Adaptation and Participatory Evaluation of Shrub Forage Legumes in Highlands of Sud-Kivu, Democratic Republic of the Congo (DRC)

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Abstract

Livestock in the highlands of DRC faces several constraints. It strongly decreased due to high rate of mortality, looting during the wars, lack of animal feeding and livestock still reared again under traditional system. However, shrub forage legumes can contribute to mitigate one part of these constraints and play an important role to improve livestock production. The objective of this study is to use for adaptation the improved shrub forage legumes previously tested by the International Center for Tropical Agriculture (CIAT) Colombia in tropical Central Asia and Latin America whose ecological conditions are similar to those in DRC. Fifteen shrub forage legumes were randomly planted. With 3 replications, nine plantations were counted per species. The cutting period was for eight weeks. The best yield shrubs were in Mulungu L. diversifolia K782, L. diversifolia 22192 and in Nyangezi C. calothyrsus. The choice of the farmers in their participatory evaluation was generally in agreement with the agronomic trial outcomes.

Subject Areas

Agricultural Science

Keywords

Shrubs Forage Legumes, Farmer’s Evaluation, Yield, Highland, DRC

1. Introduction

In the eastern highlands of the Democratic Republic of the Congo (DRC), livestock faces several constraints that hinder its harmonious development. It strongly
decreased following several constraints among which the high death rates, lack of animal feeding, social unrests and livestock looting during the wars [1]. There is also the demographic pressure on natural spaces and the increase of malnutrition rate among the population, up to 15% of global malnutrition [2]. The production of fodders to feed small animals is not practiced yet; it is only done in some private cattle farms [3]. Yet multipurpose forage production is a major component in animal livestock systems to enhance animal production, to control erosions and protect the environment. Shade trees play an important role within the agroforestry systems by influencing radiation and wind regimes as well as nutrient and hydrological cycling [4]. This study aimed to use for adaptation, combined with farmers’ participatory evaluation the improved shrub forage legumes previously tested by the International Center for Tropical Agriculture (CIAT) Colombia in tropical Central Asia and Latin America whose ecological conditions are similar to those in DRC.

2. Material and Methods

2.1. Agronomic Trials

Table 1 shows the location of the sites. Nyangezi soils are very acidic with low CEC and K than Mulungu site. Shrubs were installed in both sites in January 2009 in Mulungu and Nyangezi sites; see the characteristics of the experimental sites in Table 1. Fifteen shrub forage legumes were planted randomly opposing of the direction of the slope and distant by 1.5 m. In the line, they were separated each other by 1 m. A unit plot for every shrub comprised three plantations with 3 replications. At all, there were nine plants per specie or accession and in addition a line of Calliandra calothyrsus made a contour of all the trial. The regulation cutting done in January 2010 was made at 50 cm of height for Desmodium velutinum and Flemingia macrophylla and at 100 cm for Calliandra calothyrsus, Leucaena diversifolia, Cratylia argentea and Leucaena leucocephala. The harvest cuttings were made every eight weeks; the first one took place in March 2010 and finished on February 2011. Before every cut, height of plantations was measured, leaves and stems of each specie or accessions were weighed with an electronic weighing balance SF-400 (1 g ± 10 kg). For each specie and accession, a homogeneous sub-sample of 300 g of leaves and stems were taken at every harvest and dried during three months until the constant weight in a hangar at Kalambo CIAT office that reached 40°C to 45°C during the bright time. Nutritional quality (Dry mater = DM, Organic

| Location of the site | Soil fertility |
|----------------------|---------------|
| Site                 | Latitude | Longitude | Elevation (m asl) | pH | K     | P (O) | CEC* |
| Mulungu              | 2.19°S     | 28.47°E   | 1700             | 5.15 | 0.36 | 3 | 20 |
| Nyangezi             | 2.88°S     | 27.03°E   | 1580             | 3.94 | 0.18 | 3 | 3 |

*Cationic exchange capacity.
matter = OM, crude proteins = CP, neutral detergent fiber = NDF and True in vitro Organic Mater Digestibility = TIVOMD) of only leaf samples was analyzed by near infrared reflectance spectroscopy (NIRS) at the International Livestock Research Institute (ILRI), Addis-Ababa, Ethiopia.

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\text{Mean fresh leaf and stem yield (MFLSY) in g/plant} = \frac{\text{Fresh weight (g) \times dry matter (\%)}}{\text{Number of plants} \times 100} \quad [5]
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Impacts of diseases and insects’ damages were observed according to the [5] scale from 1 to 5.

### 2.2. Farmers Participatory Evaluation

Choices of forages in farmer’s participatory sessions were evaluated at both sites with the people involved in the seasonal trials. They were organized in a development association. To proceed to choice, farmers were subdivided into 2 groups according to the gender during the rain and dry seasons. A team comprised 5 women and another 5 men. A participating farmer had to select the three best plots in terms of crop performance by dropping a white paper in those plots chosen. Data were presented as ranks of preference by location. After the choice of forages, the two teams met to discuss for a consensus between genders [6].

### 2.3. Data Analysis

Data were statistically computed for descriptive statistics and Analysis of variance (ANOVA) using Tukey test in Genstat, Statview version 5.0. Cluster analysis was calculated by Past version 2.15. The agronomic and farmer’s participatory evaluation data were computed. Means and Standard Error of Mean (SEM) are presented.

### 3. Results

#### Agronomic Evaluation

**Nutritive Values**

Table 2 shows the nutritive values of shrub forage legumes.

CP in Mulungu are very good with a range of 19.0% - 28.2% while in Nyangezi it is 17.9% - 27%. ADF at both sites are very high for *D. velutinum* (13218, 334443, 23982 and 23996) and *F. macrophylla* 17403.

#### Diseases and Insect’s Attacks

Table 3 shows the diseases and insects ranks of the shrubs.

Fodders without diseases and pests’ damages in Mulungu and in Nyangezi were *C. calothyrsus*, all accessions of *L. diversifolia* (17503, 22192, 15551, K780, K782) and *L. leucocephala* 17263 except for Nyangezi where *L. diversifolia* 17503 suffered from diseases.
Table 2. Chemical analysis of forages in the sites.

| Shrub forage legumes | Mulungu | Nyangezi |
|----------------------|---------|----------|
|                      | DM      | OM  | CP  | ADF | TIVOMD | DM | OM  | CP  | ADF | TIVOMD |
| C. argentea 18516    | 25.6    | 90.2 | 24.1 | 29.9 | 58.2    | 23.1 | 91.6 | 21.6 | 30.5 | 60.5    |
| C. calothyrsus       | 21.4    | 94.3 | 27.2 | 29.3 | 55.0    | 30.7 | 96.4 | 21.2 | 28.2 | 61.7    |
| D. velutinum 13218   | 22.9    | 89.7 | 22.6 | 36.4 | 52.6    | 27.6 | 91.7 | 20.8 | 33.6 | 60.7    |
| D. velutinum 33443   | 27.3    | 89.7 | 21.9 | 37.8 | 52.5    | 38.4 | 92.2 | 18.9 | 34.7 | 61.1    |
| D. velutinum 23982   | 25.4    | 89.7 | 22.1 | 34.7 | 52.9    | 30.8 | 91.5 | 19.3 | 34.2 | 59.6    |
| D. velutinum 23996   | 28.3    | 89.6 | 19.0 | 38.9 | 50.5    | 31.1 | 91.3 | 18.5 | 35.1 | 58.9    |
| F. macrophylla 17403 | 22.5    | 95.2 | 23.5 | 33.9 | 50.4    | 29.5 | 96.8 | 17.9 | 32.7 | 52.8    |
| F. macrophylla 18438 | 31.6    | 93.8 | 26.0 | 24.5 | 58.5    | 28.0 | 96.6 | 19.7 | 30.9 | 55.1    |
| F. macrophylla 20618 | 24.5    | 95.3 | 22.4 | 32.6 | 50.6    | 27.4 | 96.5 | 18.6 | 31.3 | 55.6    |
| L. diversifolia 17503| 25.4    | 92.7 | 29.7 | 22.9 | 60.3    | 32.1 | 95.0 | 22.4 | 26.8 | 58.7    |
| L. diversifolia 22192| 24.6    | 93.3 | 28.2 | 26.1 | 57.8    | 32.3 | 89.7 | 27.0 | 30  | 55.1    |
| L. diversifolia K780 | 25.7    | 91.1 | 25.9 | 25.7 | 60.7    | 31.1 | 94.4 | 24.2 | 25.8 | 60.7    |
| L. diversifolia K782 | 24.2    | 93.6 | 28.0 | 26.1 | 59.6    | 33.8 | 96.1 | 22.8 | 26.1 | 60.5    |
| L. leucocephala 17263| 24.0    | 91.1 | 25.9 | 25.7 | 60.6    | 28.0 | 96.2 | 23.9 | 27.2 | 61.1    |
| L. diversifolia 15551| 24.4    | 93.4 | 27.9 | 28.1 | 54.8    | 32.5 | 96.0 | 21.6 | 29.2 | 57.9    |

Table 3. Ranks of diseases and insects attack of the shrub forage legumes.

| Shrub forage legumes | Mulungu | Nyangezi |
|----------------------|---------|----------|
|                      | Diseases | Insects | Diseases | Insects |
| C. argentea 18516    | 2    | 2    | 2    | 2    |
| C. calothyrsus       | 1    | 1    | 1    | 1    |
| D. velutinum 33443   | 2    | 2    | 2    | 2    |
| D. velutinum 23982   | 2    | 2    | 2    | 2    |
| D. velutinum 23996   | 2    | 2    | 2    | 2    |
| D. velutinum 13218   | 2    | 2    | 2    | 2    |
| F. macrophylla 17403 | 2    | 2    | 2    | 2    |
| F. macrophylla 18438 | 2    | 2    | 2    | 2    |
| F. macrophylla 20618 | 2    | 2    | 2    | 2    |
| L. diversifolia 17503| 1    | 1    | 2    | 1    |
| L. diversifolia 22192| 1    | 1    | 1    | 1    |
| L. diversifolia 15551| 1    | 1    | 1    | 1    |
| L. diversifolia K780 | 1    | 1    | 1    | 1    |
| L. diversifolia K782 | 1    | 1    | 1    | 1    |
| L. leucocephala 17263| 1    | 1    | 1    | 1    |

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Yield Biomass of Shrubs

Table 4 shows the height and vigor of shrubs.

Similar letters in Table 4 imply no significant difference according to Tukey grouping. There is a highly significant difference between the means of the height of shrubs (P < 0.001) at both sites.

The tallest forages at both sites was *C. calothyrsus*. The best vigor of shrub was observed in Mulungu on *L. diversifolia* (17503, 15551, 22192, K780, K782), *L. leucocephala*, *C. calothyrsus* and in Nyangezi on *C. calothyrsus*.

Table 5 shows the yield of shrub forage legumes.

Similar letters in Table 5 imply no significant difference according to Tukey grouping. There was a highly significant difference between the means of fresh leaves weight and stems yield at both sites (P  < 0.001). The best yield forages were *L. diversifolia* K782, *L. diversifolia* 22192 in Mulungu and *C. calothyrsus* in Nyangezi. At both sites level, *C. calothyrsus* is the best shrub in terms of yield.

Figure 1 shows the cluster of shrubs.

Figure 1 shows that the first cluster included *C. calothyrsus* and five accessions of *L. diversifolia* (17503, 22192, 15551, K780, K782), the second cluster included the other shrubs.

Participatory Evaluation by Farmers

Table 6 shows the choice of forages by farmers in Mulungu and Nyangezi.

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### Table 4. Height of shrub forage legumes (means and SEM).

| Shrub forage legumes | Height (cm) | Vigor |
|----------------------|-------------|-------|
|                      | Mulungu     | Nyangezi | Mulungu | Nyangezi |
| *C. argentea* 18516  | 152.1 ± 6.2<sup>cd</sup> | 123.6 ± 6.1<sup>bc</sup> | 4 | 3 |
| *C. calothyrsus*     | 187.7 ± 5.0<sup>a</sup> | 164.6 ± 8.6<sup>c</sup> | 5 | 5 |
| *D. velutinum* 33443 | 80.1 ± 4.4<sup>d</sup> | 75.1 ± 6.5<sup>b</sup> | 3 | 4 |
| *D. velutinum* 23982 | 70.6 ± 5.4<sup>d</sup> | 71.0 ± 5.2<sup>d</sup> | 3 | 4 |
| *D. velutinum* 23996 | 81.6 ± 8.5<sup>d</sup> | 73.5 ± 4.9<sup>d</sup> | 4 | 3 |
| *D. velutinum* 13218 | 60.3 ± 2.6<sup>e</sup> | 68.1 ± 4.4<sup>d</sup> | 3 | 3 |
| *F. macrophylla* 17403 | 71.0 ± 3.1<sup>d</sup> | 91.3 ± 8.3<sup>d</sup> | 4 | 4 |
| *F. macrophylla* 18438 | 46.2 ± 2.8<sup>e</sup> | 71.9 ± 8.7<sup>d</sup> | 2 | 2 |
| *F. macropylla* 20618 | 75.4 ± 5.0<sup>e</sup> | 76.6 ± 4.8<sup>d</sup> | 3 | 4 |
| *L. diversifolia* 17503 | 170.9 ± 4.9<sup>bc</sup> | 120.1 ± 6.1<sup>bc</sup> | 5 | 2 |
| *L. diversifolia* 22192 | 166.3 ± 4.2<sup>cd</sup> | 133.1 ± 8.9<sup>b</sup> | 5 | 3 |
| *L. diversifolia* 15551 | 166.8 ± 6.2<sup>c</sup> | 125.1 ± 7.2<sup>bc</sup> | 5 | 3 |
| *L. diversifolia* K780 | 177.0 ± 69<sup>g</sup> | 130.2 ± 9.8<sup>bc</sup> | 5 | 3 |
| *L. diversifolia* K782 | 170.7 ± 8.2<sup>bc</sup> | 126.7 ± 9.1<sup>bc</sup> | 5 | 3 |
| *L. leucocephala* 17263 | 173.9 ± 7.4<sup>bc</sup> | 104.6 ± 2.7<sup>c</sup> | 5 | 3 |
| LSD (P < 0.05)        | 18.4        | 21.9     | -   | -   |

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Table 5. MFLSY of the shrub forage legumes (g/plant and SEM).

| Shrub forage legumes | Mulungu     | Nyangeni   | Means at both sites |
|----------------------|-------------|------------|---------------------|
| C. argentea CIAT 18516 | 107.2 ± 10.44d | 18.6 ± 3.33d | 62.9 ± 9.23e         |
| C. calothyrsus       | 405.4 ± 38.23b  | 339.2 ± 51.63a | 372.3 ± 32.14a      |
| D. velutinum CIAT 33443 | 56.8 ± 2.53de  | 72.9 ± 12.34cd | 64.8 ± 7.65e        |
| D. velutinum CIAT 23982 | 60.3 ± 18.75de | 81.3 ± 28.65de | 72.3 ± 18.24de      |
| D. velutinum CIAT 23996 | 67.1 ± 12.56de | 71.9 ± 14.86de | 69.5 ± 9.54e        |
| D. velutinum CIAT 13218 | 7.6 ± 10.5e    | 47.3 ± 18.75de | 29.2 ± 10.64de      |
| F. macrophylla CIAT 17403 | 196.6 ± 38.83cd | 124.4 ± 27.43bc | 161.6 ± 24.43c      |
| F. macrophylla CIAT 18438 | 10.8 ± 4.22e   | 12.8 ± 5.44d   | 11.9 ± 3.54e        |
| F. macrophylla CIAT 20618 | 155.3 ± 22.83de | 160.4 ± 32.22b  | 157.9 ± 19.43d      |
| L. diversifolia CIAT 17503 | 399.6 ± 30.15bc | 23.1 ± 12.55cd | 211.4 ± 31.51bc     |
| L. diversifolia CIAT 22192 | 447.7 ± 33.83bc | 98.4 ± 6.33bc   | 273.0 ± 36.53bc     |
| L. diversifolia ILRI 15551 | 366.7 ± 34.15bc | 48.7 ± 21.43de | 207.7 ± 35.65bc     |
| L. diversifolia K780    | 354.8 ± 39.75bc | 72.8 ± 20.73de | 213.8 ± 32.53bc     |
| L. diversifolia K782    | 511.2 ± 50.52b  | 57.2 ± 15.92cd | 284.2 ± 46.45b      |
| L. leucocephala CIAT 17263 | 200.0 ± 21.95c  | 7.8 ± 2.14de   | 103.9 ± 19.54c      |
| Lsd (P < 0.05)          | 93.9          | 67.8         | 80.7                |

Figure 1. Cluster based on variables MFLSY, CP and height of shrubs legumes at both sites.
Table 6. Choice by farmers.

| Shrub forage legumes   | Rainy season |       |       | Dry season |       |       |
|------------------------|--------------|-------|-------|------------|-------|-------|
|                        | Mulungu      | Nyangezi | Mulungu | Nyangezi |
| C. calothyrsus         | 1st          | 1st    | 1st   | 2nd        |
| C. argentea            | 0            | 0      | 2nd   | 0          |
| D. velutinum 13218     | 0            | 5th    | 0     | 0          |
| D. velutinum 23982     | 0            | 0      | 0     | 3rd        |
| D. velutinum 23996     | 0            | 0      | 0     | 5th        |
| F. macrophylla 17403   | 0            | 0      | 0     | 0          |
| F. macrophylla 18438   | 0            | 0      | 0     | 4th        |
| F. macrophylla 20618   | 0            | 0      | 0     | 1st        |
| L. diversifolia 15551  | 3rd          | 0      | 5th   | 0          |
| L. diversifolia 22192  | 2nd          | 0      | 0     | 0          |
| L. diversifolia K780   | 6th          | 4th    | 0     | 0          |
| L. diversifolia K782   | 4th          | 2nd    | 3rd   | 0          |
| L. leucocephala        | 5th          | 3rd    | 4th   | 0          |

During the rainy season, *C. calothyrsus* was the most chosen at the first step in both the sites following by *L. diversifolia* 22192 in Mulungu and *L. diversifolia* K782 in Nyangezi. In dry season first choice was made for *C. calothyrsus* in Mulungu and *F. macrophylla* 20,618 in Nyangezi followed by *C. calothyrsus* in Nyangezi and *C. argentea* in Mulungu.

4. Discussion and Conclusion

The impact of diseases and insects’ attacks was lower in Mulungu and Nyangezi than in Colombia [7]. The healthiest shrub forage legumes at both sites were *C. calothyrsus*, *L. diversifolia* 22192, *L. diversifolia* 15551, *L. diversifolia* K780, *L. diversifolia* K782 and *L. leucocephala*. In Mulungu, the height of *C. calothyrsus* was 187.7 cm a mean after two weeks and is tallest than 170 cm observed in Rwanda after six months [8]. At both the sites, *C. calothyrsus* was the higher shrub. The best yield and vigorous shrubs in Mulungu were obtained on *L. diversifolia* (K782 and 22192). Their CP were in the same range of 25% to 32% and the TIVMOD between 56% to 61% [9]. Digestibility *in vitro* observed on *C. calothyrsus* is better than the range of 24.0% to 47% observed by [9]. The best yield production at both two sites is given by *C. calothyrsus*. It is from Central America and Mexico [9]. This shrub adjusted well without depending much on the level of soil fertility and can be considered as an option in the livestock production systems in infertile soils like *F. macrophylla* [10]. According to the farmers, their choices correspond to the one retained during the agronomic trials as observed [11] on cassava-legumes intercropping system in Sud-Kivu DRC.
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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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