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Institute for Development of Technology for Rural Advancement

Vrindavan, Mathura-281121 INDIA

Email: chiefeditor@idtra.co.in

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Nutritional Evaluation of Dinanath Grass (*Pennisetum pedicellatum)* at Pre and Post Flowering Stage for Crossbred Heifers

Awadhesh Kishore and Lakshman Singh

School of Agriculture
ITM University, Gwalior, India

Abstract

To compare the feeding value of Dinanath grass with sorghum fodder at the post-flowering stage, sixteen crossbred heifers (274±11 d) and weight (85.3±4.9 kg) were grouped in 8 pairs based on their age and weight. One animal from each pair was randomly allotted to one of the two groups DF and SF. In DF, the animals were offered Dinanath grass fodder, whereas, in SF sorghum fodder ad-lib, the fodders were enriched with urea, @ 0.4 and 0.2% on a fresh weight basis, respectively. They were also given 1 Kg concentrate mixture (40% wheat grain; 40% groundnut cake; 20 % gram husk), 30 g common salt, and chalk 30 g daily for 13 weeks. The bodyweight of the animals was calculated by weekly multiplication, of length (cm) and heart girth (cm) of the animal divided by 11200. After 21 days of adaptation, a 7-day digestibility trial was conducted to find out intake and digestibility data. The samples were chemically analyzed for proximate principles using standard techniques. The data were subjected to statistical analysis using suitable methods. It can be concluded that Dinanath grass and sorghum fodders both are equally inferior in nutritive value in the post-flowering stage and should not be continued for a long period.

Keywords: Crossbred heifers, Dinanath grass, Green fodder, Nutritive value, Pennisetum *pedicellatum*, Pre-Flowering stage, Post-flowering stage.

Introduction

The regional deficits of fodder are more important rather than the national deficit (Tewari et al 2016). The pattern of deficit varies in different parts of the country. To supply green fodder from one location to another is not feasible because of the involvement of transportation. In such conditions locally available weeds, inland, or imported fodder crops play important role in sustainable livestock production.

It is very much difficult to increase the area under fodder crops because of the population pressure for food and fiber (Riaz et al 2020). Fortunately, the Indian sub-continent is one of the world's mega centers of crop origin and crop plant diversity, because of the availability of a wide spectrum of eco-climates. The Indian gene center possesses a rich genetic diversity in native grasses and legumes. Almost one-third of Indian grasses are considered to have fodder value for livestock. It is needful explore high-yielding fodder crops which may be suitable for cultivation in particularly green fodder deficit locations, evaluate locally available fodder crops, and their improvement to overcome inferiority factors.

With profusely tillering capability, Dinanath grass (*Pennisetum pedicellatum*) is a quick-growing, luscious, leafy, and thin-stemmed grass and grows well in poor, eroded soils in areas receiving 500-1500 mm annual rainfall. It is a high-yielding, tall, erected annual tufted perennial forage. This crop is of short duration and fits well in the small period between two major crops. The grass thrives and performs well on a wide range of soils (including degraded sandy or ferruginous soils) provided they are well-drained (FAO 2010). Because of high fodder production potential, tolerance towards drought, insect and disease infestation, Dinanath grass is becoming popular day by day but reducing the unwanted volume and extracting true seeds from spikelet for efficient post-harvest handling, transportation, and various farm operations is required for large-scale utilization of Dinanath grass as forage for animals (Vijay et al 2018). Maity et al (2017) worked on layered pelleting of the nucleus seed of Dinanath grass with soil and observed the highest germination of 91%. The seed yield of grasses is very low, while demand for seed upgrading of grasslands (Meena and Nagar 2019). The feeding value of Dinanath grass fodder at early and pre-flowering stages has been assessed and found similar to sorghum fodder (Kishore and Verma 2000).

Keeping the above facts in consideration, the present experiment was conducted to compare the feeding value of Dinanath grass at pre and post-flowering stages for crossbred heifers.

Materials and Methods

Dinanath grass (Variety T-10) and sorghum (Variety CSH-1) were sown at the farm at a suitable interval to maintain the stage of plant at harvest for feeding, following standard agronomical practices. At the stage of post-flowering, the crops (Dinanath grass: 90-110 days after sowing; Sorghum: 80-90 days after sowing) were harvested for proximate analysis (O'shea and Maguire 1962, AOAC 1990) and offered to the experimental animals.

Sixteen crossbred heifers (Sahiwal x Jersey) were selected at the dairy farm and grouped into 8 pairs based on their age (274±11 d) and weight (85.3±4.9 kg). One animal from each pair was randomly allotted to one of the two groups DF and SF.

In group DF the animals were offered Dinanath grass fodder whereas, in SF sorghum fodder ad-lib. The fodders were enriched with urea, at the rate of 0.4 and 0.2% on the fresh fodder weight basis in DF and SF groups, respectively. They were also given 1 Kg concentrate mixture (40% wheat grain; 40% groundnut cake; 20% gram husk), 30 g common salt, and 30 g chalk daily.

The experimental heifers were housed in a large-sized shed having partitions in troughs for individual feeding. The fodder was offered to the animals in the forenoon and concentrate mixture in the afternoon. The heifers were let loose in an open enclosure for 4 hours before feeding fodder. The animals had free access to drinking water.

The body weight of the animals was calculated weekly based on body measurements i.e. multiplication of length (cm) and heart girth (cm) of the animal divided by 11200. After 21 days of adaptation, a 7-day digestibility and sample collection trial was conducted to find out intake and digestibility data. The collected samples were chemically analyzed for proximate principles using standard techniques (O'shea and Maguire 1962, AOAC 1990). The data recorded during the experiment were subjected to statistical analysis using suitable methods (Snedecor and Cochran, 1967).

Results and Discussion

The contents of dry matter, crude protein, ether extract, gross energy, organic matter, acid insoluble ash, hemicellulose, and total carbohydrates were present in high and crude fiber, neutral detergent fiber and acid detergent fiber, ash, and nitrogen-free extract low in sorghum fodder in comparison to those in Dinanath grass (Table 1). These results were found contrary to Kishore and Verma (2000) which could be due to the different stages of fodder harvesting. The ranges of the nutrients in both the fodders confirmed the study (Chakrabarti et al 1988, Ranjhan 1991, Kishore 1992). Because of enrichment with urea, the content of crude protein was increased which may be due to the presence of high content of nitrogen (46%) in urea.

Table 1 Chemical Composition of Dinanath Grass (%)

Nutrient	Pre-flowering stage		Post-flowering stage		Concentrate Mixture
	Enriched with urea		Enriched with urea		
	Without	With	Without	With	
DM	15.7	85	30.5	29.2	92.5
CP	7.88	17.06	4.9	7	16.9
EE	3.74	4.74	4.26	4.28	5.59
CF	32.4	34.4	38.9	38.3	18.1
NDF	65.9	65.7	68.3	67	51.3
ADF	44	42.5	39.4	39	25.7
GE*	3.19	3.29	3.31	3.28	3.73
ASH	12.09	11.69	10.3	10.2	12
NFE	43.9	32.1	46.6	39.9	47.4
OM	87.9	88.8	89.7	89.9	88
AIA	2.93	2.85	2.79	2.78	3.09
Hemicellulose	21.9	23.2	28.9	28	25.6
TCHO	76.29	66.51	80.5	78.5	65.5

** Mcal / kg*

The consistently but not significantly (P>0.05) higher dry matter digestibility of dry matter in DF compared to that in SF is contrary to the findings of Das et al (1974), which could be perhaps because of the method of estimation (Table 2). As far as the comparison of digestibility coefficients of different nutrient understudies is concerned, the findings confirmed the results of Kishore and Verma (2000). The higher digestibility coefficient in DF in comparison to those observed in the literature (Jakhmola and Pathak 1983) may be due to the enrichment of fodder with urea which increased the CP content of the feed and hence, enhanced microbial activities in the rumen ecosystem. It is a well-known fact that for the fullest expression of potential digestibility of non-leguminous forages the crude protein content of the diet should be 8 percent (Verma 1981). The digestibility coefficients of energy and fiber components especially acid detergent fiber were observed on the higher side in DF in comparison to those in SF and confirmed the findings of Kishore and Verma (2000).

Significantly higher intake of dry matter and crude protein were recorded in SF (P<0.05) in comparison to in DF (Table 2). The intake data in SF is in agreement with Randhawa, et al (1988). A higher intake of digestible nutrients like digestible dry matter, digestible crude protein, and digestible energy may perhaps be due to a higher intake of the nutrients. The present intake data was recorded in line with the results reported in the literature (Kishore and Verma 2000).

The average daily gains in the two groups (Fig) under study were non-significant (P>0.05), despite significantly higher intake data in SF. The average daily gain was showing a trend of fall. The animals started losing weight in week 10 in DF and 12 in SF. The reason for this declension could perhaps be due to the availability of nutrients in both the fodders at the post-flowering stage

Table 2 Nutrient utilization

Nutrient	Pre-flowering stage	Post-flowering stage
Digestibility (%)		
Dry matter	65.4±0.68*	60.7±1.1*
Crude Protein	69.1±1.27	68.6±1.0
Crude fibre	69.1±2.11*	40.7±3.9*
Neutral Detergent fibre	64.3±1.94*	53.2±1.2*
Acid detergent fibre	64.9±0.66*	44.0±2.2
Energy	64.7±0.59	60.1±1.3*
Intake		
Dry matter (kg/100kg LW)	2.43±0.13	2.17±0.10
($g/kgW^{0.75}$)	74.4±4.12	68.8±4.7
Digestible dry matter kg/100kg LW)	1.59±0.09	1.87±1.00
($g/kgW^{0.75}$)	48.7±2.97	38.8±2.2
Crude Protein (kg/100kg LW)	427±22.16*	243±13*
($g/kgW^{0.75}$)	13.14±0.8*	7.19±0.30*
Digestible Crude Protein (kg/100kg LW)	296±17.31*	161±9*
($g/kgW^{0.75}$)	9.2±0.67*	4.94±0.28*
Digestible energy (Mcal/100kg LW	5.12±6.57	5.12±0.27
($Kcal/kgW^{0.75}$)	157±8.62	134±7
Average Daily Gain (g/d)	412±65.6*	101±99.83*
ME (Mcal/kg)	1.72	1.66
DCP (%)	12.14*	7.79*

** Values bearing different superscripts within the row differed significantly, i.e. (P<0.05).*

The conclusion, based on digestibility, intake, and average daily gain data, can be drawn that Dinanath grass fodders at the pre-flowering stage were superior compared to that at the post-flowering stage.

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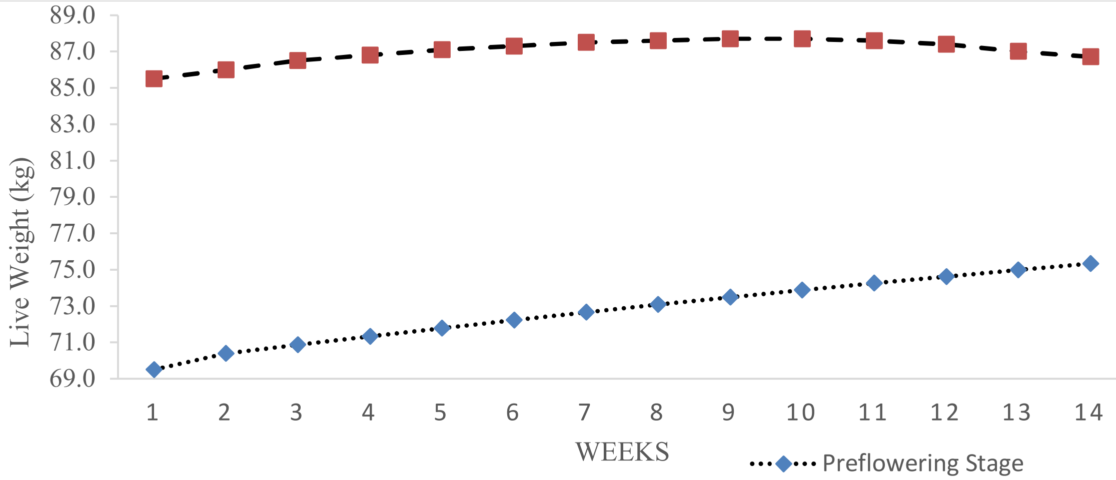

Figure 1: Average Daily Gain

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Land use changes in Agra-Mathura Region

Krishna Kant Sharma, Md. Abu Tarique*

Department of Geography,
Gandhi Smarak P G College, Surjan Nagar, Moradabad (U.P.), India

*Department of Geography,
University of Delhi, Delhi, India

Abstract

Land use is the usage of land and its resources according to the need of human beings. The study area i.e., the Agra-Mathura region has the richest historical background which is traced from ancient as well as medieval Indian history. The study used data obtained from 'Bhuvan Thematic Data dissemination' The other sources of data are census reports, village records, land ownership reports, Forest department reports, and local Institutions, of the Agra and Mathura districts. To find out the changes in the area data generated from different sources has been compiled and analyzed by interpreting the data. There is an increasing trend in the land use of agriculture and built-up area and agriculture is dominant in the region. The "forests", which include forests, non-agriculture plantations, open scrub, and deciduous, constitute 5.32 per cent, (390.2 sq. km). The "wastelands", include gullied land, saline land, and barren, rocky, and scrubland, which constitutes 4.05 per cent, (297.34 sq km). The environmentally fragile areas such as the Yamuna and its surrounding area are affected by the dumping of garbage and illegal sand mining.

Keywords: Agra, Agricultural area, Forest area, Land use, Mathura, Sand mining, Wastelands.

Introduction

Land use is the usage of land and its resources according to the need of human beings. It is the transformation of natural land as per the requirement. Land use is the term that is used to describe human uses of land, or immediate actions modifying or converting land cover (de Sherbinin 2002). It changes every nook and corner of the world from time to time but major changes occur with a particular event in that area. Land use changes at a particular location may be the shift to a different use or the intensification of the prevailing use of land. The land transformation did not abate, but rather accelerate with the globalization of the world economy, and expansion of population and technological capacity (William et al 1994). In India, it is more evident after the onset of Liberalization, Globalization, and Privatization. Generally, land use is compelling by soil characteristics, topography, vegetation, climate, and other such environmental factors. But it also reflects the importance of land as a crucial and finite resource for most human activities. Land use is a product of interactions between cultural backgrounds, state, and physical needs of the society with the natural potential of land (Karwariya and Goyal 2011). Land use changes can occur because of socio-economic and technological factors. It might be the most conspicuous form of global environmental change phenomenon occurring at spatial and temporal scales. Determining the effects of land-use change on the Earth system depends on an understanding of past land-use practices, current land-use patterns, and projections of future land use, as affected by human distribution, economic development, technology, and other factors (Tahir et al 2013).

Analyzing land use and understanding the subsequent trends of change contribute to the present complex dynamics of land cover and are important for policy-making, planning, and implementation of natural resource management. Land use shifts are caused by external and internal drivers and have been influenced by many traditional and modern resource management practices (Tahir et al 2013).

Timely and precise information about land use change detection of the earth's surface is extremely important for understanding relationships and interactions between human and natural phenomena for better management of decision making (Lu et al 2004). There should be a regular assessment of land use changes for the socio-economic development of people. For a sustainable environment and to prevent environmental degradation continuing demand for accurate and up-to-date land use changes information is required. The ultimate aim of land use change analysis is to evaluate the impacts and bring out preventive actions against the adverse environmental consequences. Many changes in land use may be small on their own but together may have an incremental effect on the landscape and harm regional and global society and the environment. Houghton (1994) pointed out that the major reason for land use change was to increase the local capacity of lands to support human enterprise.

One of the main problems with countryside areas is that these lands have a range of demands and there are conflicts between, for example, agriculture, forestry, urban expansion, and industrial development. It is interesting to see the changes in the landscape which can be easily conveyed when you go through the National Highway-2 in the Agra-Mathura region of Uttar Pradesh. This change is more visible in the past ten years because of liberalization privatization and globalization of the Indian economy. As the LPG started in 1991 in India but its impact in this area came some ten years back. Hence, there needs to be an inspection closely of the pattern of changes taking place in the countryside area. There should be the estimation and prediction of land use potential and scenarios of change, to compare policy options that may affect the patterns and land uses present in the countryside.

Study Area

The Agra-Mathura region has the richest historical background which is traced from ancient as well as medieval Indian history. This is well developed commercial center both in the ancient and medieval periods. The region came under the Agra division of Uttar Pradesh. Agra division is consisting of four districts of Uttar Pradesh but the present study took two districts of the region e.g., Agra and Mathura (Fig 1). The region is located between 26º46' to 27º57' N latitude and 77º27' to 78º48' E longitude. The Area is well developed in industrial production. One of the major contributors to the economy of Uttar Pradesh is Mathura Industries. Mathura Refinery located in the city is one of the biggest oil refineries in Asia. Tourism also contributes to a large extent to the economy of the region as this has lots of ancient and medieval monuments. The city's industrial base also produces automobiles, leather goods, handicrafts, and stone carving.

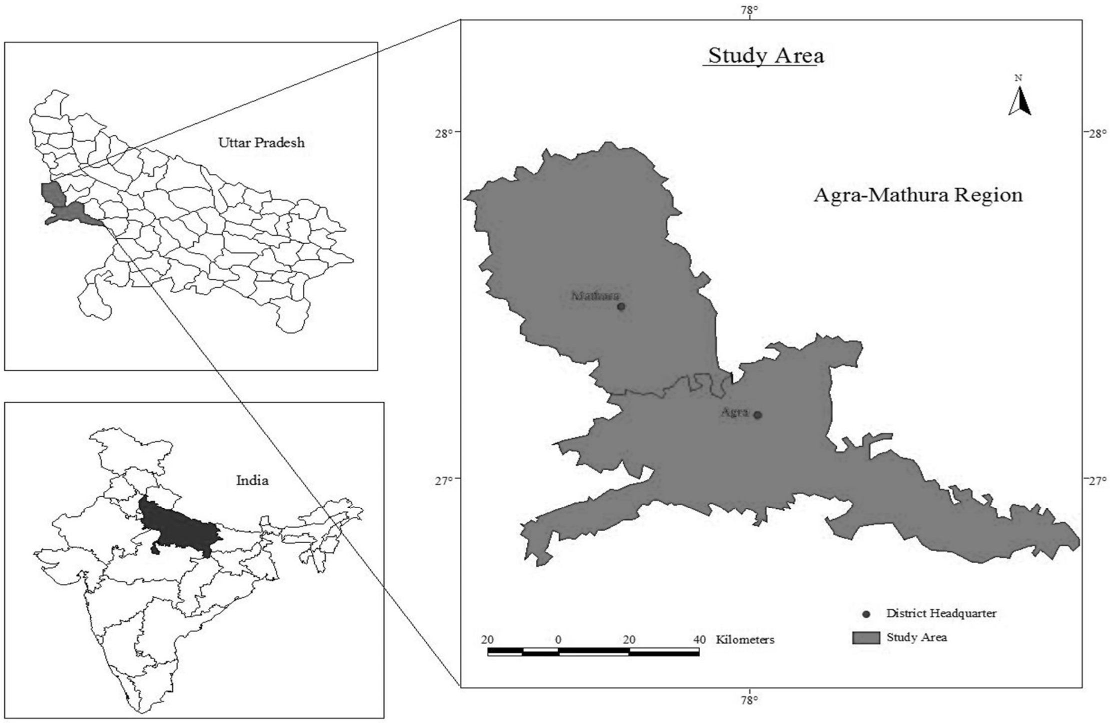

Fig.1: Location of Study Area.

The main purpose of the study is to analyze the land use change in Agra, Mathura district in particular, and the Agra-Mathura region as a whole and assess the socio-economic impact of change. As these areas are in the countryside of the National Capital Territory of Delhi, therefore it also examines the effect of NCT Delhi on this area.

Database and Methodology

The study used data obtained from 'Bhuvan Thematic Data dissemination' The other sources of data are census reports, village records, land ownership reports, Forest department reports, and local Institutions, of the Agra and Mathura districts. To find out the changes in the area data generated from different sources has been compiled and analyzed by interpreting the data.

Results and Discussion

The land use analysis through the Remote Sensing data about 2005 indicates that the "agricultural use", which includes cultivated land or cropland, fallow, plantation, and grazing, being the predominant use of land, constitutes 83.33 per cent, (6115.18 sq. km) of the total land area of the region (Table 1). The sub-region or district-wise distribution of agricultural land reveals that Agra has more area under "agriculture use", which constitutes 42.82 per cent of the total region and Mathura is 40.50 per cent as a whole but Mathura as the district has more area than Agra which is 89.77 per cent and 78.04 per cent respectively. The region has more cropland (79.05 per cent) followed by fallow (4.08 per cent) and plantation land (0.11 per cent).

The "built-up area", which includes rural as well as urban settlements, all sub-uses such as residential, transport, industries, commercial, etc. within it, is the second largest use of land in the region, constituting 5.83 per cent, (427.87 sq. km). Agra has more of the area under "built up" category (3.14 per cent) in the region in comparison to Mathura which has the area under the built-up category (2.68per cent) but as the individual district, Mathura has more area under built-up (5.95 per cent) than Agra which has (5.72 per cent) area under this category.

The “wastelands”, include gullied land, saline land, and barren, rocky, and scrubland, which constitutes 4.05 per cent, (297.34 sq km). The concentration of “wastelands” has been recorded in Agra constituting 3.26 per cent of the total wastelands of the region and Mathura has 0.79 per cent of the total area as a whole. Agra district has more wasteland than Mathura district which contributed 5.93 per cent and 1.76 per cent respectively.

The “forests”, which include forests, non-agriculture plantations, open scrub, and deciduous, constitute 5.32 per cent, (390.2 sq. km). In the case of forest cover, Agra again recorded the highest concentration constituting 5.03 per cent of the region than Mathura which has 0.29 per cent. The less concentration of forest cover is in Mathura, in the region as a whole as well as in the district because more area is under agriculture and built-up area. As a district, Agra and Mathura have a forested area of 0.64 per cent and 9.16 per cent respectively.

The “water bodies” include rivers, canals, inland wetlands, reservoirs, lakes, tanks, and ponds covering 0.93 per cent (68.42 sq. km) of the region’s total land area. Mathura has more share of the area under water bodies which contributes 2.07per cent (61.71 sq km). Agra has an area under this category is 0.17 per cent (6.71 sq km).

Table 1: Land Use of Agra-Mathura Region 2005

		2005					
S.N.	Class	Mathura		Agra		Total	
		Sq.km	Percent	Sq.km	Percent	Sq.km	Percent
1	Built-up	197.18	5.95	230.69	5.72	427.87	5.83
2	Agriculture	2972.58	89.77	3142.6	78.04	6115.18	83.33
3	Forest	21.28	0.64	368.92	9.16	390.2	5.31
4	Wastelands	58.25	1.76	239.09	5.94	297.34	4.05
5	Water bodies	61.71	1.86	6.71	0.17	68.42	0.93
	Total	3311		4027		7338	

Source: http//bhuvan-noeda.nrsc.gov.in

A comparative analysis of the Agra and Mathura district in the region reveal that both districts have more area under agricultural land than other activities. Mathura has more percent of the area in agriculture, built-up land, and water bodies while Agra has the maximum percentage in the wasteland as well as the forested area (Table 1). As it has discussed earlier the built-up area consists of rural and urban, more area is in rural land under the built-up area (142.56 sq km) in Mathura as compared to the urban area which is only 54.62 sq. km. This is a large difference which is not seen in the case of Agra which has the almost same area as the rural (113.97 sq. km) and urban (116.72 sq. km); here urban area is slightly more than the rural area.

It is interesting to see that uncultivable land has a maximum area of wasteland which is 96.41 sq. km as compared to salt-affected land, rocky, and scrubland which account for 6.11 sq. km, 80.05 sq. km, and 56.52 sq. km respectively in Agra district while in Mathura scrub land cover more area in the wasteland. In water bodies, river contributes maximum area in both Agra and Mathura.

The status of land use in the region in 2010 is very interesting (Table 2). It is seen that a large number of the area comes under agricultural land. Agriculture occupied 85.44 per cent area of the region contributing maximum land area in the region. Agra and Mathura account for the region as a whole are 44.55 per cent and 40.88 per cent respectively. In Mathura 90.60 per cent of the total area of the district, while in Agra it is 81.19 per cent comes under agricultural land. The highest number of agriculture areas shows that agriculture is the main occupation in the region, the observation shows that area has well-mechanized agriculture as an impact of the green revolution.

It is found that about 7.08 per cent of the area of the region is under the settlement/built-up category and 3.12 per cent of Mathura and 3.96 per cent of the area under this category in Agra of the region as a whole. The built-up area comprises the rural and urban residential areas roads railways etc. District-wise area in Agra and Mathura is 6.90 per cent and 7.08 per cent respectively as their area.

It is evident that the forest class accounts for 4.69 per cent area in the region and has regional disparity as Mathura district contributes only 0.15 per cent in the total area of the region while Agra 4.49 per cent. Agra and Mathura contribute 8.25 and 0.35 per cent respectively as of their geographical area.

Table 2: Land Use of Agra-Mathura Region 2010

		2010					
S.N.	**Class**	**Mathura**		**Agra**		**Total**	
		Sq.km	**Percent**	**Sq.km**	**Percent**	**Sq.km**	**Percent**
1	Built-up	229.02	6.90	290.69	7.21	519.71	7.08
2	Agriculture	2999.93	90.60	3269.78	81.19	6269.71	85.44
3	Forest	11.63	0.35	332.42	8.25	344.05	4.69
4	Wastelands	33.92	1.02	128.96	3.20	162.88	2.21
5	Water bodies	40.23	1.21	4.71	0.12	44.94	0.61
	Total	3311		4027		7338	

Source: Land Revenue Department Agra-Mathura.

It is seen that wasteland account for the area of 162.88 sq. km which is 2.21 per cent of the total area of the region. In the district of Agra and Mathura, the area comprises 1.75 and 046 per cent of the region as a whole, while regarding their geographical area the area is 3.20 and 1.02 per cent respectively.

Area shared by water bodies among all the land use account for 0.61 per cent in the region, while Agra and Mathura regarding their geographical area contribute 0.12 and 1.21 per cent respectively. Mathura has more water bodies in comparison to Agra.

A comparative analysis of data from 2005 and 2010 reveals that there is an increasing trend in the land use of agriculture and built-up area and agriculture is dominant in the region (Table1 and 2). There has been an increase in agricultural land by 2.11 per cent (i.e., from 83.33 per cent to 85.44 per cent). This increase in the short span of five years is very significant. In between Agra and Mathura, Agra shows a larger increase than Mathura. Agra has an increase of 3.15 per cent while Mathura has only a 0.83 per cent increase in the agricultural area.

The built-up area increases from 427.87 sq. km to 519.71 sq. km which is 1.25 per cent. In this category also Agra shows a maximum increase than Mathura. Agra has an increase of 1.49 per cent while Mathura has 0.95 per cent.

As it is explained earlier that except for agriculture and built-up area all other land uses have decreasing trend i.e., forest, wasteland, and water bodies. Forest area decreases by 0.62 per cent in the region as a whole. In Mathura, the forest area decreased from 21.28 sq. km to 11.63 sq. km. Agra has decreased from 5.31 per cent to 4.69 per cent regarding their geographical area.

There has been a decrease in the area of wasteland from 297.34 sq. km to 162.88 sq km which is 1.84 per cent of the total area of the region. Although there is a decrease in the wasteland in the area is an insignificant number. In 2005 Agra has 297.34 sq. km area under waste land which decrease to 162.88 sq. km. in 2010.

Water bodies are also shrinking in the region which is being converted into agricultural land as well as built-up area. Its area, which was .093 per cent in 2005, came down to 0.61 per cent.

In the absence of proper legislation to control the land uses there has been the illegal conversion of land in the area, which create regional imbalance and socio-economic problem in the area. As it is seen that water bodies are shrinking in its area which might create the problem of drinking water in the region. It is seen by the survey that environmentally fragile areas such as the Yamuna and its surrounding area are affected by the dumping of garbage and illegal sand mining. Though the Regional Plan suggested a broad policy for the development of selected centers for acting as nuclei for rural development, however, in the absence of a coordinated development strategy for the rural areas, has remained urban biased.

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Economic opportunity survey of small-scale dairy farms at Keren Sub Zone of Eritrea

Awadhesh Kishore

ITM University, Gwalior, INDIA

Abstract

An investigation was conducted to study the economic opportunities on small-scale dairy farms (SCD) to assess production and financial management and record-keeping system and to identify areas of economic opportunity on SCD at Keren Sub Zone. There were 57 market-oriented SCD in regions categorized into 4 classes, namely herd size 1-5 (A), 6-10 (B), 11-15 (C), and more than 16 (D), respectively. Through stratified random sampling, 30 SCD were selected for the economic opportunity survey, including 13, 11, 4, and 2 samples from A, B, C, and D, categories, respectively. Three-level standard questionnaire software was utilized for surveying. The primary data were used to calculate production and management indices individually for each SCD followed by statistical analysis using standard methods. It is recommended that the awareness of the farmers on scientific practices of dairy cattle needs enhancement. Dairy producers should have a continuous assessment of the profitability of their farms and develop their pastures. The area of economic opportunity needs identifying intervention to get a profit. The balanced ration should be formulated for each class of animals. Full records of the farm activities including detailed information on individual animals should be maintained on the farm.

Keywords: Economic opportunity, Eritrea, Financial management, Recordkeeping, Small scale dairy farms, Survey.

Introduction

Eritrea is located, between $12^0 42'$- $18^0 2'$ N and $36^0 30'$- $44^0 20'$ E, in the horn of Africa covering an area of 124,324 km^2. The altitude ranges from the highest mountain (3,010 m above sea level) to depression (100 m below sea level). The coastal plain consists of a semi-arid desert. The population of the country is estimated to be about 3.7 million, and 73% derive its livelihood from Agriculture (MoA 2014) accounting for about 37 percent of national GDP, and livestock products for about 5% (MOA 2011). The climate is influenced by its topography, resulting in diversified agroecological zones. Conditions range from hot and arid in the coastal plains to cool in the highlands. The problem of inadequate total rainfall over most of the country is compounded by the high variability of both total rainfall and its distribution. Mostly, the rains are bimodal starting with short rains (Apr to May), followed by a dry period before the main rains (mid-Jun to mid-Sep).

Commercial dairy farming in Eritrea was started by Italian settlers in the 20th century, when, it was under Italian colonization. The growing demand for milk, especially in urban centers, stimulated Italian settlers in the highlands to develop modern dairy farms using high merit dairy breeds. These farms were intensively managed and recognized as main milk suppliers to the urban population. The commercial dairy sub-sector reached its peak in the 1970s (AED 2011).

However, with the escalation of the war, with the Ethiopian military, from 1975 to 1991 the farmers lost their animals resulting abandonment of dairy farming. In Nov 1992, the association re-started supplying milk to the milk processing plant. There was a tremendous increase in the number of dairy cows in the last ten years (AED 2011).

Livestock farming is now an integral part of agriculture without which not a single agricultural activity can be performed. Cattle are the most important species, especially for dairy farming. In highland regions, cattle are reared for draught, milk, and meat production, whereas in lowland regions, for milk and meat only. Livestock plays a vital role in financial systems, both at the household and national levels. The livestock population in the country is 2.3 million cattle, 2.5 million sheep, 5.5 million goats, and 373,952 camels (MoA 2013).

At present, dairy farms are developing in the country, but most of them are unorganized. Like in other countries, there is a large gap between producers' incentives and consumers' motives. Possibilities for dairy quality upgrading remain fairly limited (Ruben et al 2017).

Farmers especially on the small-scale dairy farms (SCD) in the country had a lack of awareness to identify the actual problems in different areas of the dairy farm. The training provided by the government was not sufficient. The shortage of capital to run SCD was another challenge. It was thus very much needful to discover the factors and activities which are most profitable on the dairy farm so that the owners can be encouraged to make important and fruitful managerial decisions (Enseminger 1991). Keeping all the above facts in view, the present investigation was conducted to study the economic opportunity in SCDs to assess production and financial management and record-keeping system and to identify areas of economic opportunity in SCD at Keren Sub Zone.

Materials and methods

The study was conducted in Sub Zone Keren (Anseba Region). The Sub Zone is situated in North West in Asmara at an elevation of 1390 m above sea level and 15.78 latitude and 38.45 longitudes. The average annual temperature of this area is 24^{o}C, wind velocity 14 km/h northeast, and humidity 46 percent. There were169 market-oriented SCD all before 2015, but due to the relocation of dairy farms from the city and the severe drought of 2015-16 total farms are reduced to 57 now.

Under the intensive dairy farming system in the study area, the dairy farms were categorized into 4 classes, namely having herd sizes 1-5 (A), 6-10 (B), 11-15 (C), and more than 16 (D), respectively. Through stratified random sampling, 30 dairy farms were selected for the economic opportunity survey, including 13, 11, 4, and 2 samples from A, B, C, and D, categories of dairy farms, respectively.

To conduct the survey, three-level standard questionnaire software (Nourdland et al 2007) was utilized. The responses to the items on questionnaires were used to establish a database consisting of four sections; total milk production, expenses of cattle health care and feeds, inventory of herd cull and death, and milk and calf production per cow.

On-farm visits were conducted to collect all the required information through questionnaires and direct observations, including on-farm conditions, inventory, and review of records. The survey was conducted by examining all the cattle on the farm during inventory assessment and inspecting feedstuffs. The farmers were interviewed to obtain detailed and accurate data.

The primary data collected has been used to calculate production and management indices individually for each dairy farm through Microsoft Office Excel 2016 (UQ Library 2016), followed by ranking and comparing dairy farms using standard statistical methods and techniques (Snedecor and Cochran 1994). The latest version of SPSS software was used for this purpose (SPSS 2016).

Results and discussion

The number of all classes of cattle at SCD under study, except growing bulls/steers and suckling male calves (Table 1) was high in D and low in the A category. Present findings confirmed the results of Ensiminger (1993) concluding that the opportunity of getting replacement heifers increased as the herd size increased. Lactating cows as a percentage of total cows was an indirect measure of both the reproductive performances of the herd and the length of the lactations (Nordlund et al 2007), and both parameters remained similar among the four categories.

Table 1: Composition and Land and labour utilization

Parameters	A	B	C	D	P-value
(I) Composition of SCD					
Lactating cow	1.46±0.18	2.55±0.21	3.25±0.85	7.00±3.00	**0.00**
Dry cow	0.77±0.26	1.73±0.3	2.50±0.87	1.00±1.00	0.21
% Lactating cows to total cows	0.73±0.08	0.63±0.05	0.58±0.17	0.85±0.15	0.18
% Lactating cows to total cattle	0.37±0.03	0.31±0.02	0.30±0.07	0.35±0.15	0.13
Total mature cows	2.23±0.28	4.27±0.33	5.75±0.85	8.00±2.00	**0.00**
Pregnant heifers	0.08±0.08	0.09±0.09	0.25±0.25	1.50±1.50	**0.01**
Growing heifers	0.54±0.18	2.09±0.31	3.50±0.65	4.50±0.50	**0.00**
Suckling heifer calves	0.54±0.18	0.82±0.26	0.75±0.48	2.50±0.50	**0.01**
Total replacement heifer	1.15±0.25	3.00±0.30	4.50±0.29	8.50±0.50	**0.00**
Mature bulls/steers	0.00±0.00	0.18±0.12	0.50±0.29	1.50±0.50	**0.00**
Growing bulls/steers	0.23±0.12	0.36±0.15	1.25±0.75	0.50±0.50	0.10
Suckling male calves	0.46±0.18	0.55±0.21	0.25±0.25	1.00±0.00	0.60
Total male cattle	0.69±0.21	1.09±0.16	2.00±0.58	3.00±1.00	**0.01**
(II) Land and labor utilization					
Family labour	2.00±0.23	1.82±0.35	1.25±0.48	2.00±0.00	0.60
Hired Labour	0.00±0.00	0.73±0.36	1.75±0.75	0.50±0.50	0.12
Total land (ha)	0.70±0.10	1.22±0.28	1.13±0.31	0.75±0.25	0.34
Pasture (ha)	0.00±0.00	0.11±0.06	0.69±0.45	0.25±0.00	**0.03**

Insignificant family labor engagement or labor hired in four categories of SCD could be due to the family size and non-availability of hiring labor (Table 1). Almost similar total landholdings could be due to the government policy to allot standard unit area of total land to the farmers. The pasture land was highest in the category of SCD in comparison to others which could be because of Government policy and the personal interest of the farmers. Herrero et al (2014) have also explored that socioeconomic scenario is mainly the reason for the organization of a small dairy farm.

The number of milking, milk used for family and other purposes and fed to calves, milk price, and milk sold to produced ratio has remained non-significant in four categories of SCD (Table 2). The standard milking frequency in low-producing cows was twice a day and as such, it remained the same in all the categories under study. The milk used for the family purpose was depending on the family size. The milk used for other purposes was affecting the net profit of dairy farms so it was always discouraged. However, an increasing trend was observed regarding milk fed to the calves with the increased holding of the dairy farms because of variation in the number of suckling calves. As far as the milk price is concerned, it was controlled by the local market. The milk produced, sold, and total income from milk was significant and presented an increasing trend with the increase in holding of a dairy farm and confirmed the findings of Nakanwagi and Hyuha (2015). The milk sold-to-produced ratio at the dairy farms under category D was 0.08 which confirmed the findings of Bayemi et al (2007), however, in four categories of SCD under study, the results remained non-significant.

Selling of animals can be one of the production management practices in dairy cattle either to cover part of the expenditure on feed and the case of feed shortage, and health care expenses or to cull the non-productive and low producer cows associated with culling (Table 2). There were no significant differences in the number of lactating, dry, and mature cows, pregnant and suckling heifer calves, totally replacing heifers, mature bulls/steers, growing bulls/steers, and total male cattle sold in the last 12 months among four categories. This was due to the reason that the farmers were willing to maintain their stock in their dairy farms. However, there was a significant difference in suckling male calves and growing heifers sold in the last year. Keeping male calves on the dairy farm was not profitable for a dairy farm and as such those were sold. On the other hand, pregnant heifers had high market demand and value due to their longer productive life, so it was beneficial for the farmers to sell them to gain additional profits. Mattewman (1993) suggested that good herd management at a dairy farm required the exclusion of unproductive animals from the herd and replacement with improved stock. Male calves were not economical to keep on the dairy farm and farmers should remove them from the stock as soon as possible. Farmers should prefer to keep only female calves as future replacements. Present findings also confirmed the above suggestions.

Table 2: Deposition of milk produced and Animals sold

(I) Deposition of milk produced					
Parameters	**A**	**B**	**C**	**D**	**P-value**
No. Milking per day	2.00±0.00	2.00±0.00	2.00±0.00	2.00±0.00	0.08
Milk for family use (l/d)	2.54±0.43	3.18±0.38	3.25±0.85	4.50±0.50	0.34
Milk for other use (l)	0.15±0.10	1.18±0.57	1.00±0.58	1.50±1.50	0.23
Fed to Calves (l/d)	2.77±0.68	3.45±0.76	3.50±2.25	6.50±1.50	0.07
Total milk produced (l/d)	13.46±1.72	26.55±3.55	31.00±9.72	76.50±33.50	**0.00**
Milk sold (l/d)	8.00±1.10	18.73±3.06	23.25±7.34	64.00±34.00	**0.00**
Total Milk income	324.54±45.24	658.1±89.4	820.5±238.57	1967.5±892.5	**0.00**
Milk price/ l	22.85±1.91	24.73±0.38	27.00±1.08	25.50±0.50	0.72
Milk sold/produced	0.57±0.06	0.69±0.05	0.75±0.03	0.80±0.10	0.35
(II) Animals sold					
Lactating cows	0.00±0.00	0.18±0.12	0.25±0.25	0.00±0.00	0.35
Dry cows	0.00±0.00	0.09±0.09	0.00±0.00	0.00±0.00	0.65
Mature cows	0.00±0.00	0.27±0.14	0.25±0.25	0.00±0.00	0.22
Pregnant heifers	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	-
Growing heifers	0.00±0.00	0.00±0.00	0.50±0.50	0.50±0.50	**0.05**
Suckling heifer calves	0.00±0.00	0.09±0.09	0.00±0.00	0.00±0.00	0.65
Total replace heifers	0.00±0.00	0.09±0.09	0.50±0.50	0.50±0.50	0.13
Mature bulls/steers	0.08±0.08	0.00±0.00	0.00±0.00	0.00±0.00	0.75
Growing bulls/steers	0.23±0.17	0.09±0.09	0.00±0.00	0.00±0.00	0.74
Suckling male calves	0.00±0.00	0.00±0.00	0.00±0.00	0.50±0.50	**0.00**
Total male cattle	0.31±0.17	0.09±0.09	0.00±0.00	0.50±0.50	0.47

The veterinary and medical costs in four categories of SCD non-significantly differed, but the total health care costs significantly differed (Table 3). Wang et al (2017) reported that disease prevention did not have a significant influence on a dairy farm income. Forage and concentrate fed per cow, forage and concentrate unit price, and total forage and concentrate prices cost per cow were recorded as almost the same among the four categories. Feed cost as a percent of milk income was again recorded to be identical. If feed cost in terms of percentage of income from milk sale was high on a farm, there might be problems of low production per cow or high feed costs relative to other local smallholders (Nordlund et al 2007).

Death loss in any animal production enterprise is one of the major economic losses in terms of the animal itself and the production obtained from it (Table 3). The findings in this regard demonstrated that there was no significant difference in loss because of death between the four categories under study. Zero mortality rates were observed in mature bulls/steers and suckling male calves. Nordlund et al (2007) reported that if calf mortality rates on individual farms were higher than the goals, an investigation of risk factors would include evaluation of calving assistance practices, colostrum management, and calf-hood disease risks for diarrhea and pneumonia. In the present study, the mortality rate was observed to be lower which might be due to good colostrum management and low calf-hood disease risks for diarrhea and pneumonia.

Table 3: Major Expenditure and Death losses

Parameters	A	B	C	D	P-value
(I) Major Expenditure					
Veterinary cost (NKF/year)	242.30±14.80	342.70±54.20	254.00±19.30	300.00±50.00	0.11
Medical cost (NKF/year)	145.77±14.90	147.73±16.67	145.00±26.30	200.00±20.00	0.19
Total health care costs (Nkf/year)	560.40±47.80	806.80±89.00	760.00±72.20	910.00±80.00	**0.05**
Forage fed/cow (kg/day)	13.23±0.59	13.64±0.53	24.50±11.90	15.50±0.50	0.46
Forage unit price (NKF)	4.38±0.56	5.14±0.53	5.50±0.65	3.75±0.75	0.66
Total forage cost/cow/day in NKF	57.35±6.84	69.36±7.57	151.50±89.62	57.75±9.75	0.30
Concentrate fed/cow (kg)	4.43±0.52	5.42±0.79	4.63±0.83	6.25±0.25	0.30
Concentrate unit price (NKF)	12.19±0.67	13.61±0.59	11.88±0.89	14.17±1.50	0.08
Total concentrates cost/cow (NKF)	58.77±7.29	79.33±11.42	63.38±11.85	102.75±8.75	0.10
Total feeding cost NKF	116.11±8.75	148.69±14.1	214.88±83.79	160.50±1.00	0.48
Feed cost as % of milk income	0.51±0.06	0.58±0.05	0.58±0.02	0.60±0.00	0.56
(II) Death losses					
Lactating cow	0.15±0.1	0.27±0.19	0.25±0.25	0.00±0.00	0.87
Dry cow	0.23±0.17	0.09±0.09	1.00±0.58	0.50±0.50	0.10
Total mature cows	0.38±0.24	0.36±0.28	1.25±0.48	0.50±0.50	0.37
Pregnant heifers	0.08±0.08	0.00±0.00	0.00±0.00	0.00±0.00	0.75
Growing heifer	0.23±0.12	0.55±0.55	0.00±0.00	0.00±0.00	0.82
Sucking heifer calves	0.23±0.17	0.27±0.19	0.00±0.00	0.50±0.50	0.78
Total replacement heifer	0.54±0.24	0.82±0.72	0.00±0.00	0.50±0.50	0.86
Mature bulls/steers	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	-
Grow bulls/steers	0.08±0.08	0.18±0.12	0.00±0.00	0.00±0.00	0.70
Suckling male calves	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	-
Total male cattle	0.08±0.08	0.18±0.12	0.00±0.00	0.00±0.00	0.70

The animals remained for almost similar days in milk production among the four categories under study. Average milk production per cow, calving interval, and lactation length were also recorded to be non-significant (Table 4). The ideal lactation length is 305 days, but, in the present study it reached up to 415 days in category C for the reason to extend the length of day open cows, unavailability of the bull at the time of heat, and silent heat among the females.

Age at first calving was significantly decreased with the increased herd size of the dairy farms. The observed trend could be due to different managerial aspects at different categories of dairy farms. Though, the variation in age at first calving in different countries was ranging between 24 and 63 months (Nordlund et al 2007). It was advised best to have 27 months of age at this stage. Generally, heifers are the most neglected class of dairy animals, especially in nutritional supply, and as such, they attain higher age of sexual maturity.

There was a significant difference in economic opportunity for lactation length, milk production, health care cost/cows, and total economic opportunities in different categories of SCD (Table 4). The opportunity for milk production was increased and health care costs per cow decreased with an increase in herd size, but, the same for lactation length or total economic opportunity did not present any specific trend. The other parameters of economic opportunities, namely calf mortality, age at first calving, calving interval, and the number of dead/total number of born calves either alive or dead remained statistically non-significant among four categories of SCD.

Table 4: Average animal Performance and Economic Opportunities

Parameters	A	B	C	D	P-value
(I) Average animal Performance					
Days in milk (d)	138.92±22.42	164.45±25.7	242.50±42.02	172.00±54.00	0.87
Milk per day/cow (l)	10.31±1.13	10.91±1.16	9.25±1.25	11.50±0.50	0.24
Age at first calving (d)	36.31±2.24	31.27±1.04	30.75±2.72	28.50±2.50	**0.02**
Calving interval (d)	14.77±0.54	15.64±0.83	15.75±0.48	14.00±2.00	0.32
Lactation length (d)	334.92±15.14	290.73±20.90	415.25±23.99	318.50±8.50	0.64
(II) Economic Opportunities					
Opportunity from calve mortality	1315.4±972.6	500.0±309.0	0.00±0.00	0±0	0.72
Opportunity from age at first calving	17899±7045	6631±2689	8790±8790	4785±4785	0.27
Opportunity from calving interval	153.08±62.48	575.76±428.88	400±317.4	900±900	0.62
Opportunity from lactation length	8176±2029	25755±8460	0.00±0.00	0.00±0.00	0.04
Opportunity from milk production	81451±24978	131005±24725	205403±38936	332150±142	0.02
Health care cost/cows	289.6±35.3	200.13±23.69	136.91±14.99	124±41	0.01
Total economic opportunities	252347±4682	151725±14295	285450±27210	175585±25585	0.00
No dead/total No born alive or dead	0.15±0.1	0.32±0.14	0.25±0.25	0.6±0.4	0.54

Most of the farmers were highly interested in keeping reproduction records. This exercise they were completed as a result of training given by the Government to him. About 86% of the farms kept production, reproduction, and feeding records, but only as a simple notebook. The production record has been just to know the amount of milk sold.

Recommendations

Based on the present investigation, it can be recommended that the Government needs work hard to increase the awareness of the farmers on scientific managerial practices of dairy cattle and provide subsidies. Dairy producers should have a continuous assessment of the profitability of their farms. They should develop their pastures because of fluctuation in the market supply of the green fodders. An area of economic opportunity, according to their importance to take accurate intervention to get the profit, should be identified. The balanced ration should be formulated for each class of animals. Full records of the farm activities including detailed information on individual animals should be maintained on the farm.

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Nutritional evaluation of *Moringa oleifera* pod meal for white New Zealand rabbits

Awadhesh Kishore and Kesete Goitom*

School of Agriculture,
ITM University, Gwalior-474001, India.

*Department of Animal Sciences
Hamelmalo Agricultural College, Keren, Eritrea

Abstract

The study was to find out the appropriateness of 15% replacement of concentration through Moringa oleifera pod meal in non-lactating female White New Zealand Rabbit production for semi-arid reasons. The non-lactating female White New Zealand Rabbits (N=12) were randomly divided the two groups, viz. control (3.25±0.20 kg) and test group (3.20±0.18 kg). Concentrates made of HAC cafeteria left-over were given to the experimental animals to meet their daily DCP and ME requirements. Alfalfa as green fodder was offered ad-lib to the animals. In the control group, the animals received 100% concentrate, whereas in the test group, 85% concentrate and 15% moringa pod meal on a fresh basis. During the experiment, an eight-day adaptation period was followed by a five-day digestibility cum behaviour experiment. Digestibility cum behaviour experiment continued for consecutive 120 hours and dived into 24 slots of 5 hours each. The animals were offered the weighed amount of feed at the start of the slot. The refusals of feed and faeces were weighed and sampled at the end of the slot. For comparing results on two feeds 'paired t-test for the difference in means was used. The findings of the research work included that the intake of dry matter (DM), organic matter (OM), crude protein (CP), nitrogen-free extract (NFE), and total carbohydrates (TCHO) was non-significant in two groups and CF and EE were increased in the test group. The coefficients of apparent digestibility of DM, OM, CP, NFE, TCHO, and GE remained non-significant and EED increased in the test group. DMI, DOMI, DCPI, and DEI remained non-significant and DEEI significant between two treatments.

Keywords: Feed utilization, *Moringa oleifera*, non-ruminant nutrition, Rabbits, White New Zealand

Introduction

In most developing countries, the population is depending on agriculture. Agricultural production is almost low and is not efficient to support the population. There are several factors contributing to low production i.e., less rainfall, infertile soils, desertification, rugged topography, and lack of awareness and technological equipment. The poverty and lack of space for livestock especially in high population density areas are the big challenges in most developing countries. In such countries, malnutrition is very common and its consequences can be very serious, especially for children (NRC 1991). As in most developing countries and especially in those located in semi-arid Africa like Eritrea. Animal protein is usually scarce and too expensive. The majority of the population may not afford it. The development of mini-farms like intensive animal farming remains only a key solution to fight against animal protein malnutrition.

Protein supplementation is often vital to enhance animal performance, and it needs to be done concerning the requirement of the animals in addition to the balance of other nutrients available in the feed. Soybean meal and fish meal have been widely and successfully used as conventional protein sources for livestock. The issues have been generated due to the increasing competition between humans and livestock for these protein ingredients as food. The cost of such type of protein supplements for the animals is again a big challenge in Eritrea. The prices of protein sources have been escalating continuously in recent times, whilst availability is often erratic. According to Odunsi (2003), the fast-growing human and livestock population created increased requirements for food and feed in developing countries, need that alternative feed resources must be identified and tested.

There is a need, therefore, to explore the use of locally available non-conventional feed resources that can yield the same output for the animals as conventional feeds, at cheaper rates. Hence, a nonconventional feed resource that has similar or high protein ingredients and can substitute conventional protein supplements like soybean meal or fishmeal partially or completely is highly desired. This strategy may be helpful to reduce the cost of production and ensure cheaper meat production. Therefore, the economization of feed costs using cheaper and unconventional feed resources is an important aspect of commercial animal production (Vasanthakumar et al 1999, Bhatt and Sharma 2001, Muriu et al 2002).

Under these circumstances, rabbit production on moringa feed supplement seems a timely need in Eritrea. Rabbit production is widely practiced all over the world and has proved to be rewarding for both producers and consumers. The rabbits provide good quality meat and require small capital and space. Protein supplementation remains the greatest topic of interest when dealing with rabbit production. This is an interesting fact that in the utilization of moringa (*Moringa oleifera*), commonly known as horseradish tree or drumstick tree, as a protein source for livestock (Makker and Becker 1997; Sarwatt et al 2002). Moringa tree leaves have quality attributes that mark them a potential replacement for soybean meal or fish meal in non-ruminant diets. Moringa crop can easily be grown and established in the field, has a good land coping ability, as well as good potential for forage production. Furthermore, there is the possibility of obtaining large amounts of high-quality forage from this tree without any expensive inputs due to favorable soil and climatic conditions for its growth. Sarwatt et al (2004) reported that moringa tree leaves are a potential inexpensive protein source for livestock feeding. The benefits of using moringa leaves and pods as a protein resource are numerous and include the fact that it is a perennial plant. The fodder can be harvested several times in one growing season and also has the potential to reduce feed expenses. *Moringa oleifera* is in the group of high-yielding nutritious browse herbs with every part having unique feeding importance (Duke 1998).

The objective of the study was to find out the suitability of 15% replacement of concentration through moringa pod meal in non-lactating female White New Zealand Rabbit production for a semi-arid reason.

Materials and Methods

The field trial was conducted at Rabbit Farm, Hamelmalo Agricultural College (HAC), Hamelmalo, Keren, Zoba Anseba. The farm is located at an altitude of 1286 m above sea level. It has a semi-arid climate with an annual mean rainfall of 440 mm and an average annual temperature of 24^0C. The experiment was conducted in April and May 2018.

For the experimental purpose, 12 non-lactating female White New Zealand Rabbits were randomly selected and divided into six pairs based on their body weight. One animal from each pair was allotted to one of the two groups, viz. control (3.25±0.20 kg) and test group (3.20±0.18 kg). The animals were housed in the indoor cage system i.e., in separate individual cages. During the experiment, they were not allowed for routine exercise. Concentrates made of HAC cafeteria left-over were given to the experimental animals to meet their daily DCP and ME requirements (Cheeke 1987, Maertens 1992). Alfalfa as green fodder was offered *ad lib* to the animals. Each animal also received 3 g of common salt daily. In the control group, the animals received 100% concentrate, whereas in the test group, 85% concentrate and 15% moringa pod meal on a fresh basis (Table 1).

During the experiment, an eight-day adaptation period was followed by a five-day digestibility cum behaviour experiment. During the experiment, feed, leftovers, and feces were sampled for proximate analysis.

Digestibility cum behaviour experiment continued for consecutive 120 hours, dived into 24 slots of 5 hours each. The animals were offered the weighed amount of feed at the start of the slot. They had free access to drinking water round the clock. The refusals of feed and faeces were weighed and sampled at the end of the slot. The samples were preserved for proximate analysis (AOAC 2000). Gross energy was estimated by using the formula given by Kearl (1982). The intake and digestibility coefficients of different nutrients were determined using standard calculation (McDonald 2005).

For comparing results on two feeds 'paired t-test for the difference in means (Snedecor and Cochran 1994) was used. For comparing the behaviour of animals two-way ANOVA with replication technique was implemented. The data were statistically analyzed using a data analysis pack of MS Office excel 2007 (MS Office 2006).

Table 1 Experimental diet (g)

Pairs		Concentrate			Moringa pod meal			Alfalfa green	Common Salt	Water
		Fresh	Ratio (%)	DM	Fresh	Ratio (%)	DM			
1	Control	480	100	349.6	0	0	0.0	*Ad lib*	3.0	*Ad lib*
	Treatment	408	85	297.1	216	15	100.8	*Ad lib*	3.0	*Ad lib*
2	Control	480	100	349.6	0	0	0.0	*Ad lib*	3.0	*Ad lib*
	Treatment	408	85	297.1	216	15	100.8	*Ad lib*	3.0	*Ad lib*
3	Control	480	100	349.6	0	0	0.0	*Ad lib*	3.0	*Ad lib*
	Treatment	408	85	297.1	216	15	100.8	*Ad lib*	3.0	*Ad lib*
4	Control	480	100	349.6	0	0	0.0	*Ad lib*	3.0	*Ad lib*
	Treatment	408	85	297.1	216	15	100.8	*Ad lib*	3.0	*Ad lib*
5	Control	480	100	349.6	0	0	0.0	*Ad lib*	3.0	*Ad lib*
	Treatment	408	85	297.1	216	15	100.8	*Ad lib*	3.0	*Ad lib*
6	Control	480	100	349.6	0	0	0.0	*Ad lib*	3.0	*Ad lib*
	Treatment	408	85	297.1	216	15	100.8	*Ad lib*	3.0	*Ad lib*

Results and Discussion

The chemical composition of feed materials used in the experiment has been presented in Table 2. The crude protein content in moringa pod meal was higher than the literature values, which could be due to the presence of seed in the meal. Booth and Wickens (1988) and Bosch (2004) have valued the content of crude protein on a fresh basis whereas, in the present case on a dry matter basis. Further, the variation in the content of other nutrients could also be because of the same reason. The variation may also be attributed to other factors like the genetic background of the plant, agro-climatic conditions, age and season at harvest, and pod collection and handling methods.

Table 2 Chemical composition of feed ingredients

Nutrient	Unit	Concentrate	MP Meal	Alfalfa
CP	(%)	12.0	16.8	18.8
CF	(%)	0.9	30.9	28.1
EE	(%)	0.6	6.0	0.6
NFE	(%)	85.2	37.7	42.2
Ash	(%)	1.8	8.7	10.4
OM	(%)	98.2	91.3	89.6
TCHO	(%)	85.6	68.6	70.3
NFE	(%)	84.7	37.7	42.2
GE	K cal/g	4.2	4.2	3.9

The intake of DM, OM, CP, NFE, and total carbohydrates (TCHO) was non-significant ($P>0.05$) in the two groups (Table 3). The reason for the same may be the content of DCP (13.58±0.23 & 13.38±0.06%) and DE (4.05±0.00 & 4.08±0.00 Kcal/g) in the two diets was almost similar. The intake of crude fibre and ether extract was significantly higher ($P<0.05$) in the test compared to the control group. Because of the inclusion of moringa pod meal in the treatment diet, contents of CF and EE were increased and resulted in increased respective nutrient intakes. The intake values in the present study were higher than the values reported by Nuhu (2010) which could be due to the initial body weight of the experimental animals which was very much variant. The literature is scanty to confirm the present findings in terms of intake of crude protein and other nutrients.

Table 3 Nutrient intake (per Kg body weight)

Nutrient	Unit	Control	Treatment	P Value
DMI	(g)	194.08±14.82	194.22±12.74	0.49
OMI	(g)	181.88±13.90	181.31±11.90	0.47
CPI	(g)	30.30±2.29	30.40±2.00	0.47
CFI	(g)	30.34±2.17	35.30±2.21	0.00
EEI	(g)	1.16±0.09	2.86±0.18	0.00
NFEI	(g)	120.18±9.39	112.82±7.55	0.15
TCHOI	(g)	150.52±11.54	148.12±9.74	0.38

The apparent digestibility data of different nutrients have been presented in Table 4. The coefficients of apparent digestibility of DM, OM, CP, NFE, TCHO, and GE remained non-significant ($P>0.05$) in the two groups. The DCP content in the two diets was almost similar which could be the reason for similar apparent digestibility in the two groups. El-Badawi et al (2014) and Nuhu (2010) reported increased apparent DMD moringa dry leaves powder may be because of the reason that moringa dry leaves powder could have some digestion-promoting effects (El-Badawi et al 2014). However, in the present study, moringa pod meal was nutritionally analyzed; as such, the present findings could not confirm the studies. The EED was higher in the test group compared to the control, which may be due to the higher content of digestible ether extract in the treatment group (5.33±1.69) compared to that in the control group (3.72±0.90).

The digestible nutrient intake data have been presented in Table 5. DMI, DOMI, DCPI, and DEI remained non-significant between two treatments. It could be due to the reason of the insignificant difference between intake and apparent digestibility coefficients of various nutrients, respectively. The same patterns were also observed for CF, NFE, and TCHO might perhaps be because of the same reasons. However, the intake of DEE was higher in the test group compared to the control. The apparent digestibility coefficients and intakes for this nutrient were also recorded in the present study and could not be compared as the literature is lacking information in this regard.

Table 4 Apparent nutrient digestibility (%)

Nutrient	Control	Treatment	P Value
DM	84.33±1.79	85.14±0.36	0.32
OM	84.81±1.74	85.27±0.36	0.39
CP	86.96±1.49	85.47±0.35	0.16
CF	57.68±4.91	66.26±0.83	0.06
EE	73.88±2.99	88.92±0.28	0.00
NFE	91.24±1.00	91.09±0.22	0.44
TCHO	84.46±1.78	85.15±0.36	0.35
GE	84.92±1.73	85.79±0.34	0.30

Table 5 Digestible nutrient intake (per Kg body weight)

Nutrient	Unit	Control	Treatment	P Value
DDMI	(g)	163.76±12.89	165.52±11.38	0.43
DOMI	(g)	154.33±12.13	154.75±10.64	0.48
DCPI	(g)	26.36±2.02	26.01±1.79	0.41
DCFI	(g)	17.51±1.91	23.45±1.67	0.01
DEEI	(g)	0.86±0.07	2.55±0.16	0.00
DNFEI	(g)	109.69±8.64	102.83±7.07	0.16
DTCHO	(g)	127.20±10.04	126.25±8.70	0.45
DEI	K cal	668.42±52.27	680.23±46.52	0.38

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Agronomical performance, chemical composition and nutrient yield of open-pollinated and hybrid fodder varieties of sweet sorghum [*Sorghum bicolor* (L.)] at 50 percent flowering stage in Grid region

Lakshman Singh, Shiv Singh Tomar, Aman Parashar and Awadhesh Kishore

School of Agriculture
ITM University, Gwalior (Madhya Pradesh), India

Abstract

The present study was an effort to compare the agronomical performance, chemical composition and nutrient yield of fodder open-pollinated and hybrids sweet sorghum [Sorghum bicolor (L.)] in the Grid region. Two advanced sweet sorghum genotypes of open-pollinated (SPSSV15; SPSSV20), and two hybrids (PAC52093; SPSSH19) were planted at four locations of Grid region viz. two each at Sithouli (26.140°N, 78.196°E; 27.205°N, 77.498°E) and Turari (26.122°N, 78.177°E; 26.138°N, 78.207°E) of Gwalior District during rainy season of 2021. The seeds were sown using the manual dibbling method at a uniform depth of 5 cm during the second week of June in 3 replications. The recommended dose of fertilizers was applied in the form of urea, single super phosphate, and muriate of potash. Data on plant height, biomass accumulation, days to flowering and physiological maturity were recorded using standard procedures. At the 50 per cent flowering stage, ten representative plants from the four central rows of each plot were sampled. The plant biomass was oven-dried, ground and used for chemical estimation. Suitable statistical methods were used to analyze the data. The hybrid genome SPSSH19 proved superior to the rest of the genotypes under study in terms overall fodder performance including the agronomical performance, chemical composition and nutrient yield. There was no significant difference in fodder performance of four genomes at the four locations under the present study. The conclusion based on the study is that hybrid variety SPSSH19 can be recommended as a fodder crop in the Grid region.

Keywords:

Grid Region, Hybrid sorghum, Nutrient Yield, Open-pollinated sorghum, PAC52093, Sorghum Fodder, SPSSH19, SPSSV15, SPSSV20, Sweet Sorghum.

Introduction

The nutritive value of crop residues is very much inferior and cannot maintain the livestock. One of the alternatives of the crop residues is sweet sorghum (*Sorghum bicolor* L.) stalk. Sweet sorghum, provides grain for human consumption and fodder from stalk to livestock. Sweet sorghum is similar to grain sorghum but the stalks are juicy (Zhang et al. 2018) and rich in fermentable sugars. Sweet sorghum fodder may be adapted to the Grid region as a high-yielding quality green fodder. The crop needs 12-15 inches of rain only during the season. Therefore, it is suitable for dryland production or limited irrigation. It is one of the most efferent dryland perennial crops in areas that do not have a winter freeze. It is, therefore, the fifth most important cereal crop in the world. Earlier much work has not been done regarding the usage of sweet sorghum stalk as the source of roughage in the feeding of livestock in the Grid region. In India, there is a deficit of 23.4 percent in the availability of dry fodder, 11.24 percent in that of green fodder (Anonymous 2018). The status of green fodder and dry fodder in India indicated the availability of 390 and 443 m tons respectively as against the requirement of 1025, and 570 m tons. It creates a deficit of 62 and 22%, respectively. Thus, the country has an urgent need to bridge this gap and provide a balanced diet especially crude protein content and *in-vitro* dry matter digestibility to cattle through fodder crops. In the present scenario, the country is already facing a scarcity of resources, especially water. In such a grim situation, the country is limited options for fodder crops for the livestock. Hence, berseem and maize are not good options in the Grid region because of the high-water requirements. Thus, sweet sorghum is an important fodder crop that can be grown in drought and waterlogged in both conditions due to its wide adaptability. Similarly, it contributes to the food security of human beings as well as of livestock.

Sweet sorghum is one of the 5 major cultivated cereal species in the world. It is consumed as food and feed (Almodares et al. 2007) and used for sugar, ethanol, and paper pulp production (Almodares and Mostafafi 2006). The biomass and sugar content of sweet sorghum are important factors for food and industrial production. Although the effect of K fertilizer on other plants is reported (Adeli and Varco 2002) but there are few reports regarding the effect of K fertilizer on the biomass of sweet sorghum. Therefore, it is of considerable value to carry out an experiment on biomass and carbohydrate content of sweet sorghum concerning different rates of N and K fertilizers.

The present study was an effort to compare the agronomical performance, chemical composition and nutrient yield of fodder hybrids and open-pollinated sweet sorghum [*Sorghum bicolor* (L.)] in the Grid region

Materials and Methods

Two advanced sweet sorghum genotypes open-pollinated (SPSSV15; SPSSV20), and two hybrids (PAC52093; SPSSH19) were planted at four locations in the Grid region viz. Sithouli (26.140°N, 78.196°E; 27.205°N, 77.498°E) and Turari (26.122°N, 78.177°E; 26.138°N, 78.207°E) of Gwalior District during rainy season of 2021. The soil texture at the locations where the crops were cultivated varied between sandy and loam with a profile depth of 1.0 m. The crop was grown under rainfed conditions during the rainy season (June to October, Rains 710 mm; temperature range 20.3-38.6˚C, average temperature 29.0 ˚C, humidity 64%, Sun hours 9.4, rainy days 43) at all the locations.

The seeds were sown using the manual dibbling method at a uniform depth of 5 cm during the second week of June 2021 in 3 replications. Atrazine (@1 kg ha-1) was applied on the next day of sowing (pre-emergence) and 20-days after emergence (DAE) to control the initial weed flora. The seedlings were thinned to one plant and an optimum plant population of about 12 plants m^{-2} was maintained. Hand-weeding was done twice between 15 and 35 DAE. The recommended dose of fertilizers was applied (@80:40:40 kg N: P_2O_5: K_2O ha^{-1} in the form of urea, single super phosphate, muriate of potash, respectively). The half dose of N and complete P and K were administered as basal, and balance N was side-dressed at 35 DAE.

Data on plant height, biomass accumulation, days to flowering and physiological maturity were recorded using standard procedures. At the 50 per cent flowering stage, ten representative plants from the four central rows of each plot were sampled in all three replications and four locations for measuring biomass. After cutting the plants at ground level, fresh biomass of ten whole plants was weighed immediately and fresh biomass was calculated. The leaves along with sheath were stripped and panicle with last internode (peduncle) was separated and the fresh weight of stripped stalk was estimated.

The plant biomass was oven-dried and ground and used for chemical estimation (Goering and Van Soest 1970, AOAC 2019). Suitable statistical methods were used to analyze the data (Snedecor and Cochran 1994). The data were statistically analyzed using a data analysis pack of MS Office excel 2016 (U Q Library 2016).

Results and Discussion

The agronomical performance of fodder hybrids and open-pollinated sweet sorghum has been presented in Table-1. It has been demonstrated that the number of tillers, ranging between 3.06 and 3.31 per plant in various varieties of sweet sorghum, was non-significant ($P>0.01$). The stage of 50 percent flowering was attained in open-pollinated genome SPSSV20 at an early age and could provide forage earlier for the livestock ($P<0.01$) compared to other genomes. The green fodder and dry matter yield in the same genome were comparatively lower compared to others and confirmed the results the study of Sami et al. (2013). The hybrid genome SPSSH19 is revealed to show better fodder performance like plant height, leave length, number of leaves per plant, and green and dry matter yield ($P<0.01$) compared to rest of the genomes. The trend could not be confirmed due to the lack of information in the literature. The open-pollinated variety SPSSV20 had inferior agronomical performances as green fodder. The fodder performance of open-pollinated and hybrid sweet sorghum was not different at four locations, studied in the present work ($P>0.01$).

Table-1: The agronomical performance of fodder hybrids and open-pollinated sweet sorghum varieties at 50 percent flowering stage.

Parameter	SPSSV15	SPSSV20	PAC52093	SPSSH19	P-Value
Age at 50% flowering	81.9±0.4^{B}	77.1±0.4^{B}	87.1±0.4^{A}	80.2±0.4^{B}	0.00
Plant height (CM)	326±1^{B}	316±2^{C}	335±1^{B}	357±1^{A}	0.00
No. of tillers/plant	3.19±0.13	3.31±0.13	3.13±0.00	3.06±0.13	0.43
Leaf length (CM)	92.1±0.2^{B,C}	89.8±0.1^{C}	94.6±0.3^{B}	98.5±0.2^{A}	0.00
Leaf width (CM)	8.41±0.02^{A}	7.77±0.0^{B}	8.16±0.03^{A}	8.28±0.02^{A}	0.00
No. of leaves/plant	53.9±0.3^{B}	51.1±0.2^{B}	56.1±0.2^{A}	57.3±0.3^{A}	0.00
Green fodder yield (q/h)	872±5^{B}	857±4^{C}	888±4^{B}	911±4^{A}	0.00
Dry matter yield (q/h)	228±1^{B}	227±1^{B}	229±1^{B}	250±1^{A}	0.00

^{A,B,C} - *Values bearing different superscripts within the row differed significantly (P<0.05)*

Table-2: The chemical composition of fodder hybrids and open-pollinated sweet sorghum varieties at 50 percent flowering stage.

Nutrient (%)	SPSSV15	SPSSV20	PAC52093	SPSSH19	P-value
Dry Matter	20.0±2.4	19.9±2.4	20.0±2.4	19.7±2.1	1.00
Crude Protein	13.6±1.4^{B}	13.2±1^{B}	11.3±0.6^{C}	14.2±1.2^{A}	0.00
Ash	10.0±1.2	12.0±1.4	11.0±1.3	13.0±1.6	0.10
Neutral Detergent Fiber	59.3±2.3^{A,B}	61.5±1.5^{A}	57.2±2.4^{B}	61.5±2.2^{A}	0.00
Cell content	40.7±2.8	38.5±2.7	42.8±3.2	38.5±3.0	0.30
Acid Detergent Fiber	41.7±3.0	40.5±2.2	38.7±2.5	41.3±1.9	0.50
Cellulose	27.1±2.1	23.3±1.9	24.1±1.9	24.8±2	0.10
Hemicellulose	17.6±1.9	21±2.1	18.5±1.5	20.2±1.8	0.10
Acid Detergent Lignin	11.6±2.1	14±1.6	11.5±1.2	13.2±1.7	0.10
Acid Insoluble Ash	3±0.40	3.2±0.40	3.1±0.40	3.3±0.40	0.80

^{A,B,C} - *Values bearing different superscripts within the row differed significantly (P<0.05)*

Table-2 includes the chemical composition of open-pollinated and hybrids of sweet sorghum fodder genomes at the 50 per cent flowering stage. The nutrients under study except for crude protein and neutral detergent fiber were more or less similar and remained non-significant in open-pollinated and hybrid genomes of sweet sorghum (P>0.01). It could be because of similar agronomical operations and environmental conditions during the cultivation of these genomes. The content of crude protein and neutral detergent fiber were lowest in hybrid genome PAC52093 of sweet sorghum in comparison to others. The content of neutral detergent fiber increased with the advancement of the age of the crop (Zemene et al. 2020). The variation in crude protein could be due to the varietal variation of the fodder crops. The chemical composition of open-pollinated and hybrid sweet sorghum was non-significant at four locations, studied in the present work (P>0.01).

The nutrient yields of open-pollinated and hybrids of sweet sorghum fodder genomes at the 50 per cent flowering stage have been presented in Table-3. The observations revealed that there was no significant difference in nutrient yield including dry matter, crude protein, ash, neutral detergent fiber, acid detergent fiber, cellulose, hemicellulose, acid detergent lignin, and acid insoluble ash, in open-pollinated and hybrid sweet sorghum genomes under study (P>0.01). The dry matter yield could not confirm the findings of Qu et al. (2014), perhaps because of different stages of harvest and variations in environmental factors. The reason could be the agronomical practices and environmental factors during the cultivation of experimental crops were similar. The yield of other nutrients could not be compared because limited information is available in the literature in this regard. The results for various locations under study were also remained non-significant (P>0.01).

Table-3: The nutrient yield of fodder hybrids and open-pollinated sweet sorghum varieties at 50 percent flowering stage.

Nutrient (q/h)	SPSSV15	SPSSV20	PAC52093	SPSSH19	P-value
Dry matter yield	228 ± 1^{B}	227 ± 1^{B}	229 ± 1^{B}	250 ± 1^{A}	0.00
Dry Matter	174±21	171±21	177±22	179±19	1.00
Crude Protein	24.7±5.4	23.1±4.3	20.5±3.5	25.9±4.1	0.40
Ash	18.3±4.2	21.5±4.9	20.5±4.7	24.4±5.3	0.50
Neutral Detergent Fiber	105±16	106±14	103±16	111±15	0.90
Acid Detergent Fiber	84.3±5.9	82.2±6.9	82.3±6.1	87.5±4.7	0.90
Cellulose	64.8±9.8	62.5±8.2	62.0±8.9	66.8±7.7	0.90
Hemicellulose	20.1±4.3	23.5±3.4	20.4±3.7	23.7±4.0	0.50
Acid Detergent Lignin	14.0±2.9	13.9±2.8	14.5±3.1	14.5±2.8	1.00
Acid Insoluble Ash	5.47±1.26	5.79±1.32	5.84±1.35	6.14±1.33	0.90

^{A,B} *- Values bearing different superscripts within the row differed significantly (P<0.05)*

The nutritional profile of fodder hybrids and open-pollinated sweet sorghum genotypes at the 50 percent flowering stage (Fig 1) showed a similar pattern (P>0.05). The Cell content ranged between 39 and 43, hemicellulose 23 and 27, cellulose 18 and 21, lignin 12 and 14, and acid insoluble ash 3 percent and confirmed the observations of Sriagtula et al. (2021).

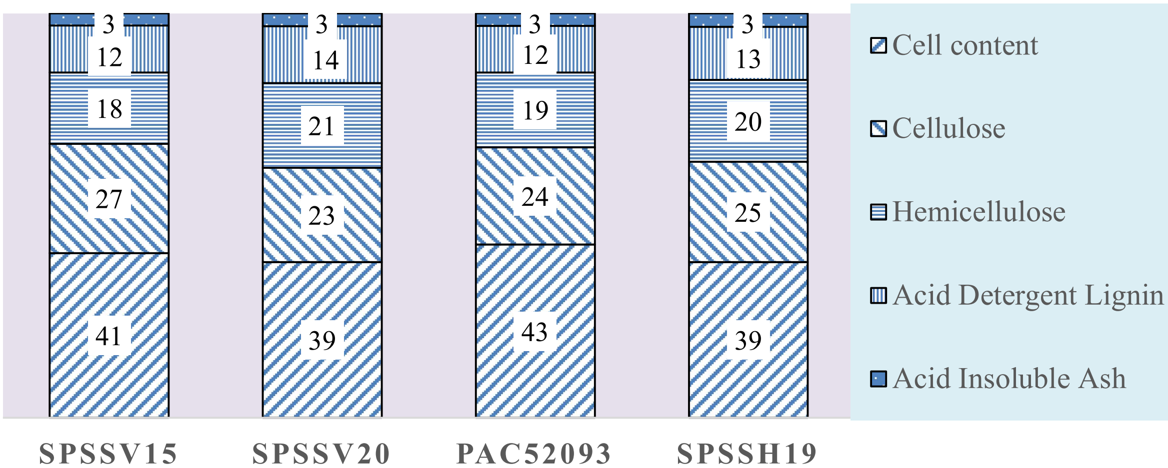

Fig 1 Cell Profile

Conclusion

The hybrid genome SPSSH19 proved superior to the rest of the genotypes under study in terms overall fodder performance including the agronomical performance, chemical composition and nutrient yield. There was no significant difference in fodder performance of four genomes at the four locations under the present study. The conclusion based on the study is that hybrid variety SPSSH19 can be recommended as a fodder crop in the Grid region.

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Influence of manipulated rumen fermentation using buffers on the ruminal environment in crossbred calves

Short Title: Buffers on the ruminal environment in crossbred calves

Tushar Sharma[1], Awadhesh Kishore[2], and Prakash Chandra

Department of Animal Husbandry and Dairying, Raja Balwant Singh College, Bichpuri, Agra-283105 (U.P.), India

[1] College of Biotechnology, Uttar Pradesh Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura, India.

[2] School of Agriculture, ITM University, Gwalior (Madhya Pradesh), India

Abstract

To study the effect of manipulation of rumen fermentation using buffers in crossbred calves on the rumen environment nine crossbred calves were divided into three groups based on different phenotypic traits (Age 131-221d, lightweight-LW 57.5-93.9 Kg) and were given grass mixture and wheat straw as green and dry roughages and concentrate mixture contained barley grain and mustard cake. One animal from each group was randomly allotted to one of the three treatments viz. T-1, T-2, and T-3. Buffer in the form of sodium bicarbonate and magnesium oxide in combination at the rate of 0.00 and 0.00, 0.20 and 0.10, and 0.40 and 0.20 per cent of LW were given in T-1, T-2, and T-3, respectively. The ruminal study trial was conducted 30 days after the start of the experiment and lasted for 5 consecutive days. During this period, the ruminal liquor was sampled after 0, 2, 4, 6, 8 and 10 hours of feeding and analyzed for pH, total volatile fatty acids, acetate, butyrate, iso-butyrate, Iso-valerate, propionate, valerate, acetate to propionate (A:P) ratio, total nitrogen, ammonia nitrogen, urea nitrogen and non-ammonia and urea nitrogen. The data were analyzed statistically using suitable procedures. The results of the rumen metabolism study indicated that the pH and content of acetate, propionate and ammonia nitrogen decreased and TVFA, BA, VA, and A:P ratio increased in the rumen liquor due to the supplementation of buffer in calves' nutrition. A declining pattern of pH up to 10 hours; concentration of IBA, AN, and urea nitrogen up to 8 hours and total volatile fatty acid up to 6 hours in rumen liquor after feeding were recorded. The overall conclusion can be made that the addition of buffer in ruminant nutrition (buffer feed technology) was responsible to change the ruminal environment in such a way that it became helpful to produce additional fat due to manipulated pH and A:P ratio.

Keywords:

A:P ratio, Ammonia nitrogen, Buffers, Crossbred calves, Magnesium oxide, Rumen fermentation, Ruminal environment, Sodium bicarbonate, TVFA.

Introduction

Buffer feed technology reveals to add buffers in animal nutrition with the object to keep pH constant in rumen fluid. At constant pH between 6.5 to 7.0 maximum potential can be explored from the animals but in general, after 4 to 6 hours of feeding, the acidity of rumen content goes down drastically (Kishore et al. 1996) due to the fermentation of feed and production of several volatile fatty acids and results to depress microbial activity in rumen ecosystem.

To check the fall of ruminal pH many chemicals have been tried but the use of sodium bicarbonate and magnesium oxide in combination showed better potential in terms of intake (Toro et al. 1982), digestibility of different nutrients (Pierce et al. 1983), higher volatile fatty acid concentration in rumen liquor (Rogers et al. 1985), milk yield (Elekelberger et al. 1985), yield of different milk constituents (Singh et al. 1996).

A significant effect on acetate and propionate production, however, was not observed but Acetate to propionate (A:P) ratio was increased in rumen liquor when sodium bicarbonate (Mees and Merchen 1985) or with magnesium oxide (Lee and Hsu 1985) was included in cattle nutrition. On the other hand, many research workers reported increased production of acetate in rumen fluid on buffer included diet (Kishore et al. 1996) in goats. Which is the main precursor to the synthesis of milk fat and thus the yield of milk fat is increased. Teh et al. (1985), Zhelev and Proferov (1987), Johnson et al. (1988), Solorzano et al. (1989), Kishore (1997), and Singh et al. (1996) worked out that buffers (in the form of sodium bicarbonate or with magnesium oxide) inclusion to the diet either increased milk fat yield or keeps it constant.

But before offering the buffer feed technology directly to the cow, a thorough study of calves to fix the level suitable for cattle is needed. The present investigation is, therefore, an effort to study the effect of manipulation of rumen fermentation using buffers in crossbred calves on the rumen environment.

Materials and methods

Nine crossbred calves were selected from the herd of the college Dairy Farm. At the start of the experiment, the age (131-221d), live-weight (LW=57.5-93.9 Kg), heart girth (91-105 cm), body length (75-92 cm), height (78- 93 cm), collar length (52-71 cm) and tail length (42-57 cm) were recorded. All the animals were dewormed and housed in calf sheds having separate feeding mangers and water troughs for individual feeding. The large-sized open enclosure was used for exercise. All of the animals received grass mixture as green fodder and wheat straw as dry fodder. The concentrate mixture contained barley grain and mustard cake. The chemical composition of feeds and fodders offered to the animals is presented in Table 1. The amount of each feed ingredient for each animal was calculated based on the NRC feeding standard. Apart from this, each animal was also given 20 g of common salt and 25 g of mineral mixture daily.

Based on different phenotypic traits viz. age, weight, heart girth, and length, the animals were divided into three groups. One animal from each group was randomly allotted to one of the three treatments viz. T-1, T-2, and T-3. Buffer in the form of sodium bicarbonate and magnesium oxide in combination at the rate of 0.00 and 0.00, 0.50 and 0.25 and 1.00 and 0.50 per cent of assumed dry matter intake to be 4 per cent of LW or 0.00 and 0.00, 0.20 and 0.10, and 0.40 and 0.20 per cent of LW were given in T-1, T-2, and T-3, respectively.

The ruminal study trial was conducted on subjected animals 30 days after the start of the experiment and lasted for 5 consecutive days. Rumen liquor was collected with the help of a rubber tube inserted into the rumen through the mouth of the animal and by creating a vacuum with the help of a hand-driven suction pump. The samples of rumen liquor were drawn after 0, 2, 4, 6, 8, and 10 hours of feeding. The liquor collected was filtered through muslin cloth and then used for analysis. The pH, ammonia nitrogen, and urea nitrogen were estimated immediately. A 1.0 ml sample was preserved for total nitrogen and 10 ml for volatile fatty acid determination. The samples obtained during the ruminal study trial were analyzed for pH, total volatile fatty acid, acetate, butyrate, iso-butyrate, iso-valerate, propionate, valerate, total nitrogen, ammonia nitrogen, and urea nitrogen (Isshiki et al. 1981, Oser 1965 and ISI 1975). A:P ratio and non-ammonia and urea-nitrogen were analyzed mathematically. The data recorded during the experiment were analyzed statistically using factorial design using the method discussed by Snedecor and Cochran (1967).

Table 1: Chemical composition of feeds (%DM)

Parameters	Straw	Grass	Barley grain	Mustard cake	Buffer
DM*	91.2	28.2	90.3	99.2	100
Ash	10.0	10.6	9.30	7.50	100
Organic matter	90.0	89.4	90.7	92.5	0.00
Crude protein	3.10	6.90	10.2	35.0	0.00
Ether extract	1.00	1.80	2.60	2.00	0.00
Total carbohydrates	85.9	80.9	77.9	55.5	0.00
Gross energy#	3.98	4.06	4.20	4.62	0.00
Crude fibre	35.2	44.6	10.1	7.90	0.00
Nitrogen free extract	50.7	36.1	67.8	47.6	0.00
Calcium	0.10	0.40	0.20	0.20	0.00
Phosphorus	0.10	0.20	0.20	0.20	0.00
Sodium	0.20	0.60	0.40	0.40	18.0
Magnesium	0.10	0.30	0.30	0.40	19.5
Potassium	5.80	0.90	0.50	1.20	0.00
Neutral detergent fibre	74.2	71.1	56.8	53.5	0.00
Acid detergent fibre	51.1	38.2	42.0	43.9	0.0
Hemicellulose	23.1	32.9	14.8	9.60	0.00
Cellulose	43.0	31.9	37.0	33.0	0.00
Lignin	2.80	2.70	2.30	2.00	0.00
Cell content	25.8	28.9	43.2	46.5	0.00

** Fresh basis; # M cal/Kg DM*

Results and discussion

Voluntary intake of digestible dry matter, digestible organic matter, and digestible energy (Table 2) did not differ in T-1 and T-2 and T-2 and T-3, whereas intake of crude protein and digestible crude protein was lowest only in T-1 and remained qual in T-2 and T-3 and that remained unchanged among all the treatment in terms of per Kg $W^{0.75}$ but when these were expressed in terms of per 100 Kg LW, intake of digestible dry matter and digestible organic matter became non-significant and digestible energy was noted to be lowest only in T-1 and remained non-significant in T-2 and T-3. Increased intake of digestible dry matter in T-3 was due to the effect of buffer addition in the diet on the digestibility coefficient of dry matter (Kishore 1997). A similar pattern of intake of these nutrients is reviewed in the literature (Hemminger and Krichgassner 1972, Toro et al. 1982, Johnson et al. 1988. Solorzano et al. 1989, and Kishore et al. 1998). The reason could be that the addition of buffers increased liquid turnover rate, solid retention time (Stocks 1983), rate of dilution of ruminal fluid, outflow rate, and duodenal passage of digesta (Dewhurst et al. 1972). Water intake is reported to be related directly proportionate to the level of buffers inclusion in the diet Kishore (1997). The reason for the same could be the addition of sodium ions (Fettman et al. 1981, Stocks 1983, Rogers et al. 1985, Johnson et al 1988, Kishore et al. 1996, and Kishore et al. (1998).

Table 2: Voluntary Intake (g)

Nutrients	Voluntary Intake (per Kg $W^{0.75}$)				Voluntary Intake (100Kg LW)			
	Treatments				Treatments			
	T-1	T-2	T-3	CD at 5%	T-1	T-2	T-3	CD at 5%
DM	78.1 ±9.0	84.3 ±4.6	85.1 ±1.5	11.2	2.59 $\pm0.07^{\#}$	2.69 $\pm0.05^{\#}$	2.73 $\pm0.06^{\#}$	0.39
DDM	42.8 $\pm0.7^{B}$	49.4 $\pm3.4^{A,B}$	52.1 $\pm1.5^{A}$	7.9	1.42 $\pm0.03^{\#}$	1.57 $\pm0.04^{\#}$	1.67 $\pm0.06^{\#}$	0.21
CP	4.6 $\pm0.4^{B}$	6.9 $\pm0.4^{A}$	7.6 $\pm0.4^{A}$	1.7	153 $\pm12^{b}$	231 $\pm15^{a}$	245 $\pm17^{a}$	53
DCP	2.70 $\pm0.20^{B}$	4.10 $\pm0.20^{A}$	4.90 $\pm0.20^{A}$	1.1	88.7 $\pm7.7^{b}$	139 $\pm8^{a}$	156 $\pm9^{a}$	38
DE	183 $\pm2^{*B}$	194 $\pm7^{*AB}$	206 $\pm8^{*A}$	17	6.05 $\pm0.13^{\$b}$	6.45 $\pm0.15^{\$a}$	6.65 $\pm0.06^{\$a}$	0.35

* In Kcal; $^{\#}$ In Kg; $^{\$}$ In M cal.

^{A,B} = Value bearing different subscripts among the row and group differ significantly i.e., P<0.05.

^{a,b} = Value bearing different subscripts among the row and group differ significantly i.e., P<0.05.

Increased level of buffers addition in the ruminant diet is inferred to increase total volatile fatty acid production in rumen liquor (P<0.05) (Table 3 A and B). A similar trend was also reported by Rogers et al. ((1985), The et al. (1985) and Awadalla and Raghib, (1986), and Kishore et al. (1996).

Administration of buffers affected acetate production adversely i.e., an increased dose of buffers decreased production (P<0.05). A similar pattern was advocated by Hadjipanayiotou (1982) and Kishore et al. (1996). Mees and Merchen (1985), Armbel et al. (1988), and Johnson et al. (1988) did not note any exact trend in this regard, while, Rogers et al. (1985) and Teh et al. (1985) reviewed a positive correlation between the dose of buffers and production of acetate in the rumen ecosystem. The variation between the trends may be due to the various ratio of roughage and concentrate offered to the animals.

Buffer supplementation in calves' nutrition was responsible to increase butyrate concentration in rumen liquor with the enhancement in the level (P<0.05). Increased production of butyrate with an increased dose of buffer had been observed by Armbel et al. (1988) and Kishore et al. (1996) whereas, Rogers et al. (1985) did not show any significant trend.

Production of iso-butyrate followed the same pattern as recorded in the case of butyrate production. A higher amount of buffer regime was significantly related to the production of iso-butyrate (P<0.05). The increasing pattern of production of iso-butyrate with the increased dose of sodium bicarbonate and magnesium oxide separately (Armbel et al. 1988) or a combination of both chemicals (Kishore et al. 1996).

Iso-valerate production was unaffected by the level of buffer administration to the ruminant diet (P>0.05). Armbel et al. (1988) reported that the use of sodium bicarbonate caused increased synthesis of this fatty acid salt but the use of magnesium oxide altered this trend. The combined effect of both chemicals appeared in the present study. Rogers et al. (1985) explored that the use of sodium bicarbonate had no specific effect on the production of iso-valerate during the buffer regime.

Table 3A: Characteristics of the ruminal environment

Parameter	T-1	T-2	T-3	CD at 1%
pH	61.5±0.08[b]	6.67±0.07[a]	6.71±0.09[a]	0.08
TVFA	88.3±0.4[c]	93.1±0.6[b]	100.8±0.5[a]	1.4
Acetate (meq/l)	62.8±0.0[a]	62.7±0.1[b]	62.5±0.0[c]	0.2
Butyrate (mg/l)	11.6±0.1[c]	12.7±0.1[b]	14.0±0.1[a]	0.3
Isobutyrate (mg/l)	1.06±0.01[a]	1.26±0.02[b]	1.40±0.01[a]	0.04
Isovalerate (mg/l)	2.21±0.01	2.20±0.01	2.18±0.01	0.03
Propionate	26.0±0.00[a]	25.1±0.0[b]	24.4±0.00[c]	0.1
Valerate (mg/l)	2.51±0.1[c]	2.34±0.02[b]	2.58±0.01[a]	0.02
A:P ratio	2.47±0.00[c]	2.50±0.00[b]	2.56±0.00[a]	0.02
Total-N (mg/l)	55.1±0.8	55.5±0.68	54.1±0.6	1.13
NH3-N (mg/l)	7.76±0.03[a]	7.55±0.03[b]	7.43±0.04[c]	0.06
Urea-N (mg/ml)	3.08±0.01[c]	3.36±0.01[b]	3.77±0.02[a]	0.03
NAUN (mg/ml)	44.2±0.8	44.8±0.7	43.8±0.6	1.1

[a,b,c] =Values bearing different superscripts differed significantly.

Data revealed that an increased dose of buffers in ruminant nutrition interrupted the synthesis of propionate in the rumen (P<0.05). Armbel et al. (1988) reported that the use of sodium bicarbonate and magnesium oxide stimulated the synthesis of propionate. Similar findings were observed by Hadnipanayiotou (1982), Rogers et al. (1985), The et al. (1985), Zelev and Profirov (1987), Johnson et al. (1988) and Kishore et al. (1996).

The pattern of valerate production in the rumen was increased with the increased level of buffers in ruminant nutrition. Similar findings were recorded by Armbel et al. (1988) and Kishore et al. (1996), whereas Teh et al. (1985) and Rogers et al. (1988) did not prove any trend in their study. It could be presumed that the addition of magnesium oxide which was given by Armbel et al. (1988), Kishore et al. (1996), Rogers et al. (1985), and The et al. (1985) provided stability to the pattern.

The trend of the ratio between acetate and propionate (A:P) revealed that an increased level of buffers made the ratio wider. Similar findings were observed by Mees and Merchen (1985), Rogers et al. (1985), Teh et al. (1985), Armbel et al. (1988), Johnson et al. (1988), and Kishore et al. (1996). The main reason could be due to the low production of propionate and the higher production of acetate in the rumen ecosystem.

The trend of development of acidity in rumen liquor with the regime of buffer showed that it had a negative correlation with the level of dose of buffers i.e., an increased level of buffer caused decreased acidity or increased pH. Stocks (1983), Rogers et al. (1985), Teh et al. (1985), Newbold et al. (1991) and Kishore et al.

(1996) recorded similar findings i.e., increased level of buffer inclusion in the diet caused to increase in ruminal pH or to decreased ruminal acidity (Kishore et al. 1996). It is fact that sodium bicarbonate and magnesium oxide both are alkaline and became a factor to increase the pH of the rumen liquor immediately, but higher pH in rumen liquor recorded was responsible for more fibre degradation in the rumen (Erdman et al. 1980 and Kishore et al. 1998) and resulted in higher production of acetate and propionate, which caused to neutralize increased pH or decreased acidity. A similar trend was observed by Mees and Merchen (1985), Zhelev and Profirov, (1987), lee and Hsu (1992), and Kishore (1997).

Table 3B: Characteristics of the ruminal environment

Parameter	P-1	P-2	P-3	P-4	P-5	P-6	CD at 1%
pH	7.00 ±0.08[a]	6.65 ±0.08[b]	6.57 ±0.11[c]	6.39 ±0.19[d]	6.12 ±0.25[f]	6.24 ±0.04[e]	0.02
TVFA	95.4 ±1.8[a]	93.1 ±1.6[b]	93.0 ±1.5[b]	93.3 ±1.5[b]	93.9 ±1.9[b]	95.7 ±2.2[a]	0.9
Acetate (meq/l)	62.7 ±0.1	62.6 ±0.1	62.5 ±0.1	62.7 ±0.1	62.6 ±0.1	62.6 ±0.1	0.2
Butyrate (mg/l)	12.9 ±0.3[ab]	13.1 ±0.4[a]	13.0 ±0.3[ab]	12.5 ±0.3[c]	12.4 ±0.3[c]	12.8 ±0.4[b]	0.2
Isobutyrate (mg/l)	1.20 ±0.04[d]	1.20 ±0.04[d]	1.27 ±0.05[b]	1.31 ±0.06[a]	1.24 ±0.05[c]	1.22 ±0.04[cd]	0.02
Isovalerate (mg/l)	2.20 ±0.02	2.18 ±0.02	2.20 ±0.02	2.20 ±0.02	2.18 ±0.01	2.19 ±0.02	0.02
Propionate	25.2 ±0.2	25.1 ±0.2	25.1 ±0.02	25.2 ±0.2	25.2 ±0.2	25.2 ±0.2	0.1
Valerate (mg/l)	2.34 ±0.06[b]	2.34 ±0.06[b]	2.33 ±0.07[b]	2.38 ±0.05[a]	2.35 ±0.05[b]	2.39 ±0.07[a]	0.02
A:P ratio	2.49 ±0.02	2.49 ±0.02	2.49 ±0.02	2.49 ±0.02	2.49 ±0.02	2.49 ±0.02	0.01
Total-N (mg/l)	54.7 ±0.92	54.8 ±1.0	54.9 ±1.0	55.6 ±1.0	55.6 ±1.0	54.4 ±1.1	1.4
NH3-N (mg/l)	7.56 ±0.10[cd]	7.60 ±0.1[bc]	7.53 ±0.07[d]	7.66 ±0.04[a]	7.52 ±0.03[d]	6.65 ±0.02[ab]	0.05
Urea-N (mg/ml)	3.36 ±0.08[d]	3.39 ±0.08[c]	3.37 ±0.09[cd]	3.43 ±0.11[ab]	3.42 ±0.09[b]	3.45 ±0.12[a]	0.02
Non-Ammonia and urea nitrogen (mg/ml)	43.8 ±0.9	43.9 ±1.0	43.5 ±1.1	44.6 ±1.0	44.6 ±1.0	43.1 ±1.1	1.6

[abc]- *Values bearing different superscripts differed significantly.*

The content of total nitrogen in rumen liquor remained non-significant with the buffer regime in animal feeding. The trend in literature concluded that the increased dose of buffers in caprine nutrition declined total nitrogen in rumen liquor (Kishore et al. 1996). The difference may be due to the different animal species used for the experiment.

Decreasing pattern of the content of ammonia nitrogen in rumen liquor with an increased level of buffers included in the diet was observed in the present study. It was presumed that during the proteolytic activity, deamination took place in the rumen liquor by which proteins braked down to peptides, amino acids, and finally ammonia. Carbon dioxide, produced during the metabolism of carbohydrates, combined with the ammonia and produced urea, Due to the addition of buffers in the diet microbial population (Shimada et al. 1989), which resulted in increased production of urea nitrogen in the rumen liquor. Similar results were recorded in the present investigation. As far as the content of non-urea and ammonia-nitrogen concentration in rumen liquid was concerned it remained unchanged with the increased level of the buffer. It could be due to the faster recycling of nitrogen to form microbial protein. However, results in this connection are not available in the literature to confirm the results.

The results of the rumen metabolism study indicated that pH declined, the concentration of total volatile fatty acid, butyrate and valerate, and A:P ratio also increased, and the concentration of acetate, propionate and ammonia nitrogen decreased in rumen liquor due to supplementation of buffer in calves' nutrition. The pattern of pH showed decreasing up to 10 hours and total volatile fatty acid up to 6 hours, and iso-butyrate, ammonia nitrogen, and urea nitrogen concentration in rumen content followed an equal pattern. Thus, the overall conclusion can be made that the addition of buffer in ruminant nutrition (buffer feed technology) was responsible to change the ruminal environment and thus it became helpful to produce surplus fat due to the appropriate pH and A:P ratio.

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