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RESEARCH ARTICLE

ANDROPOGON GAYANUS KUNTH FORAGE PRODUCTION AND NUTRITIVE VALUES UNDER DIFFERENT CUTTING INTERVALS IN SOUTH REGION OF BENIN.

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Abstract

The grassland resource could be better managed if the effect of different defoliation regimes on the amount of the dry matter and nutritive value was known. Consequently, 9 accessions of Andropogon gayanus Kunth were evaluated in south region of Benin with an average 1100 mm annual rainfall during 3 years for ley pasture without any fertiliser input. Three cutting regimes (3-10-3, 5-6-5 and 6-4-6-week) were tested for dry matter production (DM), crude protein (CP) content, CP production and mineral (Ca, Mg, P, K, Na, Zn, Mn, Cu and Co) contents. Significant differences were observed between accessions ($p<0.05$), cutting regimes ($p<0.05$) and years ($p<0.05$) for DM and CP production. Accession and cutting regime influenced significantly CP content ($p<0.05$) but year had no influence. Forage harvested from 3-10-3-week regime produced significantly ($p<0.05$) more DM (4742 kg $DMha^{-1}$) than 5-6-5-week (3635 kg $DMha^{-1}$) or 6-4-6-week cutting regime (3789 kg $DMha^{-1}$). But the reverse effect was observed for CP content as 3-10-3-week regime (5.68 gkg^{-1} DM) had significantly ($p<0.05$) lower CP than those of 5-6-5-week (8.55 gkg^{-1} DM) or 6-4-6-week cutting regimes (7.15 gkg^{-1} DM). Mineral concentrations varied between accessions but not by cutting regimes and years. Three accessions (n° 1, 4 and 5) consistently outproduced than others and can be harvested through 5-6-5-week cutting regime. P, Na, Zn and Cu deficiencies were the most common detected in the cropped forages.

Introduction:-

In savanna region of West Africa, agriculture is facing increasing pressure as a result of continuing increases in both human and livestock populations. In this region, inadequate supply of feeds is the bottleneck to livestock production. Basically, this situation is related to the dependence of livestock raising on naturally available feed resources and little development of forage crops for feeding to animals. One of the alternatives to improve livestock feeding, and thereby productivity, could be the cultivation of productive nutritious forages to be offered during critical periods of the production cycle of animals when other sources of feeds are in short supply. In most of the cases, pasture grasses in the tropics cannot satisfy even the minimum requirement of nutrients of animals due to harvesting or grazing at advanced stage of maturity. Pastures rapidly decrease in acceptability and digestibility, particularly with crude protein (CP) as low as 2–3% in some periods of the year (Teka et al., 2005) and this is far below the minimum CP requirement of 7-8% for livestock maintenance (Coleman et al., 2003). There is a need for pasture species with

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high dry matter (DM) production and quality in order to enhance livestock productivity in grazing or cut-and-carry system. In both systems, one of the main issues to be addressed is how often to use forage for better DM production and quality forage. Several studies have been conducted to test the effect of age of cutting on both yield and quality factors. Babatoundé (2005), Onyeonagu (2012), Adjolohoun et al. (2013) and Gbenou et al. (2018) commented that cutting frequency was the major factor that influenced the DM production and nitrogen concentration of grasses. Generally, studies conducted on the effect of cutting frequency on plant DM production showed that the more infrequent cutting, the higher the DM yields but the crude protein concentration and the proportion of digestible forage dropped correspondingly. Even if most of these studies have reported positive increasing effect of cutting interval on DM production and the adverse effect on harvested forage quality, some authors have pointed out some variation between species and even between accessions in the same species. For example, in Venezuela, Morillo et al. (1997) had tested three cutting frequencies (28, 42 and 56 days) and reported that P. maximum forage yield was not influenced by cutting interval but CP concentration and mineral nutrients of the plant were affected. Studying the influence of cutting frequency on three P. virgatum cultivars in Canada, Madakadze et al. (1999) reported significant cultivar*cutting interval interaction, suggesting that, in the same species, different clipping schedules should be recommended for cultivars. In North of Benin, work of Michiels et al. (2000) reported that, P. maximum forage crude protein content increased simultaneously with DM production from the beginning of the rainy season up to about 4 weeks and after decreased sharply up to about 8 weeks following the onset of the rainy season. These results showed that the effects of cutting intervals on grass forage DM production and quality vary and need a case-by-case study for each variety or accession and region.

In West Africa, pasture species evaluation with the objective of identifying the most productive and adapted species has been of interest for some years (Michiels et al., 2000 ; Buldgen et al., 2001; Babatoundé, 2005 ; Adjolohoun et al., 2013). Most of these species concerned exotic plants such as Pennisetum purpureum, Brachiaria. ruziziensis, Centrosema pubescens, Stylosanthes hamata and Aeschynomene histrix. Very few studies were conducted on autochthonous species such as Andropogon gayanus accessions which could have a potential for animal production. The aim of this study was to identify A. gayanus accessions and cutting regimes which could both maximizing forage production and nutritive values on low fertility soils in order to provide recommendations on accessions and cuttings management to smallholder farmers.

Material and methods:-

Site description

The experiment was conducted near Sègbohouè, located in Kpomassè region (7°60'N, 2°54'E), in southern Benin during 3 rainy seasons (2016-2018). The region has a sub-humid climate with a long term annual rainfall of 1100 mm and a bimodal distribution lasting from March–October with peaks in June and September. Annual rainfall in the region during the period of the experiment is 1200, 1105 and 1058. Minimum and maximum temperatures are observed in December (dry and cold season) and March (dry and hot season) with 19-20 °C and 30-33 °C, respectively. Soil at the experimental site was sandy (89% sand) with a pH of 6.0, organic carbon 0.8%, nitrogen 0.08% and P (extractable) = 8 ppm. Other mineral element concentrations were 0.9 cmol/kg for potassium and sodium, 1.6 cmol/kg for magnesium and 3.5 cmol/kg for calcium, giving an effective cation exchange capacity (ECEC) of 6.5 cmol/kg.

Culture establishment, DM and CP production evaluation

Some characteristics of A. gayanus accessions for this experiment are presented in table 1.

Table 1 summarizes some morphologic and agronomic traits of these accessions. The site was ploughed and harrowed before planting in 7 m x 7 m (49 m^2) plots separated from each other by a 2-m band. The nine A. gayanus accessions were established at the beginning of raining season in 2016 at 40-cm spacing (optimal density) using crown splits (4-5 tillers/hole). During the 3 experimental years, weeding was done manually with hand hoes. The following three cutting regimes were tested: 3-10-3, 5-6-5 and 6-4-6-week giving a constant period evaluation of 16 weeks for each cutting regime during each three years. They were chosen as a combination of four commonly cutting intervals to simulate grazing system (3 to 6-week interval) or a possible interval (10-week) in hay production systems. Treatment was a combination of each accession with cutting regime and was replicated 4 times, giving a total of 9×3×4 = 108 plots arranged in a complete randomised block design. Three weeks after planting, all the plots were cut back to a suitable height of 15 cm (standardization cut to promote a uniform stand) without recording biomass production data. Thereafter, a given cutting regime affected to each plot was applied and at the appropriate cutting date. Three quadrats of 1 × 1 m were randomly chosen in each plot and harvested at 15 cm above soil level using a sickle and immediately weighed. After each harvest, the residual biomass of the plots was cut to the same height and removed. Afterwards, forage from the 3 quadrats of each plot was bulked and 2 samples (approximately 200 g) were taken from each plot and oven-dried for 48-72 h at 60 °C and weighed for dry matter content and yield determination. These 2 samples were bulked per plot and ground through a 1-mm screen prior and analysed for CP (Kjeldahl-method, N×6.25). The DM production data over 16 weeks for each year was obtained by combining yields of the 3 harvest intervals of each cutting regime (3-10-3, 5-6-5 and 6-4-6-week) in each year. Forage CP content and CP production per ha were calculated for each year and treatment on the basis of the contribution of each cutting to total DM of the year. Standardization cuts were done each year at the beginning of raining season and harvested material was discarded.

Macro- and micro-nutrients determination

All samples harvested for each accession were pooled within years for each regime cutting on the basis of their contribution to total dry matter recorded in the year. Pooled samples were used to measure mineral concentrations. Ca, Mg, K, Na, Zn, Mn, Cu and Co concentrations were determined by atomic absorption spectrophotometry using a Perkin Elmer AAS-800 (Wellesley, MA). P was determined by the colorimetric method using Molybdovanadate reagent.

Statistical analysis:-

Means and standard error of means on DM production per ha, CP content and CP production per ha data were calculated for n = 4 for each treatment and year. The means were classified by the Differences of Least Square Means method using the MIXED procedure of the SAS 8.02 software (SAS Inc, Cary, NC, USA) with the following model: $A= \mu + Ei + Cj + Yk + (E*C)ij + (E*Y)ik + (C*Y)jk +(E*C*Y)ijk +eijkl$.

Where A is the result of the measurement, μ = overall mean, Ei = accession effect (i= 1, 2, …, 9), Cj = cutting regime effect (i = 1, 2, 3), Yk = year effect (k = 1, 2, 3), and their above two or three way interactions. The term eijkl = experimental error. When significant interaction occurred, the data were reanalysed separately by two- or one-way analysis of variance. Mineral content data were analysed through the following model: $B = \varepsilon + Mi + Nj + (M*N)ij + eijk$. Where B is the result of the measurement, ε = overall mean, Mi = accession effect (i= 1, 2, …, 9), Nj = cutting regime effect (i = 1, 2, 3) and (M*N)ij their interaction. A $p < 0.05$ level of significance was used to separate means

Results:-

Dry matter, crude protein content and crude protein production

DM production data of tested accessions are presented in Table 2. There was significant difference between accessions ($p<0.05$), cutting regimes ($p<0.05$) and years ($p<0.05$) (Table 3). DM production averaged across accession, cutting regime and year was 4055 kg $ha^{-1}year^{-1}$ (not showed in table 2). Averaged over accessions, accession 4 was the most productive (7871 kg $ha^{-1}year^{-1}$, not showed in table 2). DM production of accession 5 (5630 kg $ha^{-1}year^{-1}$) and accession 1 (5587 kg $ha^{-1}year^{-1}$) were significantly lower than that of accession 4. DM production of accession 9 (3734 kg $ha^{-1}year^{-1}$), accession 2 (3439 kg $ha^{-1}year^{-1}$), accession 8 (3201 kg $ha^{-1}year^{-1}$), accession 6 (2806 kg $ha^{-1}year^{-1}$) and accession 3 (2639 kg $ha^{-1}year^{-1}$) were not significantly different ($p>0.05$) (not showed in table 2). Accession 7 produced the lowest DM (1589 kg $ha^{-1}year^{-1}$). Over cutting regimes, 3-10-3-week cutting regime had produced (4742 kg $ha^{-1}year^{-1}$) significantly ($p < 0.05$) more than the two others (4-6-4- and 5-6-5-week with 3789 and 3635 kg $ha^{-1}year^{-1}$, respectively). There is no significant difference between DM productions of 4-6-4- and 5-6-5-week cutting regimes. The two or three-way interactions were not significant except for accession*year ($P=0.013$) (Table 3).Through accessions and cutting regimes, year 1 (4742 kg $ha^{-1}year^{-1}$) produced significantly ($p<0.05$) more DM than year 2 (3789 kg $ha^{-1}year^{-1}$) and year 3 (3635 kg $ha^{-1}year^{-1}$). A decrease in DM production was observed for all accessions during the three year experiments but the extent of decrease varied largely according to accessions. Accession 1 was less affected by DM decreasing. In year 3, this accession produced 64% of the forage yield in year 1 but other accessions produced only between 25 and 50% of their DM yielded in year 1.

Crude protein concentrations of tested accessions were presented in table 4. There was significant difference between accessions ($p < 0.05$) and cutting regimes ($p < 0.01$) for CP content but year effect was not significant ($p > 0.05$) (Table 3). Cutting regime influenced more significantly forage crude protein content than accession. CP per ha is presented in table 5. It was significantly influenced by accession, cutting regime and year (table 3).

Mineral concentrations

Among tested plants, accession 7 appeared to be more concentrated for macronutrients content (Table 6). Its forage ash content was the highest and represented 1.5 to 2.6 times those of others accessions. Its P content was 1.8 to 2.9 times as compared to others. Its Mg and K contents were the highest of all. Accessions 1, 4 and 8 showed the lowest Ca concentrations. All accessions had similar Na concentrations. For micro-nutrients, significant differences were observed between accessions for Zn, Mn and Cu. However accessions didn't differ significantly in Co content (Table 6).

Discussions:-

Dry matter production, crude protein content and crude protein production

Despite that all accessions belong to the same species, significant difference ($p < 0.05$) for DM production appeared between them across cutting regimes and years, showing that they react differently toward these parameters. Therefore, there are great possibilities for choosing some of them for increasing animal feeds in West Africa region. Accession 4 was consistently the highest and accession 7 the lowest yielder. The superior yield of accession 4 at all harvest regimes may be a function of its better soil nutrients or water use (Pieterse et al., 1997; Adjolohoun et al., 2008; Buldgen and Dieng, 1997, Buldgen et al., 2001). On the other hand, accession 4 was reported by Adjolohoun (in press) to have more leaves than others. This intrinsic trait of this accession can allow it to have more surface area and therefore more photosynthesis activity due to more solar irradiance quantity which could be intercepted. This particular characteristic can contribute to its higher DM production (Alejandra et al., 1997; Buldgen and Dieng, 1997). A decrease in dry matter production was observed through the years for all tested accessions. This could be explained by low soil fertility, non-input nutrient to soil during three years harvesting and, probably, a rainfall decreasing through three year experiments. A decrease in DM production has been reported in others studies in the area (Adjolohoun et al., 2008). Out of these nine accessions, accession 9 had a lesser DM decreasing, showing its better adaptation to environment conditions prevailing in the testing area.

There were no significant accession*cutting regime interaction ($p = 0.663$) for DM production. This result shows that cutting regime influence through accessions for DM was similar for all nine tested accessions. This result is interesting and of practical implication as it allows for suggesting to small farmers the same cutting regime independently to accessions or harvesting year. Cutting regime of 3-10-3-week had produced constantly the highest dry matter. Nevertheless, all of forages harvested according to this regime had between 5-6 g CPkg^{-1} DM and therefore, less than 7-8 g CPkg^{-1} DM required by Minson (1990) and Coleman et al. (2003) for adequate ruminant nutrition. Such forages with low CP content will limit micro-organism activities in the rumen and therefore induce slow rate of digestion. This would result in decreased DM intake and reduced animal performance. So, cutting regime of 3-10-3-week, even if it allows the highest dry matter production couldn't be recommended to farmers.

Minerals concentration of forages

Accession 5 forage concentrations in Ca are more than three times that of accession 8. All of forage concentrations in Ca are above the requirements levels of 2.4 g/kg (Rivière 1991) except for accession 8 (2.08 g/kg). Herbage Ca is used very efficiently by cattle when necessary and an average forage Ca absorbability of 0.68 can be exceeded (AFRC, 1991) for tested accessions. The highest level of 7.21 g/kg obtained with accession 5 can suggest a possible toxicity for sheep, but Ca is not generally regarded as a toxic element, because homeostatic mechanisms ensure that excess dietary Ca is extensively excreted in faeces (Underwood et al.1999). P forage concentrations (0.62-1.81 g/kg DM) recorded in this trial were lower than that reported for P. maximum cv Mulate (2.5 g/kg DM) (Pieterse et al., 1997) but, forage P of accession 7 (1.81 g/kg DM) compared well with those noted for P. maximum cv Petrie, Gatton and Vencidor (1.7-1.8 g/kgDM) reported by Pieterse et al. (1997). Deficiency for P is the most common nutritional mineral problem for the tested accessions in the area (Adjolohoun et al., 2008, Adjolohoun et al., 2013), probably due to the low P levels in soils. P supplementation would be necessary for animal feeding in the area. Under the same environmental and growing conditions, concentration in P forage of accession 7 was more than 3-fold that of accession 2 showing the possibility of choosing maximum A. gayanus accession that could have an important contribution for herbivorous P diet for this region. K concentrations of tested forages were largely above the critical values for deficiency suggested for grazing ruminants and summarized by (NRC, 2000). Except for accession 7, forage Mg contents observed in this study were in the range 1.05-1.97 g/kg DM. They were lower than the range of 2.4-3.9 g/kg DM reported for P. maximum cv. Gatton by Davison et al., (1987). Except for accessions 4 and 6, forage Mg content differences were lower to meet animal requirements, specially for pregnant and lacting cattle which need 1.4-2.1 g kg^{-1} DM (Sultte, 1983). The low concentrations of forage in Na, Zn and Cu need a provision of mineral supplements when the forages are solely used in animal feeding.

Conclusion:-

gayanus is one of the important forage species in West Africa. This study had produced valuable findings as it demonstrated an useful great variability in potentials between tested accessions for dry matter and nutritious forage production never reported among indigenous accessions of this species. Such investigations should be continued to increase this species germplasm availability for improving ruminant nutrition in West Africa. Under the conditions of this experiment, it can be concluded that accessions 1, 4 and 5 are the most interested for both dry matter and crude protein production. Among the 3 cutting regimes tested, 5-6-5-week regime could be recommended for maximizing both quantity and quality forage production. In general, forage of tested accessions had adequate Ca, K, Mg and Co contents for satisfying livestock dietary maintenance requirement. However, forages need to be complemented for P, Zn and Cu for good animal production. Due to variation in the area conditions and their effects on plant production, we suggest that the study should be continued in others environments. On another hand, the accessions were chosen and tested for their use by farmers as ley pastures under low input conditions. Therefore, the study should be followed by complementary work on the influence of these accessions on soil nutrients depletion after three years cultivation without fertilizer input.

Tableau 1:-Some morphologic, agronomic and physiologic traits of tested Andropogon gayanus accessions

Traits		Accession								
		1	2	3	4	5	6	7	8	9
Morphologic										
Plant height (cm)		123	178	271	166	258	328	430	359	233
Leave length (cm)		47	59	66	51	76	87	107	93	55
Leave wide (mm)		25	32	37	26	34	37	42	38	37
Tiller per stuff (unity)		33	49	43	57	48	52	44	64	77
Tiller diameter (mm)		7	6	5	5	6	5	6	4	4
Stuff diameter at 75 cm above soil level (cm)		40	40	53	57	53	58	52	59	69
Panicle length (cm)		38	41	39	46	60	74	114	95	39
Agronomic										
Leaf/stem (ratio)		1.35	1.18	1.0	1.02	0.99	0.91	1.05	0.99	0.75
Leave number/tiller (unity)		7.6	7.5	7.4	12.0	8.6	9.4	8.0	9.5	8.0

Table 2:-Dry mater yield (kgha^{-1}) of 9 Andropogon gayanus local accessions under 3 cutting regimes during three years

	Year								
Accession	2009			2010			2011		
	3-10-3	5-6-5	6-4-6	3-10-3	5-6-5	6-4-6	3-10-3	5-6-5	6-4-6
Accession 1	5403 Acd[1]	4104 Acd	4218 Ac	4341 Bc	3322 Bc	3434 Bc	3377 Cc	2602 Cb	2808 Cb
Accession 2	5531 Acd	4786 Acd	4987 Ac	3965 Bcd	3105 Bc	3260 Bc	2144 Cd	1599 Cbc	1571 Ccd
Accession 3	4177 Ae	3845 Ad	4065 Ac	3014 Bd	2594 Bcd	2468 Bd	1451 Ce	1065 Ccd	1076 Cd
Accession 4	11106 Aa	9689 Aa	9887 Aa	9567 Ba	7109 Ba	8210 Ba	6045 Ca	4539 Ca	4687 Ca
Accession 5	9400 Ab	7999 Ab	8056 Ab	6509 Bb	4472 Bb	4656 Bb	4443 Cb	2305 Cb	2800 Cb
Accession 6	4277 Ae	3590 Ad	3806 Ac	3200 Bd	2506 Be	2697 Bde	2199 Cd	1475 Cc	1500 Ccd
Accession 7	3136 Ae	2139 Ae	2560 Ad	2056 Bd	985 Be	1290 Be	910 Ce	405 Cd	820 Cd
Accession 8	6560 Ac	5256 Ac	4945 Ac	3502 Bcd	2076 Bd	2301 Bd	2015 Cd	910 Cd	1243 Cd
Accession 9	10023 Aab	8643 Aab	7780 Ab	6134 Bb	4967 Bb	5060 Bb	3541 Cc	2051 Cbc	2080 Cc
Mean	6624	5561	5593	4699	3460	3708	2903	1883	2065
SEM	557	521	485	439	346	414	346	224	242

[1] Values within a column followed by the same lower case letter do not differ significantly ($p<0.05$). For the same cutting regime and for the same accession, values followed by the same upper case letter do not differ significantly ($p<0.05$).

Tableau 3:-Results of a 3-way ANOVA (GLM) showing the significance of accessions (9 accessions), cutting regimes (3-10-3-week, 6-5-6-week, 5-6-5-week), year (2009, 2010, 2011) and their interactions on dry matter production, crude protein content and crude protein production

Effect	Dry matter yield	Crude protein content	Crude protein yield
Accession	< 0.05	0.037	0.013
Cutting regime	< 0.05	0.017	0.015
Year	< 0.05	0.601	0.003
Accession×cutting regime	0.663	0.097	0.232
Accession×Year	0.013	0.261	0.076
Cutting regime×year	0.720	0.321	0.231
Accession×cutting regime×year	0.874	0.881	0.695

Table 4:-Crude protein concentrations of 9 Andropogon gayanus local accessions under 3 cutting regimes

Cutting regime	Accession									Mean
	1	2	3	4	5	6	7	8	9	
3-10-3	5.41 ABc(1)	5,80 ABc	5,24 ABc	5,76 ABc	5,23 ABc	5,02 Bc	5,95 ABc	6,01 Ac	6.00 ABc	5,68
5-6-5	8,66 Ba	8,76 ABa	9,00 ABa	8,99 ABa	8,55 BCa	7,34 Ca	8,89 ABa	9,64 Aa	8,07 Ba	8,55
6-4-6	7.01 Bb	6,98 Bb	7,55 Bb	8,03 ABb	7,85 ABb	6,89 Bb	7,44 Bb	8,32 Ab	7.00 Bb	7,15
Mean	7.03	7.18	7.26	7.59	7.21	6.42	7.43	7.99	7,02	7,12
SEM	0.22	0.21	0.26	0.23	0.24	0.17	0.20	0.25	0.14	0,13

(1) Values within a column followed by the same lower case letter do not differ significantly ($p<0.05$). In the same line, values followed by the same upper case letter do not differ significantly ($p<0.05$).

Table 5:-Crude protein production per ha of 9 Andropogon gayanus local accessions under 3 cutting regimes (x-y-z-week) during 2008, 2009 and 2010.

Accession	Year								
	2008			2009			2010		
	3-10-3	5-6-5	6-5-6	3-10-3	5-6-5	6-5-6	3-10-3	5-6-5	6-5-6
Accession 1	292 Ad	355 Ae	296 Af	235 Bc	287 Bc	241 Bc	182 Cbc	225 Cb	197 Cb
Accession 2	321 Ad	419 Ad	348 Ae	230 Bc	272 Bc	227 Bcd	125 Cc	140 Ccd	110 Cc
Accession 3	219 Ae	346 Ae	307 Aef	158 Bd	234 Bcd	186 Bde	76 Cde	96 Cde	82 Cd
Accession 4	640 Aa	871 Aa	791 Aa	551 Ba	639 Ba	657 Ba	348 Ca	408 Ca	375 Ca
Accession 5	492 Ab	684 Ab	635 Ab	340 Bb	383 Bb	366 Bb	232 Cb	197 Cbc	220 Cb
Accession 6	215 Ae	264 Af	262 Af	161 Bd	184 Bde	187 Be	111 Ccd	108 Ce	103 Cc
Accession 7	187 Ae	190 Af	190 Ag	122 Bd	88 Be	96 Bf	54 Ce	45 Cf	61 Cd
Accession 8	394 Ac	507 Ac	411 Ad	211 Bc	200 Bd	192 Bd	121 Cc	88 Cde	104 Cc
Accession 9	601 Aa	698 Ab	544 Ac	368 Bb	401 Bb	354 Bb	213 Cb	165 Ccd	146 Cc
Mean	373	482	421	264	299	278	163	165	155
SEM	33	45	38	25	30	33	20	21	19

(1) Values within a column followed by the same lower case letter do not differ significantly ($p<0.05$). For the same cutting regime and for the same line, values followed by the same upper case letter do not differ significantly ($p<0.05$).

Table 6:-Macro- and micro-mineral concentrations of Andropogon gayanus accessions compared with ruminant needs (n = 3)*.

Accession	Ash	Macro-minerals					Micro-minerals			
		Ca	P	Mg	K	Na	Zn	Cu	Mn	Co
	(% DM)	(g/kg DM)					(mg/kgDM)			
Accession 1	5.77 e[1]	6.66 a	0.62 e	1.97 b	10.59 b	0.1 a	14 b	3 b	81 ab	0.1 a
Accession 2	9.05 b	6.61 a	0.59 e	1.89 b	8.46 c	0.2 a	12 b	6 a	75 bc	0.1 a
Accession 3	7.43 cd	5.55 b	0.92 bc	1.40 c	7.98 c	0.1 a	16 ab	5 ab	66 c	0.1 a
Accession 4	5.90 e	5.95 b	0.87 c	1.05 c	9.04 c	0.1 a	15 ab	4 b	88 ab	0.1 a
Accession 5	10.01 b	7.21 a	0.65 de	1.93 b	10.88 b	0.2 a	16 ab	7 a	80 ab	0.2 a
Accession 6	6.66 de	6.01 ab	1.01 b	1.07 c	12.02 b	0.1 a	15 ab	4 b	91 a	0.1 a
Accession 7	15.09 a	5.98 b	1.81 a	2.65 a	21.6 a	0.1 a	20 a	5 ab	77 b	0.1 a
Accession 8	5.78 e	2.08 d	0.77 cd	1.91 b	8.21 c	0.1 a	17 ab	4 b	69 c	0.1 a
Accession 9	8.55 bc	3.76 c	0.79 c	1.36 c	10.55 c	0.1 a	18 a	3 b	65 c	0.1 a
Mean	8.25	5.87	0.86	1.69	11.04	0.1	16	5	77	0.1
SEM	3.2	1.01	0.3	0.8	9	0.0	4	0.5	14	0.0
Ruminant needs[2]	-	2.4	1.2	1.2	6-8	0.7	50	10	50	0.1

[1] Values within a column followed by the same case letter do not differ significantly ($p<0.05$). Cutting regime had no significant effect on accession mineral concentrations and therefore, only means through accession are presented.
[2] Requirements for cattle (200 kg LWt) with average liveweight gain of 100 g/d (Rivière 1991) for Ca, P and S; NRC (2000) for K, Na and Underwood and Suttle (1999) for Mg.

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