Regenerative Fertility / ART Fertilization

1 - Plant Nutrition from the ART point of view

Looking at plants as autotrophic living beings makes it easier to understand their nutritional needs. Unlike animals, they produce their own food from sunlight.

The main nutritional process of plants occurs through photosynthesis which happens in its green leaves. This process needs some elements to happen:

- 98% are cosmic elements: light, heat, C02 and planetary influences.
- 2% are terrestrial elements: macro and micronutrients + useful nutrients.
- The water that constantly travels through the raw and elaborate sap. When transpired by the stomata the water becomes a fundamental factor for photosynthesis to happen.

All these elements are essential for plant nutrition to occur, therefore, ART fertilization processes also occur at these 3 levels: (A) cosmic nutrition, (B) terrestrial nutrition and (C) water availability.

It is important to emphasize that plants are social beings and that they live in constant mutual relationships with others. The soil is a place where important partnerships occur among plant roots and many species such as: bacteria, fungi, algae, arachnids, earthworms, just to name a few. Those relations are fundamental for plant nutrition and the preservation of them is important, especially considering terrestrial nutrition.

(A) Methods to foment cosmic nutrition

Cosmic nutrition "comes for free" to Earth and it is necessary to adjust them whenever possible. The ART principles for that are (i) protect the plant from excessive wind-induced transpiration, (ii) keep the appropriate heat amount, and (iii) adjust the degree of sunlight. All those principles aim to favor photosynthesis in the cultivation area, through the following measures:

1) Strips of windbreak trees in the form of agroforestry strips, in a distance of 14 to 22m between them. For this purpose, fertilizer trees are used. They provide RCW, reduce wind speed and stabilize photosynthesis. Over time they increase crop productivity by 20%.

2) Mulch with layers of RCW. The use of 1 to 2.5 cm layers 1 or 2 times a year is sufficient to preserve water available in the soil. The water is used for transpiration by preventing excessive evaporation. Covering soil also favors the life of other beings.
3) Polycultures. They increase the leaf area per soil area, multiplies commercially useful photosynthesis and protects the soil from the devitalizing effects caused by the excessive tropical sun.

(B) Methods that harmonize terrestrial nutrition

When we talk about terrestrial nutrition it is necessary to guarantee full fertility, and not only chemically. Full fertility is the effective availability of nutrients + physical and biological fertility. The great ART inspiration is based on what happens in Tropical Forests: the ground is always covered and protected.

ART prioritizes biological fertility, and this takes care of chemical and physical aspects. The double layer of soil protection by RCW and green manure at least 2 months of the year, added to polyculture, simulates what happens in the tropical forest. The practices adopted are:

1) Once a year the application of 12 to 25 ton/ha of RCW. In Southeastern Brazil the suggestion is to apply it in November (beginning of rain season) or in April (at the beginning of the dry season).

2) Planting of dense green manure 1 to 2 times a year for better soil coverage and inhibition of weeds. In the beginning, for soil recovery, it is recommended the use of a high proportion of leguminous species. From the 2nd year they can be reduced and increase the amount of green manure from other families such as corn, sunflower, millet and forage turnip. Suggestion for duration of green manure on field:

- 120 days in the 1st cycle, during the warm and rainy season.
- 75 days during the peak rain, from December to February.
- 45 days in the high winter of June and July.

From the 4th year onwards, and especially after the organic matter content of the soil reaches an ideal %, a single green manure is enough.

Area (Treatments)	**Fertilizing Summer**	**Commercial Planting Autumn**	**Fertilizing Winter**	**Commercial planting Spring**
Time	75 days	125 days	45 days	120 days
Ruas	RCW + durable green manure	Vegetables and herbs	RCW + Winter green manure	Vegetables and herbs
Florestal Stripes	Weeds management	Fruit growing	Weeds management	Fruit growing

1) Management of weeds biomass: ART favors the growth of broadleaf weeds through selective weeding of grasses and sedges. Broadleaf herbs are very welcome as they favor fertility during the growing season. They keep the soil covered and have the advantage of growing spontaneously. But they also have to be frequently managed.

2) Agroforestry polycultures: between the forest strips are densely planted vegetables, herbs and fruit trees. Companion planting prevents the soil from running out of living ground cover and losing organic matter.

(C) Water availability

The sum of the above methods (A) and (B) favors the availability of water for cultivated plants, even in dry farm agriculture. This availability depends on two factors: water storage in the soil and useful water spare for photosynthesis. Temporary water deficit depends on the sum of those two factors. Together, they are potentiated as follows:

Water storage in the soil (RCW + Green manure)	**+**	**Useful water for photosynthesis (Forest strips)**	**=**	**Available water (Productivity)**
Increase of OM at least 5%		Windbreak effect		Evaporation decrease
>Macroporosity = water infiltration		< Stomatal closure		More water for sweating = more photosyntynthesis
>Microporosity = water storage		> water flow for transpiration		Less need of irrigation (decrease of é up to 1/3)

ART practices to maintain the available water in the soil acts on the following ways:

1. By increasing the capacity of the soil to receive rainwater: to increase the infiltration capacity of the soil its macro-porosity must rise. This is done by preventing the impact of raindrops and favoring soil life, especially earthworms. The use of green manure, RCW mulch, densification of plants by polyculture, intercropping of fruit and vegetables and the forest strips favor macro-porosity.

2. By increasing the soil water retention capacity: the microporosity of a soil is favored by technologies that increase its humus amount. The humus ratio rises when the input of OM is bigger than its output, which happens as CO2. The OM is provided by the intensive input of biomass: RCW, green manures and management of broadleaf weeds. Those managements also reduce the temperature of the soil and decrease the loss of humus.

3. Protection of the system against wind, which occurs due to the presence of forest strips. They significantly reduce the evaporation of water from the ground to the atmosphere and favor the maintenance of the stomata open, favoring transpiration and, consequently, photosynthesis.

2- Rameal chopped wood sources (RCW): the use of planetary trees

We have a specific chapter for those who would like to know the fundamentals of planetary trees.

In this context we recommend the use of trees that are well adapted to the climate where you are planting and that have good regrowth. It is important because they will provide branches every 2 years. You can also plant exotic and hardwood trees to be used as a source of income in the future.

Suggestions of trees and shrubs to be used as source of RCW, and according to planetary qualities:

	Trees	**Especial plants**	**Shrubs**
Planets	**Classics**	**Medium large size**	**Small**
Moon	Mulberry	Banana tree	*Schefflera arboricola*
Venus	Synamom	Moringa oleifera	*Tecoma stans*
Mercury	*Anadenanthera colubrina*	*Acacia podalyriifolia*	*Malvaviscus arboreus*
Sun	Peach palm	Araucaria	*Dracaena trifasciata/Sphagneticola trilobata*
Mars	Jackfruit	Bamboo	Annatto
Jupiter	Avocado tree	*Syzygium cumini*	Hibiscus
Saturn	Eucalyptus	Conifers	*Dombeya wallichii*

Those trees are planted in forest strips at a distance of 16 m between the strips. The strips width is from 2 to 4 meters, so strips for annual crops have 12 to 14 meters.

3 - The fertility evolution in ART management

Most agricultural land is degraded. The soils show signs of erosion, low content of organic matter (O.M.), little porosity, insufficient friability and nutritional disequilibrium. The degradation is caused by the unbalance of the 3 fertility factors:

1. Chemical: most considered aspect when talking about fertility in agriculture
2. Biological: aspect that is generally careless. Studies and experiments are being initiated.
3. Physical: this aspect is also regardless. The mechanical movement of the soil (that has a short-term effect) is often seen as the best solution to correct physical issues.

We believe that this management mindset needs to change for soils to reach their true potential. The ART soil management considers the chemical, biological and physical aspects. We do emphasize physical and biological fertility, which usually has desirable consequences, being some of them predictable.

The soil management is designed to provide the best conditions for roots to develop and strive. Cosmic nutritional factors are ahead of terrestrial nutrition, especially regarding the supply of N, P, Ca, Mg and K. Those nutrients, when inadequately managed, kill the soil life. The consequences in focusing on cosmic nutricion are:

i. Increase in productivity. Important to consider that in the first harvest the production is below the average of other agricultural managements;
ii. Surprising plant health, with little use of phyto protective mixtures;
iii. Good nutritional quality. There is an increase in the brix degree, color, flavor and vitality of foods;
iv. Physical fertility, which is the maintenance of a proper temperature and the presence of macro and microporosity of the soil. They improve significantly already in the 1st cultivation cycle, resulting in biologically useful water.
v. Increase in soil life;
vi. Chemical fertility is a consequence of physical and biological fertility;
vii. Over 2 to 3 production cycles, the chemical fertility equals the levels of other cultivation methods. While this does not happen, there may be a need for support fertilization, specially for more demanding crops:

Auxiliary fertilizers

i) Organic poultry litter: used in small doses, from 10 to 40 g/m2, when planting highly demanding vegetables: beetroot, brassica (cabbage, cauliflower, broccoli), nightshade (tomato, pepper, eggplant).

ii) Wood ash: made over the winter by burning dead wood from the farm. They should be stored in tin barrels. The dosage is 40 g/m2 during the growing season, applied in coverage or by fertigation, splitted 2 to 4 times.

iii) Rocking: soil application of ground silicate rocks and minerals. When to apply: (1) in weathered oxisols, both acidic and alic; (2) sandy soils of any class; (3) eroded and very degraded soils. In this case add limestone (50% of the recommended dosage) and rock phosphate (30% of the recommended dosage). The dosage of rocking is 7 ton/ha or more, in total area. The incorporation is done by double cross harrowing. This overturning is done only once and can triple the effect of the rock powders.

1. Meaning of Rocking in sustaining life soil

4.1. Characterization of tropical and subtropical soils

Tropical soils are usually deep, developed and weathered. They are minerally depleted, being classified as mature to very old. Tropical soils are the result of a

warm and often rainy climate in which the soil aging processes are accelerated. They have little or no reactive silt fraction.

The silt of young soils is often composed of fragments of unweathered parent rock. The size of those fragments are between sand and clay, which are also part of the soil composition. Silt contains a considerable storage of nutrients that will be available for the soil life when its minerals are weathered. Tropical soils, as a rule, have little or no silt fraction. But when it does it is formed by sand shards. Therefore, they are soils with little or no mineral reserves. And they can be supplied with igneous rock powder, preferably from basalt or granite origin (or other basic silicate rocks).

4.2. Rocking as foundation of the soil-root relationship

The strengthening of the soil-root relationship in tropical climates takes place by the creation of a stimulating mineral environment for both the roots and the soil life. They are healthy as long as they can weather minerals from rocks. Instead of applying a highly soluble mineral, the rock powder is applied and the soil life itself is in charge of digesting this material as needed, without excesses. In Brazil, that effect lasts for decades because the rock powder here has different particle sizes, ranging from clay to very coarse sand. The content of clay + silt is below 20%. In the short term a dosage of 7,000 kg of rocking is equivalent to 1,400 kg of clay + silt and only in the long term the other 5,600 kg will be accessed by biological weathering. It generates a long-term effect.

Co-authorship:
Cristiano Pettersen
Manfred von Osterroht
Richard Charity

Revision:
Cristiane Guerreiro