The objective of this study was to evaluate seed germination of three different forage species subjected to saline stress. The seeds remained in salt for 0 to 24 h and were then deposited in field beds. After 15 days, the germination was evaluated from its emergence. The effect of NaCl on germination was evaluated for the following treatments: a) 0 h (control); b) permanence in NaCl for 6 h; c) permanence in NaCl for 12 h; d) permanence in NaCl for 18 h; e) permanence in NaCl for 24 h. Five treatments with five replicates were applied to each forage species. The experimental design was completely randomized where the treatment was represented by the moment of observation, being 0, 6, 12, 18 and 24 h. For this experiment, differences (P < 0.05) were observed among treatments for the three forage species. For black oat and calopogonium, the different moments of salt stress in which their seeds were treated did not affect their germination. Perennial soybean suffered a decrease in germination as its seeds were exposed to salt for 6 h resulting in only 1.6% of germinated seeds. Saline stress did not affect the germination of black oat and calopogonium, both had higher values as compared to perennial soybean, in exposure time of 24 h. It is concluded that in the experimental conditions, black oat and calopogonium can be mixed with the mineral salt, without negative effect on its viability.

**Key words:** Seed dormancy, saline stress, mineral salt, environmental sustainability.

**INTRODUCTION**

In tropical regions, grasses are traditionally the most exploited because they have a forage production potential 2-3 times higher than leguminous (Valente et al., 2016). However, in the last few years, the interest of researchers in pastures has increased, aiming at the use of tropical forage legumes in animal feed, both in the form of hay and in the form of exclusive pastures and/or intercropping and more recently in the form of protein bank (fodder bank). Basically, this interest is due to the high nutritional value of these plants, which is symbiosis with bacterium of the genus *Rhizobium* that fixes atmospheric nitrogen (Pupo, 1979).

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Table 1. Agronomic characteristics of forages, black oats, calopogonium and perennial soybean.

<table>
<thead>
<tr>
<th>Agronomic characteristics</th>
<th>Black oat</th>
<th>Calopogonium</th>
<th>Perennial soybeans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination (%)</td>
<td>75</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Purity (%)</td>
<td>95</td>
<td>85</td>
<td>95</td>
</tr>
<tr>
<td>Cultural Value (%)</td>
<td>71.25</td>
<td>51</td>
<td>57</td>
</tr>
<tr>
<td>Green mass production (t/ha)</td>
<td>30 - 60</td>
<td>20 - 30</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Fixation of nitrogen (kg/ha)</td>
<td>--------</td>
<td>60 - 80</td>
<td>60 - 80</td>
</tr>
<tr>
<td>Weight of 1,000 seeds (g)</td>
<td>20 - 23</td>
<td>12 - 13</td>
<td>5 - 6</td>
</tr>
<tr>
<td>Sowing density (kg/ha)</td>
<td>65 - 80</td>
<td>8 - 10</td>
<td>7 - 8</td>
</tr>
</tbody>
</table>

The cultivation of forage species that present dormant seeds becomes a problem due to delay in the germination of these seeds, which slows down the development of the seedlings and is susceptible to fungal attacks, which can cause both production and economic losses (Santos et al., 2004; Valente et al., 2017). For it to germinate, the seed must be alive and not dormant, and the ability of a seed to germinate under a broad limit of conditions defined as the manifestation of its vigor depends, among other factors, on the environmental conditions found at the place where it was sown. Periodic droughts, for example, can be found in the field, and the seed should be vigorous to be competitive (Perez and Tabelini, 1995). In addition to moisture, some external factors such as ambient temperature, oxygen, available nutrients, pH and salinity may exert influence on this process.

Among the methods of planting forage fodder in already established pastures, the rational dispersion of the seeds using the animals themselves as propagating agents has been increasingly explored by reducing costs (Silva, 2008; Deminicis, 2009). In this way, the seeds could be mixed or offered next to the mineral salt of the animals, without the salt negatively affecting the germination.

The objective of this study was to evaluate the seed germination of 3 different forage species, black oats (Avena strigosa Schreb), calopogonium (Calopogonium mucunoides) and perennial soybean (Neonotonia wightii) subjected to saline stress.

MATERIALS AND METHODS

Study location

The experiments were conducted in the dairy cattle, horticulture and chemical laboratory sectors of the Fazenda Escola da Etec Benedito Storani, in Jundiaí city, State of São Paulo, Brazil (23°11’S and 46°53’W) in an altitude of 761 m.

Seed source and agronomic characteristics of black oat, calopogonium and perennial soybean forage

Seeds of 3 species of forage were used, black oats (A. strigosa Schreb), perennial soybean (N. wightii) and calopogonium (C. mucunoides). These seeds were acquired through donations from the company, SEMENTES PIRAI LTDA, and the agronomic characteristics are described in Table 1.

Treatments

The effect of NaCl on germination was evaluated for the following treatments: a) 0 h (control); b) permanence in NaCl for 6 h; c) permanence in NaCl for 12 h; d) permanence in NaCl for 18 h; e) permanence in NaCl for 24 h. Five treatments with 5 replicates were evaluated for each forage species. The experimental design was completely randomized, where the treatment in this case was represented by the time of observation which is 0, 6, 12, 18 and 24 h, where 5 replicates were adopted.

The quantity of seeds and salt followed the one adopted by Deminicis (2009). Thus, each sample evaluated consisted of 10 g of seeds and 90 g of NaCl. After observing all treatment times, 50 seeds of each sample were separated and immersed in boiling water (100°C) for 20 min and seeded in beds. The germination readings occurred after 15 days of sowing.

Statistical analysis

The obtained data were analyzed through an inferential statistical analysis. A comparison was made between the different reading moments, and between species for each moment.

First, in order to assess normality, the Shapiro-Wilk test was conducted at 0.05 significance level. In all cases, no adherence to the normal distribution was observed (P> 0.05), which directed the choice by non-parametric tests. The comparison of independent variables was performed using the Kruskal Wallis test (α = 0.05), while the comparison between the study moments was conducted according to the Friedman test (α = 0.05). The logistic regression was used to obtain the equation of the germination % as a function of the residence period to the salt and the respective R².

RESULTS AND DISCUSSION

Analysis of the variance indicated that there was a difference (P> 0.05) among treatments for the 3 forage species (Table 2). For the forage species, black oat and calopogonium, the different moments of salt stress in which their seeds were submitted did not affect their germination. Unlike the perennial soybean species, when their seeds were exposed to salt, a decrease in their % germination could be observed (1.6) (Table 2). The saline...
Table 2. Average seed germination % for each species subjected to different periods of saline stress after 15 days of sowing.

<table>
<thead>
<tr>
<th>Treatments (h)</th>
<th>Black oat</th>
<th>Calopogonium</th>
<th>Perennial soybean</th>
<th>Total</th>
<th>SE</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20^{AB}</td>
<td>30^{A}</td>
<td>12.4^{AB}</td>
<td>20.5</td>
<td>3.95</td>
<td>0.0314</td>
</tr>
<tr>
<td>6</td>
<td>24^{A}</td>
<td>24^{A}</td>
<td>1.6^{B}</td>
<td>16.3</td>
<td>5.78</td>
<td>0.009</td>
</tr>
<tr>
<td>12</td>
<td>36.4^{A}</td>
<td>27.2^{A}</td>
<td>8^{AB}</td>
<td>23.5</td>
<td>6.48</td>
<td>0.007</td>
</tr>
<tr>
<td>18</td>
<td>28.4^{A}</td>
<td>29.2^{A}</td>
<td>6.4^{AB}</td>
<td>21</td>
<td>5.78</td>
<td>0.011</td>
</tr>
<tr>
<td>24</td>
<td>27.2^{A}</td>
<td>20.4^{A}</td>
<td>9.2^{AB}</td>
<td>18.7</td>
<td>4.06</td>
<td>0.047</td>
</tr>
</tbody>
</table>

*Means in the same column, followed by the same lowercase letters do not differ from each other by the Kruskal-Wallis test at 0.05 of significance. **Means in the same line, followed by the same capital letters do not differ from each other by the Kruskal-Wallis test at 0.05 of significance. SE- Standard error of the mean.

Figure 1. Regression curves for % germination of black oats (*Avena strigosa* Schreb), calopogonium (*Calopogonium mucunoides*) and perennial soybean (*Neonotonia wightii*), as a function of salt permanence intervals.

stress did not affect the germination of black oat and calopogonium, where both had higher values (P> 0.05) as compared to the perennial soybean. Considering the above, NaCl can be used as a vehicle in the administration of black oat and calopogonium seeds by cattle, without affecting the quality of the seeds, at 24 h exposure time.

This result was also obtained by Deminicis (2009) who observed that the species that suffered the greatest damage due to salt permanence was perennial soybean, where the % germination was reduced by almost half, as compared to the permanence values of 6 (65.5%) and 24 h (33.0%). In the same work, it was observed that saline stress, up to 18 h, did not present a risk in the germination of perennial soybean seeds, showing that after this period, failures in seed protection and failure in repair mechanisms begin to compromise the activity of seeds and plant development. The regression analysis of the equations that describe the behavior of the number of germinated seeds as a function of salt permanence intervals is shown in Figure 1.

In relation to the treatment with black oats, R² was 0.695, indicating that the period of time predicts the percentage of germination in 69.5%. The treatments with calopogonium and perennial soybean had lower determination coefficients, being 0.364 and 0.420. Although, black oats had a higher correlation when compared with the other species, it was observed that there was an increase in the % germination as a function of time of exposure to saline stress. This fact was not observed in the other two species, and it could be assumed that this factor (saline stress) was not the only one that influenced the germination process of the same species, according to Jeller and Perez (2001). Saline stress interferes more strongly with germination speed of the seed as compared to germinability.
Naturally, the high content of salts in the soil, especially NaCl, can inhibit germination, initially due to osmotic effects and, in some cases, to toxic effects whose magnitude depends on the degree of tolerance and/or resistance to salinity, not only on the species as well as the salt type (Ferreira and Rebouças, 1992).

Conclusions

For the forage species, black oat and calopogonium, the different moments of saline stress in which their seeds were subjected did not affect their germination. Different from the perennial soybean species, from the moment their seeds were exposed to salt, a decrease in their percentage of germination can be observed. The saline stress did not affect the germination of black oat and calopogonium where both had higher values as compared to perennial soybean, in the exposure time of 24 h. Seeds of forages mixed with salt, and offered to cattle, can pass through the digestive tract and germinate in pastures; however, there are species that are more sensitive to this stress, which may impair its viability and establishment in a pasture.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

The research is financed by Instituto Federal Goiano, Brazil.

REFERENCES