RUFORUM Working Document Series (ISSN 1607-9345), 2018, No. 17 (2): 591-596.
Available from http://repository.ruforum.org

Research Application Summary

Growing range grasses in mixed stands increase productivity and does not affect the nutritional quality and digestibility of the hay produced

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Abstract

The increasing pasture establishment under irrigation to bridge feed shortages as a result of seasonal variations has been reported in the Arid and Semi-Arid Lands (ASALs) of East Africa. The natural pastures have declined increasing need for solutions to feed deficit situations. Pasture production seems a promising venture. However, most producers involved in pasture production have been practicing monocultures of range grasses. This study seeks to evaluate the productivity of monocultures established with good quality forages compared to mixed stands. The grasses evaluated were *Chloris roxburghiana* (CR), *Eragrostis superba* (ES) *Enteropogon macrostachyus* (EM), *Cenchrus ciliaris* (CC), *Chloris gayana* (CG) and *Sorghum sudanense* (SB). The findings show that mixed stands could be advantageous in increasing biomass productivity. However, there are no differences in proximate composition, quality and digestibility between pure and mixed stands at the common harvesting stage of maturity with ripening seeds for all the six grasses evaluated. Therefore, we conclude that farmers can grow the range grasses in mixed stands to increase productivity without compromising feed value. This will also help in increasing biodiversity and reduce risks associated with monocultures.

Key words: Arid and Semi-Arid Land, East Africa, forage quality, mixed stand, proximate composition, range grasses, South eastern Kenya

Résumé

L'établissement de pâturages de plus en plus irrigués pour combler les pénuries d'aliments en raison des variations saisonnières a été signalé dans les terres arides et semi-arides (ASAL) d'Afrique de l'Est. Les pâturages naturels ont décliné le besoin croissant de solutions pour alimenter les situations de déficit. La production de pâturages semble une entreprise prometteuse. Cependant, la plupart des producteurs impliqués dans la production de pâturages ont pratiqué des monocultures de graminées de parcours. Cette étude vise à évaluer la productivité des monocultures établies avec des fourrages de bonne qualité par rapport aux peuplements mixtes. Les graminées évaluées étaient *Chloris roxburghiana* (CR), *Eragrostis superba* (ES) *Enteropogon macrostachyus* (EM), *Cenchrus ciliaris* (CC), *Chloris gayana* (CG) et *Sorghum sudanense* (SB). Les résultats montrent que les peuplements mixtes pourraient être avantageux pour augmenter la productivité de la biomasse. Cependant, il n'y a pas de différences dans la composition, la qualité et la digestibilité immédiates entre les peuplements purs et mixtes au stade de récolte commun de maturité avec des graines mûrissantes pour les six graminées évaluées.

Par conséquent, nous concluons que les agriculteurs peuvent cultiver les graminées de parcours dans des peuplements mixtes pour augmenter la productivité sans compromettre la valeur alimentaire. Cela contribuera également à accroître la biodiversité et à réduire les risques associés aux monocultures.

Mots clés : Terres arides et semi-arides, Afrique de l'Est, qualité du fourrage, peuplement mixte, composition proche, graminées de parcours, sud-est du Kenya

Introduction

Pasture production under irrigated systems has been promoted as one of the ways to enhance adaptation of livestock production to climate change in the drylands. This has increased the efforts for established pastures for strategic feeding during the dry seasons (USAID, 2011). This is because pasture production under natural rainfall has failed to sustain the pastoral production systems. A number of studies in the past have evaluated the performance of range grasses under irrigation and some species have shown greater potential for higher yields under cultivation (Opiyo, 2007; Mganga *et al*., 2010b; Ogillo *et al*., 2010; Opiyo *et al*., 2011). However, most of these studies focused on productivity and other morphometric characteristics of the grass species growing in pure stand, but very few if any evaluated the practical feasibility of cultivating the species under irrigation and in mixed stands for increased biodiversity. The study question under this work is to evaluate if pastures grown in pure or mixed stands have variations in forage quality. Since these grasses in the natural pastures grow in mixed stands, one would want find out which is more productive either as pure (monoculture) or mixed stands. If mixed stands are more productive, which species are more compatible and/or how many species give the optimum forage quality? It was hypothesized that answers to these questions would inform future pasture establishments if the option of producing fodder in the arid and semi arid lands (ASALs) through irrigation is to be up scaled. It is from this background that this study evaluated the quality of six range grasses when grown in pure and in mixed stands, in terms of their nutritional content, digestibility and biomass yields.

Research methodology

Study area and treatments. The study was done in the arid rangelands in South Eastern Kenya. The experimental design was completely random design (CRD) where plots were randomly allocated six grass species and mixture or 2, 3, 4 and 5 species with three replicates. The grass species were grown in land that had not been cultivated for the previous two seasons which was cleared, ploughed and harrowed to fine tilth. The land was later divided into 30 subplots measuring 5 × 5 m with 1 m boundary between the plots. Seed planting done by broadcast method. The grass was grown to the stage of seed maturity and ripening (12 weeks from planting). The grass was harvested and cured for three days before bailing and storage in a hay ban.

Proximate components determination. Forage quality of the six grass species and their mixtures was determined from the bales of hay. One kilogram forage samples for each species were collected from randomly selected bales. The samples were ground through a 1 mm sieve hummer mill and stored in labeled containers for analyses. The ground samples were oven dried at 105^{o}C to constant weight for Dry Matter (DM) determination. Percent Crude Protein (CP), crude fibre (CF), and ether extract (EE) were determined following the Micro-Kjeldal procedures (AOAC, 2005). The percent NDF, ADF and ADL were determined according to Van Soest *et al*. (1991).

Results

Proximate analysis results of the six range grass species grown singly and in mixtures at different phenological stages are presented in Table 1 below. Dry matter content was more than 90% for all the grasses in pure and in mixed stands. There was no significant difference in DM, Ash, CF, NDF, ADL and EE among the species and their mixtures. All the pure and mixed stands had CP greater than 6%, with *S. Sudanense* having lower CP and ash content amongst the six grasses at 12 weeks seed ripening phenological growth stage. The ash content for the six range grasses and their mixtures ranged from 8-16%, with *C. roxburghiana* having the highest. EE was between 1-2.5%. The six grasses and their mixtures had ADL ranging between 5-13%. The in sacco Dry Matter Digestibility (ISDMD) was not significantly different among the pure grass and mixture treatments with CC having the highest (31%). Notably, the highest (5) species mixture treatment had a significantly higher biomass yield of 9.5 tonnes followed by *Sorghum sudanense* (9.4 tonnes), which was not included in the mixture treatment based on its growth morphology, being a very tall grass that is cultivated and not found naturally growing in the rangelands. Generally, all the pure and mixed stands showed varied biomass yields.

Discussion

The high DM content observed in all the grasses studied indicates their high potential to support livestock in the drylands. The DM content of any animal feed material determines its nutritional value (Allen, 2000). Grazing animals derive their nutritional requirements from the DM and hence, the higher the DM the higher the available nutrients. According to Oba and Allen (2000), animal performance and productivity is influenced by forage DM supply, dry matter intake (DMI) and adequate nutrient supply. The ash content in all the six grasses and the mixtures was higher than 3-12% reported by Linn and Martin (1999) as adequate levels for most grass species. This is an indication of better capacity for the studied grasses to provide the required minerals for normal animal performance. The observed variability in the ash content could be due to genetic variability that influence the soil extraction levels (Burvall, 1997). The observed higher ash in *C. roxburghiana* could be due to its extensive and fibrous rooting pattern which enhanced absorption. Under mixture species, ash content tended to be higher than in monoculture and this could be attributed to the compounded differences in species absorption, for example*, C. roxburghiana, E. macrostachyus* and *C. ciliaris* had high ash contents.

The EE was within the nutritionally beneficial level of 1-5% of a diet according to Palmquist and Jenkins (2003). Leng *et al*. (1992) reported the need for calcium mineral supplement if the percentage EE content exceeded 5% to enhance rumen digestibility efficiency and increased energy yields of the forages. This implies that the observed levels may not require calcium supplementation, and the observed ash levels may supply adequate amounts. Composition of the EE fraction varied insignificantly among the species studied, which is in agreement with the observation of (Weiss *et al*., 1992).

The CP of all the pure and mixed stands was >6% indicating the species were of better quality at this stage. Meissner *et al*. (2000) reported CP of between 6 and 8% was adequate in meeting animal nutritional needs (NRC, 1996). Crude protein is an indicator of forage quality (Caddel and Alllen, 2000) and highest priced supplement nutrients for livestock (Redfearn *et al*., 2004). Crude protein in pastures varies with species, stage of maturity, climatic conditions during growth and soil fertility (Johnson *et al*., 2001). The decline in CP with grass species maturity is due to the increase in structural carbohydrates, and also, the change in leaf:stem ratio (Arzani *et al*., 2004). The slightly lower CP in *S. sudanense* amongst the six grass species can be attributed to faster growth rate, hence more stems than

leaves at week 12 as leaves contain more CP than the stems (Arzani *et al*., 2004). The observed CF, NDF and ADF in this study play an important role in determining digestibility, with higher levels reducing dry matter degradability (DMD) and consequently leading to poor quality feed that reduce animal performance (Theron and Snyman, 2004). The NDF in grasses encompasses cellulose and hemicellulose which are either indigestible or slowly digestible components in plant cell walls (Kozloski *et al*., 2005), though they constitute diet easily digestible by ruminant's microbes providing energy compared to ADF and ADL which are more of plant lignin components. These components vary among species, stage of maturity, and growing environment (Kozloski *et al*., 2005; Mahyuddin, 2011). In this study, the ADL level was below 15% for all the grasses and may not have adverse effects on animals' digestibility (Nsinamwa *et al*., 2005). Grass species with higher ADL are of low palatability resulting to poor intake by ruminants, and is also inaccessible to digestive enzymes and hence not beneficial to ruminants' nutrition (Crowder and Chheda, 1982). Pure stand or mixed species did not show any significant difference in percent ISDMD content. However, there could be benefits in growing higher mixture stands in terms of increased biomass yields, and probably to benefit from the variable growth rates that may provide varied nutritional benefits at different stages of utilization.

Table 1. Proximate feed composition (%) % IN SACCO dry matter digestibility (ISDMD), above ground biomass (kg/ha) of grass species grown in pure and mixed stands under supplemental irrigation at 12th phenological stage

Species	DM	Ash	E.E	C.P	C.F	NDF	ADF	ADL	% ISDMD	Biomass (kg/ha)
C R	91.9±6.2	15.2±2.2	1.0±0.1	6.5±2.1	48.6±9.0	75.2±3.4	40.1±11	10.1±3.1	24.5	3600.4b ± 76.9
E S	94.0±8.9	10.2±3.1	1.0±0.3	7.0±1.3	38.6±5.6	74.8±8.2.	32.8±4.9	10.3±4.1	23.9	3468.3b ± 34.0
EM	93.7±11.2	12.2±2.2	1.5±1.1	6.0±2.1	42.7±4.9	70.1±8.1	36.8±9.1	8.4±3.1	20.9	6600.6b ± 37.7
CC	92.4±25.1	12.7±3.1	1.2±2.0	6.3±1.2	37.3±11	71.0±9.6	45.3±5.1	10.6±2.3	31.0	4064.6b ± 18.9
CG	93.0±13.5	10.8±2.7	1.1±0.4	6.2±1.3	44.4±9.2	71.1±7.0	42.1±4.6	11.1±4.5	25.9	7932.2e ± 93.1
SB	94.2±21.2	9.3±1.8	1.3±1.2	6.1±0.7	43.2±9.2	75.8±8.1	35.2±3.2	11.4±5.1	26.0	9464.4e ± 23.1
CR/ES	91.8±17.9	15.9±5.1	1.1±1.6	6.5±1.2	46.5±8.1	739±9.0	33.1±8.1	8.9±3.1	23.1	4000.8b ±84.1
C R / E S / EM	92.5±17.2	13.8±3.1	1.3±1.0	6.6±1.3	37.5±3.1	74.5±7.2	36.7±8.1	9.1±1.2	24.9	3932.5b ± 14.4
C R / E S / EM/CC	95.3±8.9	12.2±3.7	1.1±1.2	6.1±2.2	38.0±1.2	72.1±9.8	40.5±6.7	12.1±3.4	27.3	5532.7b ± 11.5
C R / E S / EM/CC/ CG	94.0±11.1	8.4±2.3	1.5±0.1	6.4±3.1	45.9±2.1	74.0±8..2	41.1±2.1	11.2±4.1	23.7	9524.2e ± 163.3

Key: CR = Chloris roxburghiana, ES = Eragrostis superba, EM = Enteropogon macrostachyus, CC = Cenchrus ciliaris, CG = Chloris gayana, SB = Sorghum sudanense

Conclusions and implications for policy and development

This study has demonstrated that there is no much variation in nutritional quality and digestibility in growing range grasses as pure or mixed stands. However, there are added benefits in growing mixture stands in terms of increasing biomass yields. This could also bring in the benefit of enhanced biodiversity and reduced risk associated with mono-cropping. Therefore, it may be important to encourage farmers to establish mixed pasture stands with the assurance of increased yields at no loss to feed quality.

Acknowledgements

This paper is a contribution to the Sixth Africa Higher Education Week and RUFORUM 2018 Biennial Conference.

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