

Feed ruminants using *Tithonia Diversifolia* as a forage

Abstract

The negative climate change effect on ruminant production is increasing the risk of food security. Therefore, the search for alternative forages able to provide high volume of biomass and nutritional qualities and also adapted to a poor soil and climate conditions are extremely necessary. In this context, the high tropical biodiversity is able to provide potential forages for ruminants as a pasture or even as a fodder bank. The promissory results of our work on the use of *Tithonia diversifolia* as feed for dairy and beef cattle in Brazil and Colombia are showing its potential to attend nutritional requirements for medium and high performance cows. In addition, these studies are in line with the guidelines advocated by Food Agriculture Organization (FAO) for the promotion of sustainable intensification of animal production in the tropical world.

Keywords: dairy cattle, beef cattle, nutritional supplementation, tropical forage, *Tithonia diversifolia*

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Introduction

Several basic and practical questions are raised by livestock players when “new” forage plants are released from research institutions, agribusiness companies or even from farmers/stakeholders for public use. In the past, these questions were always similar (e.g. nutritional values? biomass production? stocking rate capacity? fertilize recommendations? etc.) but actually, as the humanity has to face the negative effects of climate change, other aspects are needed. As the natural resources to sustain the livestock products demand are limited, “new feeds” need to be produced using sustainable principles including low demand for fertilizer, water and high biomass production. Therefore, we start this article asking some questions about one new forage that is coming out from tropical countries: What is *Tithonia diversifolia*? Do you know that it can grow in poor and dry soils and produces a huge amount of biomass? Do you know that *T. Diversifolia* has an enormous potential as a nutritive source of biomass for ruminant nutrition.

Plant description—*Tithonia diversifolia*

T. Diversifolia is an herbaceous/shrub species, branched whose height could vary from 2 to 4 meters (Super division Spermatophyta, Class Eucotiledoneae, Subclass Metaclamideae, Order Campanuladas, Family Asteraceae, Genus *Tithonia*, Species *Tithonia diversifolia* (Hemsl.) Gray. It is distributed in Africa (e.g. Nigeria, Kenya),¹⁻³ South America (Colombia, Venezuela, Bolivia e Brazil),⁴⁻⁷ North America (e.g. Mexico),⁸ Central America and the Caribbean (Costa Rica, Panamá, Cuba)⁹ and Asia (China and Vietnam).^{10,11}

T. Diversifolia can growth in acid soils including high levels of aluminium and low levels of phosphorus.⁹ It is important to mention that *T. Diversifolia* is able to take mobilized phosphorus from the soil to the plant, which is a positive characteristic for most of tropical soils. It requires 800 to 5.000mm of water, 16 to 30°C and can growth from sea level to 2.500m altitude.⁹ Usually, *T. Diversifolia* occurs in marginal area as of roads, around crop fields and hedges or close to

farm houses. In Latin America and Caribbean (Colombia, México, Cuba, Panama, Dominican Republic and Brazil) pure stands are growing fast as farmers start to recognize the high biomass production and nutritional value of the plant.

Usually, *T. Diversifolia* is propagated from stem cuttings of 20 to 40cm length, inserted vertically into the soil, 10 to 20cm deep. Seeds can also be used as they germinate under the canopy or even in plastic bags, and then seedlings transplanted to other areas. The main benefit of this method is that the roots will grow deeper in the soils, compared to vegetative method, and the growth is improved. However, the biomass production is influenced by soil quality, planting methods, cutting frequency, stand density and weather.^{9,12,13}

Although it has been used as a fodder for animal nutrition,^{4,7,8,14} there are several uses reported for *T. Diversifolia* like insect repellent and negative effect against ants,¹⁵ allelopathic effect against other plants,^{16,17} source of nectar for bees¹⁸ and sources of nutrients (N, P and K) for degraded soils as the biomass is quickly decomposed and consequently nutrients are easily released to the soil.^{2,19}

Nutritive value

The studies developed by The University of Sao Joao del-Rei – Brazil (UFSJ) and CIPAV (Colombia) showed promising results for the use of *T. Diversifolia* as forage for ruminant nutrition. The chemical constituents of whole plant, leaves and stem obtained during the booting and pre-flowering stage when plant height reached 0.80-1.0m from the soil are good examples of important elements that could provide positive evidences of the nutritional values of *T. Diversifolia*.²⁰ The total dry matter (8.1ton/ha for booting and 5.6t/ha for pre-flowering) and fresh production (41.3ton/ha for booting and 24.7t/ha for pre-flowering) of whole plant were also included (alley crop system). The protein values during the booting (164.7g/kg DM) were higher compared to pre-flowering (149.1g/kg DM) stage. These values are as high as the values observed in some tropical legumes like, *Stylosanthesguianensis* (162.0g/kg DM),²¹ *Arachispintoi* (180.0g/kg DM)²² *Gliricidia sepium* (139.0g/kg DM)²² and are higher

than those observed for most tropical grasses like, *Urochloa brizantha* (69.0g/kg DM)²³ and *Urochloa decumbens* (63.0g/kg DM).²⁴ In addition, the NDF (498.0g/kg DM) are lower than common values observed for the traditional forages (e.g. *Urochloa brizantha*: 680.0g/kg DM).²³ However, the amount of protein linked to fiber is high and not available for ruminants (92.3g/kg DM). It is important to mention that forage production (alley crop) were similar to other legumes or grasses but the soil quality parameters (pH or phosphorus) required for *T. Diversifolia* to growth are much lower.

Feeding dairy cows with *T. Diversifolia* – Brazilian experiences

An *in vivo* study was conducted at UFSJ to determine the effects of replacing sugarcane fresh and concentrate (DM basis) with *T. Diversifolia* fresh fed (0, 6.4, 15.3%) to lactating cross breed dairy cows.⁷ The results found by the authors indicated that it is possible to replace sugarcane (20% DM basis) and concentrate (11.2% DM basis) in a total mixed ration diet fed to dairy cows without any change in total intake (18.7kg MS/day), milk yield (22.9kg/day) and composition. In addition, glucose, urea, triglycerides, cholesterol, non-esterified fatty acids and β -hydroxybutyrate blood parameters were not negatively affected by the inclusion of *T. Diversifolia*. This indicates that fresh *T. Diversifolia* up to 15.3% can replace sugar cane but also feed supplements (soybean and maize) without any change in intake, milk production/composition and most of the blood parameters. As concentrate has the highest cost in the diet, especially due to the inclusion of soybean meal, an alternative resource like *T. Diversifolia* might can provide important economic saving for farmers. However, there are constraints in the utilization, as it requires more labour both for planting and harvesting.

Feeding dairy cows with *T. Diversifolia*– Colombian experiences

In Colombia, the Amazon region (humid tropics) is characterized by acid soils, very poor in organic matter and phosphorus concentration. In this area an intensive silvopastoral system (iSPS) formed by grasses (*Urochloa decumbens* (Stapf) R. Webster; *Urochloa brizantha* (Hochst. Ex A. Rich.), *Brachiaria humidicola* (Rendle) Schweickerdt)

associated with *T. Diversifolia* (5,000 shrubs/ha, alley crop) and trees of *Gmelina arborea* Roxb and *Tectona grandis* (100 trees/ha) was evaluated.²⁴ Grazing was performed using rotational grazing in stripes using electric fence (3days for grazing and 35days for resting). The iSPS was compared to the conventional grazing system composed by *Brachiaria*, *Urochloa* and *Homolepsis aturensis* (Kunth) grasses, including low presence of trees. Cows were milked once a day and received no supplementation.²⁴ The grasses species presented low nutritional quality (Table 1), but when combined with *T. Diversifolia* improved the composition of the diet and promoted a better balance of nutrients that benefited the productive potential of dairy cows. It should also be considered that the increase in the total digestibility of the diet promoted by the shrub forage, increased the voluntary intake of the animals, which was reflected in the amount and quality of milk produced.²⁴

Milk production (Kg of milk/cow/day or Kg of milk/ha/day), non-fat solids (kg/cow/day or kg/ha/day) and total solids (kg/cow/day or kg/ha/day) were higher in the iSPS including *T. Diversifolia* than in the conventional grazing system (Table 2).²⁴ The daily milk production per cow in the iSPS was 4.92kg, 7% higher than the conventional system. In addition, the stocking rate and milk production (ha/year) were higher in iSPS (32.1% and 36.6% respectively).²⁴ It is important to mention that the positive results originated from the iSPS with *T. Diversifolia* provided 30% more income to the farmer and also benefits for the milk industry as there is a higher volume of milk with higher content of solids and less seasonality throughout the year.

Feeding beef cattle with *T. Diversifolia* – Colombian experiences

The Caribbean region (dry tropics), characterized by acid and poor soil, was selected for an experiment conducted with dual purpose males calves (Zebu – 170kg live weight).²⁵ The first treatment was based on grazing system composed by *Urochloa decumbens* grass, commercial minerals salt mixture and water. The second treatment used the same basal diet of *U. Decumbens* added with fresh *T. Diversifolia ad libitum*. The results demonstrated that animals reached a higher growth rate of 512g/day when supplemented with *T. Diversifolia* compared to 130g/day based on grazing only.

Table 1 Chemical analysis of forages in a rotational system with *T. Diversifolia* in Caquetá, Colombia. Adapted of the Riveira et al²⁴

Species	PB(%)	NDF(%)	ADF(%)	Ca(%)	P(%)	IVDMD(%)
<i>U. decumbens</i>	6.03	67.3	39.5	0.4	0.19	55.1
<i>B. humidicola</i>	6.13	69.5	42.4	0.37	0.17	51.9
<i>U. brizantha</i>	7.61	80.8	55.8	0.19	0.08	48.1
<i>T. diversifolia</i>	25.4	25.2	23.5	2.21	0.29	63.5

PB, Protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; Ca, calcium; P, phosphorus; IVDMD, in vitro dry matter disappearance

Table 2 Milk production and composition from cross bred cows grazing in a conventional pasture and an iSPS with *T. Diversifolia* in the amazons piedemont region (Colombia). Adapted of the Riveira et al²⁴

Parameters	Conventional	iSPS	S.E.	p- value
Stocking rate (AU/ha)	1.84	2.71	-	-
Kg of milk/cow/day	4.59 ^b	4.92 ^a	0.068	0.011
Kg of milk/ha/day	9.74 ^b	15.4 ^a	0.005	<.001
NFS (%)	8.77	8.81	0.111	0.074
NFS (kg/cow/day)	0.39 ^b	0.44 ^a	0.014	0.007
NFS (kg/ha/day)	0.86 ^b	1.36 ^a	0.002	<.001
TS (%)	12.2	12.2	0.098	0.89
TS (kg/cow/day)	0.55 ^b	0.62 ^a	0.011	0.024
TS (Kg/ha/day)	1.20 ^b	1.89 ^a	0.002	<.001
Kg of milk /ha/year	3556	5615	-	-

Isps, intensive silvopastoral system; S.E, standard error; AU, animal unit (450kg of live weight); NFS, non fat solids; TS, total solids

Conclusion

T. Diversifolia is a suitable fodder species for ruminants that has a wide range of adaptation. It is well accepted by animals, has high protein content even higher than some legumes, is a good supply of minerals and has low fibre. Its inclusion in the diet of ruminants increases nutrient intake, improves yield and helps reducing supplementation costs. When planted along with grasses in iSPS, it contributes to increase the production of meat and milk per hectare and to improve milk quality.

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Conflict of interest

Author declares that there is no conflict of interest.

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