



**PRODUCTIVE AND QUALITATIVE PERFORMANCE OF NATURALIZED AND NATIVE FORAGE LEGUMES IN THE TEMPERATE ZONE OF PUEBLA STATE, MEXICO**

**[COMPORTAMIENTO PRODUCTIVO Y CUALITATIVO DE LEGUMINOSAS FORRAJERAS NATURALIZADAS Y NATIVAS EN LA ZONA TEMPLADA DE PUEBLA, MÉXICO]**

**Juan de Dios Guerrero-Rodríguez<sup>1\*</sup>, Rocío Margarita Flores-Galván<sup>2</sup>,  
Numa Pompilio Castro-González<sup>2</sup>, Ángel Bustamante-González<sup>1</sup>  
and Ramiro Escobar-Hernández<sup>2</sup>**

<sup>1</sup> Colegio de Postgraduados, Campus Puebla. Km. 125.5 Carretera Federal México-Puebla, San Pedro Cholula, Puebla, México. CP 72760 Tel. (222) 2 85 14 42 Ext. 2208. Email: grjuan2000mx@yahoo.com; rjuan@colpos.mx

<sup>2</sup> Benemérita Universidad Autónoma de Puebla. Unidad Académica de Ingeniería Agrohidráulica-Plantel de Ingeniería Agronómica y Zootecnia. Avenida Reforma No. 165 CP 73900, Tlatlauquitepec, Puebla. México. Tel (233) 31800 07.

\* Corresponding author

**SUMMARY**

The aim of this study was to evaluate seven species of native and naturalized legumes in terms of forage production and nutritive quality. The control species, *Vicia sativa* was represented by two varieties, which maintained a high dry matter production at two locations, in one of them, matched by *Melilotus albus*. The latter species also had high yields of dry matter in two locations, but in one of them the varieties of *V. sativa* were not successful. Less yielding species were those that had lower fiber concentration, a situation that was in part due to a higher leaf:stem ratio. *Medicago polymorpha* had the lowest digestibility, which coincided with higher concentrations of neutral and acid detergent fiber. The crude protein concentration was different among species ( $P<0.0001$ ), where *M. polymorpha* consistently had low ( $P<0.05$ ) concentration (16.8%) as well as *M. albus* (17%). Among the species tested in this study, several of them have potential yield and quality to improve the diet of ruminants in the highland region of Puebla State and can replace the vetches. Additionally, even when the climate may be the same, the soil conditions also determine which species can thrive in a region.

**Key words:** herbaceous legumes; nutritive value; ruminants; temperate climate.

**RESUMEN**

Se evaluó la producción de forraje y calidad nutritiva siete especies de leguminosas forrajeras naturalizadas y nativas en región templada de Puebla. La *Vicia sativa* (testigo representada por dos variedades) mantuvo alta producción de materia seca en dos localidades, en una de ellas igualada por el *Melilotus albus*. Esta última especie mantuvo también altas producciones de materia seca en dos localidades, en una de ellas donde no prosperaron las variedades de *V. sativa*. Las especies menos rendidoras tuvieron menores contenidos de fibra, situación que fue en parte debida a que presentaron mayores relaciones de hoja:tallo. La *Medicago polymorpha* presentó los valores más bajos de digestibilidad, lo que coincidió con sus mayores concentraciones de fibra detergente neutro y ácido. El contenido de proteína cruda fue diferente entre especies ( $P<0.0001$ ), donde *M. polymorpha* consistentemente presentó menores ( $P<0.05$ ) concentraciones (16.8%) igual que *M. albus* (17%). De las especies ensayadas, varias tienen potencial productivo y cualitativo para mejorar la dieta de los rumiantes de la región de los valles altos del estado de Puebla y pueden sustituir a las vechas. Aun cuando el clima es el mismo en la región, las condiciones de suelo determinan qué especies pueden prosperar.

**Palabras clave:** leguminosas herbáceas; valor nutritivo; rumiantes; clima templado.

## INTRODUCTION

In the temperate region of Puebla, mainly in the valleys of Libres, Puebla and Serdán, there is a ruminant population of around 513,000 heads, where sheep represents 65% (INEGI, 2008). Feeding these animals relies on the consumption of native pastures and crop residues, which usually have low concentrations of protein, leading to poor liveweight gain and in some species like goats and cattle, milk production has not yet reached potential (Church *et al.*, 2004). To cover the shortfall on requirements, sometimes commercial concentrates are supplied. This means increased production costs, which affects the profitability and stability of the production system. An alternative to the deficit of protein in the diet, is the inclusion of legumes, which generally have, compared to grasses, the highest concentration of crude protein (which in several cases exceeds 20%), and higher concentrations of calcium than grasses. This makes them important elements in improving the diet and reducing production costs by way of diminishing the purchase of concentrates.

Within the main legume group grown for forage in the humid temperate region of Puebla state, there are some perennials such as *Medicago sativa* (alfalfa), *Trifolium repens* (white clover) and *Trifolium pratense* (red clover), and annuals such as, *Vicia villosa* (winter vetch) and *Vicia sativa* (common vetch). However, these species have special requirements and do not suit all environments. There are some other naturalized and native legumes, which can be options for ruminant feeding, but their productive potential and quality is unknown. Among them it can be mentioned some naturalized such as *Melilotus albus*, *Medicago polymorpha*, *Medicago lupulina* and *Vicia sativa sp nigra*, some other native as *Crotalaria pumila* and *Cologania tenuis*. Data reported for some of these species are across a wide range, but all studies have been carried out in other countries. For example, crude protein (CP) in *M. polymorpha* has a range from 11 to 25%, neutral detergent fiber (NDF) varies between 27 and 70% and acid detergent fiber (ADF) between 22 and 58%; for *M. lupulina* CP reported ranges are from 14 to 27%, NDF from 22 to 54% and the FDA between 16 and 39% (Zhu *et al.*, 1996; Sherestha *et al.*, 1998; Alford *et al.*, 2003; Muir *et al.*, 2003). In *M. albus* ranges reported for CP are from 17 to 24.7%, NDF from 32 to 34.7% and ADF from 19.8 to 24.4% (Guerrero-Rodríguez, 2006).

In the highlands valleys of Puebla, the prevailing climate is temperate in combinations of semi-dry, sub-humid and humid. Variation in soil pH and texture is broad, from saline to acid soils and from clay to sandy. It is important to know the performance of the species under different conditions to be able to

give informed recommendations. Therefore, this study aimed to evaluate the performance in yield and quality of seven species of forage legumes (biennial and annual types) in three temperate regions of the state of Puebla, Mexico.

## MATERIALS AND METHODS

### Location

This study was conducted in the municipalities of San Salvador El Verde, Tlatlauquitepec, and Libres, Puebla, Mexico. The experiments were located at: San Salvador el Verde at 19° 15.374' N and 98° 31.115' W at an altitude of 2434 meters above the sea level, in a sandy loam soil of pH 6.3; in Tlatlauquitepec at 19° 50.411' N and 97° 29.839' W at an altitude of 1959 masl and a sandy loam soil with pH of 6.7; en Libres at 19° 20.479' N and 97° 32.577' W at an altitude of 2374 masl, in a sandy soil pH 7.2. Planting dates were 12, 14 and June 24, 2008, for Libres, San Salvador El Verde and Tlatlauquitepec, respectively.

### Establishing the experiments

Seven herbaceous forage legume species were planted. Five of them are found naturally in the grasslands and roads in the temperate region of Puebla. These were: *Melilotus albus*, seeds collected from the mountains of Tentzo in the Municipality of Tecali de Herrera; *Medicago lupulina*, seeds collected from the grazing areas of San Pedro Cholula and San Salvador El Verde; *Crotalaria pumila*, *Medicago polymorpha*, *Vicia sativa sp nigra* and *Cologania tenuis*, seeds collected from pastures at San Salvador El Verde. The control species was vetch (*Vicia sativa sp sativa*) with two varieties (white flower –WF- and purple flower –PF-), seeds for both purchased from a commercial source.

### Experimental design

At each site, the species were distributed in a randomized complete block design with four replicates. The experimental unit consisted of a plot of 2x3 m. The statistical model was:  $Y_{ij} = \mu + \beta_j + \tau_i + \varepsilon_{ij}$  where  $\mu$  = the population mean,  $\tau_i$  = species effect i,  $\beta_j$  = effect of block j,  $\varepsilon_{ij}$  = experimental error. When considering locations, a combined analysis was performed where the model included the effect of Locality, Blocks nested into Locality and the interaction Species\*Locality. Comparisons among averages were carried out using the Tukey's test with  $\alpha=0.05$ . All data analyses were performed using the GLM procedure of SAS programme version 9.2 (SAS Institute, 2002).

## Crop management

The experiments were kept free of weeds, which were removed manually for all cases. There was only one sampling, in all the replicates. Quadrants of 0.5 x 0.5 m were used for harvest choosing the most representative part of the plot, taking the cut to 3 cm from the ground. It is noteworthy that with the exception of the species *Vicia sativa sp nigra* all the others were in bloom.

## Variables evaluated

To determine the yield of dry matter (DM) per hectare, the fresh herbage weight was recorded and placed in paper bags, and then the bags were dried in a forced air oven at a temperature of 60 °C for at least 72 hours until constant weight was reached.

The determination of crude protein was done following the procedure of AOAC (1975) by the Kjeldahl method. The neutral detergent fiber (NDF) and the acid detergent fiber (ADF) were conducted under the protocols of Ankom (Ankom Technology, 2006) sequentially.

The *in vitro* digestibility (IVDDM) was carried out by the enzymatic method, according to the two-stage pepsin-cellulase technique (Jones and Hayward, 1975) following the recommendations by Clarke *et al.* (1982); the enzymes pepsin and cellulase (Onozuka RS) were purchased from SIGMA-ALDRICH.

## RESULTS AND DISCUSSION

The species differed ( $P < 0.0001$ ) in dry matter production. *M. albus* and vetches, on average, were the most productive ( $P < 0.05$ ) compared to other species (Figure 1). There was an interaction Species\*Locality ( $P < 0.0001$ ). *M. albus* showed a marked superiority at the locality of Miravalles (Libres) where it was the best producer in the presence of salinity in the soil, but vetches did not prosper. This situation was not replicated in the locality of San Salvador El Verde where *M. albus* productive performance was poor compared to that of vetches. *M. polymorpha* followed a similar trend to *M. albus* across locations. *M. lupulina* also had a better production in the locality of Miravalles where its performance was 51% higher than in the locality of Tlatlauquitepec. The nigra vetch and *C. tenuis* did not survive in Miravalles, most likely by maladjustment to the alkaline soil pH. These two species together with *M. lupulina* had the lowest average yield. Although these species are well adapted to temperate climate and can be found in the wild in some of these sites, their adaptation may be limited by the absence of specific symbionts that are not found in all soils.

In relation to fiber contents, there were marked differences among species ( $P < 0.0001$ ) (Figure 2). Less yielding species had lower fiber content, a situation that was in part due to the higher leaf: stem ratio.

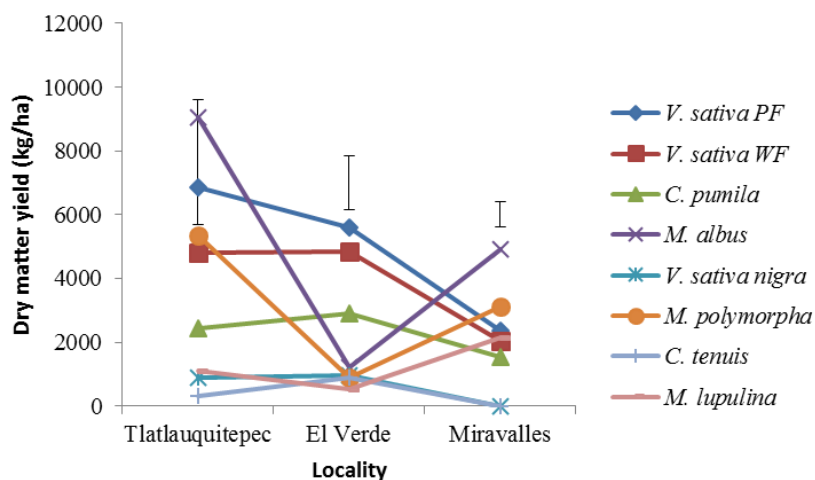


Figure 1. Dry matter production of biennial and annuals legumes in three different localities of the High Plateau of Puebla State. Bars represent the least significant difference of Tukey ( $\alpha = 0.05$ ).

Species interactions with locality were observed in *M. albus* which had low fiber concentration in the localities El Verde and Miravalles. This impacted on its IVDDM values (Figure 3) where the highest were recorded in the locality of San Salvador El Verde. On average, *M. polymorpha* had the lowest IVDDM, which coincided with higher concentrations of both

fractions of fiber. Species differ ( $P < 0.0001$ ) in their crude protein concentration (Figure 4), an aspect which was expressed mostly in the locality San Salvador El Verde, followed by Miravalles. *M. polymorpha* consistently had lower ( $P < 0.05$ ) protein content (16.8%) as well as *M. albus* (17%).

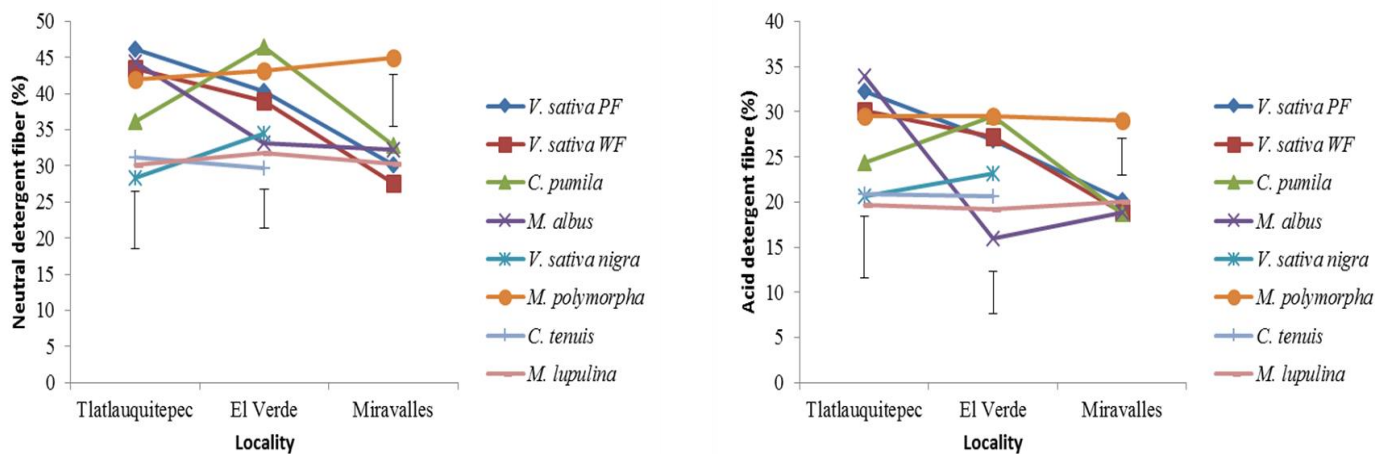


Figure 2. Concentrations of neutral detergent fiber and acid detergent fiber in annual and biennial legume species on the High Plateau of Puebla. Bars represent the least significant difference of Tukey ( $\alpha = 0.05$ ).

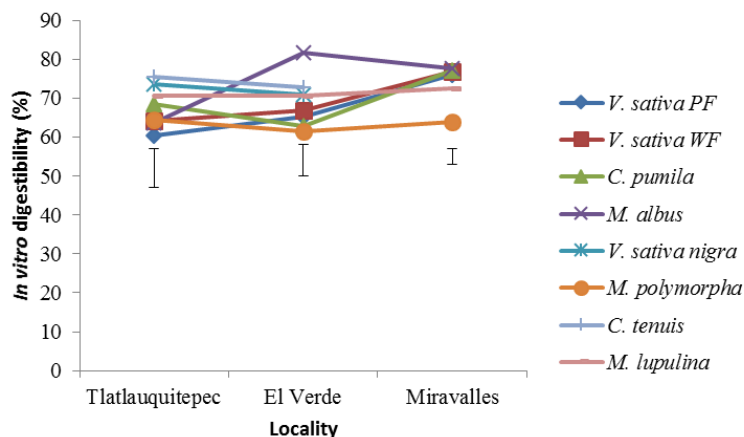


Figure 3. *In vitro* digestibility of the dry matter of annual and biennial legume species in three highland regions of Puebla. Bars represent the least significant difference of Tukey ( $\alpha = 0.05$ ).

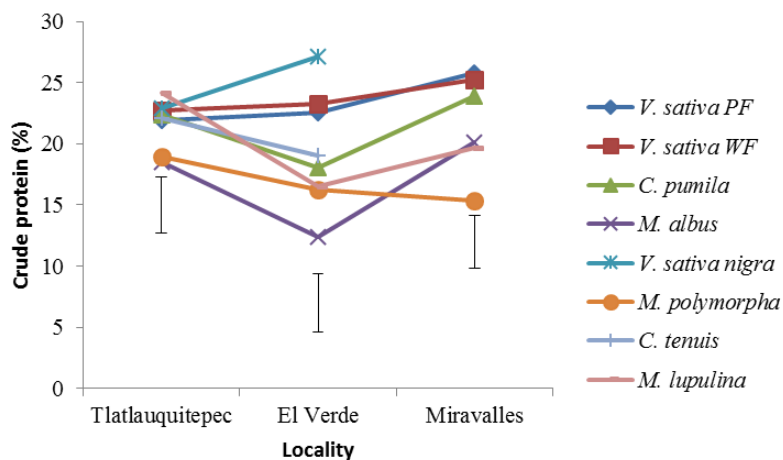


Figure 4. Crude protein content in annual and biennial forage legumes on the High Plateau of Puebla. Bars represent the least significant difference of Tukey ( $\alpha = 0.05$ ).

For the best-known naturalized species (*M. lupulina*, *M. polymorpha* and *M. albus*) the results for crude protein and fibers coincide with the data reported worldwide. There are no values reported for *Crotalaria pumila* and *Cologania tenuis*, but their values fall within the acceptable range for legumes, which is high crude protein content and lower fiber content than grasses. All these species have somewhat contrasting growth habits, having potential for a mixed of legume species pasture. For example, *M. albus* is a biennial erect growth species with high dry matter production and acceptable digestibility. This species compared with vetches which are annual, can be extended to grazing areas in rangelands and croplands, as it has good adaptation to poor soils and drought conditions found in the temperate region. Likewise, the *M. polymorpha*, although it had a somewhat lower nutritional quality than the other species, its forage yield was the same as vetches in two of the environments tested; raising the possibility of improvement through management. Knowledge in relation to the rhizobia associated with all these species is lacking, an important issue that needs to be resolved to improve the productive performance of these species by establishing effective inoculations and thereby improving the supply of nitrogen to the plant.

### CONCLUSION

Several of the species tested in this research have the qualitative and productive potential to improve the diet of ruminants in the highland region of the state of Puebla. The *Melilotus albus* and *Medicago polymorpha* surpassed or equaled the vetches which were the control species in this study. Similarly, when forage selection by the ruminants is considered, diet

quality is improved; thus, by ensuring high dry matter production and proper management of the species listed, animal production may improve. More studies are needed on the species that in the wild show abundant growth but in this study performed poorly in order to determine the limiting factors affecting their development.

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