Effect of Oversowing Leguminous Species on Dry Matter Yield and Chemical Composition of Rangelands in Shinyanga Region, Tanzania

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Abstract

A study was carried out to investigate the effect of oversowing legumes on rangeland performance in Shinyanga region, Tanzania. Four leguminous species namely Centrosema pubescence, Clitoria ternatea, Macroptilium atropurpureum and Stylosanthes hamata were oversown in a natural rangeland in a complete randomised design with control plots. Seven years after oversowing, forage dry matter yield and chemical composition were estimated both in the dry and wet seasons. Mean values of forage dry matter yield in the dry season were 1.75, 1.69, 1.62, 1.51 and 0.94 t/ha for the plots oversown with S. hamata, M. atropurpureum, C. ternatea and C. pubescence and the control plots, respectively. During the wet season the yields were 1.79, 1.70, 1.66, 1.62 and 1.25 t/ha. The CP contents of the forages during the dry season were 44.4, 37.6, 36.5, 35.0 and 29.7 g/kg DM for C. ternatea, S. hamata, M. atropurpureum , C. pubescence and the control plots, respectively. The CP content of the forage from plots oversown with C. ternatea and M. atropurpureum during the wet season were 68.8 and 65.6 g/kg DM, respectively and were significantly ($P<0.05$) higher than those oversown with S. hamata, which had CP content of 59.7 g/kg DM. During the wet season the forages from oversown plots had significantly ($P<0.05$) higher CP values than those of the control plots. During the dry season the control plot forages had significantly ($P<0.05$) higher NDF content (751.2 g/kg DM) and C. pubescence oversown plots had the lowest value (733.3 g/kg DM). During the wet season the NDF content ranged from 658.8 to 703.5 g/kg DM for plots oversown with M. atropurpureum and the control, respectively. The ADF content of the wet season forages were 52.2, 52.0, 51.1, 50.0, and 50.7 g/kg DM for plots oversown with C. pubescence, S. hamata, M. atropurpureum, C. ternatea and the control, respectively. During the dry season the ADF content ranged from 54.3 g/kg DM for plots with C. ternatea to 98.4 g/kg DM for those with M. atropupureum. ADL content ranged from 47.6 to 49.6 g/kg DM and from 48.9 to 66.4 g/kg DM for the wet and dry season forages, respectively. Forages from the control plots and those oversown with C. ternatea had significantly ($P\leq0.05$) higher ADL content than the other treatments during the dry season. It was concluded that oversowing of natural rangelands with leguminous species improves both the dry matter yield and the nutritional status of the forages.

Key words: *Oversowing, rangelands, pasture yield, chemical composition*

Introduction

Most of the rangelands located in the arid and semi-arid parts of the world are mainly used for livestock and wildlife grazing (NRC, 1994) and are mostly inhabited by livestock producers such as pastoralists and agro-pastoralists. In these areas, pasture quantity and quality are the main factors limiting animal production (Kusekwa and Kidunda, 1989). Other factors include diseases, water distribution and poor infrastructure. According to Topps (1976), a combined deficiency of energy and protein is the major nutritional limitation to beef production in these areas. This is due to the poor quality of herbage which is the only food available to the

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animals during the long dry season. The pastoral communities culturally maximize herd size aimed at minimizing the risk associated with rangelands and as an expression of social status (Nyamrunda, 1997; Roderick et al., 1998) leading to overgrazing. Overgrazing can destroy native vegetation and loss of plant and animal bio-diversity and soil erosion (Wilkinson, 1992; Haan et al., 1996). The harsh climatic conditions and seasonal shortage of rain especially during the dry season reduce the quantity and quality of the forage resulting in poor animal productivity. Interventions to improve and conserve the rangeland is, therefore, of great importance for increased livestock production. Oversowing with leguminous plant species is one of the recommended practices as most of these species fix free atmospheric nitrogen (Skerman and Rivores, 1990) which is then utilized by companion plants. Tothill (1986) reported that introduction of legumes in natural pastures can increase animal production up to ten times. Legumes have great potential for enhancing grazing resources, largely because of their ability to provide a source of nitrogen to the associated grasses (Crowder and Chheda, 1982).

Shinyanga is one of the semi-arid regions of Tanzania affected by problems related to rangelands. The problems are more serious during the dry season where both quality and quantity of animal feed is poor (Otsyina and Asenga,1993; Shem, 1996; Nyamrunda, 1997). The region is inhabited by an agro-pastoral tribe known as 'Sukuma'. They have an indigenous knowledge of conserving forage referred to as 'Ngitiri' which is aimed at sustaining dry season forage supply for livestock. 'Ngitiri' are used at the peak of the dry season and hence their forage is very poor in nutritional quality. In an effort to overcome seasonal feed shortages, studies were initiated by the International Centre for Research in Agro-forestry (ICRAF) in Shinyanga region to improve the productivity and the quality of natural rangelands by introducing high quality leguminous plant species into the existing rangeland vegetation (Otsyina et al., 1994). This study was, therefore, aimed at evaluating the influence of the introduced plant legumes on forage quantity and quality after seven years of oversowing in Shinyanga region, Tanzania.

Materials and Methods

The study area

The study was carried out at ICRAF Lubaga Research Station, which is located in Shinyanga region, Western Tanzania. The region is mostly semi-arid with an annual rainfall ranging from 600 to 800 mm. Monthly maximum and minimum temperature varies from 27.6 to 30.2 ^{0}C and 15 to 18.3 ^{0}C, respectively (Otsyina et al., 1994). The soils are mainly black clays (cambi-soils and vert-soils) locally known as "mbuga". The vegetation is mainly open bush savannah grassland with few Acacia spp and baobab *(Adansonia digitata)* trees (Nyamrunda, 1997). The dominant grasses are *Hyperrhenia rufa, Eragrostis superba, Heteropogon contortus, Chloris roxburghiana, Cynodon dactylon, Aristda asscensionis and Rynchelytrum ripens.*

Experimental design

Four leguminous plant species were oversown in the existing natural rangeland during the rain season of 1992. The legumes were *Centrosema pubescences, Clitoria ternatea, Macroptilium atropurpureum* and *Stylosanthes hamata.*

The oversown leguminous plant species were established in a completely randomized block design. The experiment had four blocks with 5 plots. The four oversown leguminous species were replicated four times, once in each block. The fifth plot was the control which was not oversown and therefore, making a total of 20 plots. The plot size was 12m x 12m. Forage samples were taken during the dry (October, 1999) and wet (March, 2000) seasons.The pastures were harvested once per year before the experiment.

Forage sampling

Forage dry matter yield was estimated using a 0.25 m^2 quadrat to dermacate the sampling area. The herbage in the sampling area was clipped to ground level using a hand shear. The herbage was immediately put in plastic bags for weighing using a spring balance and immediately taken to the laboratory in a cool box.

Sample preparation

A sub-sample from each plot was taken, weighed and put in a paper bag for drying. The samples were oven dried at 60^0 C to a constant weight.

The dry matter yield per hectare was then calculated. The dried samples were ground so as to pass through a 1 mm sieve in a Christy and Norris hammer mill. The ground samples were stored in sealed bottles for chemical analysis.

Chemical analysis

The samples were analysed at ICRAF Lubaga Research Station laboratory. Dry matter (DM), Crude protein (CP) (N x 6.25), Ether extract (EE) and ash contents were determined using the methods described by A.O.A.C. (1990). Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) were analysed according to the procedures described by Van Soest et al. (1991).

Statistical analysis

The data was analysed using SAS (1998) statistical package for complete randomized design. A two way analysis of variance was used. Means of dry matter yield and chemical composition were compared using the Least Significant Difference (LSD) test.

Results

Dry matter yield of the forages

The dry matter yields of the oversown pastures for the dry and wet seasons are shown in Table 1. The dry matter yield of the forages during the dry season ranged from 0.94 for the control plots to 1.75 t/ha for the plots oversown with *S. hamata*. During the wet season it ranged from 1.25 to 1.79 t/ha for the control plots and those oversown with *S. hamata*, respectively. For both wet and dry seasons the oversown plots had significantly ($P<0.05$) higher dry matter yield than the control plots (Table 1). The oversown plots produced higher dry matter yields than the control plots by 86.2, 79.8 72.3 and 60.6 percent during the dry season for, *S. hamata*, *M. atropurpureum*, *C. ternatea* and *C. pubescence*, respectively and 43.2, 36.0, 32.8 and 29.6 percent during the wet season. The difference in dry matter yield between the oversown plots were however, not significant ($P>0.05$). The difference in dry matter yield between seasons was not significant ($P>0.05$) though the wet season yields were slightly higher than those of the dry season.

Table 1: Mean dry matter yield (t/ha) of the oversown natural pastures during the wet and dry seasons [1]

Plots [2]	Dry[3] season yield	Increase from control (%)	Wet season yield	Increase from control (%)	SEM	Significance
Natural + CEPU	1.51[a]	60.6	1.62[a]	22.6	0.06	NS
Natural + STHA	1.75[a]	86.2	1.79[a]	43.2	0.06	NS
Natural + MAAT	1.69[a]	79.8	1.70[a]	36.0	0.06	NS
Natural + CLTE	1.62[a]	72.3	1.66[a]	32.8	0.06	NS
Control	0.94[b]		1.25[b]		0.06	NS
SEM	0.06		0.11			
Significance	*		*			

[1] In this and subsequent tables
* = $P<0.05$
** = $P<0.01$
*** = $p< 0.001$

[2]Natural + CEPU: Natural pasture oversown with *Centrosema pubescence.*
Natural + STHA: Natural pasture oversown with *Stylosanthes hamata*
Natural + MAAT: Natural pasture oversown with *Macroptilium atropurpureum.*
Natural + CLTE: Natural pasture oversown with *Clitoria ternatea*

Control: Natural pasture alone

³ *Means within the same column and within the same row having different superscript letters are significantly different at (P<0.05)*

Chemical composition of the forages

The chemical composition of forages collected from different plots during the dry and wet seasons are presented in Table 2.

Crude protein

In the dry season, crude protein (CP) content of the forages ranged from 29.7 g/kg DM for forages in the control plots to 44.4 g/kg DM for those oversown with *Clitoria ternatea* while in the wet season it ranged from 43.0 g/kg DM for the forages in the control plots to 68.8 g/kg DM for the plots oversown with *C. ternatea*. The CP content of *C. ternatea* oversown plots was significantly (P<0.05) higher than that of the other plots. The control plots had significantly (P<0.05) lower forage CP content than the other plots except that of *C. pubescence* oversown plots, which did not differ significantly (P>0.05) during the wet season. The natural pastures oversown with *C. ternatea* and *M. atropurpureum* had significantly (P<0.05) higher CP content than those of other plots during the wet season. In general, forages from the plots oversown with *C. ternatea* had significantly (P<0.05) higher CP content whereas those from *C. pubescens* had significantly (P<0.05) lower CP content than those in the other oversown plots.

Table 2. Mean chemical composition of the oversown natural pastures during the dry and wet seasons

Treatment	**Parameters (g/kg DM)**					
Dry season	**CP**	**EE**	**NDF**	**ADF**	**ADL**	**Ash**
Natural + CEPU	35.0^{b}	6.5^{c}	733.3^{c}	66.5^{b}	48.9^{b}	124.2^{a}
Natural + STHA	37.6^{b}	8.2^{b}	747.3^{b}	96.8^{a}	50.1^{b}	106.2^{b}
Natural + MAAT	36.5^{b}	10.4^{a}	751.2^{a}	98.4^{a}	49.1^{b}	101.8^{c}
Natural + CLTE	44.4^{a}	8.3^{b}	747.0^{b}	60.1^{a}	54.3^{c}	102.7^{c}
Control	29.7^{c}	6.7^{c}	751.2^{a}	68.4^{b}	66.4^{a}	112.6^{b}
SEM	1.9	0.02	8.1	4.4	5.8	0.8
Significance	**	**	**	*	*	**
Wet season						
Natural + CEPU	49.0^{c}	19.9^{c}	702.2^{a}	52.2	49.5	112.9
Natural + STHA	59.7^{b}	22.7^{a}	669.2^{b}	52.0	48.8	101.4
Natural + MAAT	65.6^{a}	21.2^{a}	658.8^{b}	51.1	45.1	110.0
Natural + CLTE	68.8^{a}	19.9^{c}	691.2^{a}	50.0	47.6	105.7
Control	43.0^{c}	12.1^{d}	703.5^{a}	50.7	49.6	106.6
SEM	1.2	0.4	5.1	4.9	4.1	4.6
Significance	**	**	**	NS	NS	NS

Cell wall contents

During the dry season, the contents of neutral detergent fibre (NDF) of the forages ranged from 733.3 g/kg DM for *C. pubescence* oversown plots to 751.2 g/kg DM for the control plots. In the wet season NDF contents of the forages from the control plots (703.5 g/kg DM) and those oversown with *C. pubescence* (702.2 g/kg DM) were significantly (P<0.05) higher than those of the other plots (Table 2). In the wet season there was no significant (P>0.05) difference in forage NDF content between plots oversown with *S. hamata* (669.2 g/kg DM) and *M. atropurpureum* (658.8 g/kg DM). Higher NDF content was recorded for the forages on the control plots, while the lowest value was recorded for *C.pubescences* oversown plots during the dry season.

The ADF contents of the forages harvested on the *M. atropurpureum* (98.4 g/kg DM) and *S. hamata* (96.8 g/kg DM) oversown plots were significantly (P<0.05) higher than those on the other plots. However, forages from *C. ternatea* oversown plots (54.3 g/kgDM) had the lowest ADF value. The ADF and ADL contents of the forages were not significantly (P>0.05) different between treatments during the wet season. In the dry season forages from the control plots (66.4 g/kg DM) had significantly (P<0.05) higher ADL content than the other plots.

Ether Extract (EE)

During the dry season forage, EE content ranged from 6.5 g/kg DM to 10.4 g/kg DM for plots oversown with *C. pubescence* and *M. atropurpureum*, respectively (Table 2). *M. atropurpureum* oversown plots had significantly (P<0.05) higher EE content than the other plots. Generally forages from all plots had higher EE content during the wet season compared to the dry season. Forages from natural pastures oversown with *S. hamata* (22.7 g/kg DM) and *M. atropurpureum* (21.2 g/kg DM) had significantly (P<0.05) higher EE content compared with the other plots during the wet season (Table 2). Forages from the control plots had significantly (P<0.05) lower EE content (12.1 g/kg DM) during the same period.

Ash content

In the dry season ash content of the forages from the plots oversown with *C. pubescence* was highest (124.2 g/kg DM) while those of *M. atropupureum* oversown plots was least (101.8 g/kg DM). The values of ash content of the forages harvested from the plots oversown with *C. pubescence* (112.9 g/kg DM) and *M. atropurpureum* (110.0 g/kg DM) were slightly higher during the wet season, however, the difference was not significant (P>0.05).

Forage chemical composition between seasons

Comparison of the chemical composition during the dry and wet seasons is given in Table 3. The CP content of the wet season forages were significantly (P<0.05) higher than the dry season forages. The wet season forages had significantly (P<0.05) lower NDF content. The ADF content of the forages was lower during the wet season compared with the dry season. There was no significant difference in ADL contents between seasons, except for the control and the plots oversown with *C. ternatea*. There was also no significant (P>0.05) difference in ash content between the dry and wet season forages except for the control and plots oversown with *M.atropurpureum*.

Table 3. Mean chemical composition of the oversown pastures during the dry and wet seasons

Treatment/Season	Chemical composition (g/kg DM)					
	CP	EE	NDF	ADF	ADL	Ash
Natural + CEPU						
Dry	35.0	6.5	733.3	66.5	48.9	124.2
Wet	49.0	19.9	702.2	52.2	49.5	112.9
SEM	1.8	0.8	8.5	7.6	5.0	4.4
Significance	**	**	**	*	NS	NS
Natural + STHA						
Dry	37.6	8.2	747.3	96.8	50.1	106.2
Wet	59.7	22.7	669.2	52.0	48.8	101.4
SEM	1.8	0.8	8.5	7.6	5.0	4.4
Significance	**	**	*	*	NS	NS
Natural MAAT						
Dry	36.5	10.4	751.1	98.4	49.1	101.8
Wet	65.6	21.2	658.8	51.1	45.1	110.0
SEM	1.8	0.8	8.5	7.6	5.0	4.4
Significance	**	*	*	*	NS	*
Natural + CLTE						
Dry	44.4	8.3	747.0	54.3	60.1	102.7
Wet	68.8	19.9	691.2	50.0	47.6	105.7
SEM	1.8	0.8	8.5	7.6	5.0	4.4
Significance	**	*	**	*	*	NS
Control						
Dry	29.7	6.7	751.2	68.4	66.4	112.6
Wet	43.0	12.1	703.5	50.7	49.6	106.6
SEM	1.8	0.8	8.5	7.6	5.0	4.4
Significance	*	*	*	*	*	*

Discussion

The overall mean dry matter yield of the natural pastures (1.87 t/ha) obtained in this study was higher than that reported by Otsyina et al. (1994), who obtained dry mater yields of 1.5 t/ha for conserved fodder during the dry season in semi arid areas of Shinyanga region in Tanzania. This difference could be due to the absence of leguminous plant species in the conserved fodder as demonstrated in the present study. It has been evident from the present study, that oversowing increased the dry matter yield of the natural pasture during both the dry and wet seasons. This could also be explained by the ability of the leguminous plant species to fix nitrogen which is then available to the companion grasses (Skerman et al.,1988; Rukanda and Lwoga, 1981). However, the observed percent dry matter increase in the present study was higher during the dry season compared with the wet season. This could be due to the fact that most of the grasses had reached their production potential during the dry period while the legumes were still growing (Skerman and Rivores, 1990). Production of large amounts of good quality forage per unit area is an important pasture parameter because of its effect on carrying capacity and hence production per animal and per unit area (Whiteman, 1980). Oversown natural pastures can allow higher carrying capacities compared with the natural pastures grown alone due to the higher dry matter yield per year (Wigg, 1973). Oversowing therefore, could be used to improve the dry matter yield of the natural grasslands for both seasons of the year and hence increased animal production.

It is evident in the present study that the crude protein content of the pasture had increased in the oversown plots showing the role of the legumes in improving the dry season feed quality. The recorded CP contents fall within the range of CP content of most of the tropical grasses (20-70 g/kg DM) during both the dry and wet seasons (Skerman and Riveros, 1990; McDowell, 1972; Van Soest, 1994). The observed CP contents of both the natural grassland and the oversown plots were lower than the minimum requirements for ruminants. These results are in agreement with those reported by Kakengi et al. (2001) working in the same region who found that the grasses in communal grazing pasture lands were poor and too low (43.1 g/kg DM CP) in quality to meet the minimum requirements for maintenance and production of lactating cows. The authors recommended the use of *Leucaena leucocephala* leaf meal as a supplement for the provision of CP especially during the dry season. The protein content of the diet has also been implicated in limiting the intake of tropical forages. Intake of grass species declines rapidly when the CP content of the consumed forage falls below 7% (Milford and Minson, 1966). Below such levels the CP content is supposedly inadequate to supply sufficient NH_3-N for optimum fibre digestion in the rumen.

The forages in oversown plots had higher CP values than the control plots. The quality of the grasses in the oversown plots was also improved. The relatively higher CP content obtained in this study may have been due to the benefits that the associated grasses obtained from the nitrogen fixed by the leguminous plant species. Tropical legumes can improve the soil fertility through nitrogen fixation (Skerman and Riveros, 1990) and also are valuable feeds as supplements to low quality forage, due to their high CP content as shown in the present study and by FAO (1979). Legumes also have higher voluntary intakes at similar digestibility than natural grasses (Thornton and Minson, 1973). A study by Rukanda and Lwoga (1981) showed a mean CP increment of 12 percent when *M. atropurpureum* and *S. guyanensis* were oversown in *Themeda-Hyparrhenia* dominated natural grassland in semi arid areas in Morogoro, Tanzania. It has been evident in the present study that the forages from oversown plots had a CP increment of 17 g/kg DM and 6.4 g/kg DM during the wet and dry season, respectively. Oversowing therefore, can improve the quality of the natural grasslands in semi - arid areas and hence improve animal performance in these areas. It can also potentially reduce the costs of supplementation during the dry seasons.

The values of the cell wall component results obtained in the present study were close to those reported by other authors (McDonald et al., 1995; Van Soest, 1994) for poor quality grass hay which had NDF content of 640 to 720 g/kg DM respectively. Kakengi (1998) working in the same study area reported a range of NDF content of 512 to 762 g/kg DM. The results for ADF content reported in the present study were within the range reported earlier from the same region during the dry season but higher during the wet season (Rubanza, 1999; Kakengi, 1998; Chenyambuga ,1994). Van Soest (1994) reported ADL range of 60 to 80 g/kg DM for grass hay.

Different authors have reported different values of cell wall components for dry season forages. This difference may be related to variation in the stage of maturity, climate and soil type (Crowder and Chheda, 1982; Van Soest, 1994). The total cell wall content in legumes does not normally appear to be large enough to seriously inhibit intake as the point which NDF become limiting lies between 50% and 60% of the forage DM. Fibre can account for rumen fill and is highly correlated with both rumination and chewing time among a wide range of forages (Van Soest, 1988; 1993).

The cell wall contents of the natural grasses in the present study were in agreement with those reported by Mero (1997) and Gohl (1981). The forages for the wet season showed higher nutritional quality than those of the dry season. The cell wall contents were particularly low and the crude protein content was higher for the wet season forages. McDowell (1972) and Payne (1990) observed the same trend when comparing chemical composition of forages between seasons.

Conclusion

It is concluded that oversowing of natural rangelands with leguminous plant species improves dry matter yield and nutritional status of the forages throughout the year. *Clitoria ternatea* and *Macroptilium atropurpureum* have shown great potential for oversowing in semi arid areas. There is need for more studies on the effect of introducing leguminous plant species on soil fertility in the area, animal performance and sward behaviour when grazed.

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