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Comparison of Multipurpose Leguminous Fodder Shrubs in the Western Middle Hills of Nepal

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Abstract
Many multipurpose perennial leguminous fodder shrubs have been introduced to mitigate the feed deficit situations of ruminants in Nepal. To evaluate these shrub species, a study was undertaken in the middle hill ecology of Nepal for two years. The experiment was executed in the Randomized Complete Block Design (RCBD) with five replications in order to compare the fodder yield and nutrient constituents and fuelwood yield of Flemingia macrophylla (Willd.) Merrill, *Leucaena leucocephala* (Lam.) de Wit. *and Tephrosia candida* DC. *The results of the study showed that the F. macrophylla had produced substantially higher ($p<0.05$) fodder yield in comparison to L. leucocephala and T. candida, with greater fodder to fuelwood ratio. The nutrient constituents were superior for the L. leucocephala. The fuelwood yield was better for T. candida and F. macrophylla. The study had revealed that a F. macrophylla shrub could be the better alternative to improve the legume fodder productivity in the Nepali middle hill farming systems, and mixing it with L. leucocephala could be a better strategy for further improvement of the fodder quality.*

Key words: *Defoliation, dried fodder yield, fuelwood, nutrient constituents*

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I. Introduction

Hundreds of fodder species and cultivars have been introduced in Nepal in order to mitigate the feed and nutrient deficit situations of ruminants in the country. Among them, several annual, biennial and perennial fodder species of different life forms (herbaceous, creepers, shrubs and tree fodder) are established in the Nepali farming systems [1, 2, 3]. The multipurpose shrubs; *F. macrophylla*, *L. leucocephala* and *T. candida,* are some of those introduced perennial fodder legumes which are most preferred by the farmers in the middle hills and Terai regions of Nepal [4, 5, 6]. *Flemingia macrophylla,* recognized as a promising perennial fodder legume and recommended by several studies for Nepali farming systems (4, 7, 8], is being popular in recent years [9]. Likely, *L. leucocephala* is also a commonly grown fodder legume for hedgerow plantations in recent years in Nepal. It is another promising perennial fodder legume with the good fodder yield and quality [1, 3]. Similarly, *T. candida* is also a potential perennial leguminous fodder shrub, which is getting popularity in Nepalese farming systems in the past few years [9, 10, 11].

Limited land holdings and resource constraints for intensive fodder cultivation characterize the hill farming systems in Nepal. In this context, promotions of the perennial leguminous fodder shrubs with the selection of the most suitable species is the felt-need of the recent ruminant production systems in those areas [4, 9]. Because of the scanty information about most appropriate species and inadequate region-specific recommendations on these fodder legumes, the present attempts to promote these species is not being effective [3, 4, 9]. In this context, a study was undertaken for two years in order to select the better perennial leguminous fodder shrub for the western middle hills of Nepal.

II. Materials and Methods

The experiment was conducted from April 2013 to March 2015 for two years in the 9-months old mature stands of perennial multipurpose leguminous fodder shrubs at the Sarpani experimental site of Goat Research Station situated in the western middle hills of Nepal. Different species of perennial leguminous fodder shrubs were taken as the treatments; *F. macrophylla*, *L. leucocephala* and *T. candida*. The experiment was laid out in Randomized Complete Block Design (RCBD) with five replications. The planting geometry was maintained at 0.9 m × 0.7 m for all the shrub species. The defoliation height and the defoliation interval were maintained as 1 m and 12 weeks, respectively for all the shrub species.

The collected fodder samples were analyzed at the laboratory of Animal Nutrition Division, Khumaltar, Lalitpur by using methods of AOAC [12] and Goering and Van Soest [13]. Data was analyzed by using the STAR Statistical Package [14]. The combined analysis of both year data was done by using ANOVA and the year effect was partitioned. The data analysis was done by using the model;

$\gamma_{ijk} = \mu + \tau_i + c_j + \beta_k + \varepsilon_{ijk}$

Where, μ is the mean, τ_i is i^{th} treatment effect, c_j is the temporal effect, β_k is block effect and ε_{ijk} is random error of observation

III. Results

Dried fodder yield

The temporal effect (year effect) was obtained significant (p>0.05) to the fodder yield of the leguminous shrub species, although, the interactions between year and species, and year and blocks were obtained non-significant (p>0.05).

The results of the study showed that the annual dried fodder yield of *F. macrophylla* was significantly higher (p<0.05) than *L. leucocephala* and *T. candida* (Table 1). It was higher (p<0.05) for the *F. macrophylla* in comparison to *L. leucocephala* and *T. candida* during every defoliation (first, second, third and fourth defoliations), except *et par* (p>0.05) fodder yield with *T. candida* in the case of third defoliation.

Table 1. Dried fodder yield of different perennial leguminous fodder shrubs

Shrub species	FD (June 26), t ha^{-1}	SD (Sept 20), t ha^{-1}	TD (Dec 14), t ha^{-1}	FoD (March 8), t ha^{-1}	Total fodder yield, t ha^{-1} $year^{-1}$
F. macrophylla	5.73± 0.92^{a}	4.29±0.79^{a}	2.77±0.53^{a}	2.56±0.43^{a}	15.35± 2.37^{a}
L. leucocephala	2.92±0.31^{b}	3.13±0.56^{b}	1.17±0.26^{b}	1.69±0.21^{b}	8.91± 1.46^{b}
T. candida	3.42±1.06^{b}	3.11±1.46^{b}	2.26±0.88^{a}	1.92±0.46^{b}	10.7± 3.88^{b}

FD= First defoliation, SD= Second defoliation, TD= Third defoliation, FoD= Fourth defoliation

The mean values in a column with different superscripts are significantly different at 5% probability level

Fodder quality

In the case of fodder quality, the *L. leucocephala* fodder had significantly higher (p<0.05) crude protein (CP) content than the fodder of *F. macrophylla* and *T. candida* (Figure 1). The neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were higher (p<0.05) for *F. macrophylla*. The NDF content was lowest for *T. candida*, followed by *L. leucocephala*. Likewise, the ADF content was statistically similar (p>0.05) for the *T. candida* and *L. leucocephala*.

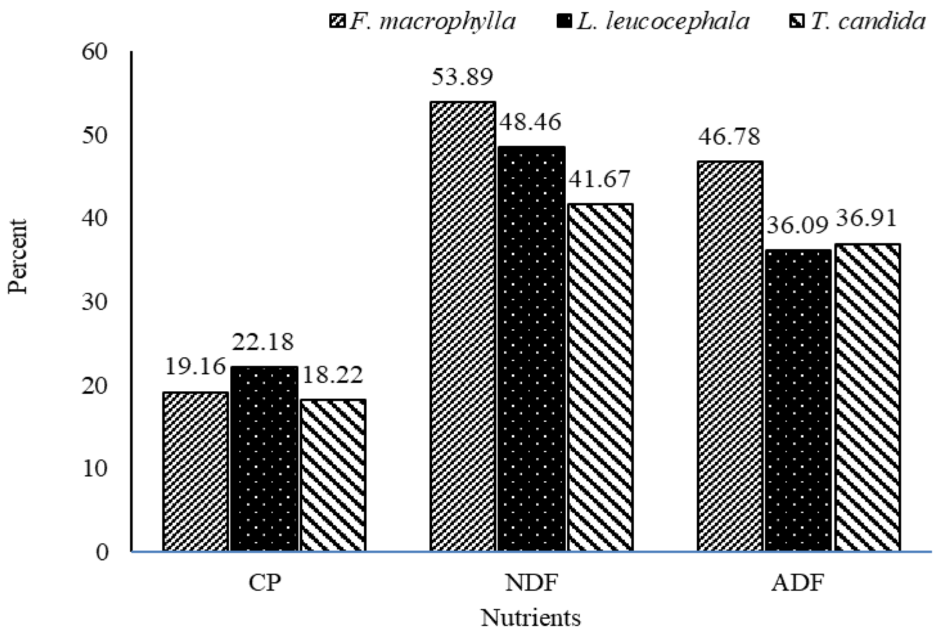

Figure 1. The crude protein and fibers contents in the fodders of different perennial leguminous shrubs in western middle hills of Nepal

Similarly, the calcium (Ca) content was found significantly higher ($p<0.05$) for *T. candida* followed by *L. leucocephala* and *F. macrophylla* fodders, although, all the species had good Ca and phosphorus (P) profiles (Figure 2). Likely, *T. candida* and *L. leucocephala* fodders had better ($p<0.05$) P contents than the *F. macrophylla* in the study.

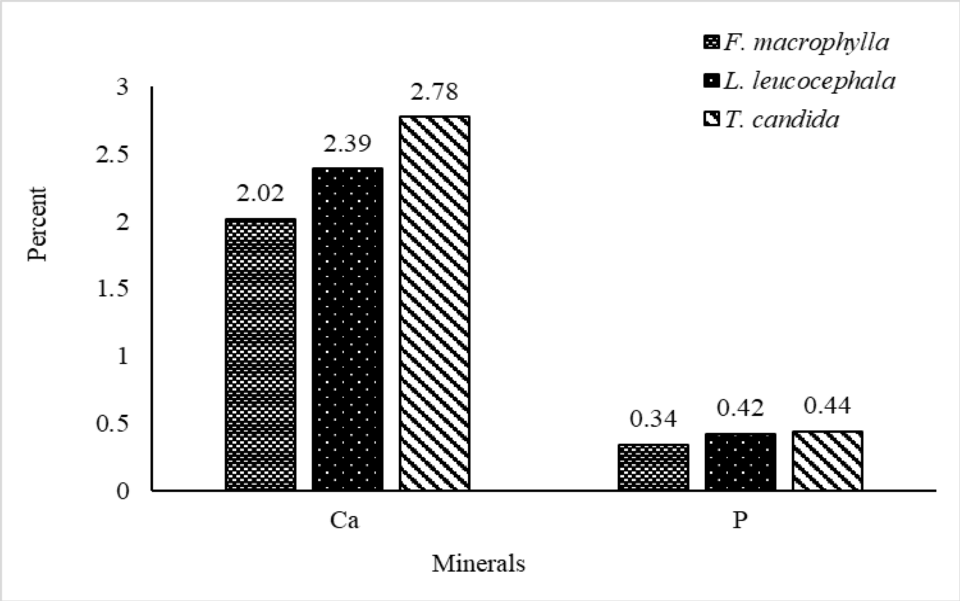

Figure 2. The calcium and phosphorus contents in the fodders of different perennial leguminous shrubs in western middle hills of Nepal

Fuelwood yield

In the study, *L. leucocephala* and *T. candida* had produced statistically similar ($p>0.05$) total annual fuelwood yield, which were significantly higher ($p<0.05$) than the fuelwood yield of *F. macrophylla* (Table 2). The greater variations in the fuelwood yield among the species were obtained during the first defoliation.

Table 2. Fuelwood yield (on fresh basis) of different perennial leguminous fodder shrub

Shrub species	FD (June 26), t ha^{-1}	SD (Sept 20), t ha^{-1}	TD (Dec 14), t ha^{-1}	FoD (March 8), t ha^{-1}	Total fodder yield, t ha^{-1} year^{-1}
F. macrophylla	4.01± 0.47^{b}	4.62±0.34	2.36±0.20^{c}	2.43±1.12^{b}	13.42± 3.04^{b}
L. Leucocephala	5.76±2.26^{a}	4.37±1.14	3.28±1.28^{b}	3.46±1.16^{a}	16.87± 5.64^{a}
T. candida	5.38±1.87^{a}	4.46±1.89	4.01±1.92^{a}	2.28±0.34^{b}	16.13 ± 6.13^{a}

FD= First defoliation, SD= Second defoliation, TD= Third defoliation, FoD= Fourth defoliation
The mean values with different superscripts in a column are significantly different at 5% probability level

Fodder to fuelwood ratio

The green fodder to fuelwood ratio was higher for *F. macrophylla* followed by *T. candida* and *L. leucocephala*. The ratio for *F. macrophylla* was gradually decreased to later defoliations. It was increased during September and March defoliations in the case of *T. candida* and *L. leucocephala*.

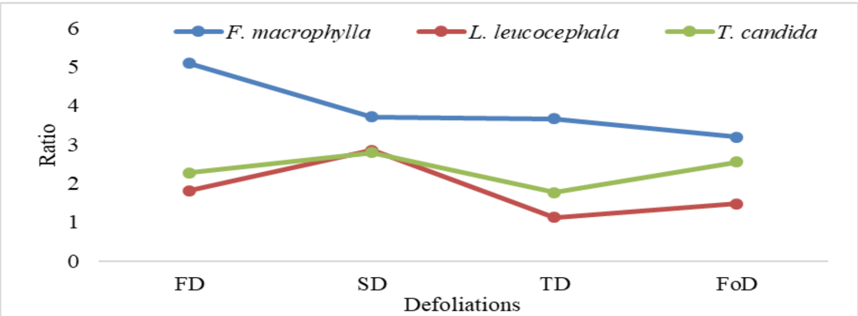

Figure 3. The green fodder to fuelwood ratio (by fresh weight) for different perennial leguminous fodder shrubs in western middle hills of Nepal

IV. Discussion

The significant temporal effect on fodder yield, but non-significant interaction effects of year with fodder yield, and year with the block had indicated the consistent yield variations on different species and on the blocks due to the years. As a result, the fodder yield of a shrub was varied between first and second years. The reason might be associated with the year-to-year variations on plant environment such as temperature, moisture, sunshine, soil nutrients and other abiotic factors [15].

The results of the study- *F. macrophylla* had produced consistently higher dried fodder yield with a greater fodder to fuelwood ratio (by fresh weight basis) compared to *T. candida* and *L. leucocephala* in all defoliations- is supported by the report of another study [16]. The authors reported that the *F. macrophylla* had yielded a significantly higher annual weight of leaves and twigs (35 t ha^{-1}) compared to *L. leucocephala* (27 t ha^{-1}) during the plantain alley cropping. In the study, the data of the dried fodder yield had shown that the variations within the yield of a shrub was higher for *T. candida* compared to the data of *F. macrophylla* and *L. leucocephala*. This larger dispersion of the data indicated higher variability in the fodder yield of *T. candida* among different plants, blocks and years.

The CP content obtained for *L. leucocephala* fodder in this study were within the ranges reported by different authors, Topps [17] and Garcia et al., [18]; which was significantly higher than *F. macrophylla* and *T. candida*. Nevertheless, the CP values obtained for all the fodder legumes were well above the minimum requirements of 11.9 percent and 12.4 percent recommended for growing and lactating 400 kg cow [19]. It indicates the adequacy of CP levels in all the evaluated fodder species to the ruminant nutrition in Nepali middle hills, although, the *F. macrophylla* had a significantly lower fraction of CP compared to *L. leucocephala* and *T. candida*.

Flemingia macrophylla is a perennial leguminous fodder that is characterized by the high fiber content in leaf therefore lower digestibility [8]. In this study too, the fodder of *F. macrophylla* had significantly higher NDF (which is a measure of the plant cell wall material) and ADF contents with the values of 53.89 and 46.78 percentages, respectively that might reduce the fodder quality in many cases. The high ADF value of *F. macrophylla* was probably due to the high cellulose content of the fodder. The finding of this study is in agreement with the reports of other authors who described that the nutritive quality of *F. macrophylla* fodder is lower than that of *L. leucocephala* and other perennial leguminous fodder shrubs, such as *Gliricidia sepium* (Jacq.) Walp. and *Cratylia argentea* (Desv.) O. Kuntze [20, 21]. *Tephrosia candida* had better NDF and ADF contents than other fodder legumes evaluated. On the other hand, higher NDF and ADF contents of *F. macrophylla* could have contributed to higher dried fodder yield and might have decreased the CP and mineral (calcium and phosphorus) contents of the fodder in comparison to other species. It had shown lower fodder quality while comparing these three perennial leguminous fodder legumes. Significantly higher CP percent on *L. leucocephala* than *T. candida*, and similar NDF and ADF contents in *L. leucocephala* and *T. candida* were obtained in another study in Nigeria [22]. The NDF values were found as 39.8 percent and 41.0 percent for *L. leucocephala* and *T. candida*, respectively whereas ADF fractions were 34.30 percent and 36.80 percent for *L. leucocephala* and *T. candida*, respectively [22]. These values were near to the values obtained in this study.

F. macrophylla had consistently shown higher green fodder to fuelwood ratio in all defoliations in the study which was in line with the findings of Perera et al. [23]. The authors reported the high leaf to stem ratio in *F. macrophylla*. The results of the study showed that *F. macrophylla* was more consistent in the fodder and fuelwood yield with lower standard deviations compared to the *L. leucocephala* and *T. candida* in all harvests and in annual yield during the combined analysis of both years' data. But, *F. macrophylla* had a greater reduction in the fodder to fuelwood ratio from the second defoliation and onwards indicating the greater wooding on the fodder branches during September, December and March defoliations. On the other hand, *L. leucocephala* and *T. candida* had better fodder to fuelwood ratios during post-monsoon (September 20) and spring (March 8) defoliations.

V. Conclusion

The study concluded that the *F. macrophylla* had better performed than *L. leucocephala* and *T. candida* in the western middle hills of Nepal in terms of fodder yield and fodder to fuelwood ratio, with satisfactory fodder quality. It is a more potential perennial leguminous fodder shrub than *L. leucocephala* and *T. candida* for the promotion to mitigate the feed and nutrient deficit situations in western middle hills of Nepal. Generations of the technologies and preparations of the package of practice (PoPs) of *F. macrophylla* and its promotions in future can make substantial contributions to improve the ruminant productivity in the western middle hills of Nepal.

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