

Mini Review

## Symbiotic interaction in forage crop cultivations: A review

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### Abstract

Brazil is an extensive forest plants producer due to the edaphoclimatic conditions though; most part of the soils constituting Brazil's territorial extension possesses features as low fertility mainly in primary nutrients. Intimate relationships on rhizosphere are mandatory to take effect in order to plants capture and assimilate nutritional elements present in the soil such as the microorganisms present in it. Nitrogen fixing bacteria and arbuscular mycorrhizal fungi are responsible for most part of the organic matter decomposition in the soil and availability of essential nutrients to plants through symbiotic relationship. This relationship can be intensified by practices such as biodiversity enrichment and microbial fauna which occurs in agrosilvopastoral system. Results contribute to better comprehension on those systems towards grassland ecosystems and the vast soil living microorganisms contribution that live in it.

**Key-words:** Bacteria, Micorryzic fungi, Grasses, Leguminous

### Introduction

Brazil is an extensive forest plants producer due to the edaphoclimatic conditions though; most part of the soils which constitutes Brazil's territorial extension has features as low fertility mainly in primary nutrients, they are, Nitrogen (N), Phosphorus (P) and Potassium (K). These soils are highly degraded, rich in iron oxide and aluminum on the clay fraction, becoming primordial fertilizer usage in order to increase forage production and maintain availability of the pasture in a sustainable manner (Abreu et al., 2011; Rezende et al., 2017; Silva Junior et al., 2017; Santiago et al., 2017).

By using nitrogen biomass on the forage ecosystems, forage grasses present increases on the number of tillering leaves. It increments its phytomass yield bringing up animal performance (Santos et al., 2017a). In order to make plants to absorb the nutrients on the soil there must be an intimate relation between rhizosphere and some soil components, among them, the microorganism present in it (Bhat et al., 2017).

Among microorganism benefits which constitute soils microbial fauna, nitrogen fixing bacteria and mycorrhizal arbuscular fungi are responsible for major part of organic matter decomposition on soils and for the availability of essentials nutrients for plants through symbiosis. It assists in the maximum capture of resources by plants (Molina-Herrera and Romanyà, 2015; Santiago et al., 2017; Zhu et al., 2017). The interaction of both microorganisms helps on continued survival of agricultural and forests species. It increases N and P fixation by plants (Dias et al., 2012), due to the synergism occurred by the microorganism-nutrient interactions to the plants (Silva and Trevizam, 2015).

The biodiversity enrichment and ecological advance on grassland areas can be accomplished by conservationist practices and the improvement of these ecosystems. Agrosilvopastoral system, which integrates forest species production, cereals, grasses, leguminous and animals further atmospheric carbon sequestration to the soil as well as the re-covering of it with the deposition of organic matter coming from animal excretion and deposition of litterfall, that

make the soils more attractive to production of forage plants (Ferreiro-Domínguez et al., 2016; Xu et al., 2017). In accordance to these conditions, implementation of intercropping of leguminous and grasses increases in better productive conditions and benefits on the stability of forage to the animals (Doneda et al., 2012; Domiciano et al., 2016).

Based on the conditions previously presented, this review aims to discuss the interaction of microorganism in forage plants productive systems on the mutual influence of symbiotic processes caused by soil's microorganism.

### Soil nutrients in grassland ecosystems

Nutritional elements for plants can be classified as macronutrients (N, S, P, Ca, Mg, K), micronutrients (Ni, Mo, Zn, Mn, B, Fe, Cl), beneficial elements (Na, Co, Se, Si) and toxic elements (Al, Cd). Macronutrients are elements which are demanded in high quantities by crops. These elements are fundamental for crops development. Micronutrients are low quantity demanded by crops. Beneficial elements activate the development of certain species under some condition. Toxic elements have toxicity and malefic reaction for crops (Malavolta, 2006).

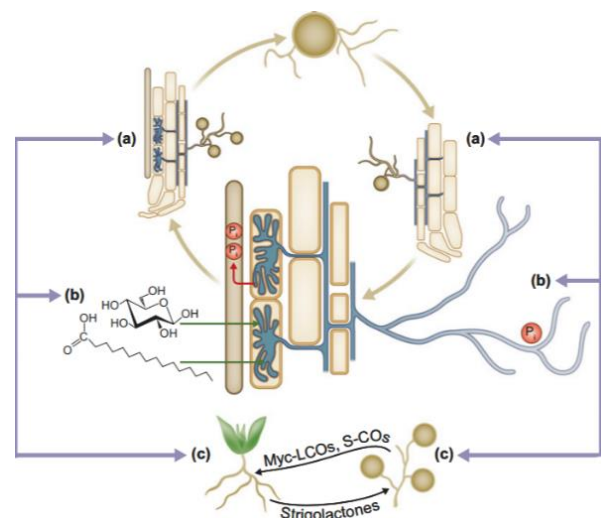
Nitrogen (N) in the agricultural production is the world second most important input factor on production of agricultural crops in farming systems. It only remains behind for water (H<sub>2</sub>O). It is also one of the most important primary and essential macronutrients for vegetal tissue growth, protein composition, DNA, RNA, development and yield of vegetables. It takes part on several metabolic and physiologic processes on plants (Malavolta, 2006; Tho et al., 2017; Kant, 2017) as well as on proteins compounds, amino acids and nucleic acids (Chen and Cheng, 2017). The availability of nitrogen is a limiting factor on grassland systems, being of vital importance to achieving high performance and forage yield, ensuring a suitable animal nutrition (Sangoi et al., 2016).

In grassland the main source of nitrogen are organic matter of the soil, nitrogen biologic fixation and nitrogen biomass. The last has a limited usage on extensive farming (Valkama et al., 2016).

In inorganic forms, nitrate (NO<sub>3</sub><sup>-</sup>) and nitrite (NO<sub>2</sub><sup>-</sup>), nitrogen can be absorbed by plants' roots (Frunghillo et al., 2016), however it is on ammonium (NH<sub>4</sub><sup>+</sup>) and nitrate (NO<sub>3</sub><sup>-</sup>) forms that this nutrient has

its maximum absorption by roots, being essentials to physiological process on plants and genes activation (Kant, 2017; Lorensini et al., 2017). According to studies conducted by Tho et al. (2017), it was observed that *Arundo donax* L. presented great leaves yield, photosynthetic rate, shoot growth and biomass content when nitrogenate fertilization in the ammonium form (NH<sub>4</sub><sup>+</sup>).

The incorporation of ammonium on amino acids occurs through the glutamine synthetase enzyme and glutamate synthase, which are responsible for synthesize glutamine, glutamate and others amino acids and their metabolites. For nitrate, it is necessary the reduction of this compound to nitrite on the cytosol by the enzyme nitrate reductase and, after that, it is converted on ammonium on the plastid, by the enzyme nitrite reductase (Kant, 2017; Taiz et al., 2017). The assimilated nitrate in amino acids and proteins has a fundamental function on the development and architectonic arrangement of the plants' roots, mainly on lateral roots (Kant, 2017) (Figure 1).



**Fig. 1.** Interaction of soil microorganism in the rhizosphere (a) to acquire the soil nutrients (b) by plants (c). Adapted from Kamel et al. (2017).

Correct application and maintenance of nitrogen in the soil in order to maintain the optimum levels for plants is an extremely important factor in the management of sustainable agricultural systems, since excessive nitrogen dosages and low contents of it for plants may cause physiological changes, growth inhibition and chlorosis in the leaves; besides it may also cause damages on ecosystems which drives to nitrate lixiviation to subterranean water and high

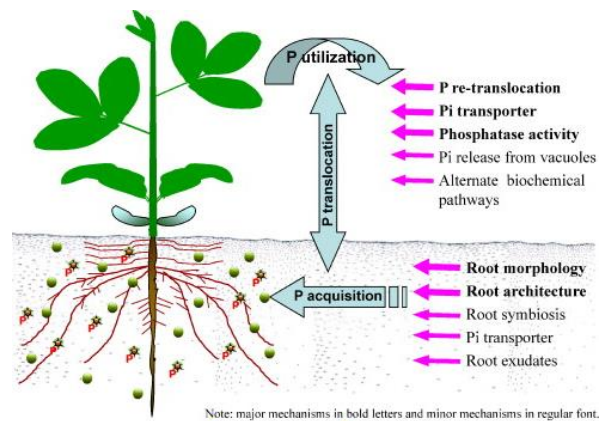
emission to the atmosphere (Taiz et al., 2017; Vakilian and Massah, 2017; Wu and Ma, 2015).

In the past 50 years, fertilizers based on nitrogen have been contributing with about 40% of increasing on agricultural production, raising grains and biomass production. Studies conducted by Singh et al. (2013) demonstrated that the application of nitrogenate fertilizers in grassland with intensive grazing contributes to pasture production and a slight increase on dry matter. Among commercial fertilizers, urea is the source of nitrogen biomass most widely used in Brazil (Sangoi et al., 2016). Nevertheless, for each 1.0 kg of mineral nitrogen added to the soil, fossil CO<sub>2</sub> occurs greenhouse gas emission between 3.5 and 4.5 kg (Ledgard et al., 2011).

Nutrients such phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) also have great importance on the growth and development of plants (Wu and Ma, 2015). The application of these elements on superficial layers of the soil (0 - 0.20 m) - region of predominance of grasses' root systems - aids to the productive development of forage plants increasing, thus, a greater accumulation of dry matter (Carvalho et al., 2017).

Phosphorus (P) is also an important macronutrient for crops. It is considered an element of high magnitude to production in the world. It is also quite expensive, besides a restraining factor to agricultural and forage crops. In soils with phosphorus, the biological activity is more accentuated (Bhat et al., 2017). In the environment, phosphorus occurs in organic and inorganic form. It varies in availability and solubility according with the type of soil. When this nutrient suffers precipitation process and reaction of sorption in soil colloids, it becomes unavailable to plants oftentimes. However, agricultural soils have a predominance of the organic form of this nutrient (Bhat et al., 2017) (Figure 2).

Studies conducted on increment of nitrogen and phosphorus in pasture demonstrated that they substantially aided the yield of the grass *Agrostis capillaris* L. and of the forage turnip (*Raphanus sativus* L.). This increment increased the plants height, biomass and chlorophylls content, which contributes also in decomposition and mineralization rate of organic matter on the soil (Stiles et al., 2017; Hanly et al., 2017).



**Fig. 2.** Absorption forms of phosphorus by plants in environmental conditions. Adapted from Wang et al. (2010).

### Contribution of nutrients to the root surface by microorganisms

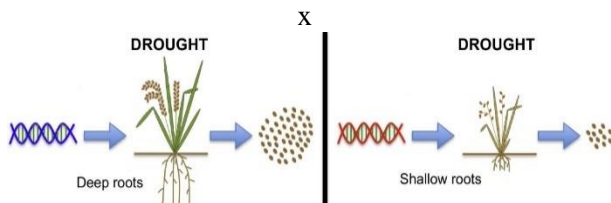
In the interaction soil-microorganism-plant vegetables acquire most of the mineral nutrients through rhizosphere by releasing secondary compounds that maximizing the nutrients absorption (Chen et al., 2017). These compounds, such as inorganics ions of high and low molecular weight interact with soil constituent and aid on nutrients absorption due to the pH changes on the soil near the rhizosphere (Bais et al., 2006; Badri and Vivanco, 2009), being that the same mechanisms could be sources of carbon and energy for some soil microorganism such as fungi and bacteria (Kurzawova et al., 2012).

These are the factors that favored plant to survive in hostile environment as well as due to the favoring of root system, contributing to adaptation of the plant in imposed environmental conditions (Postma et al., 2014a).

One of the restraining factors to the development of plants is low availability of nutrients in the soil and the microorganism interaction decrease with plants. These factors aid to vegetable production losses and low yield capacity (Isaac et al., 2012; Bargaz et al., 2017). Crops that presents root system well developed and great root densities occupying the soil present high tolerance to abiotic factors such as water deficit, which is succeed of genetic and microbiologic feature, favoring cultures not to have significant production losses (Rogers and Benfey, 2015) (Figure 3).

Studies conducted by Talaat (2014) indicated that bean plants (*Phaseolus vulgaris* L.) cv. Nebraska, when treated with different species of microorganism

(e.g. *Rhodopseudomonas* spp.; *Lactobacillus* spp.; *Saccharomyces* spp.; *Aspergillus* and *Penicillium*) presented better yields in plants height, number of leaves, foliar area index, dry weight of shoot and root compared to non-inoculated plants under different levels of soil salinity, being related the great intake of nutrients from the soil and the great stimuli of production of reactive species of oxygen (ROS).



**Fig. 3.** Contribution of the root system development on the crop yield over water stress condition. Adapted from Rogers and Benfey (2015).

These results corroborate with the findings of Hu and Qi (2013) which used some soil microorganism, previously named, inoculated on maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.). These findings demonstrated that microorganism supported better crop results such as plant height, leaves, stem and roots biomass content, and grains yield, besides the enhancement on physics and chemicals soil attributes compared to non-inoculated crops, once microorganism contributes to nutrients absorption by plants' roots (Mimmo et al., 2014).

Improvements on crops yield are also related to the root system elongation of crops that supports them to absorb great quantities of water and nutrients on profound layers. Another factor that aided the absorption of essential elements by plants is the releasing of phytohormones by plants and microorganism in great or stressful condition. When the root system is established with high roots densities, plants save metabolic energy on nutrients search on the soil since they are located near the rhizosphere, being absorbed by facilitated flow (Postma et al., 2014b; Per et al., 2018) and using the maximum soil niches that the environment has due to the architectonic and spatial variations of roots (Zhang et al., 2014).

Soil microorganisms are indispensable factors to the releasing and decomposition of organic matter on soil, releasing and making nutrients available for plants. They are responsible for weathering of the original material of the soil, making soil fertility better (Zhu et al., 2014). These, modulates

interactions aided on nutrients content in several environment and grasslands, favoring, thus, the mineralization rate (Classen et al., 2015; Sarker et al., 2018).

Assimilation of these nutrients by plants is dependent on a series of interactions of the soil, nutrients, microorganism and plant that is activated by chemical and microbiologic process. It can be influenced by synergetic and antagonistic process effect on the rhizosphere (Bhat et al., 2017). These interactions can have positive character when they benefit plants development; and it may have negative effects when they reduce the plants development (Classen et al., 2015).

### Synergism and antagonism among nutrients

Brazil is a great forage plants producer due to its vast agriculture production, predominance of tropical climate and large territorial extension. In accordance to it, cultivated grasslands areas have quite high nutrients extractivism on the soil. It can cause nutrients depletion, pasture degradation, loss of productivity, reduction of the soil biota, and consequently decline of nutrients cycling when the soil is not correctly managed. The usage of external inputs on the soil is necessary to maintain the yield (Santiago et al., 2017).

The dependency of industrialized fertilizers in agricultural properties causes an increase on production costs and, due to this, it is indispensable the use of techniques that diminish the usage of products that cause damages to the ecosystems and cause greenhouse gases emission (Huang et al., 2017). It may also be considered the use of low costs technics, correct period of seeding, and selection of grassy/leguminous, plants resistant to drought, frost and periodic flood, tolerance to plague and diseases, and tolerance to aluminum, to maintain pasture for more time. Another factor that should be considered is the fallow period, which the pasture must go by to re-establish itself (Carvalho et al., 2017).

Both macronutrients and micronutrients in grassland ecosystems can initiate a synergetic (positive) and/or antagonistic (negative) relationship among nutrients available for plants. Antagonism consists on the competitive and non-competitive inhibition causing nutrients unavailability or inefficiency for plants (negative interactions); whereas, synergism consists on an increment on



nutrients interactions that increases their reaction and better exploitation for plants (positive interaction) (Malavolta, 2006; Silva and Trevizam, 2015).

One of the reasons that can cause deficiency of some nutrients for plants is the antagonism among some elements on the soil that can cause competition among actions sites and their unavailability. On plants, the ionic transport is rarely selective, causing, thus, competition. One of the reasons that cause competition is the concentration of ions in the soil solution as well as its physic-chemical properties. They cause affinity and help on this transport. As an antagonistic activity example, there are calcium (Ca) and copper (Cu), where the former blocks the excessive absorption of the latter in order to avoid plants intoxication. Elements such as potassium (K), rubidium (Rb), cesium (Cs), sodium (Na), sulphate ( $\text{SO}_4^{2-}$ ), compete for the same transport site causing, thus, antagonism in plants (Silva and Trevizam, 2015).

According to Martin et al. (2017), potassium (K) presents antagonistic effect to calcium (Ca), being competitors for the same link site on plasmatic membrane. It causes membrane collapse and deficiency at cellular wall in vegetables. Studies conducted by Santos et al. (2017b), noticed a decline of magnesium (Mg) in foliar tissue of cherry tomato when calcium (Ca) concentration were increased. They indicated evidence of antagonistic effect for these nutrients. In Taiz et al. (2017), on soils with high sodium (Na) concentration plants presented potassium (K) deficiency because sodium (Na) block the absorption of potassium (K) due to the same action site.

Antagonistic reactions also can also occur between nutrients and soil. As an example we can mention the phosphorus (P) which possesses a quite complex dynamic because when fixed on soil colloids. It increases unavailability of this nutrient for crops decreasing the yield capacity of them, decline of roots' mass, and tillering (Malavolta, 2006; Santiago et al., 2017).

Synergetic effects were also evidenced among soil nutrients in studies (Malavolta, 2006; Silva and Trevizam, 2015; Taiz et al., 2017). As positive synergetic relationship, there are nitrogen (N) and sulphate (S); nitrogen (N) and phosphorus (P); phosphorus (P) and magnesium (Mg); and phosphorus (P) and zinc (Zn). When used together, they aid on productive performance of agricultural

crops and pasture (Malavolta, 2006; Silva and Trevizam, 2015; Santiago et al., 2017).

The synergetic effect between nutrients and plants might be occasioned by soil microorganisms' interaction. Bacteria are example of microorganisms that can cause synergetic effect on plants (Zhu et al., 2017), when they produce organic matter decomposition and provide carbon and nitrogen as well as other nutrients to plants (Molina-Herrera and Romanyà, 2015).

Mycorrhizal arbuscular fungi also aid on the yield increment of crops. It happens because hyphae and mycelium increase catchment area of rhizosphere. It increases the absorption of water and nutrients, especially those which have low mobility on the soil, such as copper (Cu), zinc (Zn) and phosphorus (P) (Santiago et al., 2017).

### **Biological nutrient fixing microorganisms**

Nutrients supply, specifically nitrogen (N) and phosphorus (P), can be provided to plants by soil microorganisms that are hosted by the plants and symbiosis occurs, which improves absorption of water, supply nutrients, and, in return, receives carbon and energy (Klabi et al., 2014; Millar and Bennett, 2016). More than 80% of plants in the world maintain one symbiotic relationship with some soil microorganism that favors the absorption of nutrients much beyond the root depletion area on underexplored regions (Field et al., 2015).

Mycorrhizal arbuscular fungi colonize roots. These organisms aid on the soil exploration by root system and nutrients cycling, that favor soil aggregation, increase the biodiversity of the microbiological environment, regenerate exploited areas and control erosion (Millar and Bennett, 2016; Faria et al., 2017). Moreover, they can promote benefits to plants, that contribute against abiotic stress factors, such as pH, salinity, and temperature (Millar and Bennett, 2016).

Arbuscular fungi aid also improve crops performance, which lead to better root-soil interaction and favor a great productive performance (Millar and Bennett, 2016). Studies realized by Klabi et al. (2014) with grassy species (*e.g. Schizachyrium scoparium; Bouteloua gracilis*) and leguminous (*e.g. Medicago sativa; Dalea purpurea*) in different period of the year, observed that species inoculated with mycorrhizal arbuscular fungi presented better

development and great absorption of phosphorus (P) and nitrogen (N) making these plants more efficient and competitive.

Depending soil's fertility conditions mycorrhizal fungi behavior may be different. This variety of fungi aids on plants' phosphorus absorption, thus, some fungi in this class reduce their taxonomic variety when undergone to nitrogen fertilizers (Millar and Bennet, 2016).

As agents of high nitrogen (N) fixation, rhizobacteria are symbiotic organisms that also colonize plants roots and aid to absorption of nitrogen from the soil and atmosphere. They also have the capacity of stimulating the production of phytohormones and enzymes that help plants growth and development. Moreover, they are capable of to producing secondary compounds which protect plants against phytopathogenic organisms (Grobela et al., 2015). Bacteria from genus *Rhizobium*, *Azospirillum* and *Pseudomonas* stand themselves out on nitrogen fixation and promote growth when associated to leguminous and grassy, in addition to promote phytoremediation in contaminated soils (Grobela et al., 2015).

Forage grassy have also the capacity of fixing atmospheric nitrogen when they are inoculated with bacteria from the genus *Azospirillum*. Studies conducted by Souza et al. (2017) demonstrated that forage plants *Mesosetum chagaseae* and *Axonopus purpusii*, when inoculated with *Azospirillum* spp., evidenced great increments on plants height, root volume and dry matter due to absorption of nitrogen by plants, making these microorganisms mandatory to improve plants growth (Cassán and Diaz-Zorita, 2016).

Plants have the ability to carry out exudates release by roots, which contributes to the nodulation process of nitrogen fixing bacteria. These nodules are organs coming from cortical cells that work as lateral roots. After the addition of these nodules to the rhizosphere there is a tendency to increase the fixation of atmospheric nitrogen, which contributes to great plant performance (Svistoonoff et al., 2014; Vasileva et al., 2017). Nodulation and inoculation when well succeeded guarantees the maximum nitrogen absorption by plants (Suzaki et al., 2015).

Studies conducted by Grobela et al. (2015), demonstrated that, when inoculated by bacteria from the genus *Rhizobium*, rapeseed plant (*Brassica napus* L. subsp. *napus*) were more productive than non-

inoculated plants. This increased production led to increments on biomass content and phytohormones synthesis. These yield increments are related to better water and nutrients absorption also benefited from microorganisms (Millar and Bennett, 2016).

Strengthening to studies mentioned on the academic literature, Vasileva et al. (2017) found better yields in underground clover (*Trifolium subterraneum* L.) when they were inoculated with bacteria genus *Rhizobium*, increase of dry biomass and root nodulation on plants were observed.

### **Agrosilvopastoral system**

Anthropogenic changes on natural and grasslands environments are increasingly responsible for degradation in ecosystems. These modifications converge to the acceleration of climate changes due to emission of greenhouse effect gases to the atmosphere. Traditional practices on land usage tend to cause effects by the fast intensification and expansion of areas. The implantation of high efficiency systems on pollutants gases sequestration, for example, silvopastoral system, is an adequate alternative to mitigate impacts (Ferreiro-Domínguez et al., 2016; Xu et al., 2017).

The increasing lands exploration over the last years has substantially increased to supply the demand of food and fodder production in several sectors (Wu and Ma, 2015). In line with this fact, mal practices on soil usage and inappropriate management of plants cause soil and grassland degradation (Machado et al., 2017) it diminishes the environmental diversity and quality. In the world, grassland occupies approximately 3.6 billion hectares, being responsible to sequester around 20% of carbon dioxide that is released to the atmosphere. It happens due to anthropic changes in lands, and it is source of climate changes mitigation. In pastures, carbon, which is retained in the soil, is a key element and it has several purposes in this ecosystem. It aids in the soil structuration, chemical properties, and on development, sustainability and productivity of pastures (Xu et al., 2017).

Ecosystems conservation and biodiversity maintenance are the most important practices for agricultural production. The usage of technics such as consortium of leguminous and grassy; and the agrosilvopastoral system, support better profit of natural resources, such solar radiation, which causes

great efficiency on land usage and promotes the productive efficiency (Machado et al., 2017; Xu et al., 2017).

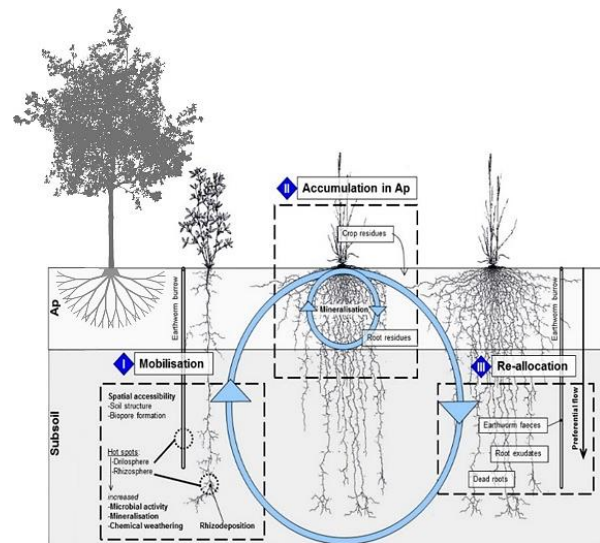
Consortium systems of leguminous and grassy are planting practices, quite ancient and efficient aiming to enrich grasslands and contribute to productivity, resilience and persistence of pasture as well as by deposition of straw on the soil to protect against erosive factors. Phytomass produced in this kind of system enriches monogastric and ruminants diet likewise it deposits nutrients and carbon (C) on soil through crops remains (Doneda et al., 2012).

Leguminous in consortium system fixes atmospheric nitrogen on the soil letting it available to cereals and pasture. This symbiotic interaction aids in a better plant development and favors the increment of the crops in deficient environment (Varshney et al., 2013). Studies conducted by Li et al. (2011) observed that the use of consortium system with cereals and leguminous favored the enrichment of niches in soil layers as well as the better resources improvement due to the differentiation types of root systems of plant species.

The recovering of degraded grassland, reduction of production costs and the intensive use of area during all year have been feasible by agrosilvopastoral system or crop-livestock-forestry integration, which involves grassy crops (crop), woody species (silviculture), forage plants and animal production (livestock) all in one and only ecosystem. It generates positive socioeconomic and environmental results. This type of system has gained appreciation of several producers in different regions in the world due to the fodder stability over the years. Another feature of this system is the thermal comfort provided to animal due to the shading caused by trees, which offers a smaller thermal amplitude and maintenance of soil and air humidity, increasing, thus, the animal welfare (Ferreiro-Domínguez et al., 2016; Machado et al., 2017).

The inclusion of woody species consortium with agricultural crops, pasture and animal production, main feature of agroforestry system, intensifies deposition of nutrients on the soil such as potassium (K), nitrogen total (N), phosphorus (P), calcium (Ca), and magnesium (Mg), as well as the microfauna enrichment and nutrients cycling. Root system in woody species aid to improve physical attributes of the soil, aeration, better plants development, and

increase the capacity of resilience in this system (Varshney et al., 2013) (Figure 4).



**Fig. 4.** Nutrients cycling in the soil and of nutritional elements acquisition by plants' roots. Adapted from Kautz et al. (2013).

Aiming better results on management and crops productivity in agrosilvopastoral system, the choice of tree size species' density by areas or cultivation zone, along with leguminous and/or grassy must be observed with caution because some grassy can diminish its productive yield when exposed to excessive shading caused by tree (Oliveira et al., 2014). Yet, according to these authors, this kind of system, when managed in a proper way is much profitable and profits are significantly high because rural producers can benefit from cellulose production (wood), pasture, grain (e.g. soy bean, bean and corn), and animal production.

Studies conducted by Domiciano et al. (2016) and Oliveira et al. (2014), showed that animal of the breed Nelore risen in agrosilvopastoral system presented great meat yield in this system. These results are connects to the quality of pasture that indicated more dry matter and protein content, furthering productive yield of the animals. Moreover, this system optimizes the soil usage and forage species present better bromatological features.

Animals in agrosilvopastoral system have better welfare and thermal comfort conditions when compared to animals risen in other types of traditional systems due to environmental variables (air temperature, humidity, solar radiation and wind speed) indicated less magnitude on the effect of animal discomfort (Domiciano et al., 2016).

Tree size species are crucial to the consolidation of system agrosilvipastoral because they beget several benefits. Souza et al. (2016), working with tree species from the Caatinga, observed that black jurema (*Mimosa tenuiflora* (Willd.) Poiret) possesses high interaction with mycorrhizal fungi that aids on nutrients cycling. These fungi, along with bacteria, aids also on nitrogen fixing for plants, producing better quality pasture to cattle (Nahed-Toral et al., 2013).

In some regions, animal production through extensive system with monoculture of pasture is commonly used; however, the usage of agrosilvipastoral system can contribute with the rise of soil quality, forage yield, making this system economically feasible due to reduction on inputs and increasing of the production (Garrett et al., 2017).

In this type of system, forage species as *Brachiaria brizanta*, *Sorghum bicolor* cv. BRS 310, *Uruchloa* spp., and soy bean (*Glycine max* (L.) Merrill) are cultivated in consortium with grains producer crops, for instance corn, sorghum, millet, rice and soy bean, presenting several advantages as production diversification, profit rise, and cost reduction (Santos et al., 2016; Santiago et al., 2017), because the synergy generated between crop and pasture, which demonstrates the importance of this type of system to the better use of land, forage yield and interaction with the soil biota.

To Kay et al. (2017), interaction of agrosilvipastoral system generates improvements to landscape and ecosystems, more carbon sequestration, interactions among pollinators, interaction between soil microorganisms and plants, better annual yield for plants, promoting sustainable agriculture. Soils have huge capacity of carbon storage and through the decomposition of materials by microorganism, the storage capacity will be higher, which shall lead to lower emission of gases from the system to the atmosphere (Classen et al., 2015).

Several studies are being carrying out to evaluate the capacity of carbon sequestration from different agrosilvipastoral system arrangements and their potential to mitigate the emission of methane from enteric fermentation of bovines (Robertson and Grace, 2004; Fisher et al., 2007). It causes low efficiency in animal rumination and pollutants gases emission to atmosphere (Perna Junior et al., 2017). Agricultural sector is responsible for 18% of the

greenhouse effect gases emission in the world (Gerber et al., 2013).

## Final considerations

Low soil fertility and the inadequate usage of mineral fertilizers in grassland ecosystems are restraining reasons to production and bioeconomic yield of forage plants, hence, these practice improvements aids pasture availability for longer periods of time.

Mycorrhizal arbuscular fungi and nitrogen-fixing bacteria are crucial elements for the existence of balance on nutrients availability to plants. This balance makes their inoculation an important practice to maintenance of productive yield and soil organic matter.

Forage plants and tree size plants integrated systems implies on higher deposition of organic matter on the soil and promote better conditions for forage plants and better thermal comfort environment for animals.

Deeper researches are necessary in the world to understand the dynamic of pastures in semiarid regions with edaphoclimatic conditions on agrosilvipastoral ecosystems to provide better alternatives to pasture production.

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