Performance evaluation of herbaceous forage grasses, legumes and multipurpose forage trees associations for forage production in Bale highland, Ethiopia

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The excreta was conducted from 2010/11 to 2012/13 with the objectives of identifying best suitable associations of perennial herbaceous forages with forage trees for their growth characteristics and bio-mass yield in the highland of Bale. Accordingly, two forage tree types Chamaecytisis palmensis L. and Sesbania sesban L. were integrated with four varieties of perennial herbaceous forages; Phalaris aquatic L., Panicum coloratum L., Medicago sativa L. and Trifolium repens L.. The result from analyzed data revealed that there is a significant difference (p≤0.05) between associations of different forage trees and herbaceous forages. According to this result P. aquatica L. and Sesbanea sesban L. association has a yielded 15.2±1.03 TDM t/h with highly yield of grass component. Out of the all association White clover and C. palmensis L. combinations has showed the best performance forage trees of which is comparable to null C. palmensis. Medicago sativa and P. aquatic L. associated with trees has revealed some negative effects on the performances of forage trees. The combination of S. sesban with herbaceous forages is not suitable which is showed much negative effect of herbaceous forages except white clover. The plot containing association of P. cloratum and Tree lucern indicated good association than other herbaceous forages.

Key words: Forage Trees, Herbaceous forages, Integration

INTRODUCTION

Livestock production is an integral part of the mixed crop-livestock farming system of Bale highlands. However, regardless of their numeric and economic importance as well as the tremendous potential, the production and productivity of livestock is very low mainly due to poor nutrition, disease incidences and poor management. Currently livestock feed problem in the area can be categorized in to feed shortage and poor feeding system. High population pressure and increasing demand for food is pushing smallholder farmers to cultivate grazing lands so as to satisfy food demand of increasing human population growth rates in the high lands of Bale (Bekele et al., 1996). This is a primary cause for shrinkage/diminishing of grazing land in the area. Shrinking of grazing land has caused livestock feed problem in quality and quantity throughout the year and seasonality. In most part of the high land areas of the region, population pressure has led to cultivation of marginal land and steep slopes (Bezuayehu et al., 2002). Particularly in Bale highlands, conversion of marginal land and steep slopes previously covered by forest and which has been used as feed source for livestock to crop land has aggravated livestock feed problem. The impact of population pressure on the forest and surrounding area at recent years has been increasing at alarming rate. In the area the average rate of dense forest cover change into open forest and other land use land cover types, during the period of 1986 to 2000 years is faster when compared with during the period of 1973 to 1986, which were 2071.3 ha/year and 2171.5 ha/year respectively (Netsanet, 2007). This created a forest free steep lands and wide area susceptible to soil erosion.

Sustainable livestock and crop production in Ethiopia is
dependent on dramatic changes in livestock management systems and strengthening the interaction of natural resource and forage production. The key components of these changes are a shift towards more intensive feeding systems, with more emphasis on cut-and-carry feeding, and a gradual shift away from uncontrolled grazing, particularly on uplands and sloping areas. The use of woody leguminous species in agroforestry, alley cropping or browse coppice systems is one of the key elements of sustainable agricultural systems in Ethiopia (Alemayehu Mengistu, 2002). Legumes are also especially emphasized because of their multipurpose utility, and their dual roles in animal nutrition and the maintenance or improvement of soil fertility and hence crop production. According to lemma et al., (1996) the economic benefit of Sesbania and Leucaena in terms of crop production. According to lemma et al., (1996) the utility, and their dual roles in animal nutrition and the maintenance or improvement of soil fertility and hence crop production. According to lemma et al., (1996) the economic benefit of Sesbania and Leucaena in terms of milk and meat has shown considerable success both under research and farmers condition. Alemayehu, (2002) indicated that Contour strips of browse or forage legumes combined with grasses increase the sustainability and productivity of most soils whilst also providing high quality forage to supplement low quality roughages and crop residues. Poorly drained areas and uplands can be developed as permanent pastures and stock exclusion areas which, although not directly integrated with cropping areas, reduce grazing pressure on cropped land. By using browse legumes in forage strategies, additional fuel wood is produced to substitute for dung fuel, which can then be returned to the soil to maintain crop and forage productivity (Alemayehu, 2002). Thus integration of livestock feed and natural resource conservation systems is essential for sustainable natural resource management and livestock productivity improvement.

The Ethiopian government has provide a due attention and designed implementation of strategy for natural resource conservation and hence improvement of the agricultural activity. Accordingly the National Strategy and Action plan for the implementation of the Great Green Wall initiative in Ethiopia, 2012 was designed cooperatively with other African countries. According to this plan and strategy in the future a particular attention will be given to traditional knowledge in the formulation and implementation of activities related to farming, rehabilitation of degraded rangelands, and development of appropriate strategies for rural water.

Based on this plan different activity of soil and water conservation has been planed and implemented for last few years in Oromia where livestock feed, deforestation and soil erosion is a severe problem. In addition to this in Bale high land adaptability of different perennial herbaceous legume and grasses as well as forage trees has been tested for many years and substantial yield was obtained. Integration of forage trees and herbaceous forages could have several advantages over sole forage trees or pasture alone. Perennial herbaceous forages has advantages of providing high dry matter and quality yield as well as merit of being integrated with forage trees in soil and water conservation of physical and biological structures.

However, though some perennial grass, herbaceous legumes and browse trees that can produce good forage products were introduced and recommended, the best types of herbaceous perennial forage grasses and legume that can be associated with forage trees for optimum forage production is not yet identified.

Therefore; it is important to identify the appropriate herbaceous perennial forage grasses and legumes that can be planted under forage trees.

**MATERIALS AND METHODS**

The experiment was carried out at Sinana Agricultural Research Center. Sinana Research Center is located at 07°07′ N latitude and 40°10′E longitude at an altitude of 2400 masl. The area is characterized by bimodal rainfall with the total annual rainfall ranging from 750-1000 mm. The amount of rainfall ranges from 250-560mm in ‘Ganna’ (Belg) and 270-550mm in ‘Bona’ (Meher) seasons. The two seasons are locally named by the time of crop harvest. The first season (‘Ganna’ or ‘Belg’) commonly extends from March to July while the second (‘Bona’ or ‘Meher’) season extends from July to December. Average annual maximum and minimum temperatures are 21°C and 9°C, respectively. The soils type is clay in texture (dark brown vertisol), slightly acidic in reaction (PH 6.2), and having 3.9 % organic matter, 0.243 % total N, 30 ppm available phosphorus and 240 mg/kg K and CEC (Cataion exchange capacity) 64 meq/kg soil (SARC, 2001).

The experiment was carried out from 2010/11 to 2012/13. Treatments were sole stand of forage trees and association of each forage trees with forage legumes or grasses. Forage trees were Chamaecytisus palmensis (Tree lucern or Tegasaste) and Sesbania sesban L., while forage legumes were Medicago sativa L. (Hunter River) and Trifolium repens L. (white clover) and forage grasses were Punicum coloratum L. and Phalaris aquatica L. (sirosa). The seedling of the forage trees were separately prepared and transplanted to the sole experimental plots. The trees are planted in the distance of 70cm between plants and rows. One year after preparation of the seedlings grasses and herbaceous legumes seeds were drilled in rows of 30cm apart. Seed rate of 12kg/ha for white clover, 10kg/ha for Alfalfa , phalares (sirosa) and panicum grass were inter-planted with trees in rows of 30cm apart. Forages were harvested at 10cm from the ground when 50% the herbaceous legumes are at pod and grasses are at milk stage taking the two randomly selected consecutive middle rows of each plot. The two middle rows of each plot containing four trees covering the area of 2.8m*1.4m was also sampled. During sampling of the forage trees all twigs...
with the diameter ≤6mm were considered as edible parts. The trees that could supply and weak trees could not supply herbage yield were considered as life tree in counting the numbers of life and died trees. The harvested sample separated from the weed and its biomass was weighted for estimation of the fresh biomass yield per hectare. Finally 500gm sample of each harvest were dried at 55°C for 48h to estimate dry biomass per hectare. The data were analysed using SAS, version 9.2 (SAS, 2009). Means were separated by Tukey pair-wise comparison procedure. The following model was used estimate the yield per hectare and variation between the treatments:

\[ y = Xa + Zb + m(ab) + e \]

where:
- \( y \) = the dry matter yield in tone/ha
- \( a \) = the effect of herbaceous forages
- \( X \) = the association of ‘a’ with Y
- \( b \) = the effect of forage trees
- \( Z \) = the associates of ‘b’ with Y
- \( ab \) = the effect of ‘a’ and ‘b’ interaction on Y
- \( m \) = the association of ‘a’ and ‘b’ interaction with Y
- \( e \) = the residual effects.

### RESULT AND DISCUSSION

Analysis of the variance of DM yield of five season data revealed that there is a significant (P<0.05) difference among the evaluated treatments (Table.1). Integration of *Phalaris aquatica* L. with *Sesbania sesban* and Treelucern has yielded 15.21 t/ha and 14.13 t/ha DM yield respectively. *Panicum coloratum* and Tree lucern combination has yielded the third largest DM yield 13.29 t/ha. Even though integrations with *Phalaris* is the highest yielder the contribution of the forage trees is below the standard composition of the pasture in supplying protein and energy source. Tree lucern has showed a better performance when integrated with herbaceous forages in general. However, the performance of *S. sesbane* and its numbers of survived trees in all plots up to the end of the experiment was low compared to treelucern. The result obtained from the experiment also indicated that Panicum was showed better association with tree lucern which can contribute more than 27.5% of DM yield from the total requirement (Figure 1). This result also revealed that *P. aquatica* L. and *Alfalfa* has showed the most negative effect (decreasing in yield) on forage trees especially on *S. sesbane*. As the duration of the experiment advances the negative effect of the herbaceous forages on forage trees was increased except white clover which showed insignificant effect.

The plot containing white clover and treelucern was the fifth highest yielder which is affected by the anatomical structure and physiological activity of the white clover. White clover is the shallow rooted plant with high capacity of nitrogen fixing and has ability of tolerating the high shadow effect of the trees. On this occasion tree lucern can take the advantage of high nitrogen fixation by white clover on the soil surface and using deep root it can up take the mineral from the soil.

In integrations of *Phalaris* and *Alfalfa* more than 60% of the forage trees were died, in contrary herbaceous forages yield were moderately increased and dominated more than 90% of the total dry matter yield from the plots.

### Table 1. Performance of the associations of herbaceous forage legumes, grasses and forage trees tested from 2010/11 to 2012/13.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Mean FTDMY t/ha±SE</th>
<th>Mean HFDMY t/ha±SE</th>
<th>Mean TDMY t/ha±SE</th>
<th>No. of trees planted</th>
<th>Mean No. of trees died</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trlu+Pha</td>
<td>1.64±0.12&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>12.48±0.80&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>14.13±0.71&lt;sup&gt;bba&lt;/sup&gt;</td>
<td>48</td>
<td>21.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Trlu+Alf</td>
<td>1.29±0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.40±0.56&lt;sup&gt;cc&lt;/sup&gt;</td>
<td>11.70±0.53&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>48</td>
<td>20.6&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td>Trlu+Panc</td>
<td>3.66±0.11&lt;sup&gt;d&lt;/sup&gt;</td>
<td>9.68±0.90&lt;sup&gt;cc&lt;/sup&gt;</td>
<td>13.29±0.72&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>48</td>
<td>32.0&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Trlu+whc</td>
<td>5.16±0.73&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.17±0.68&lt;sup&gt;d&lt;/sup&gt;</td>
<td>11.33±0.81&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>48</td>
<td>36.0&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sesb+Pha</td>
<td>0.61±0.14&lt;sup&gt;e&lt;/sup&gt;</td>
<td>14.64±1.08&lt;sup&gt;cc&lt;/sup&gt;</td>
<td>15.21±1.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>48</td>
<td>18.0&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
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<td>9.72±0.44&lt;sup&gt;dd&lt;/sup&gt;</td>
<td>48</td>
<td>21.3&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
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<td>9.68±0.79&lt;sup&gt;cc&lt;/sup&gt;</td>
<td>10.29±0.85&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>48</td>
<td>35.0&lt;sup&gt;aa&lt;/sup&gt;</td>
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<tr>
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<td>Trlu</td>
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<td>-</td>
<td>9.80±0.62&lt;sup&gt;dd&lt;/sup&gt;</td>
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<td>40.3&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Sesb</td>
<td>6.43±0.66&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-</td>
<td>6.42±0.67&lt;sup&gt;e&lt;/sup&gt;</td>
<td>48</td>
<td>36.0&lt;sup&gt;aa&lt;/sup&gt;</td>
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<td>Mean</td>
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<td>10.61±0.41</td>
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<td>29.6±1.6</td>
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<td>22.1</td>
<td>20.10</td>
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<td>4.08</td>
<td>4.21</td>
<td>-</td>
<td>9.59</td>
</tr>
</tbody>
</table>

Dry Matter Yield, HFDMY: Herbaceous Forage Dry Matter Yield, TDMY: Total Dry Matter Yield, Trlu: Tree lucern, Pha: Phalaris aquatica, Alfa: Alfalfa, Panc: Panicum coloratum, whc: white clover, Sesb:Sesbania sesban. Figures with the same letter in columns is not significantly different (P>0.05).
Conclusion and Recommendation

The different forage association result showed in this study ranks herbaceous forages and forage trees mixtures by potential total dry matter yield and proportion of the herbaceous forages and forage trees dry matter yield. Since the purpose of the experiment was to find out appropriate herbaceous forages that can be integrated with forage trees to protect marginal and eroded areas, and finally improve the productivity of the this lands through feed produced and ecosystem conservation the best association with high forage yield and high rate of success in planted trees seedling has to be selected. Accordingly the result of study showed that White clover can easily integrated with tree lucern without affecting its normal growth. Integrating Tree lucern to Panicum coloratam is also a good combination that can yield better dry forage bio-mass with more than 27% of the total dry matter yield is from forage tree.

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REFERENCES


