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

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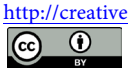

Abstract

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 specie or accession. 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 slop 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 *Callianda 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 electronical 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

Table 1. Location of the experimental sites and some characteristics.

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.

$$\text{Mean fresh leaf and stem yield (MFLSY) in g/plant} = \frac{\text{Fresh weight (g)} \times \text{dry matter (\%)}}{\text{Number of plants} \times 100} \quad [5]$$

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 forges in the sites.

Shrub forage legumes	Mulungu					Nyangezi				
	DM	OM	CP	ADF	TIVOMD	DM	OM	CP	ADF	TIVMOD
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.

Shrubs forage legumes	Mulungu		Nyangezi	
	Diseaes	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. macropylla 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

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.

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^{cd}	123.6 ± 6.1^{bc}	4	3
C. calothyrsus	187.7 ± 5.0^{a}	164.6 ± 8.6^{a}	5	5
D. velutinum 33443	80.1 ± 4.4^{de}	75.1 ± 6.5^{de}	3	4
D. velutinum 23982	70.6 ± 5.4^{de}	71.0 ± 5.2^{de}	3	4
D. velutinum 23996	81.6 ± 8.5^{d}	73.5 ± 4.9^{de}	4	3
D. velutinum 13218	60.3 ± 2.6^{e}	68.1 ± 4.4^{de}	3	3
F. macrophylla 17403	71.0 ± 3.1^{de}	91.3 ± 8.3^{cd}	4	4
F. macrophylla 18438	46.2 ± 2·8^{ef}	71.9 ± 8.7^{de}	2	2
F. macropylla 20618	75.4 ± 5.0^{de}	76.6 ± 4.8^{d}	3	4
L. diversifolia 17503	170.9 ± 4.9^{bc}	120.1 ± 6.1^{bc}	5	2
L. diversifolia 22192	166.3 ± 4.2^{cd}	133.1 ± 8.9^{b}	5	3
L. diversifolia 15551	166.8 ± 6.2^{c}	125.1 ± 7.2^{bc}	5	3
L. diversifolia K780	177.0 ± 6·9^{b}	130.2 ± 9.8^{bc}	5	3
L. diversifolia K782	170.7 ± 8.2^{bc}	126.7 ± 9.1^{bc}	5	3
L. leucocephala 17263	173.9 ± 7.4^{bc}	104.6 ± 2.7^{c}	5	3
Lsd ($P < 0.05$)	18.4	21.9	-	-

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

Shrub forage legumes	Mulungu	Nyangezi	Means at both sites
C. argentea CIAT 18516	107.2 ± 10.4^{d}	18.6 ± 3.3^{cd}	62.9 ± 9.2^{de}
C. calothyrsus	405.4 ± 38.2^{b}	339.2 ± 51.6^{a}	372.3 ± 32.1^{a}
D. velutinum CIAT 33443	56.8 ± 2.5^{de}	72.9 ± 12.3^{cd}	64.8 ± 7.6^{de}
D. velutinum CIAT 23982	60.3 ± 18.7^{de}	81.3 ± 28.6^{c}	72.3 ± 18.2^{de}
D. velutinum CIAT 23996	67.1 ± 12.5^{de}	71.9 ± 14.8^{cd}	69.5 ± 9.5^{de}
D. velutinum CIAT 13218	7.6 ± 10.5^{ef}	47.3 ± 18.7^{cd}	29.2 ± 10.6^{de}
F. macrophylla CIAT 17403	196.6 ± 38.8^{cd}	124.4 ± 27.4^{bc}	161.6 ± 24.4^{c}
F. macrophylla CIAT 18438	10.8 ± 4.2^{e}	12.8 ± 5.4^{d}	11.9 ± 3.5^{de}
F. macropylla CIAT 20618	155.3 ± 22.8^{cd}	160.4 ± 32.2^{b}	157.9 ± 19.4^{cd}
L. diversifolia CIAT 17503	399.6 ± 30.1^{bc}	23.1 ± 12.5^{cd}	211.4 ± 31.5^{bc}
L. diversifolia CIAT 22192	447.7 ± 33.8^{ab}	98.4 ± 6.3^{bc}	273.0 ± 36.5^{bc}
L. diversifolia ILRI 15551	366.7 ± 34.1^{bc}	48.7 ± 21.4^{cd}	207.7 ± 35.6^{bc}
L. diversifolia K780	354.8 ± 39.7^{bc}	72.8 ± 20.7^{cd}	213.8 ± 32.5^{bc}
L. diversifolia K782	511.2 ± 50.5^{a}	57.2 ± 15.9^{cd}	284.2 ± 46.4^{b}
L. leucocephala CIAT 17263	200.0 ± 21.9^{c}	7.8 ± 2.1^{de}	103.9 ± 19.5^{d}
Lsd ($P < 0.05$)	93.9	67.8	80.7

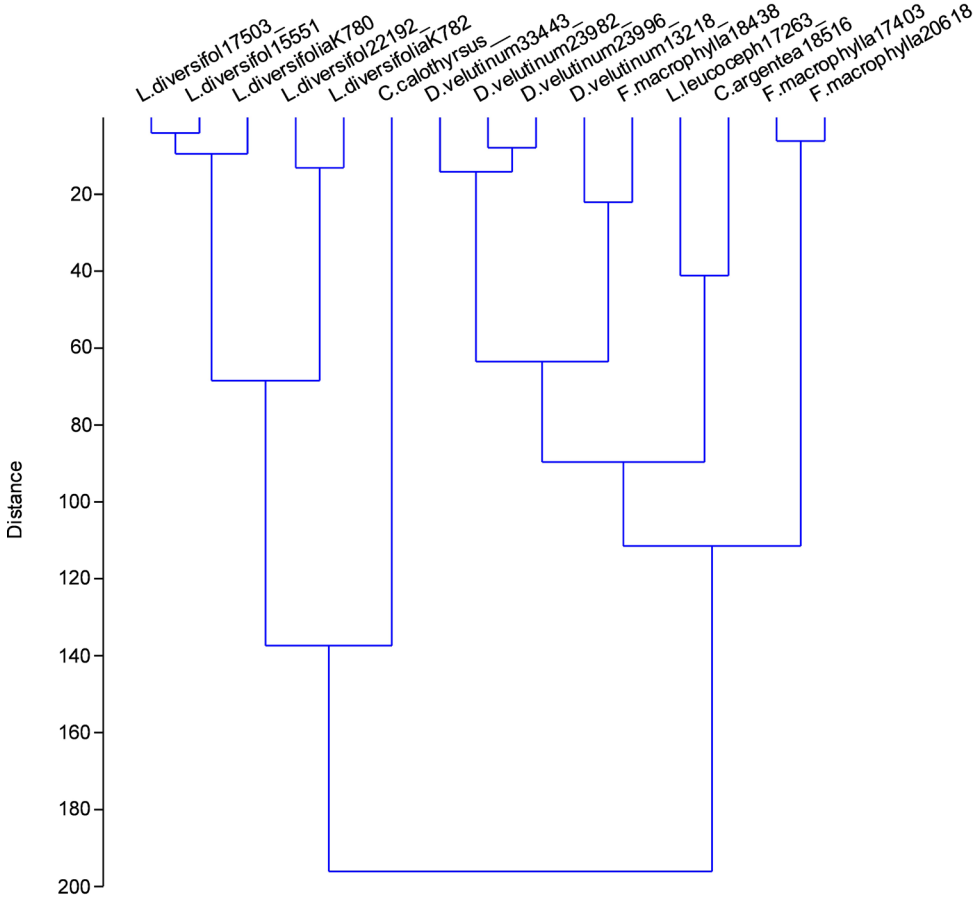

Figure 1. Cluster based on variables MFLSY, CP and height of shrubs legumes at both sites.

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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