Tropical and Subtropical Agroecosystems

EFFECT OF SEASONALITY ON FEED AVAILABILITY, QUALITY AND HERD PERFORMANCE ON SMALLHOLDER FARMS IN OL-JORO-OROK LOCATION/NYANDARUA DISTRICT, KENYA

[EFECTO DE LA ESTACIONALIDAD SOBRE LA DISPONIBILIDAD Y CALIDAD DE LOS ALIMENTOS Y EL COMPORTAMIENTO DE LOS HATOS DE PEQUEÑOS PRODUCTORES EN OL-JORO-OROK, NYANDARUA, KENYA]

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SUMMARY

The current study was conducted in Ol-Joro-Orok location in Nyandarua district, over a period of 18 months preceded by a 3-week feed survey. During the survey, a structured questionnaire was administered to 98 households out of which, 40 were randomly selected to participate in the trial. The objective was to determine the effect of seasonality on feed availability, quality and herd performance on - farm. In the 40 trial farms, ruminant livestock population comprised of 61.7% cattle, 35.1% sheep and 3.2% goats. Total herd structure constituted of, 44.5 (N=61) lactating and dry cows, heifers 21.9 (N=30), bulls 7.3 (N=10) and calves 26.3% (N=36). Wide variations were observed in feed availability and quality between wet and dry season, as evidenced by preference and availability ranking score values (PAR). While PAR for Napier grass was highest in wet season (9.55 ± 0.12), it dropped by about 24% (7.22 ± 0.47) in dry season ($P<0.0001$). That of natural grass similarly dropped from 8.89 ± 0.24 to 7.67 ± 0.45 (14%; $P<0.001$). In contrast, maize stover's PAR rose sharply from 5.72 ± 0.43 in wet to 9.28 ± 0.19 (62.2%) in dry season ($P<0.0001$). Similar trend was noted in PARs of other feed resources studied. The results also showed strong correlation between forage age and nutrient components. In vitro DMD (%), CP (g kg^{-1} DM) and ME (MJ kg^{-1} DM) are negatively correlated with cutting interval. For Napier and natural grass, CP concentration dropped from 110 and 120 to 56 and 48 g kg^{-1} DM in wet and dry season, respectively. That of maize stover (most popular dry season feed) was observed to range between 35 to 60 g kg^{-1} DM. Results further showed that lactating cows in wet performed (47%) better compared to those in dry season ($P<0.0001$; r^2=86.2%). In conclusion, seasonality has a strong influence on feed availability, quality and therefore performance of ruminants on smallholder farms in Nyandarua. In order to increase ruminant performance on these farms, deliberate efforts should be made to improve feed quality and utilization efficiency, particularly in dry season.

Keywords: Dry matter digestibility; Crude protein concentration; ruminant livestock, herd structure

RESUMEN

El presente estudio se llevó a cabo en Ol-Joro-Orok, Nyandarua, Kenya, por un periodo de 18 meses precedido por una encuesta sobre alimentos de 3 semanas. Durante la encuesta se aplicó un cuestionario estructurado en 98 unidades familiares de las cuales se seleccionaron 40 para participar en la segunda fase del estudio. El objetivo fue determinar los efectos de la estacionalidad sobre la disponibilidad y calidad de los alimentos así como el desempeño del hato. En las 40 fincas, la población de rumiantes estuvo dividida en 61.7% bovinos, 35.1% ovinos, y 3.2% cabras. El hato estuvo compuesto de 44.5 (n=61) vacas lactantes y secas, novillas 21.9 /n=30), sementales 7.3 (n=10) y becerros 26.3% (n=36). Se encontró una gran variación en la disponibilidad y calidad de los alimentos entre las épocas de lluvia y sequía. La calificación de preferencia y disponibilidad (PAR) fue más alta para el pasto Napier en la época de lluvias (9.55 ± 0.12) y se redujo 24% (7.22 ± 0.47) en la época seca ($P<0.0001$). La PAR del pasto nativo tuvo un comportamiento similar de 8.89 ± 0.24 a 7.67 ± 0.45 (14%; $P<0.001$). En contraste, la PAR del rastojo de maíz incremento de 5.72 ± 0.43 en lluvias, a 9.28 ± 0.19 (62.2%) en secas ($P<0.0001$). Tendencias similares fueron encontradas para otros alimentos. Se encontró una correlación negative entre la digestibilidad in vitro de la MS, contenido de PC y EM con el intervalo de corte. Tanto para el pasto Napier como el pasto nativo la concentración de PC bajó de 110 y 120 a 56 y 48 g kg^{-1} MS en la época de lluvias y secas respectivamente. La PC del rastrojo de maíz (alimento más popular en la época seca) varió de 35 a 60 g kg^{-1} MS. Se observó un major desempeño en la época lluvias (47%) ($P<0.0001$; $r^2=86.2\%$). Se concluye que la estacionalidad tiene una fuerte influencia sobre la disponibilidad y calidad de los alimentos y por consecuencia en el desempeño de los animals en Nyandarua.

Palabras clave: Digestibilidad; calidad de los forrajes; rumiantes, estructura del hato.

INTRODUCTION

Livestock sub-sector is a very significant contributor to the Kenyan national economy and it generates employment and income for thousands of smallholder farm households (Rees, *et al.,* 1998; Muriuki, 2002; Kurwijila, 2002). Presently however, smallholder ruminant livestock production is threatened by inadequate feed, which is directly linked to reduced average farm size. This in turn has spontaneously sparked employment of unsustainable farming methods leading to serious soil fertility decline leading to decline in crop/fodder yields and their susceptibility to pests and diseases (Nandwa & Bekunda, 1998; Nderitu, *et al*., 1997). This further exacerbated by unpredictable weather conditions. Dry season or at worst drought, is possibly the greatest factor that influences ruminant livestock production on smallholder farms in Kenya. The effects of dry season on ruminants in these farms include a whole range of consequences such as: low calving rate, low birth weight, high animal mortality (especially, that of calves), low weaning weight, reduced mature body size, low growth rate (delayed maturity) and more importantly low milk production which impacts negatively on the overall household income. It is a fact that forage quality depend on soil fertility and biomass yield depend on soil humidity which in turned depends on the amount of rainfall that infiltrates the soil. In Kenya generally, rainfall in many dairying areas is highly variable and often unpredictable with more possibility of failure than down pour. Due to this variation in annual precipitation and especially its distribution, forage biomass yield, quality and availability varies substantially from year to year. The often-observed scenario is that, surplus forage material exists during the rainy season while there is severe shortage during the dry season. The feed shortage in the dry season is further compounded by the low feed quality, which is insufficient to support satisfactory milk production and reproduction performance (Shem, 1996; Smith & Akinbamijo, 2000; Jingura & Sibanda, 1998). As a direct consequence, high losses in herd productivity have been reported (Lanyasunya, *et al*., 2005). The objective of the current study was therefore to investigate the effects of seasonality on feed availability, quality and the consequential impact on herd performance on smallholder farms.

MATERIALS AND METHOD

Eighteen-month study, preceded by a 3-week feed survey was conducted in Ol-Joro-Orok location in Nyandarua district in Kenya. During the survey, a structured questionnaire was administered to 98 smallholder farmers interviewed (all of them deriving 80% of their annual income from farming). From these farms both quantitative and qualitative baseline data on ruminant livestock population/structure, farmers' experiential knowledge on seasonal feed preference and availability fluctuations were discerned using participatory rural appraisal (PRA) tools. Individual farmers (F_i) guided by researchers and extension staff listed (1 – 10) most commonly used feed resources and ranked them (R_n: where n = 1 – 10) according to preferences, costs and availability during both wet and dry season (Chambers, 1992; McCracken, *et al*., 1988; Theis & Grady, 1991). The developed ranking matrices per farm were harmonized by attaching a concrete analyzable numerical value X_i (where X = 10 – 1, reverse order of n) in such a way that a feed resource ranked 1 (R = 1; meaning most preferred and available in wet or dry season) by a given F_i scores 10 points (X = 10) whereas that which attract rank 10 (R = 10; less preferred and not available) scores 1 (X = 1) point. All the numerical X values obtained per feed resource (i.e. Napier grass) from different sets of F_is were treated as preference and availability ranking scores (PAR) for that feed resource stratified according to seasons and therefore subjected to analytical models as independent samples. After the feed survey 40 farm households were randomly selected to participate in the long-term data collection trial. Effect of dry season on feed quality and dairy herd performance were investigated through feed sampling and collection of production data over the 18 – months study period. Feeds were sampled at different morphological stages (during both dry and wet season) for dry matter (DM) determination and chemical analysis (AOAC, 1990; Abdulrazak & Fujihara, 1999). Nitrogen (N) was determined according to the Kjeldahl method (AOAC, 1990). Crude protein was calculated as N x 6.25. The crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) contents were determined according to Van Soest & Robertson (1985) and Abdulrazak & Fujihara (1999). Milk yields of lactating dairy cows were also monitored over the study period. Data obtained were stored in MS-Excel (2000). Descriptive statistics and t-test were determined using SPSS (2003). Graphic illustrations were developed using MS-Excel.

RESULTS

Results showed wide variation in population and herd structure of ruminant livestock in the 40 study farms. It comprised of 61.7% cattle [N = 137: Friesian (54); Ayrshire (47) and Crosses (36)], 35.1% sheep and 3.2% goats. These gave an average of 4 heads/farm (range: 2 – 8 heads/farm). Herd structure analysis revealed that lactating and dry cows constituted about 44.5 (N = 61), heifers 21.9 (N = 30), bulls 7.3 (N = 10) and calves 26.3% (N = 36). PRA results revealed significant variation of the PAR values for different feed resources during wet and dry seasons (Table 1). While Napier grass preference and availability ranking score value (PAR) was highest in wet season (9.55 ± 0.12), it dropped by about 24% (7.22 ± 0.47) in dry season ($P<0.0001$). That of natural grass also dropped from 8.89 ± 0.24 to 7.67 ± 0.45 (14%) in wet and dry season respectively ($P<0.001$). In contrast, PAR for maize stover rose sharply from 5.72 ± 0.43 in wet to 9.28 ± 0.19 (62.2%) in dry season ($P<0.0001$). The PARs recorded by other feed resources studied showed similar trend.

It was observed that fluctuations in PARs (Table 1) were highly influenced by either the presence (wet season) or absence (dry season) of precipitation. Following this observation a deliberate attempt was made to relate the rainfall pattern to the forage biomass yield in the study area (Figure 1). Figure 1 clearly illustrates the period of low (October – March) and high precipitation (April – September) and projected forage biomass yield.

Using two of the commonly used forages (Napier grass: *Pennisetum purpureum* and Guinea grass: *Panicum maximum*), the obtained chemical data clearly showed effect of forage age (weeks) and precipitation, on quality (Figure 2).

The results showed strong correlation between age and nutrient components. The slopes of the fitted linear regression lines showed that, In Vitro DMD (%), CP (g/kg DM) and ME (MJ/kg DM) are negatively correlated with cutting age. The reverse was true for CF (g/kg DM) (Table 2). The study further showed that in natural grass, CP concentration dropped from 120 in wet to 48 gkg^{-1} DM in dry season. That of maize stover (most popular dry season feed) was observed to range between 35 to 60 gkg^{-1} DM.

Obtained results (Table 3) showed that lactating cows in wet season performed (47%: 345.06 ± 36.39 Lt/farm/month) better compared to those in dry season (177.18 ± 22.45 Lt/farm/month)($P<0.0001$; r^2 = 86.2%).

Table 1. Preference and availability ranking score values (PAR) of commonly used feed resources on smallholder farms as influenced by season

Feed resources	Wet season PAR score values		Dry season PAR score values	
	Mean ± Std. err	C. V	Mean ± Std. err	C.V
Napier grass	9.55 ± 0.12***	5.35	7.22 ± 0.47***	27.51
Natural grass	8.89 ± 0.24**	11.5	7.67 ± 0.45**	24.91
Maize stover	5.72 ± 0.43***	32.17	9.28 ± 0.19***	8.91
Sweet potato vines	4.33 ± 0.82*	80.33	3.5 ± 0.7*	85.01
Purchased dairy meal	5 ± 0.73**	62.12	4.83 ± 0.69**	60.74
Banana stems/leaves	2.89 ± 0.61*	91.11	3.61 ± 0.75*	88.67

Means in the same raw with: *; ** and *** are significant 0.05; 0.001 and 0.0001, respectively; C.V – coefficient of variation.

Table 2. Linear regression models for Napier and Guinea grass nutrient change as influence by age at harvest

Nutrient	Linear regression models	R^2	$S_{Y.X}$	P-Value
Napier grass				
In Vitro DMD (%)	$\mathbf{Y} = -2.44 \pm 0.21\,\mathbf{X} + 69.82 \pm 1.12$	0.9862	0.91	.0069
CF (g/Kg DM)	$\mathbf{Y} = 14.45 \pm 2.57\,\mathbf{X} + 235.8 \pm 14.1$	0.9405	11.49	.0302
CP (g/kg DM)	$\mathbf{Y} = -17.41 \pm 2.26\,\mathbf{X} + 205.2 \pm 12.38$	0.9674	10.11	.0164
ME (MJ/kg DM)	$\mathbf{Y} = -0.27 \pm 0.02\,\mathbf{X} + 9.45 \pm 0.14$	0.9834	0.12	.0083
Guinea grass				
In Vitro DMD (%)	$\mathbf{Y} = -2.31 \pm 0.21\,\mathbf{X} + 67.94 \pm 1.15$	0.9838	0.94	0.0081
CF (g/Kg DM)	$\mathbf{Y} = 14.54 \pm 2.25\,\mathbf{X} + 257.7 \pm 12.34$	0.9542	10.08	0.0232
CP (g/kg DM)	$\mathbf{Y} = -18.36 \pm 1.36\,\mathbf{X} + 205.2 \pm 7.42$	0.9892	6.06	0.0054
ME (MJ/kg DM)	$\mathbf{Y} = -0.26 \pm 0.02\,\mathbf{X} + 9.26 \pm 0.08$	0.9929	0.07	0.0036

$\mathbf{S_{Y.X}}$ = Residual square deviations; **Y** = Nutrient component; **X** = Age at harvest (weeks)

Table 3. Mean farm household monthly milk output (Lt/farm/month) during wet and dry season at Ol-Joro-Orok location

	Aver. Milk output/farm/month		R^2	P - Value
	Mean ± Std. err	C. V		
Rainy (Wet) season	345.06 ± 36.39	43.49		
Dry season	177.18 ± 22.45	52.25	0.862	0.0001

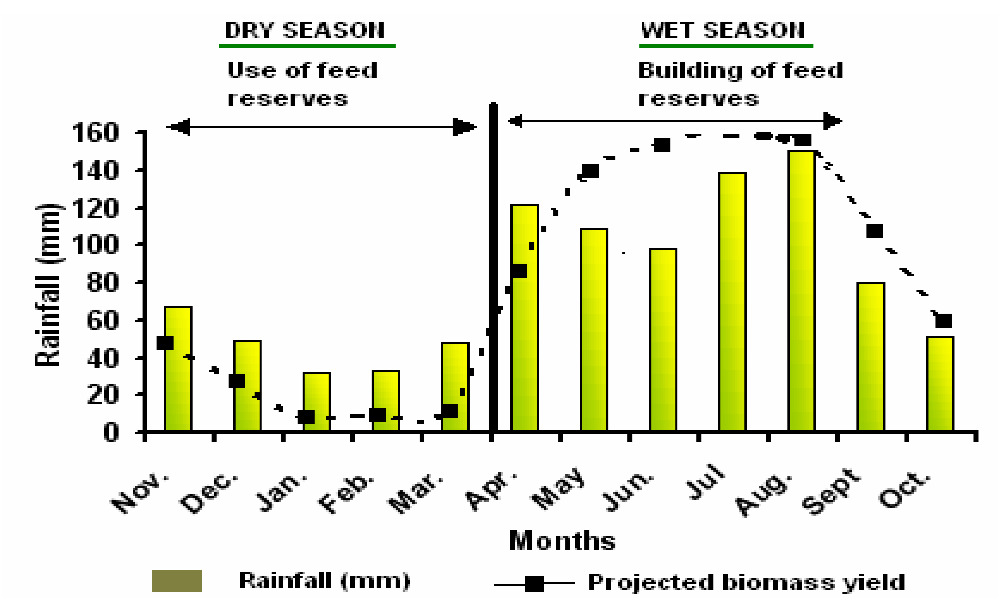

Figure 1. Rainfall pattern and projected forage biomass yield at Ol-Joro-Orok location

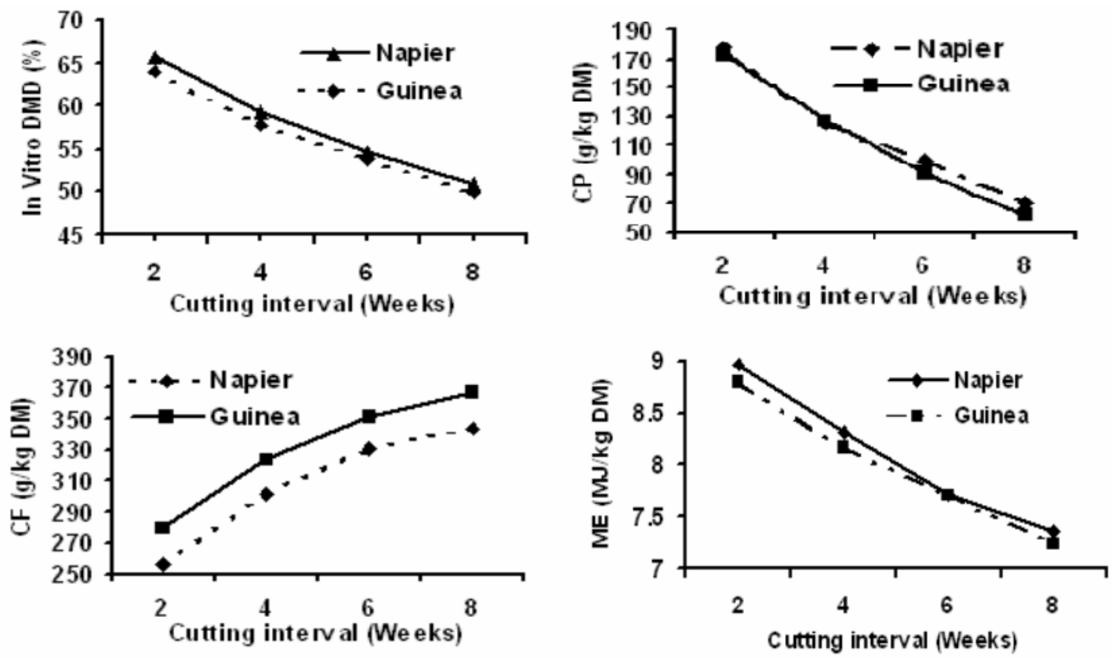

Figure 2. Effect of cutting age as influenced by season, on nutritive values of Napier and Guinea grasses

DISCUSSION

The variation observed in the population of ruminant livestock types (cattle, sheep and goats) is an indication of the value attached to them by farm households. The low percent of goats and bulls indicate that farmers attach very little value to them. Since milk production is the primary reason for keeping dairy cattle, farmers would naturally prefer cattle and more specifically, as evidenced by this study. This study further showed that rather than genetic factors, performance of smallholder dairy herd on smallholder farm is primarily limited by inadequate feed which is direct consequence of decreasing farm sizes per household. This is further compounded by the now frequent adverse weather condition exacerbated by lack of preparedness of the farmers. Recent estimates, based on farm size, land allocation and ecological potential, indicated that smallholder dairy farmers in most areas in Kenya produce at best 70% of the total feed required from within their farms (NDDP, 1993). Worse still, their ability to attain the 70% production is highly seasonal dependent (Figure 1). The current study showed that majority of smallholder farmers rely heavily on tropical pastures and crop residues during wet and dry season respectively (Table 1). It further clearly illustrated the correlation between age at harvest as influenced by precipitation and the nutritive value of commonly used forage grasses (Figure 2 and Table 2). This concurred with the findings of Milford and Minson (1966) who clearly illustrated the inverse relationship between digestibility and age in tropical grasses. Values recorded for a number of different tropical grasses indicate that there is a decrease of 0.1 - 0.2 digestibility units/day with increasing maturity (Minson, 1971). Elliott and Folkersten (1961) and Sibanda, (1984) also reported a decline in protein content in tropical grasses as the wet season progresses. In contrast, fibre content increases as the season progresses (Elliott & Folkersten, 1961).

The observed higher performance of dairy cattle in wet compared to dry season (Table 3) indicated that they are able to access good quality feed. Crop residues on the other hand constitute bulk of the dry season feed. Though their quality would depend on many factors the general consensus is that they are usually fibrous and devoid of most essential nutrients including proteins, energy, minerals and vitamins, which are required for, increased rumen microbial fermentation and improved performance of the host animal. It is therefore strongly believed that low protein concentration and energy deficiency during the dry season is the major factor limiting ruminant livestock production in Ol – Joro – Orok and indeed in many parts of Kenya.

CONCLUSION

In conclusion, the study revealed that, feed availability, quality and therefore herd performance on smallholder farms in Ol-Joro-Orok is highly seasonal dependent. The study attributes the observed lower performance of lactating cows in dry season to feed inadequacy (quantity and quality). It is, however, possible to reduce production losses through protein supplementation (using farm grown high quality legumes). Provision of non-protein nitrogen (NPN) through treatment of crop residues with Urea/alkali or feeding poultry litter is also important options to bridge protein deficiency gaps on - farm. Finally, in order to improve ruminant livestock production, future research and development should therefore focus exploring these and other feasible options so as to sustainably enhance both feed quality and quantity on smallholder resource-poor dairy farms.

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Submitted June 22, 2005 – Accepted April 07, 2006
Revised received May 11, 2006