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Review

The utilization of tropical legumes to provide nitrogen to pastures: A review

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Sustainable models of animal production constantly seek for ways to pasture production with inputs reduction. In this context, the introduction of forage legumes in the pasture system is fundamental to fix nitrogen from the atmosphere and supply it to grasses, increasing its production and persistence, enhancing animal nutrition as it grazes, at the same time. Still, the use of plant mixes in the system brings further benefits to it, such as better utilization of fertilizers as well as enhances the nutrient cycle and soil coverage. However, there are still many gaps in our knowledge regarding intercropping legumes and grasses, especially the use of tropical legumes. The purpose of this review is compiles data about forage legumes as well as analyses them to find new tendencies and gaps on the knowledge to shed some lights on researches in this area. We also expect that this review will help researchers and producers to understand the role of forage legumes in a pasture system and that there will be an increase in its utilization worldwide, especially in the tropics, where nitrogen is easily leached and lost from the pastures. With emphasis on description of promising tropical legumes but still little used *Arachis pintoi*, *Macrotyloma* and *Neonotonia whightii*.

Key words: *Arachis pintoi*, grass, *Macrotyloma axillare*, mixed pasture, *Neonotonia wightii*.

INTRODUCTION

Since 1996 there have been an increment in animal productivity (production by area unit) in milk as well as in meet and other products in tropical pasture systems without the respective increase in the pasture area (IBGE, 2016). In Brazil the total pasture area was actually reduced by 3% in the last 10 years, and is estimated to be around 172 million hectares in 2006 (IBGE, 2016). This reduction was accomplished by improving the pastures from its establishment, managing and nutrient reposition, resulting in an increase of the use of fertilizers,

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especially synthetic nitrogen. However the volume of fertilizers used in pasture in Brazil is still low and estimated to be around 3.6 kg/ha.year^{-1} of NPK formula (Barcellos et al., 2008).

Nitrogen, in modern agriculture, is used in large quantities (ANDA, 2016) and it represents the most expensive nutrient applied in crops (Cantarella, 2007). It is estimated that the use of nitrogen fertilizers warrants the livelihood of 40% of the global population, which it would not be possible without its use (Mosier and Galloway, 2005).

Amongst the macronutrients, nitrogen is the most important to maintain plant production, mainly in monoculture of grass pastures, because it works in protein synthesis, which in turn will be used in several metabolic processes in the plants, justifying the use of heavy amounts of this element (Raij, 2011). Therefore, when there is low availability of this nutrient to the plants, the process of pasture degradation is started. Degradation brings great negative consequences to the production system, such as the lost of vigor and the productivity of the forage, reflecting in the capacity of support of the affected areas, leaving them susceptible to undesired effects, such as the attack of insects and the emergence of weeds (Nascimento Junior et al., 1994).

In order to reduce the dependence on synthetic nitrogen in pasture systems there is a search for alternatives to provide this nutrient to the grasses. The most promising at this moment is the use of legumes as forage, which increases the nitrogen in the system of biological fixation of nitrogen (FBN) in symbiosis with bacteria that have an enzyme (nitrogenase), usually from the *Rhizobium* and *Bradyrizobium* genera. The FBN is the transformation of N_2 in NH_3 and after that in reactive organic forms (Cantarella, 2007). Among the forage legumes to use in pastures and used most commonly in Brazil are the genera *Arachis, Sthylosanthes*, *Neonotonia* and *Leucena*, as well as the promising *Macrotyloma*.

THE IMPORTANCE OF NITROGEN IN PASTURES

The production of grass fed bovines, due its low cost and practicality is the most common system of animal production in the world (Castagnara et al., 2011). There is the need to apply fertilizers to replace nitrogen in order to maintain or increase production in tamed pastures exclusively with grasses (Mesquita et al., 2010; Da Silva et al., 2010; Gimenes et al., 2011). This is due to the fact that nitrogen is part of several organic composts, amino acids and nucleic acides, and is necessary in higher quantities than any other nutrient by the plabts (Epstein and Bloom, 2006).

Nitrogen exists in the soil mostly in its organic form (more than 95% of the total N) and its inorganic fractions may occur as NH_4^+ and NO_3^- (Cantarella, 2007). Tropical soils are generally characterized for low pH, with influences directly the absorption of nitrogen by the plant roots, resulting in a lower intake of this nutrient by the plants.

The absorption of nitrates is greater in lower pH, while the intake of ammonia is greater when pH is near to neutrality (Costa et al., 2006). Therefore, liming influences and stimulates in many soils the growth of the root system and, in doing so, improves the utilization of the available N.

Soil utilization is a factor that acts directly on the way that crops respond to N fertilization, meaning that where soils were cultivated for just a few years or were kept in rest for a while there will be less response to N fertilization (Raij, 2011). The reason for it is that it may be occurring mineralization of the organic matter which in turn provides N to the plants.

Furthermore, it is worthy to note that it is also necessary environmental conditions, such as temperature, humidity, luminosity and nutrients availability in order for the grasses thrives in a specific area. Among these conditions, in tropical regions, the nutrient availability is one of the factors that interfere the most in productivity, mainly due the natural acidity of the soils.

If the availability of N is low for a long period of time, there is going to start a degradation process. This is because the plants that show symptoms of N deficiency have their photosynthetic rate diminished due to the yellowish color of its older leaves, which in turn reduces the plant growth, with less productivity. The low availability of N may also affect the root development, the photosynthesis and the production of photoassimilates, as well as the growth rate of leaves and roots (Taiz and Zeiger, 2004).

Usually N deficiency happens in pastures that do not receive N fertilization or received a lower dose than the recommended, as the availability of N via mineralization of organic matter it is not enough to supply the grasses demand. Therefore, it must be supplemented by N fertilization (Guilherme et al., 1995). Werner et al. (1996) recommend as a minimum to apply 40 to 80 kg/ha year of N to maintain the pastures, depending on the forage being managed.

However, the responses to N fertilization over the accumulation of forage mass depends on the potential of forage production, the relationship between the photosynthetic rate and the concentration of N, and the expansion and spatial distribution of the leaves in the pasture canopy and its impact in the light interception (Gastal and Lemaire, 2002). The nitrogen, because of its active participation in the synthesis of organic compounds, may change the structural characteristics of the plants, such as the size of the leaves, and tiller density, as well as its morphogenic characteristics, such as the rate of leaf appearance and leaf senescence (Lemaire and Chapmam, 1996; Lemaire et al., 2011).

Grass tillering is influenced by N fertilization (Jewis, 1972; Hodgson, 1990; Chapman and Lemaire, 1993). N fertilization has a direct effect over the tiller population and its density also in tropical grasses, which is determinant to forage biomass production in pastures, according to Alexandrino et al. (2004), Fagundes et al. (2005), Pates et al.(2007), that evaluated *Brachiaria brizanta* cv. Marandu, *Brachiaria decumbens* cv. Basiisk and *Panicum maximum* cv. Tanzania, respectively. Thus the number of leaves in a plant increases as the number of tillers also increases., which is an important characteristic for establishing forage productivity. However, de Fialho et al. (2012) did not find significant differences between pastures that were fertilized with N with doses varying from 50 to 200 kg/ha.year, probably due the phenotypical plasticity of the species *B. brizantha* cv. Marandu.

Other than increasing tiller population and density, N fertilization increases the ratio of young tillers in the pasture, as the nitrogen speeds the appearance and death of tillers, increasing directly the tiller's rate of senescence, due to its continuous renovation. If N fertilization is used, the forage must be harvested more frequently so the senescent material does not accumulate and the nutritive value of the forage does not decrease (Paiva et al., 2011).

The rate of leaf appearance, defined as the number of leaves that appear per tiller during a certain period of time, it is central to the plant morphogenesis, because it may change the size of the leaves, the tiller's density and the number of leaves per tiller (Lemaire and Chapman, 1996) and also suffers the influence of N fertilization, as the N fertilization stimulates plant growth, bringing as a consequence the internodes elongation, which makes the leaf to be expelled from the sheath of the previous leaf, thus increasing the rate of leaf appearance (Oliveira et al., 2007).

There are some words to describe the leaf appearance and among them there is the term "phyllochron", defined as the interval between the appearance of two successive leaves. Phyllochrons may be reduced with N fertilization because it increases the plant growth, resulting in bigger regrowth capacity, given to the plants a fast replacement of leaf area (Lemaire and Chapman, 1996).

Cassol et al. (2011) observed that with the utilization of nitrogen there was a greater amount of leaves produced by oats in 45 days than in 60 days without its use, noted that if N fertilization was not used in oats (*Avena strigosa*) and ryegrass (*Lollium multiflorum*) the plants needed 15 more days to accumulate a similar amount of dry matter than when N fertilization was used. This proves the influence of nitrogen in the production of citocinine, an hormone responsible for the plant growth and that acts activating of the process of cellular division and differentiation (Marschner, 1995). Nitrogen fertilization also helps with the activation of the meristematic tissues in plants, reducing the number of dormant gems and promoting maximum tilling in grasses (Jewiss, 1972).

Providing N to the plants increases the dry matter production in temperate grass pastures, such as perennial ryegrass (Quatrin et al., 2015) and also in tropical forages, as reported for guineagrass (*Panicum maximum* IPR-86 Milenio) (Sarmento et al., 2005), brachiaria palisadegrass (*Brachiaria decumbens* cv. Ipean) (Fagundes et al., 2005), Marandu palisadegrass under continuous stocking (Mesquita et al., 2010) and rotational stocking (Gimenes et al., 2011; Costa et al., 2016). Taffarel et al. (2016) observed that the N fertilization increased dry matter production because altered the structural characteristics of the plants, such as a higher canopy, longer stems, higher leaf elongation. Costa et al. (2016) founded that topdressing N fertilization in Marandu palisadegrass increases dry matter production and N-accumulation in plant tissues.

FORAGE LEGUMES AS A NITROGEN SUPPLIER

Monoculture of forage species was used for many years in pastures. However most of this areas are now degraded or in some stage of degradation, due mainly to mismanagement and/or for lack of nutrient reposition, especially because of low N availability (Dias-Filho, 2014). In Brazil, country with roughly 172 million hectares of pastures (IBGE, 2016), the problem of degradation in pastures is very significant. Based on the total area of pastures in Brazil, according to official data (IBGE, 2016), it would be possible to estimate that around 100 million hectares of pastures in that country would be subject to some sort of remediation because these areas would be in a moderate to high level of degradation.

Even though there is N deficiency in pasture systems, nitrogen is the most abundant element in the atmosphere, with approximately 80% on its composition. However it is found in a form that cannot be captured and metabolized by plants (N_2). It can be absorbed by most of the plants in the form of NH_4^+ or NO_3^- that are compounds more reactive and present in the soil. In legumes, that are plants of the Fabaceae or Leguminosae the nitrogen present in the air in its N_2 form is transformed by the enzime nitrogenase into NH_3 by bacteria that receive energy from the plants and transfer nitrogen in turn to them. Plants spend energy in this process but obtain, as an advantage, nitrogen, even if the soils are poor on it (Taiz and Zeiger, 2004). Biological nitrogen fixation is the process that changes inert N_2 to biologically useful NH_3. After incorporation of N in the legume plant tissue, its plant remains will go to the soil and become organic matter, where N is mineralized to the forms NH_3 and NH_4 that can be absorbed by the grasses (Raij, 2011).

In the industry, for every kg of N produced, 15 Mcal of energy is spent to produce it, energy that is coming from fossil fuel, which is not sustainable and is dependant in oil (Resende et al., 2003). As the price of fossil fuel skyrocket in the 70's, the research regarding biological fixation of nitrogen (FBN) was stimulated (Serraj, 2004).

FBN has an important role supplying N to agricultural systems as is estimated that FBN contributes with 32.0 Tg/year of N, or around 30% of the N produced artificially as a fertilizer. In Brazil the amount of N supplied by FBN is around 7.3 Tg/ano^{-} which is almost three times the amount produced by the industry (Cantarella, 2007).

Diehl et al. (2013) said that mixed systems with grasses and legumes provide a better utilization of the pastures all year round, presenting also more forage mass production and a higher stocking rate. Furthermore, areas that were cultivated with legumes have an effect on the next crops (Mesquita et al., 2015; Alves et al., 2016) as the legumes capture and release N into the system.

The introduction of legumes in pastures that have only grasses is a sustainable alternative and rarely used. It may help improve soil quality, reduce N fertilization and bring ecological benefits to the system production, as well as improve the quality of the animal diet (Barcellos et al., 2008).

The reduction of the use of nitrogen fertilizers in pasture systems via the implementation of legume forages have a direct effect in the reduction of the emission of greenhouse gases and pollutants, as well as reduce the impacts of the eutrophication in water bodies, because it lowers the lixiviation of nitrates, thus lowering the cost of production. However it is important to notice that the mix grass x legume must be adaptable and compatible with local conditions, as well as resist to insects and diseases, in order to be persistent and permanent (Valle and Zimmer, 2013).

The legumes seedlings emerge from the soil without any association between roots and rhizobia and may never have the association until the end of its cycle (Epstein and Bloom, 2006). These same authors also relate that in conditions where N is limited the symbionts reach out one to each other, via signal exchange, which results in the process of infection and development of the nodules that will capture nitrogen. The most common symbiosis occurs between legumes and bacteria known as rhizobia, which includes the *Rhizobium* and *Bradyrhizobium* genera.

The FBN occurs through the symbiosis between the microorganisms that exists in the soil and the plant legumes, contributing to the self-sufficiency of all plants (legumes and grasses) of the mixed pasture as the source of nitrogen, The legumes transfer nitrogen to the grasses of the system through the decay of its vegetative material that fall in the soil, exudates and through the roots. Carranca et al. (2015) noticed that visible roots and nodules of the legume European yellow lupine (*Lupinus luteus* L.) and subterranean clover (*Trifolium subterraneum*) may contain from 7 to 11% of the total N fixed by the plant.

Thus, the release of the N fixed in the soil will supply the needs of the legume and the grass established. This association may incorporate up to 500 kg/ha.year of N (Siqueira and Franco, 1988). However, data from tropical legumes show lower quantities of N fixed per year. Giller (2001) in his book reports that FBN in tropical legume species such as *Arachis pintoi* may fix from 1 to 7 kg/ha of N in a 12 week period of evaluation in Colombia (estimated 4 to 21 kg/ha.year); *Calopogonium mucunoides* supplied from 136 to 182 kg/ha.year and 64 kg/ha.ano in the Samoa Island and in Brazil, respectively; for *Stylosanthes spp.* cultivated in Australia the N fixed was 39 kg/ha in a 17 weeks period (estimated 110 kg/ha.year).

The lower values for N fixed per year in tropical regions, when compared to the potential fixation, may be associated to the higher exigency level for nutrients by legumes versus tropical grasses (Werner et al., 1996), not always met by the soil reserves, often acids and low in phosphorus, calcium and micro nutrients. Another difficulty for increasing N fixation is the fact that legumes are plants that have a C3 carbon metabolism, whereas tropical grasses are plants with a C4 cabon metabolism and ideal temperature around 35°C, which makes tropical grasses more aggressive in competition for water and efficient in its utilization of nitrogen (Corsi and Nascimento Junior, 1984). These two limitations for the complete development of forage legumes in mixed systems of tropical pastures help to explain the low persistence of the legumes in these systems and demonstrate the great challenges that must be surpassed by research.

Spain and Pereira (1985) estimated that the ideal ratio of legumes in consortium with grasses in temperate pastures is from 20 to 40% of the forage mass expressed in dry matter of the pasture, in line with information from Thomas (1992) that estimated the ideal ratio above 20 to 30% of total mass of forage. Saia et al. (2016) researching several temperate legumes and ryegrass reported the presence of legumes in the mix varying from 30% (*Trifolium resupinatum* L.) to 69% (*Trigonella foenum-graecum* L.) of the total forage mass. Aguirre et al. (2014) reported problems with excessive participation of common vetch (*Vicia sativa* L.) during the winter (56% of the forage mass), reducing in the summer to 8.8% in a mix with Coastcross grass (*Cynodon dactylon* L. Pers. Cv. Coastcross-1), while arrowleaf clover participated with 17.6 to 5.8% of the forage mass also in mixed pasture with Coastcross.

There are no specific studies to estimate the ideal range of participation of the legumes in the forage mass in tropical grasses and legumes in mixed pastures. However the presence of legumes even below 20% has shown an increase in the forage mass and also in the nutritive value of the pasture. Pinheiro et al. (2015) reported that pastures with 14 to 17% of Brazilian stylo Campo Grande (a mix of 80% *Stilozanthes capitata* and 20% *S. macrocephala*) in the composition of the forage mass in a mix with Tanzania guineagrass (*Panicum* *maximum* cv. Jacq. Tanzania 1) produced forage equivalent to a pasture fertilized with 75 and 150 kg/ha of N.

Martuscello et al. (2011) compared the dry matter production of Brachiaria decumbens with Estilozantes cv. Mineirao (*Stylosanthes guianenses*), Calopo (*Calopogonium mucunoides*) and a pasture fertilized with 50 or 100 kg/ha of N and concluded that the dry matter production of the mix with Brazilian stylo was similar to the pastures fertilized with 100 kg/ha of N, while the mixed pasture with Calopo did not differ of a pasture without fertilization with N. However, there is no mention in this research of the ratio of the legume forage mass and total mass, which cannot explain if the presence of Calopo was enough to be effective in the total mass of forage in the pasture.

On the other hand, in a experiment conducted in the Instituto de Zootecnia, in Nova Odessa, Brazil, where legumes were implanted in separate plots in pastures already established with Aruana guineagrass (*Panicum maximum* cv. Aruana) for 5 years, Calopo was the legume that persisted in the pasture with the lowest ratio, when compared with other legumes, with a total forage mass of 13.3%, and, as a result, the protein brute in this mixed pasture was similar to pastures with a monoculture of Aruana guineagrass (Gerdes et al., 2009), which indicates that to increase the presence of Calopo in established pastures more research must be done.

Even if a reduction of the presence of forage legumes, or its complete extinction from the system, occurs, there will be a persistence in the N cycling and there will be some benefits for the mixed pasture. According to Menezes et al. (2015) would be necessary from 130 to 150 kg/ha of N to maintain the pasture productivity in areas with Xaraes palisadegrass two years after the disappearance of Brazilian stylo that exists in that pasture before, at the ratio of 34 and 52%. Also in this research Alves et al. (2016) evaluated the production and morphogenic characteristics of Xaraes grass and concluded that there was a residual effect from the incorporated nitrogen to the system by the legumes.

The amount of N incorporated by legumes in pasture systems range from 75 to 150 kg/ha.year of N (Martuscello et al., 2011; Menezes et al., 2015; Pinheiro et al., 2015) and are very significant to the maintenance of pasture productivity, avoiding the degradation of these systems, justifying financially environmentally researches to use forage legumes in mixed pastures.

CHARACTERÍSTICS OF SOME PROMISING LEGUMES TO USE IN TROPICAL REGIONS

The utilization of legumes as a forage is a promising alternative in the search for sustainability in several types of climate and soils. Brazil is considered a continental country and has several biomes bringing with them variations on climate, soils and its natural acidity. Acidity is one of the main factors that may affect the establishment of legumes. However some tropical forage legumes are highly adaptable to soils with low fertility and acids (Barcellos et al., 2008; Andrade et al., 2015).

By the end of the 80's several were the studies with legumes and many of the plants shown potential and were efficient. Even showing potential, many of them are still unexplored due to low initial growth and lack of persistence of some species, recognized as the most limiting characteristic impeding its use.

Currently the cultivars of forage legumes that have being more studied and, thus, have more information compiled are: Brazilian stylo (*Stylosanthes spp.*), forage peanut (*Arachis pintoi*) and leadtree (*Leucaena spp.*), as they are more cultivated and/or promising.

There is an attempt, on this review, to discuss legumes that have a high potential to be used in mixed pastures with grasses but they are still underused by rural producers, like *Neonotonia wigthii* (perennial soybean), *Macrotyloma axillare* (perennial horse gram). Among them, there is *Arachis pintoi* (forage peanut), because even though there are several studies about this genotype it is not well utilized by the producers, probably because the need to reproduce them by seedlings which makes it more expensive and difficult to disseminate.

Perennial soybean (*Neonotonia wightii*)

Perennial soybean is originally from Africa and is also found in Southwest Asia (Tang et al., 1987). Perennial soybean is one of the most known forage legume in Brazil, due to its adaptability to the local climate changes. It was introduced in Brazil by the Instituto Agronomico de Campinas in 1956 (Alcantara and Mattos, 1976). It needs fertile soils, with pH around 6.0 and it is exigent in phosphorus as some other legumes are. It is considered by Barcellos et al. (2008) as a possible invasive in areas of crop-pasture integration because it benefits from the fertilizations done to the crops.

It is a perennial legume, herbaceous, prostrated, voluble, with trifoliate, oval and elliptical leaves and deep root system (Veasey et al., 1993). In ideal conditions this plant can fix from 40 to 140 kg/ha.year of nitrogen, if its nutritional needs are met and the pH is in an adequate range (Carvalho, 1986). Werner et al. (1996) classify this legume in the Group I of exigencies in soil fertility, recommending a soil base saturation to its implementation around 70 and 60% to its maintenance.

Barcellos et al. (2008) highlight the species low tolerance to overgrazing which is consistent with its growth behavior (voluble) and its good natural re-seeding. Perennial soybean (*N. wightii* Verde cv. Tinaroo) as a monoculture in pastures shown to be very promising as animal fodder and resulted in higher weight gain in beef cattle (1,375 kg/ha of weight gain) then Green Panic grass (*Panicum maximum* var. Trichoglume cv. Petrie) fertilized with nitrogen (75 kg/ha.year of N) (1,047 kg/ha of weight gain) in an experiment conducted for 4 years (Lourenço et al., 1998).

Before they started this experiment, grasses and legume had being seeded in together. However an insect attack (spittlebug) on the Green Panic helped the perennial soybean to dominated the pasture and it becomes exclusive, indicating a great potential to be planted in such with other grasses (Lourenço et al., 1998). The authors note that the pastures were fertilized before the experimental period started with phosphorus (100 kg/ha P_2O_5) and potash (60 kg/ha K_2O) and the pastures that had only legumes were fertilized with micro nutrients (5 kg/ha of copper sulphate, 5 kg/ha of zinc sulphate and 200 g/ha of sodium molybdate), which may be one of the causes to the high persistence and animal productivity of the perennial soybean-exclusive pasture.

Gerdes et al. (2009) reported that when perennial soybean (*N. wightii* NO 2348) was seeded in Aruana guineagrass pastures five years old it reached 42.2% of the total forage mass one year after its seeding when grazed by sheep, standing higher than the 20% recommended by Spain and Pereira (1985) as a minimum ratio. There was a significant transfer of nitrogen from the legume to the grass, which increased the protein brute of the grass to 10.9% when compared to pasture of exclusively Aruana guineagrass (9.3% PB). It was emphasized that P and K was supplied, as well as micro nutrients, which are important to meet the nutritional needs of the forage legumes.

The studies with *N. wightii* have being rescued by group of researchers in order to increase the knowledge about this plant so it can be introduced in new mixed pasture. The results obtained in hothouses evaluating the access of perennial soybean *N. wightii* NO 278 described its implementation capacity (Silva et al., 2016a) and the morphogenesis of its development using the elongation rate of its leaflets in length and width in its initial phase (Silva et al., 2016c).

Perennial horse gram (*M. axillare*)

Another option as a promising forage legume is *M. axillare* that was originally from tropical Africa (Bogdan, 1977) and it was introduced in Brazil in the middle of the 60's when a collection was sent to the Instituto de Zootecnia (Rocha, 1988; Paulino et al., 2008). It is a perennial plant, herbaceous, climber, voluble with branches finely pubescent and trifoliate leaves (Bufarah et al., 1981).

This legume has important characteristics to adequate itself in a pasture system, especially in regions where the soils are deficient in nutrients; it is fast growing and has good tolerance to low fertility soils, as already noticed by Werner et al. (1996) when it was classified in the group with a lower exigency among the forage legumes, needing a soil base saturation around 50%. Furthermore its persistence is high under grazing, because it has its growing favored for a low acceptance by the cattle, due to its bitter flavor due to its tannin content (Barnes, 1996).

Matos and Pedreira (1984) observed that this species has good growth along the different seasons of the year, which is a very important factor to productivity and persistence of the forage plant. Also in some recent studies Silva et al. (2016b) described the establishment of the perennial horse gram access and the morphogenesis of its development through the elongation rate of the leaflets and its length and width during the initial phase (Silva et al., 2016c).

Perennial horse gram access *M. axillare* NO 279 did not shown differences in its development with increasing doses of calcium (Barbosa, 2016), corroborating the information from Werner et al. (1996), which was its good tolerance to acid soils and with low base saturation. On the other hand, increasing phosphorus doses increased the dry matter mass production of the shoots, roots, nodules, leaf area, leaf numbers, branch numbers and nodule numbers (Barbosa, 2016) indicating the need for supplying phosphorus even in soils with median level of this nutrient (above 15 mg/dm^3 described by Werner et al., 1996).

Gerdes et al (2009) in an experiment already described for perennial soybean observed a good stand of *M. axillare* NO 279 in Aruana guineagrass pastures, with the legume reaching up to 43.2% of the forage mass after one year of the seeding and the protein brute of Aruana guineagrass reaching 11.9% among all mixed pastures.

Pinto peanut (*A. pintoi*)

A. pintoi is a native plant from the Cerrados of Brazil, adapted to acid soils and low fertility. The cultivar Belmonte is prominent in tropical regions because of its high nutritive value, high persistence and tolerance to shade, showing that it is apt to mixed pastures with grasses (Barcellos et al., 2008), *A. pintoi* cv. Belmonte is an herbaceous plant with stolons that is vegetative propagation (Paganella and Valls, 2002).

The genus *Arachis* comprises plants adapted to tropical and subtropical conditions with uniform rainfall and a dry season not superior to four months (Ramos et al., 2010). As per its persistence, *A. pintoi* cv. Belmonte have characteristics such as a prostrated growth behavior and it is stolonifera (which protects the plant from grazing), long life cycle and tolerance to shade (Andrade et al., 2006).

Assis et al. (2008) evaluated 21 genotypes of pinto peanut and observed that the dry matter production varied from 1,609 to 4,132 kg/ha.year, and the Belmonte cultivar was a highlight among all genotypes. It is worthy to note that the mix between Belmonte cultivar and the forage grasses has increased the productivity and profitability of the systems where it is already in use (Andrade et al., 2012; Oliveira, 2007).

Fialho (2015) studying the characteristics of *A. pintoi* cv. Belmonte under continuous stocking observed that the grazing intensity increases the leaf appearance rate, thus given evidence that this plant is capable of adjusting its growth at different defoliation rates. Furthermore, the results indicate a consistency in the leaf area index, which indicates that the Belmonte cultivar has a higher adaptation capability, which may be useful as it gives more flexibility to be used and managed.

Conflicts of interests

The authors have not declared any conflict of interests.

REFERENCES

Alcantara PB, Mattos HB (1976). de. Caracterização de algumas variedades de soja-perene, *Glycine wightii* Wild. Bol. Ind. Anim. 3:87-93.

Alexandrino E, Nascimento Junior D, Mosquim PR, Regazzi, AJ, Rocha FC (2004). Características morfogênicas e estruturais na rebrotação da *Brachiaria brizantha* cv. Marandu submetida a três doses de nitrogênio. Rev. Bras. Zootec. 33(6):1372-1379.

Alves EB, Menezes RC, Lara MAS, Casagrahde DR, Bernardes TF (2016). Residual effects of stylo on the morphogenetic and structural characteristics of palisadegrass pasture. J. Japonese Society Grassland Sci. 62:151-159.

ANDA (2016). Associação Nacional Para Difusão De Adubos. Principais indicadores do setor de fertilizantes 2016. São Paulo: ANDA, 2016. Available in: < http://www.anda.org.br/estatistica/Principais_Indicadores_2016.pdf>. Access in: 15/09/2016.

Andrade CMS, Garcia R, Valentim, JF, Pereira OG, (2006). Grazing management strategies for massaigrass-forage peanut pastures. 1. Dynamics of sward condition and botanical composition. Rev. Bras. Zootec. 35(2):334-342.

Andrade CMS, Ferreira AS, Farinatti LHE (2011). Tecnologias para intensificação da produção animal em pastagens: fertilizantes x leguminosas. In: Simpósio sobre Manejo da Pastagem, 26, A empresa pecuária baseada em pastagens. Anais ... Pedreira CGS, Moura JC, Faria VP (Ed.). Piracicaba: FEALQ 320 p.

Andrade CMS, Garcia R, Valentim JF, Pereira OG (2012). Productivity utilization efficiency and sward targets for mixed pastures of marandugrass, forage peanut and tropical kudzu. Rev. Bras. Zootec. 41(3):512-520.

Assis GML, Valentim JF, Carneiro Jr JM, Azevedo JMA, Ferreira AS (2008). Seleção de genótipos de amendoim forrageiro para cobertura do solo e produção de biomassa aérea no período de estabelecimento utilizando-se metodologia de modelos mistos. Rev. Bras. Zootec. 37(11):1905-1911.

Barbosa HZ (2016). Combinações de doses de fósforo e cálcio para leguminosa macrotiloma. 2016. 75p. Dissertação (Mestrado em Produção Animal Sustentável). Instituto de Zootecnia. APTA/SAA, Nova Odessa.

Barcellos AO, Ramos AKB, Vilela L, Martha Junior GB (2008). Sustentabilidade da produção animal baseada em pastagens consorciadas e no emprego de leguminosas exclusivas, na forma de banco de proteína, nos trópicos brasileiros. Rev. Bras. Zootec. 37:51-67.

Barnes P (1996). Research note: Dry matter production and chemical composition of introduced forages at two moist savanna sites in Ghana. Trop. Grasslands 30:418-421.

Bogdan AV (1977). Tropical pasture and fodder plants. Longmans: London, 475 p.

Bufarah G, Ghisi OMAA, Alcântara VBG, Mecelis NR, Alcântara PB, Oliveira PRP, Luchesi MF (1981). O *Macrotyloma axillare*. Nova Odessa: Divisão de Nutrição Animal e Pastagens: 8 p. (Nota cientifica n°1. Seção de Agronomia de Plantas Forrageiras).

Cantarella H (2007). Nitrogênio. In:. Novais RF, Alvarez VH, Barros NF, Fontes RLF, Cantarutti RB, Neves JC (Eds.). Fertilidade do solo. Viçosa: Sociedade Brasileira de Ciência do Solo, pp. 375-470.

Carranca C, Torres MO, Madeira M (2015). Underestimated role of legume roots for soil N fertility. Agron. Sustain. Dev. 35:1095-1102.

Carvalho MM (1986). Fixação biológica como fonte de nitrogênio para pastagens (1985). In: Simpósio Sobre Calagem E Adubação De Pastagens, 1., Anais... Nova Odessa: IZ pp.125-143.

Cassol LC, Piva JT, Soares AB, Assmann AL (2011). Produtividade e composição estruturas de aveia e azevém submetidos a épocas de corte e adubação nitrogenada. Ver. Ceres 58(4):438-443.

Castagnara DD, Mesquita EEI, Neres MA, Oliveira PSR, Deminicis BB, Bamberg R (2011). Valor nutricional e características estruturais de gramíneas tropicais sob adubação nitrogenada. Arch. de Zootec. 60(232):931-942.

Corsi M, Nascimento Junior D (1984). Princípios de fisiologia e morfologia de plantas forrageiras aplicados ao manejo das pastagens. In: PEIXOTO, A.M. (Ed). Pastagens: fundamentos da exploração racional. 2º Ed. 1994, Piracicaba : FEALQ, pp. 15-48.

Costa CHM, Crusciol CAC, Soratto RP, Neto JF, Moro E (2016). Nitrogen fertilization on palisadegrass: phytomass decomposition and nutrients release. Pesqui. Agropecu. Trop. 46 (2):159-168.

Costa KAP, Oliveira IP, Faquin V (2006). Adubação nitrogenada para pastagens do gênero *Brachiaria* em solos do cerrado. Embrapa Arroz e Feijão. (Documentos / Embrapa Arroz e Feijão). 60p.

Da Silva SC, Gimenes FMA, Fialho CA, Gomes MB, Berndt A, Gerdes L, Colozza MT (2010). Animal performance and productivity on marandu palisadegrass subjected to strategies of rotational stocking management and rates of nitrogen fertilization: preliminary results from a farmlet based study. In: International Workshop: AN OVERVIEW OF RESEARCH ON PASTORAL-BASED SYSTEMS – In the Southern part of South America, 2010, Tandil, Argentina. Procedings...Tandil:Editorial Universidad Nacional del Centro de La Provincia de Buenos Aires, pp. 215-231.

Dias-Filho MB (2014). Diagnóstico das pastagens no Brasil. Belém, PA: Embrapa Amazônia Oriental 36 p.

Diehl MS, Olivo CJ, Agnolin CA, Bratz VF, Bem CM, Aguirre PF, Glienke CL, Correa MR, Serafim G (2013). Produtividade de sistemas forrageiros consorciados com leguminosas. Arq. Bras. de Med. Vet. e Zootec. 65(5):1527-1536.

Epstein E, Bloom A (2006). Nutrição mineral de plantas: princípios e perspectivas. Trad. Maria Edna Tenório Nunes – Londrina: Editora Planta 403.

Fagundes JL, FONSECA DM, Mistura C, De Morais RV, Vitor CMT, Reis da C, Casagrande DR, Santos MER (2005). Índice de área foliar, densidade de perfilhos e acúmulo de forragem em pastagem de capim-braquiária adubada com nitrogênio. Bol. Ind. Anim.. 62(2):125-133.

Fialho CA, Da Silva SC, Gimenes FMA, Gomes MB, Berndt A, Gerdes L (2012). Tiller population density and tillering dynamics in marandu palisade grass subjected to strategies of rotational stocking management and nitrogen fertilization. Acta Scientarium. Anim. Sci. 34(3):245-251.

Fialho CA (2015). Características morfogênicas e estruturais de amendoim forrageiro (*Arachis pintoi* Krapovickas & Gregory cv. Belmonte) submetido a intensidades de pastejo sob lotação contínua. 121p. Tese (Doutorado em Ciência Animal) – Escola Superior de Agricultura “Luiz de Queiroz”. Piracicaba.

Gastal F, Lemaire G (2002). N uptake and distribuition in crops: na agronomical and ecophysiological perspective. J. Exp. Bot. 53:789-799.

Gerdes L, Colozza, MT, Werner JC, Premazzi LM, Cunha EA, Mattos WT, Giacomini AA (2009). Introdução de leguminosas em pastagem já estabelecida de capim Aruana em pastejo com ovinos In: Reunião Anual da Sociedade Brasileira de Zootecnia, 46, Maringa, PR. Anais..., Lavras: SBZ, CD-ROM.

Giller KE (2001). Nitrogen fixation in tropical cropping systems. 2 ed. Oxon: CAB International 423 p.

Gimenes FMA, Da Silva SC, Fialho CA, Gomes MB, Berndt A, Gerdes L, Colozza MT (2011) Ganho de peso e produtividade animal em capim-marandu sob pastejo rotativo. Pesqui. Agropecu. Bras. 46(7):751-759.

Guilherme LRG, Vale FR, Guedes GAA (1995). Fertilidade do solo: dinâmica e disponibilidade de nutrientes. Lavras: ESAL/FAEPE 171p.

Hodgson J (1990). Grazing management: Science into pratice. Longman Scientific and Technial, Longman group.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). Disponível em: <http:/www.ibge.gov.br>. Acesso em: 20 setembro 2016.

Jewiss OR (1972). Tillering in grasses: its significance and control. J. British Grassland Soc. 72:65-82.

Lemaire E, Chapman D (1996). Tissue flows in grazed plant comunities. In: Hodgson J, Illius AW (Eds.) The ecology and management of grazing systems, pp. 3-36.

Lemaire G, Hodgson J, Chabbi A (2011). Grassland productivity and ecosystem services. Cabi, Wallingford. 312p.

Lourenço AJ, Boin C, Alleoni GF (1998). Desempenho de Bovinos em Pastagens de soja perene exclusiva e Green Panic Fertilizado com Nitrogênio. Rev. Bras. Zootec. 27(1):16-22.

Marschner H (1995). Mineral nutrition of higher plants. 2.ed. London: Academic Press 889 p.

Martuscello JA, Oliveira AB De, Cunha D DE NFV DA, Amorim P L DE, Dantas PAL, Lima D DE A (2011). Biomass production and morphogenesis of signal grass grown under nitrogen levels or intercropped with legumes. Rev. Bras. Saúde Prod. Anim. 12 (4):923-934.

Matos HB, Pedreira JVS (1984). Crescimento estacional de oito leguminosas forrageiras de clima tropical. Bol. Ind. Anim. 41:145-157.

Menezes RC, Alves EB, Casagrande DR, Lara MAS, Evangelista AR, Bernardes TF (2015). Xaraes palisadegrass remains productive after the disappearance of stylo in tropical legume-grass pasture. Sci. Agric. 72 (6):484-488.

Mesquita P, Da Silva SC, Paiva AJ, Caminha FO, Pereira LET, Guarda VD, Nascimento Junior D (2010). Structural characteristics of marandu palisade grass swards subjected to continuous stocking and contrasting rhythms of growth. Sci. Agric. 67:23-30.

Mosier A, Galloway J (2005). Setting the scene – The international nitrogen initiative. In: International Workshop On Enhanced-Efficiency Fertilizers, Frankfurt, Proceedings... Paris, International Fertilizer Industry Association 10 p.

Nascimento Junior D, Queiroz DS, Santos MVF (1994) Degradação das pastagens e critérios para avaliação. In: Simpósio Sobre Manejo De Pastagem, 11., Piracicaba. Anais... Piracicaba: FEALQ pp.107-151.

Oliveira AB, Pires AJV, Matos Neto U, Carvalho GGP, Veloso CM, Silva FF (2007). Morfogênese do capim-tanzânia submetido a adubações e intensidades de corte. Ver. Bras. Zootec. 36(4):1006-1013.

Oliveira AGL (2007). Caracterização da pastagem, desempenho animal e viabilidade econômica em coastcross consorciado ou não com *Arachis pintoi*. 140 p. Tese (Doutorado em Zootecnia) – Universidade Estadual de Maringá, Maringá.

Paganella MB, Valls JFM (2002). Caracterização morfo-agronômica de cultivares e acessos selecionados de *Arachis pintoi* Krapov. & W.C. Gregory (LEGUMINOSAE). Pasturas Trop. 24:23-30.

Paiva AJ, Silva SC, Pereira LET, Caminha FO, Pereira PM, Guarda VDA (2011). Morphogenesis on age categories of tillers in marandu palisadegrass. Sci. Agric. 68:626-631.

Pates NMS, Pires AJV, Silva CCF, Santos LC, Pinto, GG, De Carvalho GGP, Freire, MAL (2007). Características morfogênicas e estruturais do capim-tanzânia submetido a doses de fósforo e nitrogênio. Rev. Bras. Zootec. 36(6):1736-1741.

Paulino VT, Gerdes L, Valarini MJ, Ferrari Junior E (2008). Retrospectiva do uso de leguminosas forrageiras. PUBVET 2:1-37.

Pinheiro AA, Cecato U, Lins TOJDA, Beloni T, Rutzmann A, Iwamoto BS, Mari GC (2015). Accumulation and forage morphological composition of Tanzania grass fertilized with nitrogen or intercropped with Campo Grande Stylosanthes. Biosci. J. 31(3):850-858.

Quatrin MP, Olivo CJ, Agnolin CA, Machado PR, Nunes JS, Correa MR, Rodrigues PF, Bratz VF, Simonetti D (2015). Efeito da adubação nitrogenada na produção de forragem, teor de proteína bruta e taxa de lotação em pastagens de azevém. Bol. Ind. Anim. 72(1):21-26.

Raij BV (2011). Fertilidade do solo e manejo de nutrientes. Piracicaba: International PlantNutrition Institute 420 p.

Ramos AKB, Barcellos AO, Fernandes FD (2010). Gênero Arachis. In: Fonseca DM, Martuscello JA (Ed.) Plantas forrageiras. Viçosa, MG: UFV, pp. 249-293.

Resende AS, Xavier RP, Quesada DM, Urquiaga S, Alves BJR, Boddeu RM (2003). Use of Green manures in increase inputs of biological nitrogen fixation to sugar cane. Biol. Fertil. Soils 37:215-220.

Rocha GL (1988). A evolução da pesquisa em forragicultura e pastagens no Brasil. Anais da Escola Superior de Agricultura Luiz de Queiroz 45:5-51.

Saia S, Urso V, Amato G, Frenda AS, Giambalvo O, Ruisi P, Miceli G (2016). Mediterranean forage legumes grown alone or in mixture with annual ryegrass: biomass production, N2 fixation, indices of intercrop efficiency. Plant Soil 402(1):395-407.

Sarmento P, Rodrigues RLA, Lugão SMB, Cruz MCP, Campos FP, Ferreira ME (2005). Respostas agronômicas e morfológicas de *Panicum maximum* JACQ cv. IPR-86 Milenio sob pastejo à adubação nitrogenada. Bol. Ind. Anim. 62(4):333-346.

Silva GLB, Barbosa HZ, Della Gracia G, Terra SR, Batista K, Giacomini AA, Premazi LM, Fialho CA, Gerdes L, Gimenes FMA (2016a). Growth leaves in a soybean legume (*Neonotonia wigthii*) under establishing conditions subjected to nitrogen doses. In: 53º Reunião Anual da Sociedade Brasileira de Zootecnia, 2016, Gramado.Brazil. Anais... Gramado. Brazil.

Silva GLB, Della Gracia G, Terra SR, Barbosa HZ, Premazzi LM, Giacomini AA, Batista K, Fialho CA, Mattos WT, Gimenes FMA (2016b). Growth leaves in a legume macrotiloma (*Macrotyloma axillare*) under establishing conditions subjected to nitrogen doses. In: 53º Reunião Anual da Sociedade Brasileira de Zootecnia, 2016, Gramado.Brazil. Anais... Gramado. Brazil.

Silva GLB, Terra, SR, Della Gracia G, Barbosa, HZ, Giacomini AA, Batista K, Premazzi LM, Mattos WT, Gerdes L, Gimenes, FMA (2016c). Establishment of macrotiloma and perennial soybean forage legumes under nitrogen doses. In: 53º Reunião Anual da Sociedade Brasileira de Zootecnia, 2016, Gramado.Brazil. Anais. Gramado. Brazil.

Siqueira JO, Franco AA (1988). Biotecnologia do solo: fundamentos e perspectivas. Brasília, DF: MEC/ESAL/FAEPE/AEBEAS 236 p.

Serraj R (2004). Symbiotic nitrogen fixation: prospects for enhanced application in tropical agriculture. New Delhi: IBH 367 p.

Spain JM, Pereira JM (1985). Sistemas de manejo flexible para evaluar germoplasma bajo pastoreo: Una propuesta. In: Lascano C, Pizzaro E (eds.) Evaliación de pastos com animales. Alternativas metodologias. RIEPT, Cali, Colômbia: CIAT. pp. 85-87.

Taffarel LE, Mesquita EE, Castagnara DD, Galbeiro S, Costa PB, Oliveira PSR (2016). Tifton 85 grass responses to different nitrogen levels and cutting intervals. Semin. Ciênc. Agrár. 37(4):2067-2084.

Taiz L, Zeiger E (2004). Fisiologia vegetal. 3ed. Porto Alegre: Artmed Editora 719p.

Tang M, Hernandez L, Hernandes CA (1987). *Neonotonia wigthii* e Arn. Lackey. Pastos Forajes 10:1-24.

Thomas RJ (1992). The role of the legume in the nitrogen cycle of productive and sustainable pastures. Grass For. Sci. 47:133-142.

Valle CB, Zimmer AH (2013). Leguminosas forrageiras em pastos consorciados: experiências do passado que podem fomentar o futuro. In: AS FORRAGEIRAS E AS SUAS RELAÇÕES COM O SOLO, O AMBIENTE E O ANIMAL. Anais... Lavras: UFLA, pp.17-28.

Veasey EA, Alcantara PB, Otsuk IP, Corrente JE (1993). Caracterização morfológica e fenológica de diferentes acessos de soja perene (*Neonotonia wightii*). Rev. Soc. Bras. Zootec. 22(2):248-260.

Werner JC, Paulino VT, Cantarella H (1996). Forrageiras. In: Raij B. van, Cantarella H, Quaggio JA, Furlani AMC (Ed.). Recomendações de adubação e calagem para o Estado de São Paulo. 2. ed. Campinas: Instituto Agronômico pp. 263-273.