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Research Article

Agronomic Behaviour and Chemical Composition of Three Varieties of *Pennisetum* sp in the Peruvian Tropics

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Livestock production in the Peruvian tropics is mainly based on grazing and cutting grasses, which have variable productive and nutritional characteristics according to the variety of grasses, agronomic management, and climatic conditions. The objective of this research was to compare the agronomic behaviour and chemical composition of three varieties of *Pennisetum* sp (*Pennisetum purpureum* Schum cv. Cameroon or Cameroon grass, *Pennisetum* sp. or Maralfalfa, and *Pennisetum purpureum* × *Pennisetum typhoides* or King grass). The experiment was carried out at the Estación Experimental Agraria "Campo Verde," Ucayali, Peru, under a randomized complete block design (RCBD) with a 3 (*Pennisetum* sp. variety) × 3 (cutting age) factorial arrangement and 4 replicates each. Thirty-six subplots were installed, and treatments were randomly assigned, using vegetative seed with three buds each. Measurements of agronomic behaviour and chemical analysis were carried out in the 8th, 12th, and 16th week. The data were subjected to ANOVA and multiple comparisons with the Duncan and Kruskal–Wallis tests ($p < 0.05$) and correlations using Pearson coefficients ($p < 0.05$). The agronomic behaviour did not vary between *Pennisetum* sp. varieties, but according to cutting age, Cameroon grass produced greater plant height, biomass, dry matter, and Mg content at the 8th week. The highest concentrations of N (2.38 ± 0.11%), P (0.18 ± 0.01%), and Ca (0.70 ± 0.03%) were recorded at the 8th week, Zn (27.33 ± 1.91 mg/kg) at the 12th week, and Mg (0.26 ± 0.02%) at the 16th week. A negative correlation was found between biomass and the stem-leaf ratio at the 12th week because the first leaves of plants died, but the stems increased in size. It is concluded that, at an early cutting age in varieties of *Pennisetum* sp., lower biomass and dry matter result, but higher content of N, P, Ca, and Fe; and at a late cutting age, it shows greater biomass, dry matter, Cu, and Mg content.

1. Introduction

In Peru, 70% of the deforested forests in the Amazon have been destined for the establishment of cultivated pastures for extensive livestock activity [1]. Pastures are generally managed without adequate soil and pasture management techniques, resulting in overgrazing and erosion [2, 3]. Overgrazing causes negative effects on pastures, such as accelerated compaction, which reduces pore space and drainage capacity, hindering plant root development [4, 5].

Grazed grasses are the main source of food for livestock in the tropics, as they provide nutrients at a low cost compared to concentrated feed [6, 7]. However, the dry season dramatically impacts the productivity and nutritional quality of these pastures, dependent on adequate humidity and light incidence [8–10], causing losses in livestock productivity [11]. Cutting grasses can contribute to meeting feed needs during the dry season [12, 13]. Cutting grasses, such as those of the genus Pennisetum, were introduced from North America and tropical Africa and adapted to the tropical regions of Peru [14], exhibiting high biomass yields and nutritional content; however, agronomic behaviour can vary, depending on the type of soil, fertilization, as well as the frequency and intensity of cutting [15].

Pennisetum sp. o Maralfalfa is characterized by its adaptability up to 3000 meters above sea level and reaching a protein content of up to 16% in fertile soils and Ca, P, Mg, and K contents of 0.37%, 0.50%, 0.37%, and 6.28%, respectively [16, 17]. *Pennisetum purpureum* × *Pennisetum typhoides* or King grass reaches a protein content of 12–15%, lignin between 5.3 and 6.5% [18], and other varieties range between 3.85 and 6.70% [19]. There are few reports of productivity of these species adapted to the Ucayali region, Peru; however, environmental conditions and crop management are relevant factors in the expression of agronomic behaviour and establishment of *Pennisetum* sp. Appropriate age and cutting height could influence the growth rate, yield per hectare, nutritional quality, and persistence of the crop over time [20, 21]. Therefore, the objective of the study was to compare the agronomic behaviour and chemical composition of three varieties of *Pennisetum* sp subjected to different cutting ages.

2. Materials and Methods

2.1. Study Area and Location. The experiment was carried out at the Estación Experimental Agraria "Campo Verde" in Coronel Portillo province, Ucayali department, Peru. The area is located between the coordinates of 08°32′23.81″S south latitude and 74°52′48.86″W west longitude, at an altitude of 140–300 meters above sea level (Figure 1). The average annual relative humidity is 84.2%, the average temperature is 31.60°C, and the average precipitation is 2191.96 mm.

2.2. Experimental Design. The experiment was carried out in a randomized complete block design (RCBD) with a 3 × 3 factorial arrangement (*Pennisetum* sp variety × cutting age). Four blocks per treatment were used, considering the blocking criteria to irregular soil topography. In an area of 3,072 m^2 (128 × 24 m), four plots or blocks of 945 m^2 each (32 × 24 m) were divided. In each block (B1, B2, B3, and B4), 3 main plots were established, with an effective area of 210 m^2 each (32 × 6 m), making a total of 12 plots. Within each plot, 3 secondary plots or subplots were randomly arranged, with an effective sampling area of 50 m^2 (10 × 5 m) each, and this excludes the edge effect (Figure 2). The experimental unit consisted of 175 plants planted at a distance of 1 m between rows and 0.5 m between plants. Three varieties of *Pennisetum* sp. were installed: Maralfalfa (*Pennisetum* sp.), King grass (*Pennisetum purpureum* × *Pennisetum typhoides*), and Cameroon (*Pennisetum purpureum* Schum cv. Cameroon).

2.3. Pasture Installation and Fertilization. The soil characteristics at the time of the experiment were as follows: sandy clay loam texture, pH 5.12, N 0.08%, P 2.66 mg/kg, and K 0.22 Cmol/kg. The preparation of the land was performed manually, and phosphate rock and dolomite were incorporated by broadcast in a ratio of 100 kg of each per plot. Sowing was carried out using vegetative seed, with cuttings that had three buds.

2.4. Agronomic Behaviour. The variables such as plant height (cm), coverage (%), number of tillers, and stem/leaf ratio were recorded at three cutting ages at the 8th, 12th, and 16th week of growth. Plant height was measured with a metric ruler and was considered from the base of the soil to the highest part of the plant without stretching or counting inflorescence. Coverage was recorded as a percentage per square meter and was estimated based on the apparent proportion in which the pasture covered each area of the quadrat. The number of tillers was counted in an area of 1 m^2, and the number of seedlings within the square meter was considered. The stem/leaf ratio consisted of the quotient of the weight of all the leaves between the weight of all the stems. For the biomass yield, a vegetative material of 1 m^2 was cut and weighed, taking into account the established cutting frequencies. The cut was made at a height of 15 cm from the soil, later extrapolating the value to one hectare. The dry matter was obtained from the fresh weight and dry weight of the sample in grams, and 250 g of biomass was used to submit to 60°C in an oven (Memmert, Germany) until a constant weight was obtained.

2.5. Chemical Composition. A total of 16 samples were analysed, the samples were weighed and ground in a hammer mill for further analysis, and to determine the nitrogen (N) content, micro-Kjeldahl digestion was used [22]; phosphorus (P) content was determined by colorimetry [23], and potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn), and manganese (Mn) contents were determined by the Mehlich method using an atomic absorption spectrophotometer [24].

2.6. Data Analysis. The normality of the data of quantitative variables was verified using the Shapiro–Wilk test ($p > 0.05$), and homogeneity of variances was verified with the Levene test ($p > 0.05$). Then, analysis of variance was performed, and if the difference between groups was significant, multiple comparisons were performed with Duncan's parametric test ($p < 0.05$) for the agronomic variables and for N, P, K, Mg, Fe, and Mn. The concentration of Ca, Cu, and Zn was also

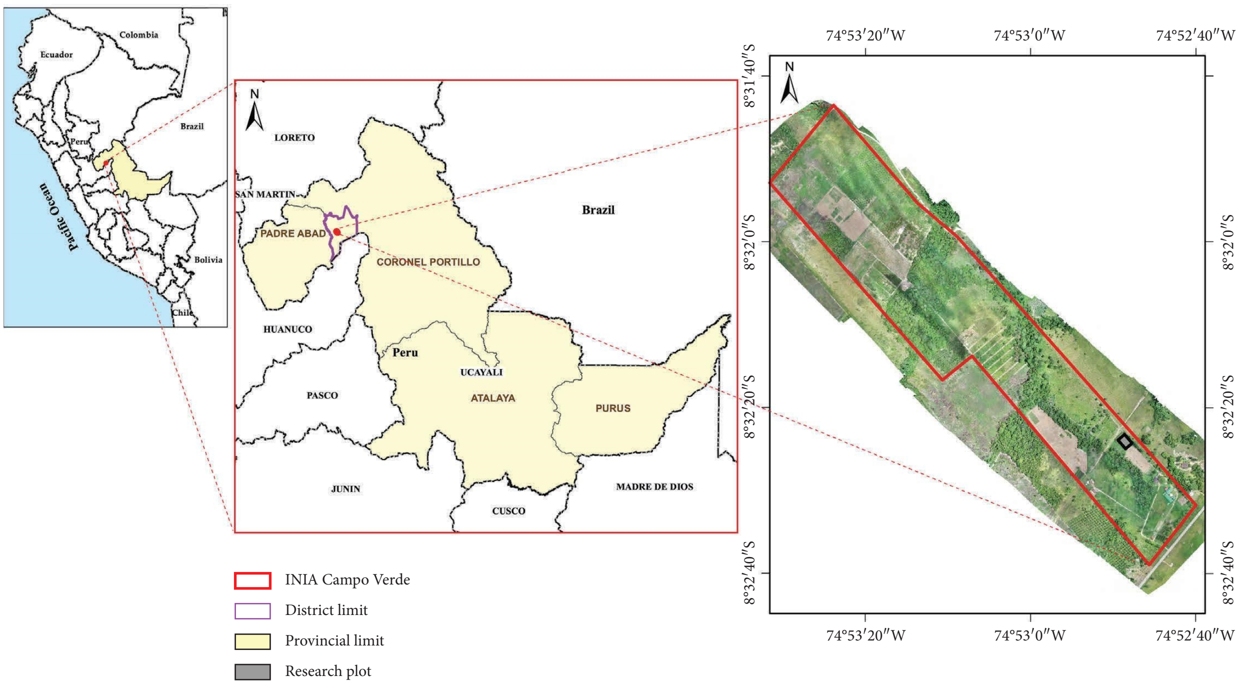

Figure 1: Geographical location of the experiment.

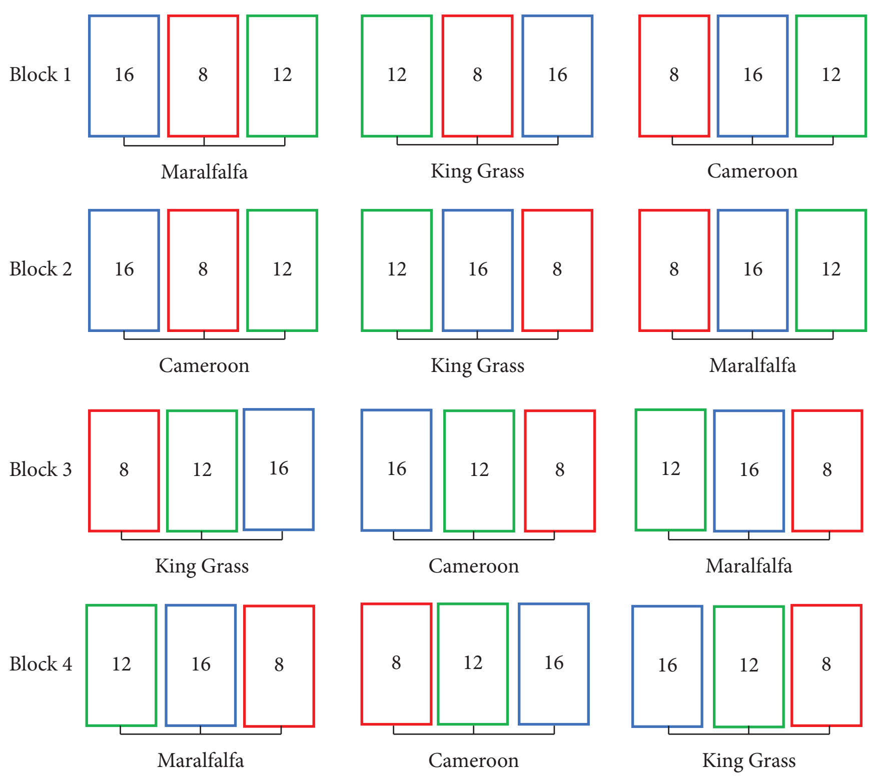

Figure 2: Distribution of treatments. 8, 12, and 16 are weeks indicating the moment of the cut. Red color indicates 8 weeks of age, green color indicates 12 weeks of age, and blue color indicates 16 weeks of age.

analysed with the Kruskal–Wallis nonparametric test. All the multiple comparisons were made using the SPSS v.26 software, and the correlations of the agronomic and chemical variables were made with the Pearson test ($p < 0.05$) in R Studio v. 4.2.1.

3. Results and Discussion

3.1. Agronomic Behaviour. The average values of the agronomic behaviour of the three varieties of *Pennisetum* sp and according to their cutting age are detailed in Table 1. No significant differences ($p > 0.05$) were found between varieties for any of the agronomic variables. Plant height, the number of tillers, biomass, and dry matter content were affected by cutting age ($p < 0.05$). The tallest plants were observed at the 16th week, but the highest number of tillers was observed at the 8th and 12th week, with no significant differences between them ($p > 0.05$). Biomass production was higher in the 16th week, and dry matter was higher in the 12th and 16th week ($p < 0.01$).

The results found in plant height are lower than that of *Pennisetum* sp reported by Hermitaño et al. [13], with 257 cm length at 75 days. Calzada-Marín et al. [25] also reported higher heights of *Pennisetum* sp in warm subhumid climates (230 cm at 150 days). Variations in plant height can be explained by the size of the leaf area, since with a greater leaf area, there will be greater competition for light between plants. Anten and Hirose [26] maintained that the height of the plant decreases with a greater leaf area, since the penetration of solar rays to other plants is difficult. Plant height is strongly linked to the length of the photoperiod, temperature, humidity, and soil fertility. If these environmental variables are suitable for the physiology of grasses, they will accelerate their growth [27, 28]. The height and other morphophysiological changes of plants are observed when 95% of light interception is exceeded, this being the optimal time for grass harvesting [29, 30].

A greater number of tillers were found in 8th and 12th weeks of cutting age. According to Tinini and Limache [31], the number of tillers in pasture for cutting, especially in *Pennisetum* sp, varies from 14 to 55 tillers. *Pennisetum* sp is characterized by developing high capacity to generate numerous tillers [13, 32]. The growth dynamics of the morphological components of *Pennisetum*, such as tillering, leaves, stems, and dead material, constantly increase up to 151 days [25]. For this reason, Portugal et al. [33] argued that tropical pastures need more efficient handling, because they present high rates of pasture mass accumulation due to the high number of tillers, but quality could deteriorate more quickly.

Biomass production and dry matter content varied according to cutting age. These findings coincide with the reports by Cifuentes et al. [34], who found biomass productions of 30.66, 47.88, and 51.11 t DM/ha in Maralfalfa. In the case of Maralfalfa, Hermitaño et al. [13] reported that biomass did not differ between 45, 60, and 75 days of cutting age. The dry matter content in this research varied according to cutting age, from 28 to 51 g DM/100 g MV. In this regard, Gurrola et al. [35] reported approximately 22 t DM/ha in Maralfalfa (*Pennisetum* sp) at 90 days of age, and Araya and Boschini [36] found 15.2 t DM/ha in King grass. The production of biomass and dry matter content were due to the contribution of leaves and stems and to the phenological state of the plant [37, 38].

In the stem/leaf ratio, no significant differences were found between varieties of *Pennisetum* sp and cutting age. However, Calzada-Marín et al. [25] mentioned that the ratio tends to decrease as the age of the pasture increases. This is supported by the increase in biomass of the stems, and the leaves begin to be senescent [39]. No significant effect of the interaction between variety and cutting age was found for any variable evaluated for agronomic behaviour.

3.2. Chemical Composition. The chemical composition of the three varieties of *Pennisetum* sp is detailed in Table 2. The content of N, P, K, Ca, Fe, Cu, Zn, and Mn did not differ significantly ($p > 0.05$) between varieties, but Mg concentration was higher ($p < 0.05$) in the Cameroon variety ($0.27 \pm 0.02\%$) than in Maralfalfa ($0.22 \pm 0.01\%$) and King grass ($0.19 \pm 0.01\%$). Cutting age had a significant effect ($p < 0.05$) on the content of N, P, Ca, Mg, Fe, and Zn, where at the 8th week, the highest content of N, P, Ca, and Fe was observed, and Zn and Mg were higher at the 12th and 16th week, respectively.

The concentration of macroelements in pastures is important because minerals establish a vital factor and imbalances or deficiencies thereof can cause serious pathologies, which will generate productive and economic losses for producers [40]. For example, the initial postpartum stage is where the metabolic-nutritional axes that control Ca, P, and Mg levels are most compromised, and the association of endocrine systems that control metabolism and regulate the immune system is evident [41].

The N content varied according to cutting age, which coincides with Ramos-Trejo et al. [42] and Herrera et al. [43]. The N content reduces as plants become more adult and mature, and cellulose content will increase [19]. The reduction in protein content as the grass ages is due to the reduction in the metabolic activity of the plant, so that as the grass is harvested at an older age, the synthesis of protein compounds in the plant is lower. Therefore, at older age, the *N* values will be lower [44]. For this reason, determining an optimal grass cutting moment is important to obtain grass with the highest protein content [45]. P in animal feed is directly related to the productive and reproductive efficiency of cows [46, 47]. In soils rich in P, grasses will have a high concentration of this mineral, but if P is not usable, the grass will be deficient in this mineral [48], generating the need for mineral supplementation. In this study, P concentrations in *Pennisetum* sp. varied between 0.10% and 0.18%. For dairy cattle, a P concentration of 0.31%–0.38% is recommended in the diets of moderate-to-high producing cows [49].

3.3. Correlations. Correlations between the agronomic behaviour variables according to age are shown in Figure 3. Biomass and dry matter were positively correlated with plant height ($p < 0.05$); however, at the 8th week, a negative

Table 1: Agronomic behaviour of three varieties of *Pennisetum* sp according to cutting age and interaction variety × cutting age[1].

Variables	Plant height (cm)	Coverage (%)	Tillers (N/m^2)	Biomass (kg/m^2)	Dry matter (g·DM/100 g·MV)	Stem/leaf ratio
Variety						
Maralfalfa	157.15 ± 18.77	23.73 ± 3.14	21.33 ± 2.30	2.91 ± 0.39	43.83 ± 4.82	2.41 ± 0.85
King grass	159.95 ± 17.78	25.10 ± 2.18	19.75 ± 1.50	2.51 ± 0.50	39.92 ± 4.12	3.27 ± 0.60
Cameroon	154.40 ± 19.15	17.65 ± 2.66	16.75 ± 1.71	2.19 ± 0.39	44.33 ± 4.67	2.79 ± 0.68
p value	0.801	0.106	0.166	0.188	0.676	0.698
Cutting age						
8th week	79.23 ± 6.11c	26.72 ± 3.12	22.50 ± 1.91a	1.25 ± 0.24c	28.75 ± 0.49b	2.34 ± 0.63
12th week	173.85 ± 6.70b	18.30 ± 2.00	19.91 ± 1.97b	2.50 ± 0.37b	48.33 ± 5.51a	2.74 ± 0.62
16th week	218.41 ± 6.00a	21.47 ± 2.74	15.41 ± 1.24c	3.87 ± 0.27a	51.00 ± 2.37a	3.39 ± 0.87
p value	<0.001***	0.078	0.021*	<0.001***	0.001**	0.363
Block						
B1	148.29 ± 19.25b	18.21 ± 2.31	17.00 ± 1.46	3.10 ± 0.47	38.33 ± 3.97	1.82 ± 0.25
B2	177.27 ± 20.80a	19.49 ± 3.02	21.89 ± 3.17	2.10 ± 0.51	45.44 ± 5.80	2.34 ± 0.66
B3	150.56 ± 23.08b	24.63 ± 3.30	16.89 ± 1.32	2.30 ± 0.50	43.00 ± 5.47	4.74 ± 1.24
B4	152.56 ± 22.25b	26.31 ± 3.73	21.33 ± 2.07	2.66 ± 0.50	44.00 ± 5.72	2.39 ± 0.48
p value	0.020*	0.173	0.147	0.143	0.697	0.43
Variety*cutting age						
Maralfalfa*8th week	78.95 ± 17.35	28.80 ± 15.98	25.25 ± 8.26	1.24 ± 0.30	29.25 ± 1.50	1.59 ± 0.39
Maralfalfa*12th week	172.65 ± 20.85	19.40 ± 4.24	23.00 ± 8.08	3.46 ± 0.44	49.50 ± 20.09	1.35 ± 1.26
Maralfalfa*16th week	219.85 ± 32.45	23.00 ± 9.99	15.75 ± 5.74	4.04 ± 0.76	52.75 ± 13.45	4.27 ± 4.80
King grass*8th week	86.60 ± 32.81	26.70 ± 7.58	22.50 ± 6.81	1.25 ± 0.31	29.00 ± 1.15	1.56 ± 0.57
King grass*12th week	179.00 ± 31.51	25.20 ± 1.36	21.50 ± 3.00	1.86 ± 1.68	42.25 ± 21.17	4.41 ± 1.98
King grass*16th week	214.25 ± 15.70	23.40 ± 11.97	15.25 ± 1.50	4.42 ± 0.81	48.50 ± 5.80	3.83 ± 2.33
Cameroon*8th week	72.15 ± 11.19	24.65 ± 10.18	19.75 ± 5.12	1.26 ± 1.52	28.00 ± 2.45	3.86 ± 3.50
Cameroon*12th week	169.90 ± 22.07	10.30 ± 2.56	15.25 ± 7.18	2.17 ± 1.05	53.25 ± 19.96	2.47 ± 2.29
Cameroon*16th week	221.15 ± 15.42	18.00 ± 2.56	15.25 ± 5.74	3.15 ± 0.91	51.75 ± 4.50	2.05 ± 0.84
p value	0.868	0.673	0.741	0.178	0.926	0.475

[1]Mean values ± standard error of the mean are presented. Different superscript letters in columns (a, b, c) represent significant differences at the $p < 0.05$ level (*), at the $p < 0.01$ level (**), or at the $p < 0.001$ level (***) by multiple comparisons with Duncan's test.

correlation between biomass and dry matter was observed. This is explained by the fact that at the 8th week, the plant still contains a greater volume of water in its cells and that as the plant becomes an adult, the water levels drop and dry matter increases [36]. The negative correlation between biomass and the stem/leaf ratio at the 12th week is due to the first leaves of plants dying, but the stems increase in size [39].

The correlations of agronomic behaviour according to *Pennisetum* sp varieties are shown in Figure 4. We found significant correlations between plant height and biomass and dry matter ($p < 0.05$). Plant height of King grass was positively correlated with biomass and dry matter ($p < 0.05$). In this regard, Contreras et al. [19] indicated that the higher the altitude, the greater the production of biomass and dry matter.

The correlations of chemical composition according to age of *Pennisetum* sp varieties are shown in Figure 5. N is positively correlated with P and Ca ($p < 0.05$), and P is positively correlated with K, Ca, and Cu ($p< 0.05$). Sterling and Guerra [50] mentioned that Ca and P contents are generally similar between *Pennisetum* sp varieties. This would indicate that deficiency of Ca in soil, therefore relatively high acidity, and the agronomic development of the crop could be affected by this variable. Maleko et al. [51] indicated that Ca and P concentrations in Napier pastures generally coincide with the values reported in this research, where P ranged between 0.13 and 0.19% and Ca ranged between 0.21 and 0.29%. According to NRC [52], minerals are very essential for ruminant reproduction (conception, gestation, and parturition), growth, maintenance, and production (e.g., milk and meat). However, the P and Ca contributions of *Pennisetum* sp. varieties are below the recommended levels in cattle of 0.36 and 0.43%, respectively [52]. The concentration of minerals in pastures is influenced by edaphic factors, seasons, and proportion of dry matter of biomass [53].

The correlations of the chemical composition according to *Pennisetum* sp varieties are shown in Figure 6. Correa [15] found Ca, P, Mg, and K contents of 0.37%, 0.50%, 0.37%, and 6.28%, respectively, in Maralfalfa at 56 days. However, in the present research, we found a higher level of Ca and lower levels of P, Mg, and K. Likewise, Andino and Pérez [54] reported values of 1.0% N, 0.6% P, 1.6% K, 0.2% Ca, and 0.15% Mg in *Pennisetum* sp. In the present research, we found higher levels of N, Ca, and Mg and lower levels of P and K. The high Ca level in this research could be related to the application of dolomite and phosphate rock at the time of planting.

Maleko et al. [51] and NRC [52] indicated that minerals are very essential for ruminant reproduction (conception, gestation, and parturition), growth, maintenance, and production of milk, meat, and wool. The reports of Maleko

Table 2: Chemical composition of three varieties of *Pennisetum* sp according to cutting age and interaction variety × cutting age[1].

Variables	N (%)	P (%)	K (%)	Ca (%)ǂ	Mg (%)	Fe (mg/kg)	Cu (mg/kg)ǂ	Zn (mg/kg)ǂ	Mn (mg/kg)
Variety									
Maralfalfa	1.72 ± 0.19	0.12 ± 0.02	1.47 ± 0.13	0.53 ± 0.02	0.22 ± 0.01b	191.0 ± 28.05	10.67 ± 1.02	12.67 ± 4.27	140.00 ± 11.96
King grass	1.62 ± 0.16	0.13 ± 0.01	1.70 ± 0.15	0.55 ± 0.03	0.19 ± 0.01b	194.50 ± 33.96	11.00 ± 0.72	10.33 ± 3.26	121.67 ± 12.87
Cameroon	1.81 ± 0.10	0.15 ± 0.01	1.73 ± 0.15	0.64 ± 0.02	0.27 ± 0.02a	241.19 ± 46.29	17.00 ± 4.90	10.83 ± 3.34	154.33 ± 21.44
p value	0.41	0.16	0.24	0.103	<0.001**	0.32	0.204	0.893	0.32
Cutting age									
8th week	2.38 ± 0.11a	0.18 ± 0.01a	1.76 ± 0.13	0.70 ± 0.03a	0.21 ± 0.01b	253.83 ± 27.71a	14.00 ± 0.60	3.83 ± 0.97b	145.50 ± 15.55
12th week	1.44 ± 0.10b	0.10 ± 0.01c	1.64 ± 0.13	0.49 ± 0.01c	0.20 ± 0.02b	291.33 ± 33.19a	9.00 ± 0.87	27.33 ± 1.91a	123.50 ± 9.34
16th week	1.32 ± 0.08b	0.13 ± 0.01b	1.50 ± 0.16	0.53 ± 0.03b	0.26 ± 0.02a	81.52 ± 8.98b	15.67 ± 4.96	2.67 ± 0.67b	147.0021.36
p value	<0.001***	<0.001***	0.28	<0.001***	0.002**	<0.001***	0.26	<0.001***	0.5
Block									
B1	1.52 ± 0.17	0.15 ± 0.02a	1.85 ± 0.17a	0.58 ± 0.05	0.20 ± 0.01	212.92 ± 46.74	16.89 ± 6.77	10.89 ± 4.04	120.89 ± 19.88
B2	1.70 ± 0.16	0.13 ± 0.02ab	1.21 ± 0.08b	0.58 ± 0.05	0.25 ± 0.02	256.67 ± 51.24	11.11 ± 1.06	8.67 ± 3.38	172.22 ± 19.79
B3	1.88 ± 0.14	0.15 ± 0.01a	1.60 ± 0.09a	0.57 ± 0.04	0.24 ± 0.02	187.78 ± 26.93	11.11 ± 1.06	11.56 ± 4.89	144.67 ± 11.35
B4	1.77 ± 0.29	0.11 ± 0.01b	1.87 ± 0.20a	0.57 ± 0.05	0.21 ± 0.03	178.22 ± 41.84	12.44 ± 0.60	14.00 ± 4.51	116.89 ± 18.41
p value	0.18	0.022*	0.010*	0.99	0.069	0.26	0.61	0.85	0.14
Variety*cutting age									
Maralfalfa*8th week	2.46 ± 0.52	0.18 ± 0.05	1.76 ± 0.39	0.62 ± 0.04	0.21 ± 0.06	210.00 ± 0.05	14.00 ± 8.08	4.00 ± 2.31	124.00 ± 48.74
Maralfalfa*12th week	1.54 ± 0.37	0.10 ± 0.02	1.59 ± 0.29	0.51 ± 0.03	0.20 ± 0.05	268.50 ± 0.07	7.00 ± 4.04	32.00 ± 3.40	121.00 ± 30.53
Maralfalfa*16th week	1.18 ± 0.25	0.10 ± 0.05	1.06 ± 0.41	0.46 ± 0.02	0.24 ± 0.03	94.50 ± 0.04	11.00 ± 6.35	2.00 ± 0.01	175.00 ± 23.12
King grass*8th week	2.22 ± 0.40	0.16 ± 0.02	1.76 ± 0.65	0.68 ± 0.07	0.18 ± 0.13	243.00 ± 0.02	13.00 ± 7.51	4.00 ± 8.53	124.00 ± 46.50
King grass*12th week	1.27 ± 0.28	0.10 ± 0.02	1.83 ± 0.44	0.48 ± 0.03	0.16 ± 0.05	261.50 ± 0.02	10.00 ± 5.57	25.00 ± 2.40	120.00 ± 43.70
King grass*16th week	1.37 ± 0.37	0.13 ± 0.03	1.51 ± 0.50	0.50 ± 0.02	0.24 ± 0.03	79.00 ± 0.06	10.00 ± 5.57	2.00 ± 0.01	121.00 ± 56.63
Cameroon*8th week	2.47 ± 0.26	0.18 ± 0.04	1.76 ± 0.45	0.81 ± 0.05	0.26 ± 0.08	308.51 ± 0.01	15.00 ± 8.66	3.50 ± 1.73	188.50 ± 49.08
Cameroon*12th week	1.53 ± 0.41	0.10 ± 0.02	1.51 ± 0.59	0.48 ± 0.01	0.24 ± 0.03	344.00 ± 0.04	10.00 ± 5.77	25.00 ± 4.67	129.50 ± 30.52
Cameroon*16th week	1.41 ± 0.26	0.16 ± 0.05	1.92 ± 0.52	0.64 ± 0.08	0.32 ± 0.14	71.06 ± 0.07	26.00 ± 15.01	4.00 ± 2.31	145.00 ± 119.97
p value	0.69	0.22	0.13	0.08	0.76	0.65	0.47	0.27	0.46

[1]Mean values ± standard error of the mean are presented. Different superscript letters in columns (a, b, c) represent significant differences at the $p < 0.05$ level (*), at the $p < 0.01$ level (**), or at the $p < 0.001$ level (***) by multiple comparison with Duncan's test (N, P, K, Mg, Fe, and Mn) and ǂKruskal–Wallis (Ca, Cu, and Zn).

FIGURE 3: Correlations of agronomic behaviour according to age. 8 w, 12 w, and 16 w indicate age. *Significant correlation according to Pearson's test ($p < 0.05$). AP: plant height; C: coverage; M: tillers; B: biomass; MS: dry matter; RTH: stem/leaf ratio.

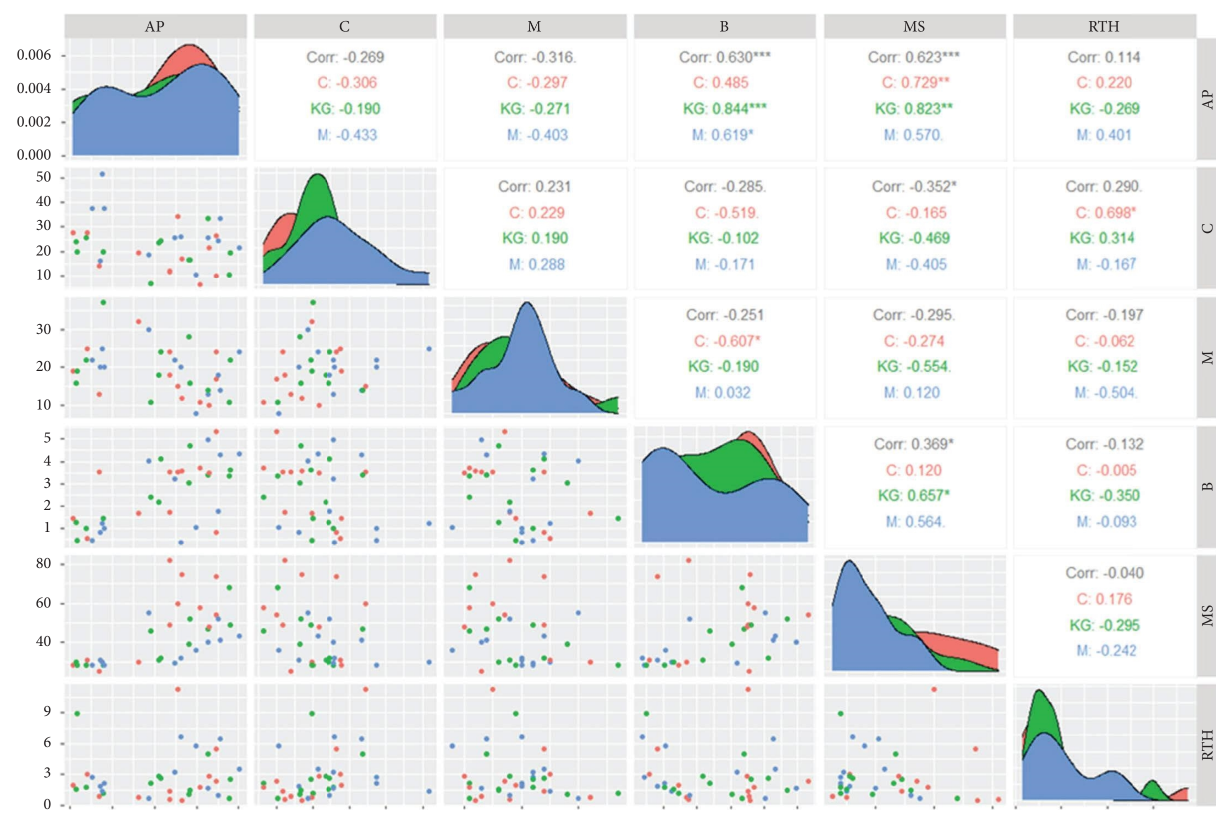

FIGURE 4: Correlations of agronomic behaviour according to variety of *Pennisetum* sp. C: Cameroon, KG: King grass, and M: Maralfalfa. *Significant correlation according to Pearson's test ($p < 0.05$). AP: plant height; C: coverage; M: tillers; B: biomass; MS: dry matter; RTH: stem/leaf ratio.

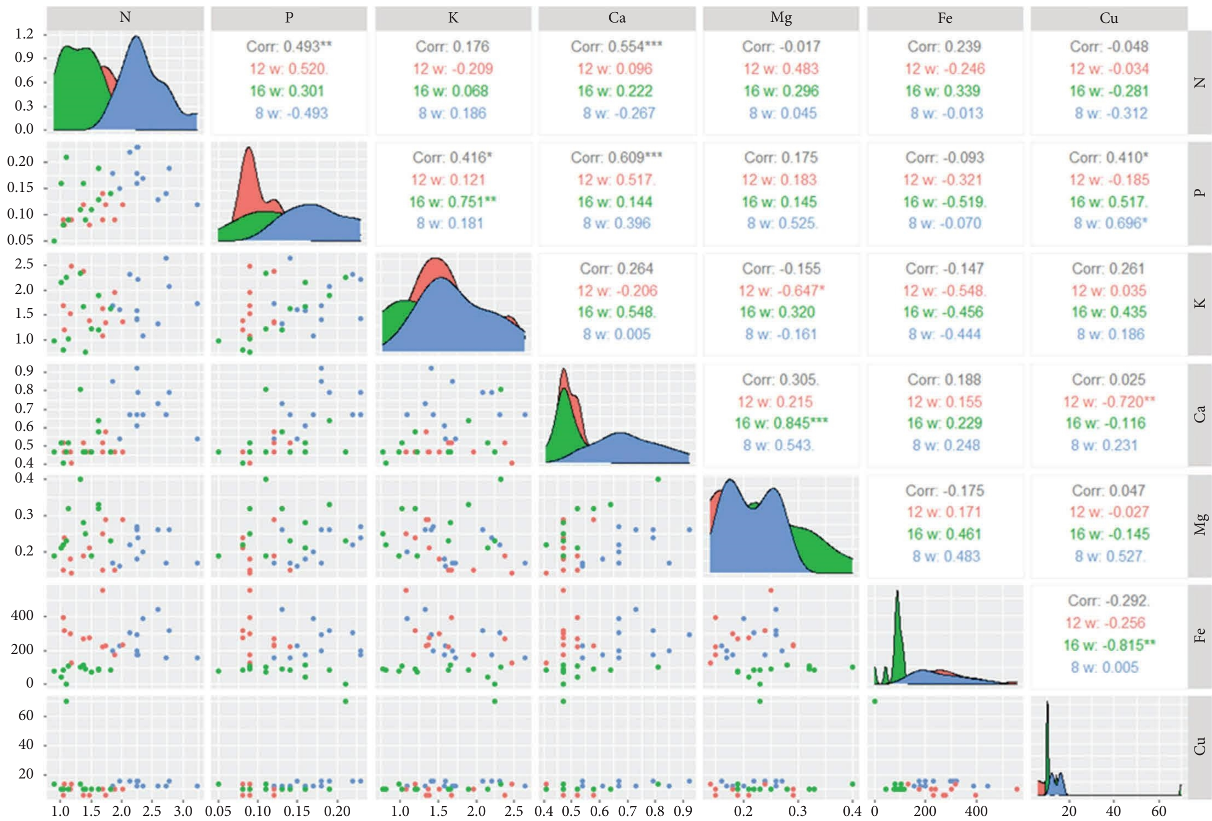

Figure 5: Correlations of chemical composition according to age. 8 w, 12 w, and 16 w indicate age. *Significant correlation according to Pearson's test ($p < 0.05$).

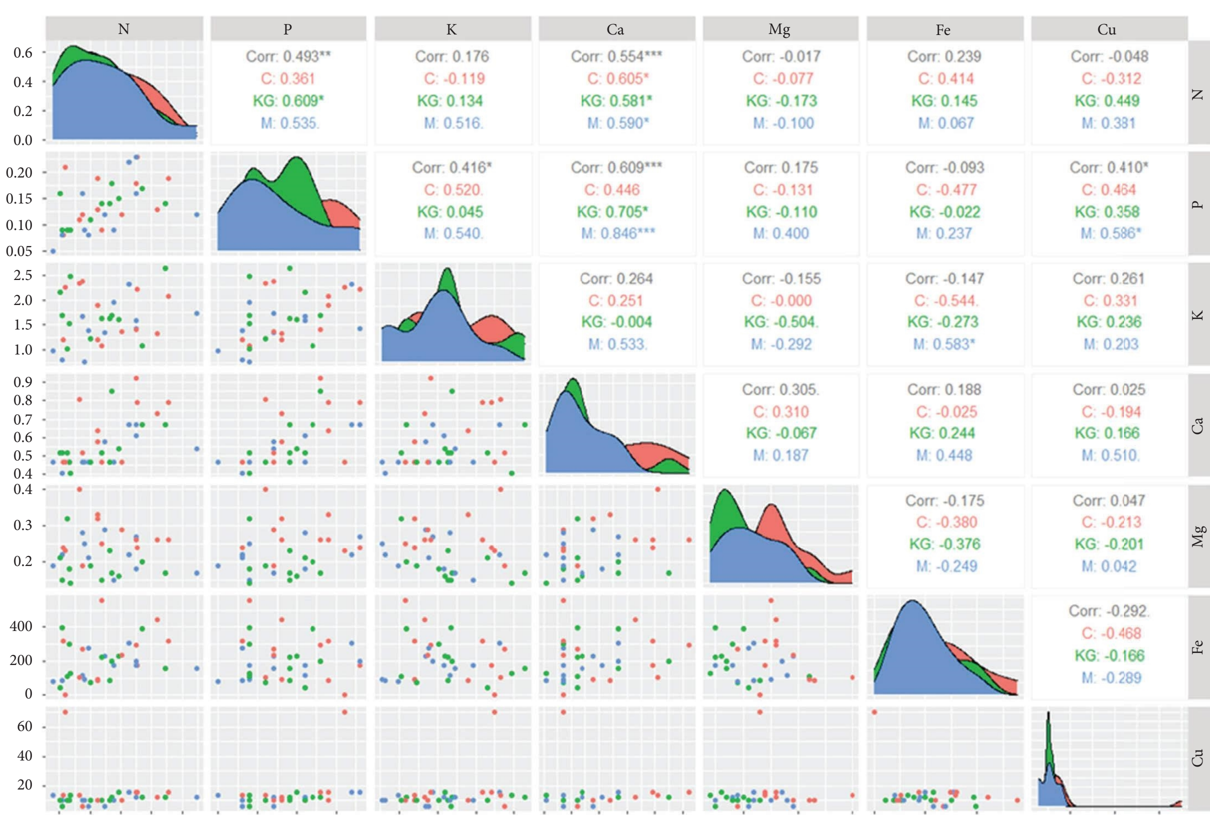

Figure 6: Correlations of chemical composition according to *Pennisetum* sp. varieties. C: Cameroon, KG: King grass, and M: Maralfalfa. *Significant correlation according to Pearson's test ($p < 0.05$).

Table 3: Correlation values between chemical composition and agronomic behaviour according to age and *Pennisetum* sp. variety[1].

Variables	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (mg/kg)	Cu (mg/kg)	
Age								
GC	−0.740***	−0.507**	−0.282	−0.557***	0.28	−0.355*	−0.100	HP
16 w	0.243	−0.314	−0.249	−0.12	−0.219	0.362	−0.628*	
12 w	0.272	−0.027	−0.221	0.278	0.2	0.596*	−0.199	
8 w	−0.205	0.151	−0.26	0.47	0.327	0.042	0.296	
GC	0.218	0.264	−0.179	0.063	−0.082	−0.014	0.250	C
16 w	−0.479	−0.040	0.015	−0.387	−0.431	−0.326	0.439	
12 w	0.018	0.248	−0.487	0.628*	0.162	0.558	−0.519	
8 w	0.102	0.041	−0.398	−0.450	0.070	−0.362	−0.093	
GC	0.179	0.101	−0.268	0.311	−0.189	0.399*	−0.111	T
16 w	−0.378	−0.224	−0.349	−0.373	−0.391	−0.197	−0.045	
12 w	−0.016	0.007	−0.659*	0.266	0.271	0.512	−0.411	
8 w	−0.441	0.026	−0.312	0.452	−0.035	−0.12	−0.105	
GC	−0.556***	−0.197	−0.159	−0.331*	0.31	−0.419*	−0.006	B
16 w	0.217	0.078	−0.266	−0.03	0.371	0.294	−0.175	
12 w	−0.162	0.263	0.255	−0.049	−0.338	−0.144	−0.243	
8 w	−0.046	0.409	0.027	0.515	0.45	0.197	0.475	
GC	−0.525**	−0.346*	−0.112	−0.472**	0.268	−0.104	0.096	DM
16 w	0.406	0.43	0.37	0.113	0.027	−0.345	0.342	
12 w	−0.07	−0.217	−0.122	−0.284	0.372	0.321	0.272	
8 w	−0.263	0.092	−0.381	0.006	0.247	0.429	−0.051	
GC	−0.006	0.073	0.236	−0.181	−0.018	−0.213	0.513**	SLR
16 w	−0.142	0.575	0.401	−0.166	−0.133	−0.616*	0.813**	
12 w	0.461	0.098	−0.204	0.277	0.17	0.074	−0.06	
8 w	0.382	−0.437	0.562	0.264	−0.375	−0.296	−0.438	
Variety								
GC	−0.740***	−0.507**	−0.282	−0.557***	0.28	−0.355*	−0.100	HP
C	−0.758**	−0.506	−0.149	−0.526	0.392	−0.242	−0.010	
KG	−0.725**	−0.406	−0.135	−0.628*	0.373	−0.483	−0.628*	
M	−0.796**	−0.645*	−0.579	−0.781**	0.184	−0.443	−0.410	
GC	0.218	0.264	−0.179	0.063	−0.082	−0.014	0.250	C
C	0.027	0.243	0.228	0.077	−0.327	0.120	0.590*	
KG	0.227	0.226	−0.462	0.179	−0.093	0.157	0.007	
M	0.392	0.502	−0.122	0.433	0.310	−0.163	0.354	
GC	0.179	0.101	−0.268	0.311	−0.189	0.399*	−0.111	T
C	0.423	−0.086	−0.680*	0.152	−0.270	0.544	−0.113	
KG	0.015	0.408	0.029	0.685*	−0.316	0.331	−0.147	
M	0.166	0.142	−0.146	0.342	0.173	0.388	−0.084	
GC	−0.556***	−0.197	−0.156	−0.331*	0.310	−0.419*	−0.006	B
C	−0.310	0.102	0.320	−0.177	0.379	−0.719**	0.106	
KG	−0.693*	−0.408	−0.357	−0.537	0.500	−0.375	−0.578*	
M	−0.680*	−0.392	−0.542	−0.699*	0.170	−0.210	−0.389	
GC	−0.525**	−0.346*	−0.112	−0.472**	0.268	−0.104	0.096	DM
C	−0.845**	−0.603*	−0.164	−0.818**	−0.181	0.036	0.022	
KG	−0.422	−0.287	−0.091	−0.556	0.547	−0.602*	−0.317	
M	−0.605*	−0.579*	−0.509	−0.650*	0.107	−0.346	−0.206	
GC	−0.006	0.073	0.236	−0.181	−0.018	−0.213	0.513**	SLR
C	−0.356	0.223	0.141	−0.351	−0.094	−0.255	0.857***	
KG	0.470	−0.023	0.486	0.099	−0.192	−0.241	0.106	
M	−0.008	−0.010	0.200	−0.134	0.291	−0.071	−0.411	

[1]HP: plant height; C: coverage; T: tiller; B: biomass; DM: dry matter; SLR: stem/leaf ratio; C: Cameroon; KG: king grass; M: maralfalfa; GC: general correlation.
*Significant correlation according to Pearson's test ($p < 0.05$).

et al. [51] are even further below the recommended concentrations of 0.36% and 0.43% for P and Ca, respectively, by NRC [52], while Louhaichi et al. [53] indicated that the content of minerals and pasture ash is influenced by edaphic factors, seasons, and proportion of dry matter of biomass.

The N, P, K, Ca, Mg, and Fe contents are negatively related to biomass, dry matter, and age of the plant (Table 3). As the yields and age of the plant increase, the concentrations of these elements decrease. Otherwise happens with the Cu concentration, which is positively related to the stem/leaf ratio. This is due to the most of Cu translocated towards the flowering part of the plant [54].

4. Conclusions

The agronomic behaviour did not vary significantly between the *Pennisetum* sp. varieties evaluated or in the interaction between variety and cutting age. The Cameroon variety presented a higher Mg content and higher plant height, biomass, and dry matter content, although not significantly. Cutting at the 8th week allows obtaining a higher content of N, P, Ca, and Fe in the forage, Zn at the 12th week, and Mg at the 16th week. At an early cutting age, in varieties of *Pennisetum* sp., it shows lower biomass and dry matter result, and higher content of N, P, Ca, and Fe; but at a late cutting age, it shows greater biomass, dry matter, and Cu and Mg content.

Data Availability

All data pertaining to the current study are available from the corresponding author upon a reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

ESWE, RJR, GAT, and CEAA performed conceptualization, funding acquisition, data curation, investigation, methodology, project administration, resources, validation, formal analysis, visualization, writing the original draft, and writing, reviewing, and editing the manuscript. JASU and PHIS contributed to investigation, methodology, reviewing, and editing the manuscript. DLR and ESWE were involved in visualization, validation, and reviewing and editing the manuscript. JASU was involved in supervision, visualization, validation, and reviewing and editing the manuscript. JASU and DLR were involved in conceptualization, supervision, visualization, validation, and reviewing and editing the manuscript. All the authors have read and approved the final manuscript.

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