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Original article

Effects of different ratios of associations of forage grasses and herbaceous legumes on the bio-mass yield in Bale highland, Ethiopia

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ABSTRACT

The experiment was conducted from 2010/11 to 2012/13 with the objectives of identifying the appropriate types and level of grass-legume association for pasture productivity improvement in highlands of Bale. Accordingly, two herbaceous forage grasses phalaris aquatica L. and Panicum coloratumL. Were integrated with two varieties of herbaceous forage legumes; Medicago sativa l. and Trifolium repens L. in different association ratio. The mean result of six season analyzed data revealed a significant difference ($p<0.05$) between associations of different forage legumes and grasses as well as different proportions. According to this result, the association of all types of forages 50% legumes to 50% grasses has shown a better result. Association of 50% alfalfa and 50% phalaris, and 75% phalaris and 25 % alfalfa has shown the average dry matter yield of 15.7±3.4 tone/ha with 40.8% legume and 14.0±3.4 tone/ha with 45% legume DM yield respectively. Phalaris 75% with white clover 25% has shown the high yield of 15.5±3.4 t/ha with only 0.8 t/ha white clover. This result indicates that the 50%/50% and 75% /25% proportion of phalaris and alfalfa is a good dry bio-mass yielder and can satisfy the best requirement of grass to legume composition of the pasture.

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1. Introduction

The highlands of Ethiopia are characterized by crop-livestock mixed farming systems. Nearly 90% of the total human population and 70% of the livestock population of the country inhabit in the highlands (Saleem and Tedla, 1995). Despite enormous contribution of livestock to the livelihood of farmers in the highlands, they are faced with multifaceted problems in the production system, among which the major one is the quantitative and qualitative inadequacy of feed supply. Different studies (Solomon, 2004; Worku et al., 2008; Dawit et al., 2012) indicated that the overall shortage of feed and the seasonal fluctuation in the quantity and quality of feed are the main challenges facing livestock production in the highlands of Bale.

The main reason for livestock feed problem is changing of the pasture land to crop land and over grazing of the grazing land. The natural pasture land which is previously covers 30.5% of the total highland area in Ethiopia is gradually diminishing due to high human population growth (Alemayehu Mengistu, 2006). Over grazing of the natural pasture and poor pasture management was caused poor species composition and low yield of the pasture land. Study conducted in different places in Ethiopia by Bilatu et al. (2013) and Solomon et al. (2008) indicated that CP level of the natural pasture is insufficient to satisfy the minimum requirements of the animals. Saleem and Tedla (1995) also reiterated that herbage from natural pasture are usually inadequate quantitatively and qualitatively to support reasonable livestock production. Low productivity of indigenous grasses and legumes (Saleem and Tedla, 1995; Bilatu et al., 2013), poor balance of grass and legume combinations and late harvesting of the natural pasture to obtain high bio-mass yield (Solomon et al. 2008) contributes for lower protein content and digestibility.

Pasture management play a useful role in providing a high quality feed during dry season (Zinashi et al., 1995). There are a number of interventions to improve native pasture among these, use of fertilizer, over-sowing or fully replacement of natural pasture by cultivated pasture species are the most practiced activities (Tekleyohannis and Worku, 1999). However, using of fertilizer input and over-sowing is not recommended for the area which are over degraded and invaded by unpalatable plants. Over-sowing is also not recommended for arable land in which high yield is expected from small plot of land through improved pasture grasses and legumes. The replacement of natural pasture by cultivated pasture species is more important in the area receiving adequate rainfall through out a year particularly in an agro-ecology of bimodal rain season like Bale highland.

In the past three decades to solve the feed shortage problems a number of attempts were done to adapt and extend improved verities of forage crops, grasses and fodder trees. However, these technologies are not well promoted and implemented by the farmers (Sisay et al., 2012) and the efforts done in the past was only towards improvement of bio-mass yield of a single forage variety not balancing the nutritional content to be obtained from the pasture land. As a solution to this integrating grasses and legumes in the pasture field to improve the total biomass yield and balance the nutritional content of feed to be obtained from the pasture land is technically feasible and economically important. Hence, the objective of this study was to determine the appropriate types and level of grass-legume association for pasture productivity improvement in mid and highland of Bale, Ethiopia.

2. Materials and methods

The experiment was carried out from 2010/11 to 2012/13 at Sinana Agricultural Research Center. The center is located at 07˚07' N latitude and 40˚10'E longitude at an altitude of 2400 m asl. The area is characterized by bimodal rainfall with the total annual rainfall ranging from 750-1000 mm. 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.

The experimental treatments were association of two grass varieties Phalaris *aquatic L (serosa)* and Panicum *coloratum L*. and two forage legumes White clover and Alfalfa (hunter river). The treatment association contains 25%/75%, 50%/50% and 75%/25% grass-legume combination. The treatments were randomly distributed using RCBD with three replications. Each treatment was in plot of 2.m*2.m. Herbaceous legumes seed was inoculated and drilled in rows 30cm apart. Seed rate of 10kg/ha for white clover and Alfalfa (hunter river), and 12kg/ha phalares *aquatica* (sirosa) and panicum *coloratum* grass were used. Forage was harvested when the herbaceous

legumes are at >50% podding stage and grasses at the milk stage taking the two consecutive middle rows of each plot cutting at about 10cm from the ground. The harvested sample was separated from the weed and the combination components were separated and measured separately for their fresh bio-mass yield. 500gm of fresh biomass was sampled and oven dried at 105^{o}C for 24 hour to estimate dry biomass yield per hectare. The data was analysed using SAS, version 9.2 (SAS, 2009). Means were separated using Tukey pair-wise comparison procedure. The following model was used estimate the yield per hectare and variation between the treatments:

$$y = \mu + xb + za + e$$

Where:

y = the dry matter yield in tone/ha

μ = Overall mean

b = the effect of forage association ratio

X = the association of b with Y

a = the effect of block variation

Z = the associates of a with Y

e = the residual effects.

3. Results and discussion

Analysis of the variance of DM yield revealed a significant ($P<0.05$) difference among treatment on both total dry bio-mass yield, and grasses and legume components dry bio-mass contribution. From both side of legume and grass varieties in every proportion of the mixture, Alfalfa and Phalaris associations were yielded higher.

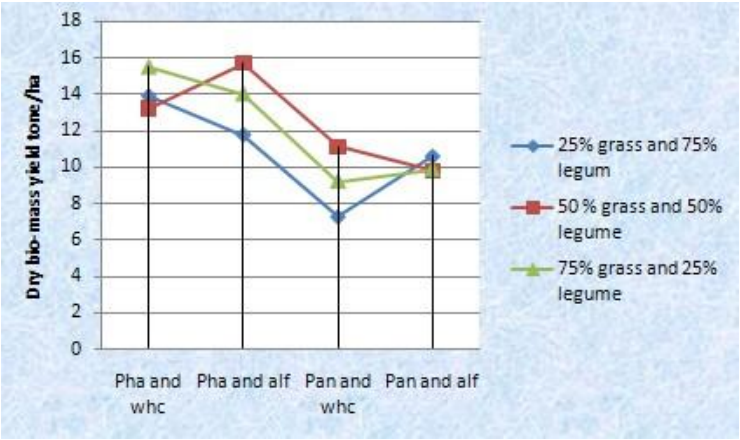

Fig. 1. Dry bio-mass yield of grass-legume associations at different ratio of association.
Pha = Phalaris, alf = Alfalfa, Pan = Panicum and whc = white clover.

Accordingly, mean associations yield of 50% phalaris and 50% Alfalfa is the nearly balancing and the maximum score of 8.1 and 7.6 t/ha of DMY respectively (fig 1.). Association of phalaris *aquatica* (sirosa) 75% and white clover 25% had the second highest yield of 15.5 t/ha as compared with other integrations. But the result from this association indicated that only 5% of the total yield is contributed by white clover which is bellow the optimum legume requirement of the grazing as well as the pasture products to be preserved.

Phalaris *aquatic L. (siroco)* and Medicago *sativa L.* (Hunter River) has showed high dominance. This result is agreed with finding of Watson *et al.* (2000) which justifies as Phalaris can dominate pastures and exclude all legumes causing a decline in pasture quality and production. Watson *et al.* (2000) also indicated that Phalaris *aquatica L.* is bunch type and high tillers grass with extensive and deep fibrous root system which can exploit soil moisture to a depth of two meters thus supplying moisture to the plant during periods of low rain fall. Due to this character it has showed high dominance on the other legume herbaceous forages types and ratios used in the experiment except 50% Alfalfa.

Table 2
Mean biomass yield of associations of - herbaceous forage legumes and grasses with different ratio of integrations.

Treatments	Mean grass dry BM Y t/ha	Mean legume dry BMY t/ha	Mean integration dry BMY t/ha
phalaris 75% + white clover 25%	14.7[a]	0.8[f]	15.5[a]
Phalaris 50% + white clover 50%	12.6[a]	0.6	13.2 [a]
Phalaris 25% + white clover 75%	12.5[a]	1.4[e]	13.9[a]
phalaris 50% + alfalfa 50%	8.1[ab]	7.6[ab]	15.7[a]
phalaris 75% + alfalfa 25%	7.7[ab]	6.3[ab]	14.0 [a]
panicum 50% + white clover 50%	6.7[ab]	4.4[d]	11.1[ab]
Panicum 75% + white clover 25%	4.7 [b]	4.5[d]	9.2[eed]
phalaris 25% + alfalfa 75%	4.7[b]	7.1[ab]	11.8[ab]
Panicum 25% + white clover75%	2.4[b]	4.9[d]	7.3[e]
Panicum 75% + Alfalfa 25%	2.2[b]	7.6[a]	9.8[b]
panicum 50% + alfalfa 50%	1.9[c]	7.9[a]	9.8[b]
panicum 25% + alfalfa 75%	0.7	9.9[a]	10.5[ab]
CV	14.4	17.9	7.0
LSD	6.2	2.5	3.4
Mean	6.6	5.3	11.8

[abc] Means in a column with different letters are significantly different at P < 0.05, CV: Coefficient of variation, LSD: Least Significant Difference, BMY: Bio-mass yield.

Medicago *sativa L.* (Hunter River) is the deep root type with high tiller. It can tolerate moisture shortage and remain green. This made alfalfa highly dominant over the grass types and ratios used in the experiment except 50% phalaris. Due to this the mixture of alfalfa 50% and phalaris 50% is the excellent integration with high yield of dry bio-mass per ha and grass-legume yield proportion. In addition to this grass-legume mixtures can prolong higher quality of feed into the dry season.

The associations of panicum *coloratum L.* and white clover are of the lowest yielders in every combination. This is due to the low number of tiller of panicum as compared to phalaris while the white clover is shallow rooted type which could not tolerate moisture shortage.

4. Conclusion

The experiment was intended to find out appropriate association of grass-legume ratio of seed to be planted on a given plot of land with a balanced level of expected grass and legume dry matter yield. The results of study showed that different ratio of phalaris and alfalfa association produces higher yield. However; high yield and best proportion of the dry matter yield was obtained from plots with 50% alfalfa and 50% phalaris association. This is because Alfalfa has high ability to regenerate during first shower rain and stay green for long period of time when the rain stops. Phalaris also has character of high rain shortage resistance and high number of tiller development. Phalaris is able to carry high stocking rates as well as produce high quality pasture for livestock (Watson *et al*, 2002). Alfalfa could also produce high bio-mass with high protein contribution to the livestock. In addition, alfalfa contributes to the N fixation in to the soil which can further support the productivity of the pasture and minimize the cost for fertilizing the pasture land.

One of the most significant benefits in livestock feeding under pasture condition is that combinations of legumes and grasses species helps improvement of forage quality and provide a proper diet as well as meet the daily protein requirements of livestock grazing. So, as the result from the study indicated; in Bale highland the establishment of permanent grass-legume pasture is more recommended if it comprises 50% phalars *aquatica L.* and 50% Medicago *sativa L*. with seed rate mixture of both forages 10kg/ha.

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