Genetic and morphological diversity of *Tithonia diversifolia* (Hemsl.) A. Gray for use in silvopastoral systems of Latin America

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**Introduction**

*Tithonia diversifolia*, a tropical shrub native to Mexico and Central America, presents characteristics of great interest for ruminant production systems (Mauro et al., 2017). This species, a shrub of the Asteraceae family, is considered a forage species of great importance due to its chemical composition, productive performance, and adaptation (Tendonken et al., 2014). In plant species, genetic and morphological variability are considered the basis for their adaptation and ability to respond to challenges and threats (Govindaraj et al., 2015). The study of genetic diversity in plants allows the selection of the best genotypes in terms of productivity and forage quality (Ruiz et al., 2013).

**Objective**

To determine the phenotypic diversity of *Tithonia diversifolia* in Colombia and Mexico, and recognize its productivity and socio-economic potential in cattle systems.

**Materials and Methods**

**Genetic diversity**

**Localization**

Rainforest regions in Colombia. 26 collection sites in Colombia. 30 collection sites in Mexico.

**Figure 1.** Collection sites of *T. diversifolia*.

- Molecular markers: Cytochrome P450 and ISSR markers (Yamazaki et al., 2003), and amplifications of the ITS region of ribosomal DNA using the oligos ITS1 S-3' and ITS4 S-3'.
- Conglomerate analysis (Yeh et al., 1999) and genetic structure evaluation (Pritchard et al., 2000). Analysis in R-Studio software (POPGENE, R-Studio Team, 2018).
- Multivariate statistical analysis in chemical and morphological evaluations (PCA).

**Figure 2.** Agarose gel showing the amplification products for the molecular markers of *T. diversifolia*. A) ISSR (GA) BTY; B) Cytochrome P450 CYPA1F / heme286.

**Figure 3.** UPGMA dendrogram for the 31 collections of *T. diversifolia* from Mexico and Colombia (index of dissimilarity of Dice, high correlation coefficient (0.87) and agglomeration coefficient (0.8)).

**Morphological and chemical characteristics in collections of *T. diversifolia***

**Figure 4.** Variability and correlation of morphological and chemical characteristics of *T. diversifolia* in Colombia (DM: dry matter, EE: extract ether, ADF: acid detergent fiber, NDF: neutral detergent fiber, CP: crude protein, P: Phosphorus, Ca: Calcium, Na: Sodium, K: Potassium, Si: Silicon).

**Table 1.** Morphological characteristics of *T. diversifolia* collected in Colombia (45 days growth).

<table>
<thead>
<tr>
<th>Leaf weight (g)</th>
<th>Stems weight (g)</th>
<th>Branches (K)</th>
<th>Height (cm)</th>
<th>Stem diameter (mm)</th>
<th>Leaf area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80.3±16.4</td>
<td>153.4±85.5</td>
<td>26.8±20.9</td>
<td>113.9±62.2</td>
<td>11.9±6.7</td>
<td>178±12.2</td>
</tr>
</tbody>
</table>

**Table 2.** Chemical composition of *T. diversifolia* collected in Colombia (45 days growth).

<table>
<thead>
<tr>
<th>Ash (%)</th>
<th>EE (%)</th>
<th>ADF (%)</th>
<th>NDF (%)</th>
<th>CP (%)</th>
<th>P (%)</th>
<th>Ca (%)</th>
<th>Zn (%)</th>
<th>Fe (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.4±1.5</td>
<td>15.4±1.2</td>
<td>15.7±0.76</td>
<td>64.9±9.4</td>
<td>48.8±12.5</td>
<td>29.1±3.3</td>
<td>0.03±0.001</td>
<td>4.2±0.6</td>
<td>136.7±7.9</td>
</tr>
</tbody>
</table>

**Figure 5.** Milk productivity in systems with and without use of *T. diversifolia*.

**Results and discussion**

**Genetic diversity**

The Shannon information index (I) was 0.130 to 0.67, with a mean genetic diversity of 0.4320 ± 0.2267 indicating the high polymorphism through the loci.

**Molecular diversity and morphological assessment (PCA)**

**Figure 6.** Stacking rate (animal per hectare) with and without the use of *T. diversifolia*.

**Figure 7.** Cost-benefit ratio in milk production in systems with and without *T. diversifolia*.

**Internal rate of return, benefit/cost ratio of 3.20 and 0.74 (<0.05), favoring a higher level of employment generation (4.3 and 0.6 per ha per year, respectively), and 8% more of gross profit in systems with *Tithonia* (40 vs. 49%).

**Conclusion**

*T. diversifolia* has a wide phenotypic diversity and adaptation to different agro-ecological conditions, including high-quality ecotypes that offer greater nutrients in cattle systems and great potential to contribute to the income and welfare of livestock producers.

**References**