FARM

"Planting and harvesting is good, but doing so by seeing soil biodiversity evolve is priceless."

The loss of biodiversity caused by the conversion of native ecosystems and the unsustainable use of natural resources on cultivated land directly impacts the productive potential of crops, and this can be made worse by climate change forecast in the coming years.

The regeneration of degraded areas, considering the ecological and economic relevance of landscape connectivity, is recognized as an important strategy for mitigating loss of biodiversity and recomposing ecosystem services, such as pollination and the formation of healthy soil suitable for crops with high productive potential.

Among the various pressures that result in a loss of biodiversity and ecosystem services are changes in land use, migrating from native to degraded areas with low potential for biological shelter, and climate change. The agricultural sector was and is the main driver of change in land use and it is essential that it approach the biodiversity and ecosystem services agenda, combining conservation, improvement, and production. The first step is to understand what the main bioindicators in the balance of systems are.

Visible fauna, such as bees, earthworms, and insects in general, is extremely important for processes such as increased pollination and fruit picking, soil aeration, revolving between layers, and decompressing surface soil layers.

So, allowing the transit of these lifeforms through the areas and attracting them into the systems is an important point in the process of using ecosystem services and synergistic action with nature in its balanced form.

The focus of attention is usually only on the visible biota. However, biodiversity below ground, such as bacteria, fungi, protozoa, and nematodes, is also critical to cycling and nutrient availability, the decomposition of organic matter, the formation of active aggregates in the soil, and ecological services of succession and balance between pathogenic and beneficial microfauna – factors that influence not only the health of the soil but also of the plants.

FERNANDO DINI ANDREOTE, LECTURER AT ESALQ/USP

"Methodological development for proper access to the living fraction of soils has allowed us in recent years to understand the real importance of these organisms so that the soil presents all the characteristics necessary to support the development of plants. Currently, the idea of soil quality and, consequently, the quality of agricultural production, is not conceived of without considering the microbiology existing in this environment. Any management aligned with the promotion of biodiversity, and the consequent biological activity of soils, will be aligned with agronomic efficiency, resulting in more resilient and sustainable production systems."

LOOKING AT WATER

Although Brazil is rich in fresh water, having 12% of the planet's reserves, water availability is on the agenda because of the unsustainable use of surface and groundwater.

The quality of this water is also a very important point – erosive processes, leaching of harmful substances, and percolating are processes that directly impact the potability and support capacity for aquatic life, and its surroundings.

It is extremely important to ensure the preservation of water bodies against siltation and water infiltration along the soil profile, resulting in the replacement of underground water reserves and the rational reuse of this resource.

And how can we work proactively to ensure the best use of water? When we increase the levels of organic matter in the soil we contribute to improved water retention, which occurs directly when water molecules are retained by organic matter and indirectly when water infiltrates the aggregates formed by it.

This optimizes water use by plant roots, making this resource more efficient in the production system.

Vegetation then develops better and creates a virtuous cycle of greater photosynthetic capacity and crop productivity.

For example, in 2021 we had the worst drought ever in the state of Sao Paulo and a record number of fires in Brazil and worldwide. At Toca's Farm, we had nine millimeters of rain in July and August, compared with a historical average of 42 mm (a reduction of 80%).

Despite this, we harvested white oats for human consumption during this period. How was that possible? Our organic regenerative agriculture tripled the organic soil matter on the farm (from 1% to 3%). Soil with 3% of this matter is capable of absorbing and storing 196,000 liters of water per hectare more than soil with 1%.

When it rains a lot, this water does not erode or flood rivers. When there is a prolonged drought, like that in 2021, the water is saved longer for crops. So, we "planted" 69 million liters of water along with the oats on these 350 hectares of grain from at Toca's Farm Organics, the result of which applies not only to harvested oats but also to all subsequent crops over the years.

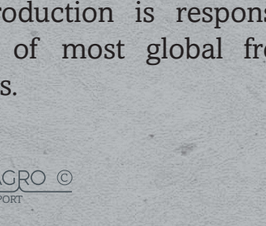
In addition, the use of biological and organic inputs helps a lot to maintain the quality of the water in the systems, since there is no contamination by pesticides or salinization and modification of the physical-chemical characteristics of this important resource for the maintenance of plant and animal life.

Water is essential for the cycles of living beings, allowing micro and macro-life to thrive.

WATER INDICATORDS ANALYZED:

AVAILABLE WATER CAPACITY

AWC



MARÍA VICTORIA RAMOS BALLESTER
LECTURER AT CENA/ESALQ

"In recent decades, multiple, complex, and interactive human activities have changed the Earth System quickly and profoundly. The mark left by human action spreads globally, affecting ecosystems and societies on all scales, raising concerns about how these changes can affect ecosystems and human well-being.

In addition, the demands for solutions derived from environmental science that society needs to adapt to global environmental changes are increasing. Food production is responsible for the use of most global freshwater resources.

On average, agriculture accounts for 70% of annual freshwater consumption by human activity. However, in many regions of the world, water for food production is used inefficiently, while the conversion of forests into monoculture areas results in the modification of the water cycle, and the high use of fertilizers and pesticides which in turn leads to environmental degradation by the depletion and pollution of aquifers, lakes, and rivers, as well as wildlife habitats.

In this scenario, organic agriculture and agroforestry systems are fundamental not only to mitigating global warming, but also to offer healthier food, produced with less of an environmental impact and in increasingly resilient systems.

These production models are increasingly adherent to the objectives of sustainable development and have become an important alternative in small, medium, and large-scale agriculture."

IT IS TIME TO ROLL UP OUR SLEEVS. OR RATHER, TO GET OUR HANDS DIRTY!

After doing studies and agricultural and financial modeling, Rizoma Agro has achieved a major goal: producing food profitably by expanding the limits of knowledge in the regeneration of organic production systems.

The indicators that are listed in the analysis protocol used by Rizoma Agro are, in essence, support for evaluations over time of how much each system can create a healthy productive environment in terms of carbon sequestration, attractiveness to biodiversity, and the optimization of water use.

Monitoring these indicators is vital to managing adjustments that will be needed. The management of quantitative and qualitative indicators allows an understanding of what are the best practices for the health of the productive environment are, in synchronization with increased harvest productivity and quality.

And all this will be shared, given that the principal goal is to regenerate the planet, uniting forces from the entire production chain in this much-needed step in the context of increased food demand.

In practical terms, the Rizoma Agro team has been working in the field for three consecutive years with a robust protocol created in conjunction with research institutions, such as Wageningen University & Research and the University of Sao Paulo, analyzing the data to measure the regenerative impact of the practices adopted.

The analysis is based on soil collection, monitoring by accredited laboratories, and reports made from 2019 to 2021. This provides the background, evolution, indicators that still need more time to be interpreted, and an overview of the company's regenerative capacity.

Good reading!

FERNANDO TERSI, OPERATIONS DIRECTOR AT RIZOMA AGRO

"The organic regenerative production system has succeeded in improving soil, water, and biodiversity regeneration indicators with excellent agricultural productivity results when compared with conventional agriculture.

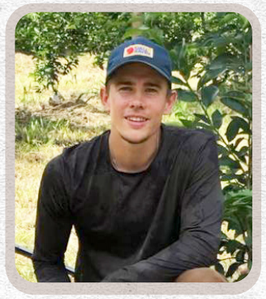
Rizoma Agro has achieved these good results in agricultural product productivity and quality through the continuous improvement of production standards and consequent balance of the productive potential of soils, combined with the use of agricultural equipment and production support adapted to the production system, the continuous training and development of our employees, and its association with researchers from research centers and universities, and partnerships with supply chain companies."

LUCAS PEREIRA, DIRECTOR OF THE GREEN INITIATIVE

"The restoration of native forests, agroforestry systems, and agriculture are seen today as some of the most important strategies for removing carbon from the atmosphere. These activities, in addition to contributing to the mitigation of climate change, are also fundamental for the provision of various environmental services, such as water flow regulation, sedimentation control, and so on. The UN declared that we are in the decade of restoration (21-30), because we urgently need to develop strategies for large-scale restoration across the planet."

MICHELLE SAVIAN PHD STUDENT AT UNIVERSITY COLLEGE OF DUBLIN

"The ecosystem services provided by agricultural land are much more extense than just the production of food, fiber, and biofuels. The impact happens throughout the chain, and not only inside the farm gate – and this is the analysis of the life cycle, which permeates the whole context of measuring agricultural practice, from inputs to end consumers."



JONAS STEINFELD, PHD STUDENT AT WAGENINGEN UNIVERSITY AND RESEARCH

"Regenerative agriculture is very promising, and I am very excited to see thatthe data show truly positive trends. It shows that we are not caught in a choice between producing a lot or regenerating: you can do both together."

ORGANIC MATTER

Decomposition of plant and animal material

WHATS IS THIS?

Transformations that occur from the incorporation of fresh organic matter to the formation of the most stable humified fractions comprise the evolution of organic matter in soil (GUERRA et al., 2008). The addition of organic matter in the soil occurs via the deposition of organic residues, mainly of a plant origin, but also animal. Through photosynthesis, plants capture atmospheric CO2, fixing it to plant tissue. Through the release of root exudate in the soil profile, during the growth phase of the vegetables, part of the C fixed photosynthetically is deposited in the soil. The remainder is incorporated into the soil by the addition of leaves or all stem parts of the plants, after their senescence.

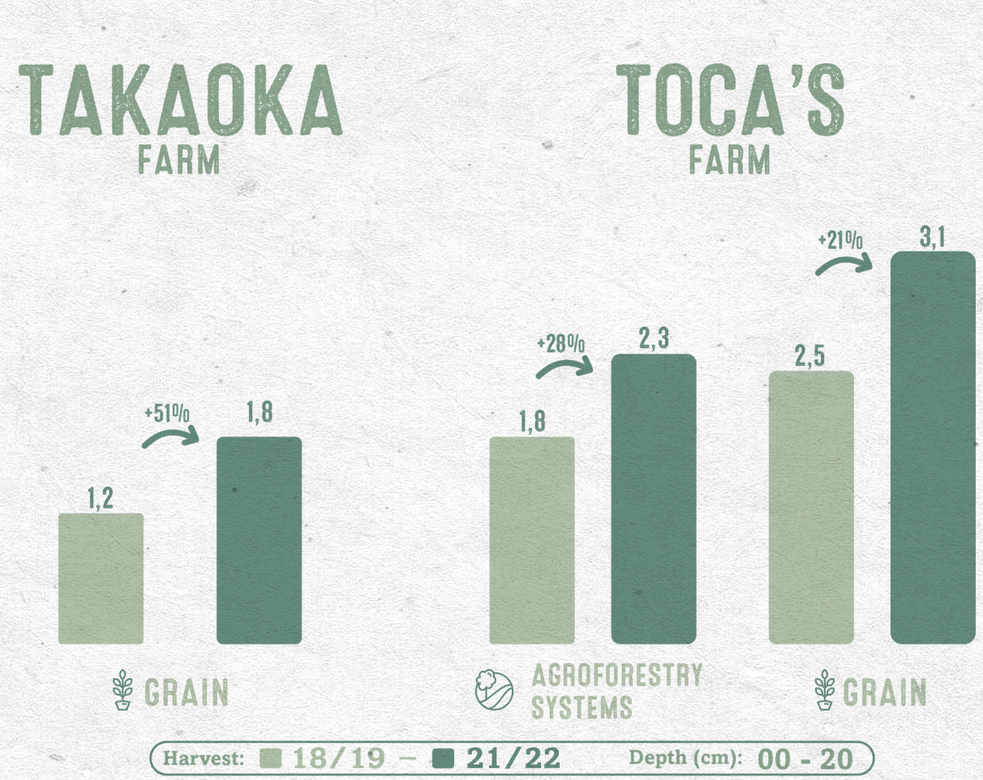
WHY WAS THIS INDICATOR CHOSEN?

The maintenance and improvement of soil quality in continuous cultivation systems is essential to ensure agricultural productivity and environmental quality for future generations. Organic soil matter plays an important role, being considered the main indicator of soil quality (LAL, 2004) and culminating in several other processes of soil health improvement, such as biodiversity and water retention capacity.

The higher the percentage of organic soil matter, the more the other cycles benefit – both in carbon sequestration and in increased biodiversity, greater water retention and better productive performance of the areas.

It is understood that organic matter is very positive in soils. But how does this organic matter behave over time, and how can we increase this factor of paramount importance in our areas?

As we can see in the graphs on the next page, both at Fazenda Takaoka and Fazenda da Toca, we have analyzed the organic soil matter indicator for four years since the 2018/19 season.

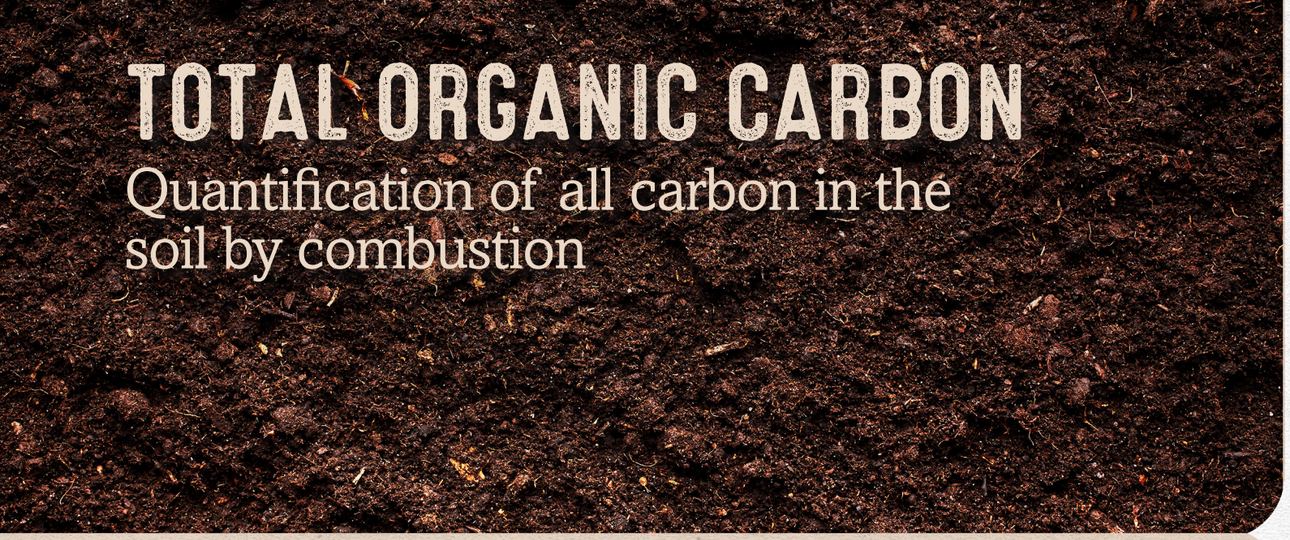


There is a clear increase in percentage levels in practically every plot of land, so our management is based on regenerative practices that provide this increase consistently.

In grain areas, organic soil matter is mainly increased by conservation practices such as minimum tillage and terrace construction, together with the practice of including poultry manure in high doses for nitrogen and potassium fertilization in production areas, as well as crop rotation and the use of green fertilizers.

Does this mean we are applying the best possible practice in grain production? Not necessarily. Potentially, the no-tillage system, without annual soil disturbances, retains much more vegetable and microbiological matter, further increasing our operation's ability to increase organic matter, and consequently sequester carbon. And we are looking to enable this system within the organic concept of production, without the use of herbicides, using new and developing tools for weed control.

In the agroforestry systems, where biomass accumulation and an absence of soil disturbance allow even more interesting results for organic matter accumulation and other indicators (which will be seen later in this report), the data also show very interesting values in organic soil matter increases. In summary, on both farms and both systems studied the development of organic soil matter is evident, so we are on the right track.



TOTAL ORGANIC CARBON

Quantification of all carbon in the soil by combustion

WHAT IS THIS?

It is the measure of all the carbon in the soil, be it in living microorganisms or in organic matter at different levels of decomposition. This data allows calculations of carbon balance in the different systems analyzed.

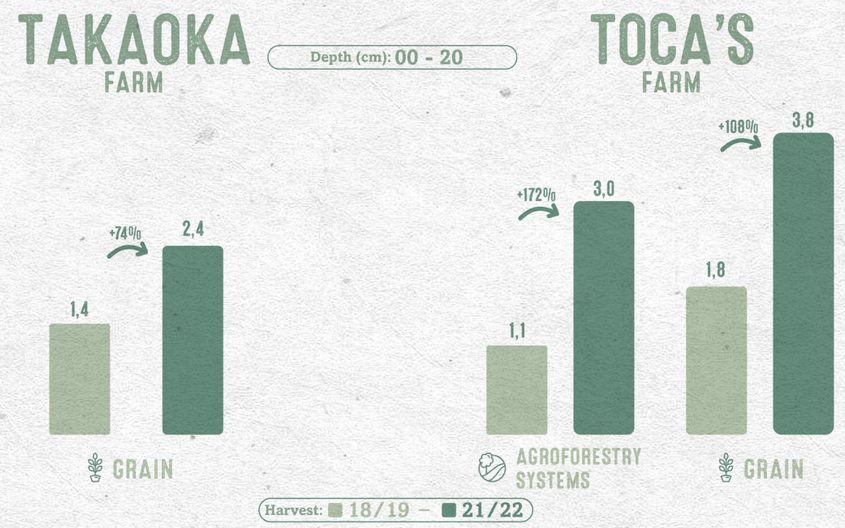
WHY WAS THIS INDICATOR CHOSEN?

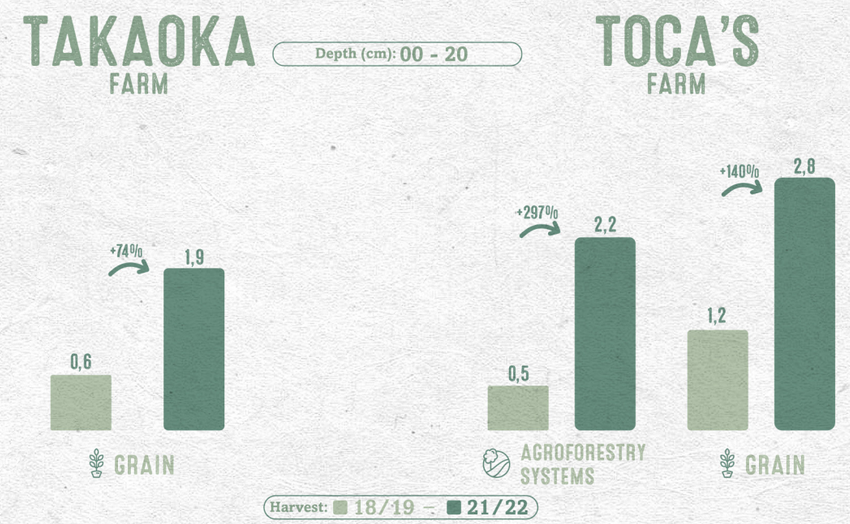
As organic matter is a key attribute in the soil regeneration process, as an increase makes the system as a whole function better (from increased microbiology, to improved plant growth and productivity) and it improves carbon sequestration rates, TOC evaluation offers robust analysis of increased carbon chains in the soil and, therefore, organic matter and the carbon balance of the systems.

The measurement of total organic carbon in the soil is very important as a complement to organic soil matter analysis, as it is a direct measure, without correction factors, and provides a real understanding of the carbon balance in the soil.

Together with Wageningen University in the Netherlands, we have been analyzing this indicator since the 2019/20 harvest, making three years of soil carbon collection through combustion, which burns all the C content present and provides precise information on the soil contents.

This is an indicator that we are now able to understand better. The graphs on the next page show a significant elevation in the levels of C, both at Fazenda Takaoka and Fazenda da Toca. The results in the 20-40cm deep layer are very interesting. The carbon contained in the surface layer (0-20cm) is usually more unstable, newly decomposed, or even contained in the active microbiota.





In the subsurface layer (20-40cm), the high levels mean that, whether in grain or agroforestry production, we are managing to retain carbon in its most stable fraction, previously decomposed by microorganisms and more strongly bonded to soil.

This is, therefore, the safest way to stock carbon in the soil, given that it is less susceptible to losses from surface management (tillage and other conservation rotations).

Most likely we are talking about a set of factors assist in increasing carbon throughout the soil profile, both through good practices, rotations, additions of organic fertilizers, and organic management (which allows maintenance of other aspects that are also important in the soil, such as functional biodiversity and macro-organisms that act in the formation of initial particulates of organic matter).

ENZYMATICS PROCESSES

Enzyme indicators for soil organic matter decomposition, and phosphorous and sulfur solubilization

WHAT IS THIS?

When the soil microbiota decomposes organic soil matter and other cycles to feed itself, these organisms release specific enzymes that can be used to measure decomposing levels, which can be understood indirectly by the enzymatic activity in the soil, measuring whether microorganisms (bacteria, fungi, and other beneficial lifeforms) are present and acting in the areas.

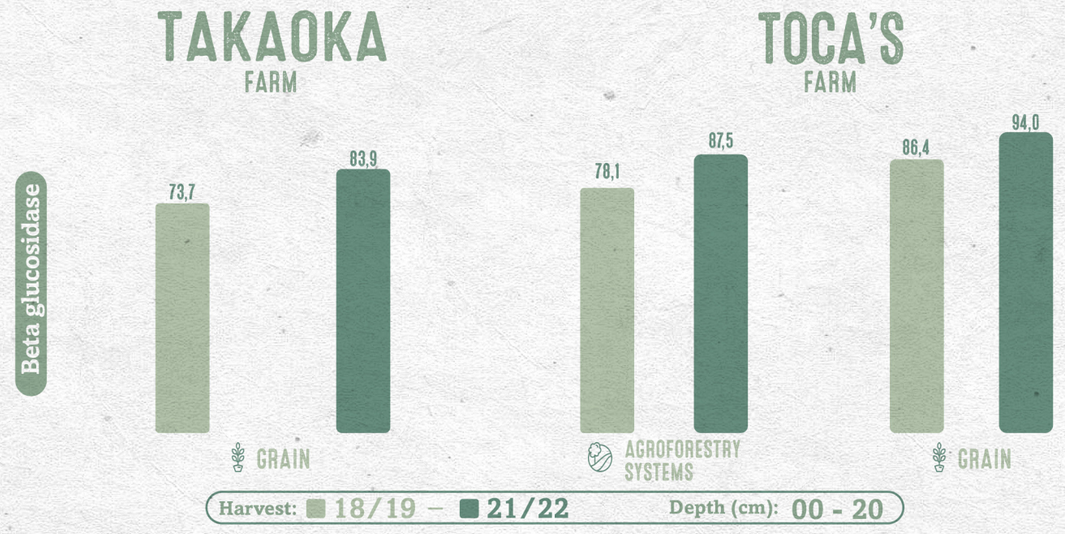
WHY WAS THIS INDICATOR CHOSEN?

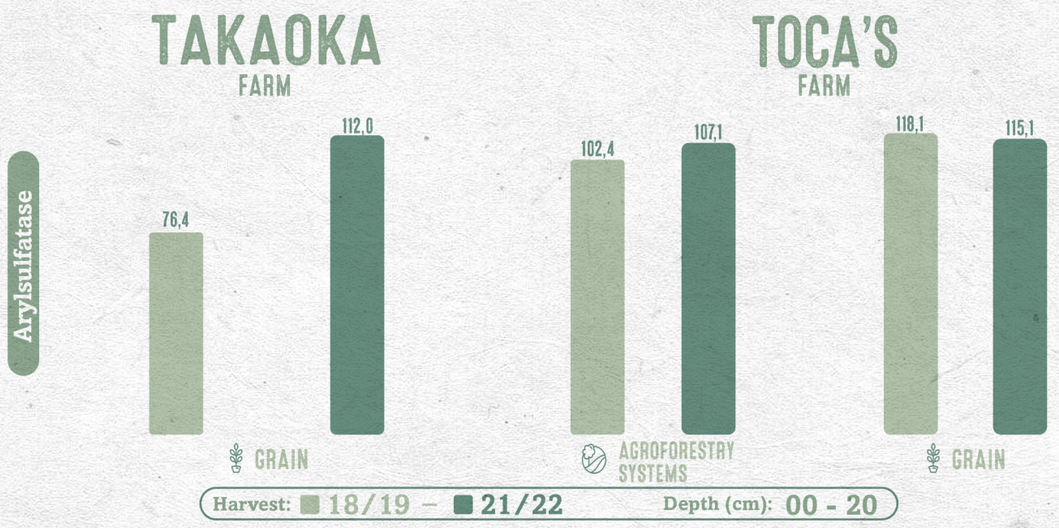
The analysis of the activity of some enzymes, such as beta glycosidase, arylsulfatase, and acid phosphatase, is important to potentially infer how active the soil microbiota is in the decomposition of organic material in the soil and, therefore, the indicator was chosen to correlate the presence and elevation of enzyme content with microbiological activity in the different systems. This contributes to nutrient cycling processes (mineralization) and a gain in productivity.

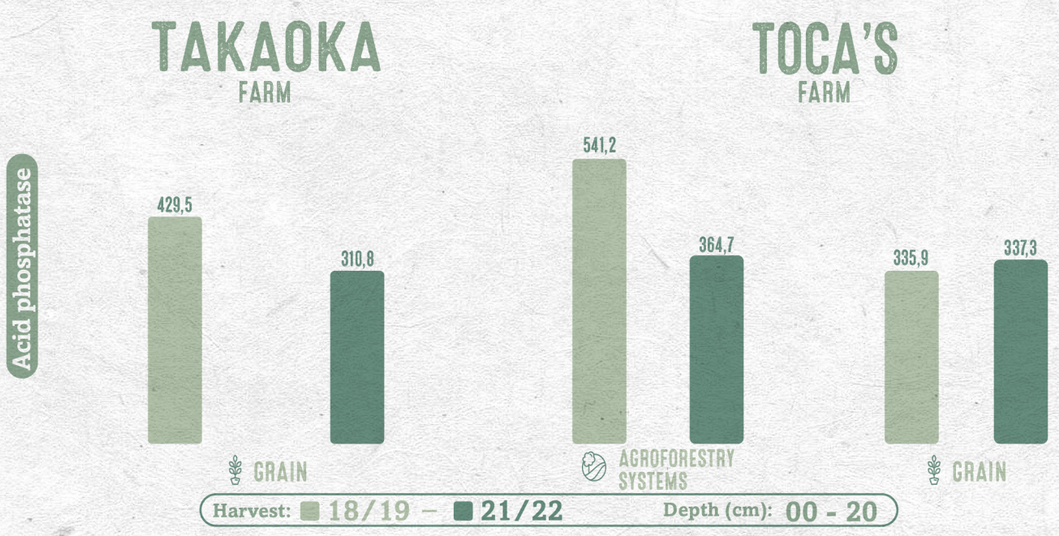
First, it is important to understand the difference in interpretation between the indicators on the next page. For beta glycosidase (the enzyme responsible for decomposition of chains of organic matter) and for arylsulfatase (the enzyme responsible for breaking sulfur chains), ideally higher levels are expected over time. This increase shows we are enabling these microorganisms to live and reproduce and, consequently, to work for us in the production areas.

In the case of acid phosphatase, an enzyme responsible for making labile phosphorus available from the systems to the plants, the evaluation is not exactly linear. That is to say, in well-corrected soils with high phosphorus availability for plants, there is no stimulus for microorganisms that release acid phosphatase. The three enzymes are analyzed only in the 0-20cm layer, where almost all generalist microorganisms working in the soil are concentrated.

So, this is the first group of indicators not evaluated in the 20-40cm layer for this reason. In the literature, much is said about organic matter and its relationship with enzymes released by microorganisms. In this case, from the work carried out by Rizoma Agro, we did not find a direct correlation between them, but it is clear that the grain and agroforestry systems allow an increase in both organic soil matter and microorganisms, which has a very positive impact on the regeneration of agricultural environments in this comparison from 2019/20 to 2021/22 (a total of three years).







MICROBIAL BIOMASS CARBON

Quantification of carbon from microbial biomass in soils

WHAT IS THIS?

It is the evaluation of the proportion of carbon present in the cells of living organisms in relation to the total organic carbon in the soil.

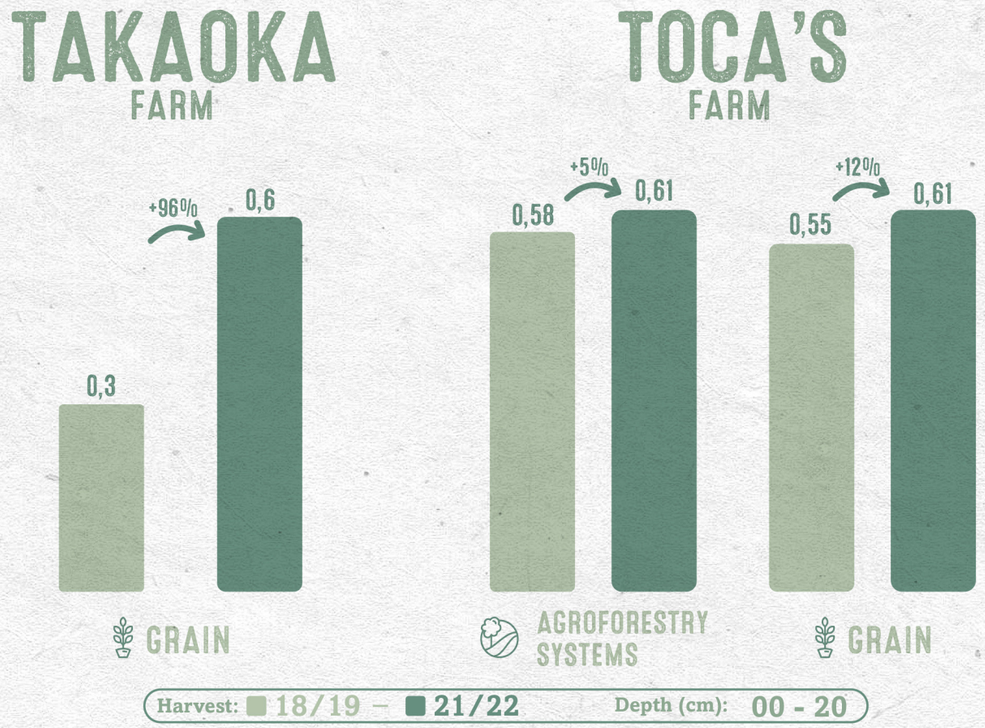
WHY WAS THIS INDICATOR CHOSEN?

Total organic carbon is one of the indicators analyzed in the protocol. However, the indicator for the microbial biomass carbon ratio in relation to total organic carbon indicates how much of this carbon is in the living and active phase of the soil, besides acting on physical properties, such as soil aggregation.

Biomass carbon is composed of what is called total organic carbon, a measurement that encompasses all forms of carbon chains in the soil. The higher the ratio between biomass carbon and total organic carbon, the richer the soil is in microorganisms (living and dead).

In the same way as other microbiological indicators of enzymes, microbial biomass carbon is also evaluated only in the 0-20cm layer. In both farms the levels increased significantly in this comparison from the 2019/20 season to 2021/22 (especially Fazenda Takaoka). This means that, regardless of the type of microorganism (bacterium, fungus, protozoan, or nematode), there is an increase in microscopic life present in the soils of the productive areas owned by Rizoma Agro.

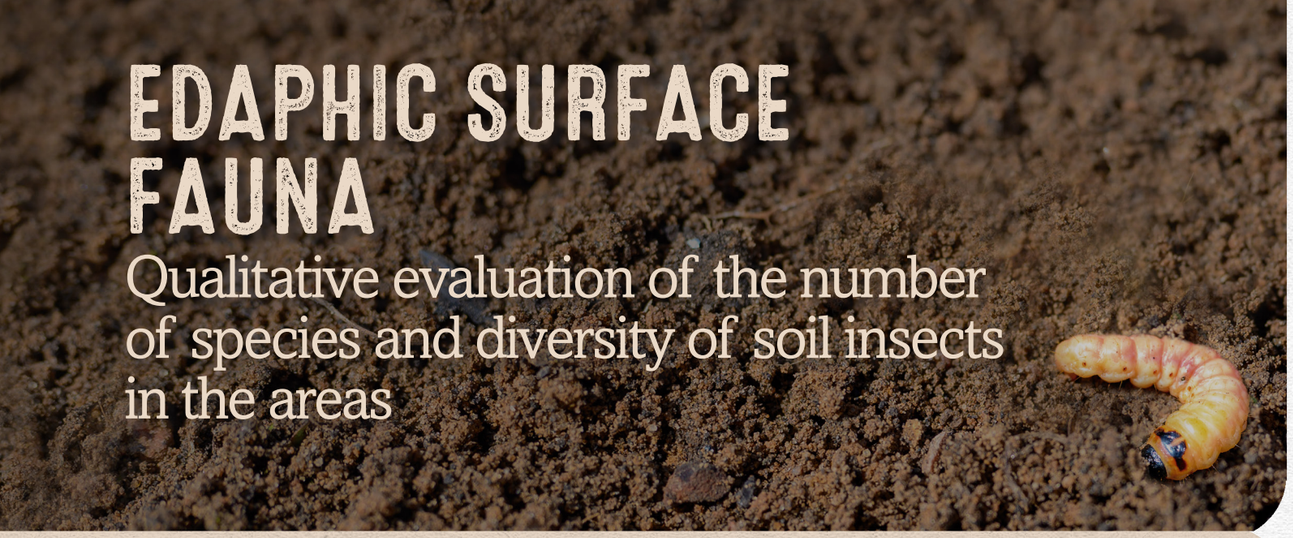
Microbial biomass carbon, as well as other microbiological indicators, form a virtuous cycle with the elevation of organic soil matter (and total organic carbon), where one feeds the other, and vice versa. So, when we use a system to improve carbon sequestration, we are in turn improving the ability of beneficial microorganisms to survive and reproduce.



This directly impacts the balance of microscopic populations, which could possibly be pathogens and which, in conditions of greater competition with countless other groups of microorganisms, become less problematic for crops.

This indicator, although invisible, is very important. Having bacteria and fungi in abundance in agricultural systems means occupying rhizosphere binding sites that could be occupied by pathogens – that is, microorganisms that are harmful to crops.

In addition to this antagonistic and suppressing effect, the biota in healthy, balanced soils is responsible for making the unstable fraction of carbon more stable, therefore, not worsening the greenhouse effect and climate change.



EDAPHIC SURFACE FAUNA

Qualitative evaluation of the number of species and diversity of soil insects in the areas

WHAT IS THIS?

This is a quantitative and qualitative analysis of arthropods in the soil for analysis of insect diversity and permeability for the systems studied.

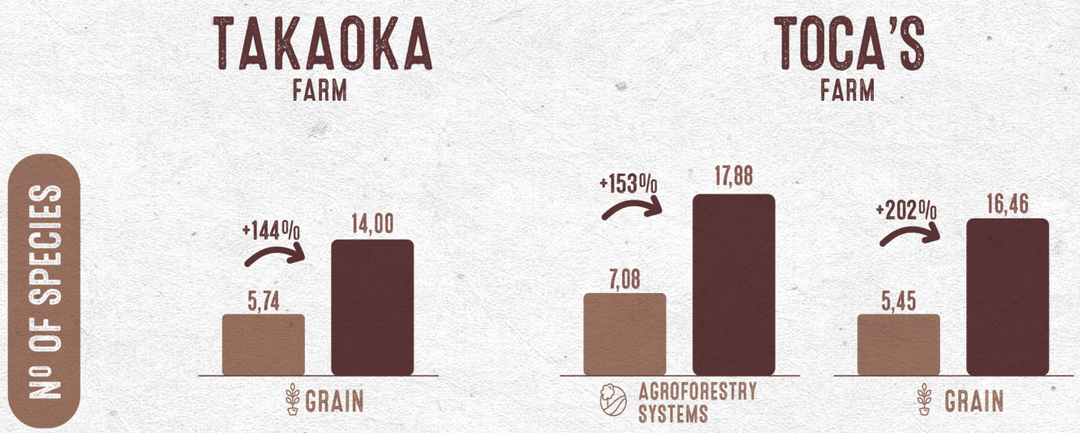
WHY WAS THIS INDICATOR CHOSEN?

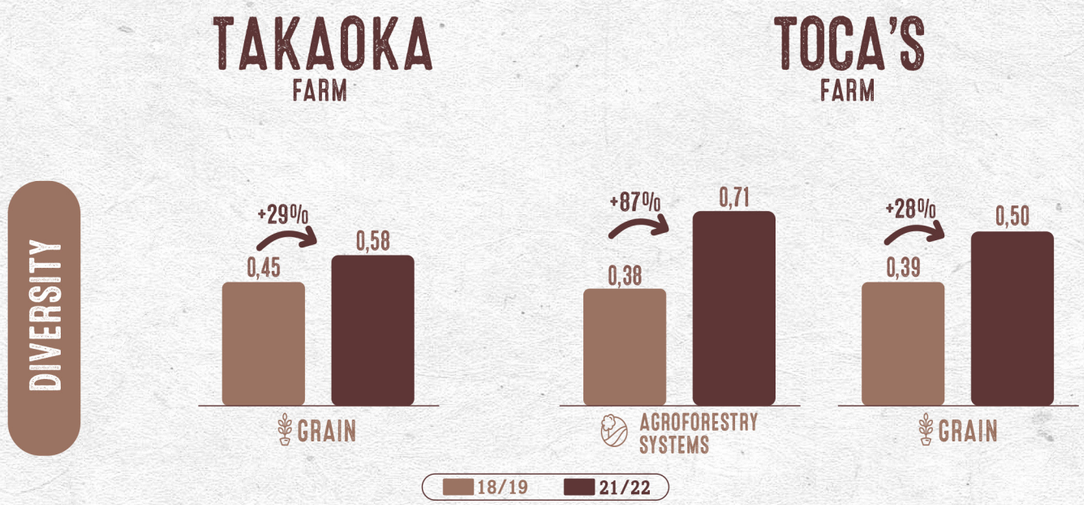
Considering that the action of microorganisms in the decomposition of organic matter is only possible after the action of the edaphic insect fauna, which reduces large particles to small, assimilable particles, this indicator was chosen because of the need to verify which, and how many, species are forming soil pores, reducing fragments of organic matter and, therefore, facilitating the penetration of roots, improving plant productivity. In addition, a diverse range of arthropods indicates a more balanced productive environment and may be a precursor to the appearance of antagonist species - predators, parasites, or competitors - that help in the biological control of the areas.

Insects are extremely important to the initial processes of decomposition of coarse particles of organic matter, such as branches and leaves. Because they are large organisms, compared with microbiology, they more efficiently bioturbate material for the subsurface.

The larger the number of species, the better. And the higher the diversity index, the better. But what does that mean?

The number of individuals alone does not tell us much; after all, a sample could contain many individuals of a single species, generating functional redundancy and eventually suppressing populations of other species. When the indicator is for a number of species, we have a broad spectrum, which tells us something more qualitative.





And finally, when the indicator is for diversity, we are creating an index of the interaction between individuals and the number of species, generating a ranking that shows balance in the systems. The closer to one, the more balanced it is.

Both at Fazenda Takaoka and Fazenda da Toca, a significant increase in the number of species can be observed for grain and agroforestry systems. Even more relevant to the productive environment, an increased diversity of these systems is noted, enabling functional redundancy and the occupation of different niches and activities by these insects and other small detritivores.

Again, biodiversity is helping the agroecosystem.

POLLINATORS

Assessment of pollinating insect presence and diversity in agroforestry systems

WHAT IS THIS?

It is an indicator that counts, identifies, and analyzes the presence of pollinating insects in Rizoma Agro's agroforestry systems and undergrowth using traps left for approximately eight hours in each collection area.

WHY WAS THIS INDICATOR CHOSEN?

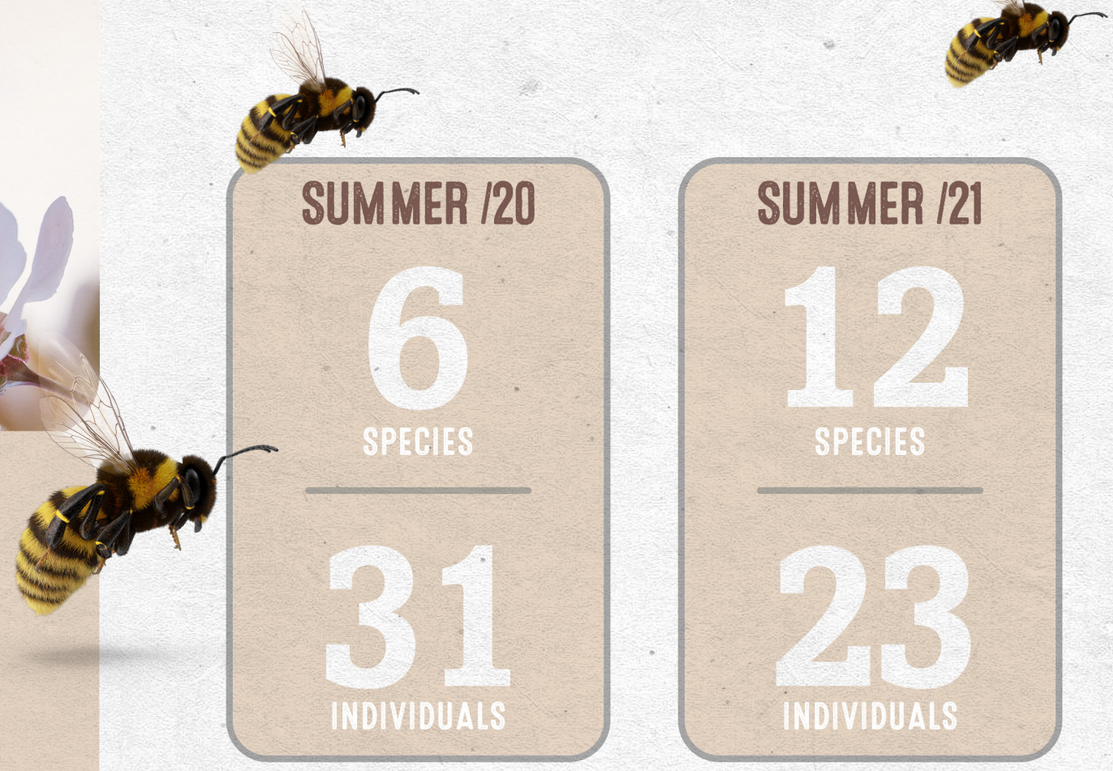
Pollinators are essential to the functioning of ecosystems in general. Several studies have shown that the use of agricultural pesticides has lethal effects on these insects, causing losses to biodiversity and risks to food production. As an organic regenerative producer, Rizoma Agro is very interested in encouraging pollinators in its production systems.

Although limes are self-compatible - that is, they do not require pollination to produce fruit, pollinators help productivity, and allowing the free transit of these insects increases pollinating biodiversity and improves ecosystem maintenance.

The methodology used - terrestrial traps placed for eight hours - may underestimate the diversity and quantity of individuals present in the systems, since they are set at a lower height than flowers. This methodology is used by Rizoma Agro for its practicality and ease of replication in various systems and locations, and it produces relevant data.

All the species found in 2020 were found in 2021 as well, which indicates that these species are always present in the sampled areas.

Analyzing the species found this year, two species of stingless bees were identified: Melipona SP and Paratrigona lineata. This is a very important data, as stingless bees are responsible for 40 to 90 percent of tree pollination in Brazil.



Dialictus sp and Auglochlora sp, which are from the halictidae bee family, were also found in the samples. They are small to medium size bees of bright metallic color and can vibrate their antennae, so pollinating species for which pollen is the only floral resource - such as annatto, tomato, passion fruit, and pepper.

Some of the species found in the samples (Hylaeus sp, Psaenythia bergi, Dialictus sp) are classified as solitary. Having them in the system is an excellent indicator of environmental preservation and biodiversity accumulation, as they have difficulty surviving in environments with greater imbalances, where more aggressive and social bees (such as Apis mellifera) dominate.

The larger presence of species in 2021/2022 compared with the season before indicates that the agroforestry system is encouraging permeability and reproduction for these bees.

The ecosystem service provided by pollination is well known, but nevertheless often underestimated. The maintenance of bees in agroecosystems is synonymous with food production for humans.

NATURAL ENEMIES

Qualitative assessment of soil insect diversity and richness in the areas

WHAT IS THIS?

It is an indicator of the diversity and richness of natural enemies in organic agroforestry systems with limes and conventional monocultural areas of the same crop.

WHY WAS THIS INDICATOR CHOSEN?

Considering the importance of natural enemies to the biological control of key pests in lime crops, analysis of the diversity and richness of these individuals in different management systems is of great help in understanding the effect of pesticides on beneficial biology that assists in the balance and maintenance of plant health for citrus plants.

The greater the abundance and richness of natural enemies, the higher the level of pest and disease control in crops, which can reduce the need for inputs for phytosanitary control.

The table below shows the quantity and diversity of natural enemies are significant in agroforestry systems focused on by this analysis.

	AGROFORESTRY SYSTEMS		CONVENTIONAL SYSTEM	
	Individuals	Species	Individuals	Species
NATURAL ENEMIES Diversity and richness	20	10	11	4
ARANEAE Spiders	4	3	1	1
COLEOPTERA Beetles	3	2	0	0
NEUROPTERA Chrysopidae	3	1	1	1
HYMENOPTERA Bees, hornets, ants, etc.	6	2	9	2
	Vespidae and Aphidae		*Only species of the formicidae family	
HEMIPTERA Bugs	3	1	0	0

AVAILABLE WATER CAPACITY

Quantitative assessment of soil water retention

WHAT IS THIS?

It is the specific capacity that soil has to retain and store water for a given time, so providing water for plant development, microbiological growth, and nutrients in the soil solution. It can be calculated by the difference between field capacity and permanent wilting point.

WHY WAS THIS INDICATOR CHOSEN?

The available water capacity is specific to each type of soil but can be influenced by the management adopted and the variation of organic matter in the soil. Therefore, this indicator was chosen.

WHY DO WE NOT HAVE CONCLUSIVE DATA ON THIS INDICATOR YET?

This indicator, although very important for Rizoma Agro, as it signals the potential resilience of systems to bad weather, especially in Indian summers, is recommended for long-term assessments. It may take five years to see some results. So, we chose to present this attribute of available water capacity only at the most opportune time.

It is of interest to Rizoma Agro that all attributes be analyzed in depth, for carbon, biodiversity, and water. Other indicators that take in micro and macro scales of the landscape are still being studied and could result in rich studies in the future.

FIELD SAMPLING PROTOCOL

Choice of sampling points and collection process

Just as for the well-known collections for chemical analysis of soil, the choice of sampling points must be made carefully, ensuring the representativeness of the data to be analyzed later.

The points chosen should be in zigzags, making 10 to 12 points per homogeneous plot (the sampling unit does not exceed 30 hectares). In plots larger than this, subdivision is suggested so that a composite sample is not made in a very large area.

Each of these 10 to 12 points generates a simple sample, which must be homogenized with the other points to form a composite sample, and this must be properly identified and forwarded to laboratories or other places for analysis.

The identification mentioned above must be done carefully, avoiding errors or misunderstandings. It should contain collection date (day/month/year), the farm name, plot name, depth, indicator to be analyzed, and the name of the person who collected it.

In this protocol there is no need to refrigerate any samples, if they are kept in a cool environment and forwarded within three days to their respective analysis sites.

Collections may be made following the same procedure in neighboring areas and scrubland, to compare results, facilitating an understanding of the level at which the indicators are found in the sampled location.

Other analysis can help in understanding the results, such as macro and micronutrients, pH, cation-exchange capacity, organic matter, base saturation (V%), and crop productivity in the areas.

Careful analysis of the collection points, the accuracy of the collection at each point, and the correct identification of each of the points are critical, as the results represent an entire area and any error in depth, for example, represents a large sampling error that can directly interfere with the analysis and subsequent result.

A table should be produced in Excel, or equivalent tool, with all the statuses of each sample, the nomenclatures of points sampled, all the indicators, and respective locations to fill in the results, bringing reports together and allowing a visual comparison of the plots using different indicators.

FIELD COLLECTION MATERIAL CHECKLIST

- Dutch auger (TOC and microbiology)
- Large knife (TOC and microbiology)
- Reinforced plastic bags (Size A4) (TOC and microbiology)
- Pen and labels for sample identification (all)
- Hoe (all)
- Plastic tape measure (1m) (all)
- Volumetric rings (AWC and density)
- Small hammer (1kg) (AWC and density)
- Small piece of wood to use with the hammer (AWC and density)
- Roll of plastic film (AWC and density)
- PPE: shoes, long pants, long sleeve shirt, leg protection, cap, and sunscreen; gloves/goggles may be required

SPECIFIC MATERIAL FOR COLLECTING POLINATORS, EDAPHIC SURFACE FAUNA, AND NATURAL ENEMIES

- 200ml pots painted blue, yellow, and white (pollinators)
- Transparent 200ml pots (edaphic fauna)
- Barbecue sticks (edaphic fauna)
- Plastic or Styrofoam plates (edaphic fauna)
- 1m support for plates (pollinators)
- Water + detergent solution (950ml + 50ml) (both)
- Alcohol 70% (both)
- Fine sieve (both)
- Post hole digger (edaphic fauna)
- Pen and labels for sample identification of samples (both)

TOTAL ORGANIC CARBON (TOC)

The collection should be made at two depths: 0-20cm and 20-40cm.
With the aid of the Dutch auger, collect from all the simple sample points (10 to 12), scraping lumps or excess on the sides of the auger with a knife.

The final composite samples must contain 100g per sample and the final number of samples sent to the laboratory is equivalent to the number of plots (sample units). After packing the samples in a properly identified plastic bag, take them to a reliable laboratory that performs elemental carbon analysis via dry combustion in a LECO TruSpec® CNHS Micro elemental analyzer and wait for the results. After getting the data, transpose the information into the appropriate analysis worksheet.

MICROBIOLOGICAL ANALYSIS

The collection should be carried out at a depth of 0-20cm, only. With the aid of a Dutch auger, collect the points in each of the plots (10 to 12), following the same protocol as for total organic carbon collection. The final composite samples must contain 100g/sample, and a single collection process can be made for all the indicators (TOC, enzymes, and microbial biomass carbon). The samples should be sent to an accredited laboratory that can perform two analyses:

- Analysis of enzymes by the colorimetric determination of p-nitrophenol sulfate after incubation of the soil with a solution buffered with a substrate specific to the three enzymes (beta glycosidase, arylsulfatase, and acid phosphatase), with a reading performed by a spectrophotometer at 410nm, and enzymatic activities are obtained by interpolation in a standard curve with a known concentration of p-nitrophenol sulfate (results expressed in µg PNS/g of soil/hour);

-Carbon analysis of microbial biomass by fumigation with alcohol-free chloroform and extraction with potassium sulfate, comparing them with an extract from the respective non-fumigated control soil (result obtained by the difference between the fumigated and non-fumigated sample, expressed in mg of Soil C/g).

WATER

Collect undeformed soil samples with the aid of a stainless-steel volumetric ring (50mm x 50mm) at depths of 10cm and 30cm (to occupy the average space between the layers of 00-20cm and 20-40cm), with the aid of hoe to open the collection ditch, a small hammer and piece of wood that prevents the hammer from hitting the soil contained in the rings.

After collection, the samples should be wrapped in plastic film and, having been identified, sent to an accredited laboratory for analysis of available water capacity (and in this same analysis, the results of soil density are produced).

Note that in this indicator, because it is an undeformed sample, it is not possible to generate simple samples and composite samples. So, instead of 10 to 12 points per plot, collect from only three points per plot, sending them to the laboratory and generating triplicates for the results.

ABUNDANCE AND RICHNESS OF POLLINATORS

This evaluation should demonstrate way bees behave in each system or crop on the property. For each system or plot sampled, 10 to 12 points will also be sampled.

Traps must be installed at each of these points. Each trap consists of three colored pots on the ground - one white, one blue and one yellow - covered with water + detergent, which attract different bees and trap them in the aqueous solution with a low surface tension.

The traps should be as close as possible to the plants of interest. In the forest, if the installation is made for comparative analysis, they should be in the an environment that is most similar to the agroforestry system - that is, with good lighting and the free flow of insects.

After 24 hours, the traps should be removed from the field, grouped (samples from the simple samples, preferably maintaining separation by color) and identified, and the bees should be removed from the water and detergent solution and immediately packed in glass bottles with 70% alcohol solution and with tops to maintain the characteristics required for identification at an accredited laboratory.

Some important points to note:

- Homogenize the time of installation and collection of the traps, installing them with a maximum of one hour difference between the first and last.

- Collect the traps 24 hours after their installation, following the same sequence as at the time of installation.

DIVERSITY OF EDAPHIC SURFACE FAUNA

The method for obtaining data to be used is passive, using traps.

For this passive methodology, install 10 to 12 plastic pitfall traps with a capacity of 500ml buried at ground level (with the aid of a post hole digger) per field, placing a plate on top of each trap to avoid direct sun or rain harming the trap.

The traps must contain a 200ml water + detergent solution, so the insects fall in and cannot get back (the top of each pot should be level with the soil on its sides, with no mound of land hinders the insects).

After 48 hours, remove the properly identified samples and transfer all the individuals collected in each field to a single container with a 70% alcohol solution.

The evaluation should take place as soon as possible, identifying morphospecies to calculate the diversity index (Shannon & Weaver) and equability (Pielou), classifying individuals collected by size (<0.2mm, >0.2mm/<2mm and >2mm), and analyzing more important categories, such as ants and termites. If it is not possible to do an on-site evaluation, use an accredited laboratory.

Specificity of this collection:

Do not keep the traps in the field on nights below 10°C (which significantly reduces the movement of insects) and do not install the traps when more than 10mm of rain is forecast.

DIVERSITY AND RICHNESS OF NATURAL ENEMIES

The collections should be carried out following the proposed methodology for specific crop inspection.

For example, in the case of perennials such as citrus plants, twenty plants should be analyzed in each citrus sampling unit.

Each of these plants should be divided into four quadrants (such as north, south, east, and west) and in each quadrant three branches and one fruit (if any) should be looked at.

One analysis should be of the shoots, one of the leaves in the middle of the canopy, and one of the leaves in the inside of the canopy.

The inspection, carried out for organisms visible to the naked eye and for organisms visible using a 10x magnifying glass, should be followed by putting the sample is a rigid pot with wide top and screwcap, approximately half filled with a 70% alcohol solution.

After collection, the samples should be kept out of the light and quickly sent to an accredited laboratory, which will identify, count, and classify the natural enemies present in the samples and issue a report.

RIZOMA AGRO

SPECIAL THANKS

Nature teaches us about interdependence. We are one great organism that works in unison, supporting life and teaching us lessons.

Similarly, this report is the result of an effort made over many years for this noble purpose – co-creating solutions for organic regenerative agriculture. We at Rizoma Agro now take this opportunity to thank all our partners who have worked with us on this mission.

Everyone who has worked on organic regenerative agriculture in the past, in any scale of production.

Our suppliers of seeds, biological inputs, fertilization inputs, machinery, and any other support for agricultural systems.

Rizoma Agro employees who have worked so well over these crop seasons, doing their best to make it happen.

The buyers of our products, making our business viable.

Our financial partners, who believe in what we do and invest in the idea.

Our academic partners, who have worked in R&D and measured the regenerative capacity of our operation.

We count on this great network of stakeholders, certain that all the links in the chain will strengthen the regenerative movement in Brazil and worldwide.

CENTRAL OFFICE - SÃO PAULO / SP

TOCA'S FARM - ITIRAPINA / SP

TAKAOKA FARM - IARAS / SP

DRYING SOLO - CERQUEIRA CÉSAR / SP

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