Contribution of Soil Type to Quantity and Nutritional Value of Grass Species on the South African Highveld

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Abstract: The biggest threat to cattle production in most South African communal areas is poor management of grazing, which negatively affects vegetation and soil structures. This study was conducted to assess the spatial variation of grass species density, production potential and quality in Breynet (Hutton soil type), Davel (Avalon soil type), and Wesselton (Clovelly soil type) communal rangelands in the highveld region of Mpumalanga province. Three 100 m transects per grazing area, placed at 50 m intervals (0, 50, and 100 m) were used to collect soil samples at 200 mm depth. A 100 m permanent line point method, replicated three times (50 m apart) per site, was used to identify and collect grass species samples. Grass species were classified according to life form, palatability, ecological status, and abundance. Grasses species were also harvested for chemical composition and in vitro ruminal dry matter degradability determination. Soils from the study areas had an acidic pH range (3.5–4.5). Hutton soil had the highest (p < 0.05) nitrate (N-NO3) concentration (0.770 mg/kg) compared to Clovelly (0.030 mg/kg) and Avalon (0.533 mg/kg) soil types. Thirty-one grass species were identified in the study areas. About 16% of identified grass species were classified as highly palatable, 39% as moderately palatable, and 32% as unpalatable. Across all soil types, Digitaria eriantha had the highest (p < 0.05) crude protein (CP) (106.5 g/kg DM) content when compared to other grass species. In the Avalon soil type, D. eriantha had the lowest (p < 0.05) neutral detergent fiber (NDF) (696.4 g/kg DM). Across all soils, D. eriantha, Aristida congesta, Eragrostis curvula, Eragrostis gummiflua, and Eragrostis plana grasses had the same (p > 0.05) 48-h in vitro ruminal dry matter degradability. Hutton soil had a higher proportion of common and dominant grass species as well as more palatable species with higher crude protein content than Avalon and Clovelly soils. However, for all three rangelands, there is a need for supplementary feeding to enhance the production efficiency of livestock given that the nutritive value of grasses was low.

Keywords: chemical composition; ecological status; herbaceous species; grass desirability; grassland ecosystem; livestock production; nutritive value

1. Introduction

Usable communal rangelands continue to shrink due to overgrazing-induced degradation as well as conversion to other uses, such as crop production [1,2]. The reduction in size and health of communal rangelands negatively affects livestock productivity, which manifest as weight losses, delayed calving and high levels of mortality [3,4]. The functional and operational management systems for communal rangelands are reportedly limited...
by a lack of empirical data to support decision-making [5]. There is, therefore, a need to generate data on plant species diversity, density, and nutritional value as well as determine how these parameters are influenced by grazing management practices. This will allow rangeland scientists and users to design suitable management systems that ensure sustainable rangeland utilization for cattle production [5].

Grazing pressure is known to influence above ground biomass and soil fertility [6,7]. Intensive grazing has been reported [8] to severely destroy vegetation leading to changes in soil fertility. In addition, heavy grazing tends to compromise the competitive advantage of palatable plant species [9] creating an opportunity for pioneer species, such asIncreasers. Indeed, Roodt [10] demonstrated that increaser species thrive under intensive grazing management systems. In addition to the structure of plant biomass, soil nutrients are also influenced by livestock stocking density through the deposition of dung and urine as well as other grazing-related effects, such as trampling [11,12]. Soil trampling has been reported to increase bulk density and mechanical strength of the soil, thus reducing porosity and water infiltration [13]. On the other hand, Mayel et al. [14] reported on the positive impact that light—moderate grazing has on soil properties, such as organic carbon, total nitrogen, potassium, bulk density, and water content.

In order to sustain rangelands and enhance the productivity of livestock, information on how grazing management practices influence vegetation diversity, density, and nutritive value is vital [15,16]. However, this information is not readily available for most South African rangelands, especially in the highveld of Mpumalanga province. Information on species distribution, quantity, and nutritional quality is useful when designing rangeland management strategies [17,18] that will contribute towards the restoration of communal rangelands and improved cattle productivity and offtake. The study assessed how current grazing management practices affect vegetation density, diversity, and distribution and whether such grazing practices are sustainable under the current soil and vegetation structures in three selected communal rangelands in the highveld region of Mpumalanga province, South Africa.

2. Materials and Methods

2.1. Study Sites

The study was carried out in three communal rangeland sites in the Gert Sibande District, Msukaligwa municipality, South Africa (Figure 1). The sites were Breyten (26°29′59.000″ S 30°12′000″ E), Davel (26°46′8.000″ S 29°66′52.000″ E) and Wesselton (26°30′38.182″ S 29°57′38.451″ E), all approximately ± 30 km apart, selected based on soil type variations. The size of the areas was not measurable due to vandalized fences. The soils at Breyten, Davel, and Wesselton sites were identified as Hutton, Avalon, and Clovelly types, respectively. Both Breyten and Wesselton sites have the Eastern Highveld Grassland vegetation type with grass and tree species, such as Aristida, Digitaria, Eragrostis, Themeda, Tristachya, Senegalia caffra, Celtis africana, Diospyros lycioides, Parinari capensis, Protea caffra, Protea welwitschii and Rhus Maqalismontanum while Davel has the Soweto Highveld Grassland vegetation with Themeda triandra, Eragrostis raeomosa, Heteropogon contortus, Tristachya leucothrix and Elionurus muticus as some of the dominant species [19]. All three areas fall under the Grassland biome and are found at an altitude of 1629–1715 m above sea level with ambient temperatures ranging from 6 to 34 °C in summer and from −2 to 24 °C in winter while average rainfall varies from 662 to 726 mm annually. Indigenous beef cattle, sheep, goats, horses, and donkeys utilize the studied rangelands. However, indigenous cattle were the majority of grazers in the three areas. This study was authorized by the North-West University Ethics Committee standards (Ethical Clearance Number: NWU-00658-18-A5).
2.2. Soil and Grass Sampling and Species Identification

Three 100 m transects per grazing area, placed 50 m apart, were used to guide the collection of soil samples and grass species on a single occasion. The soil samples (depth of 200 mm) were collected at an interval of 50 m (0, 50, 100 m) per transect. The samples were air-dried at room temperature for a week, ground and sieved through a 2-mm screen. Nitrate nitrogen, nitrogen-peroxynitric acid, soil macro- and micro-minerals were analyzed according to guidelines by the Agricultural Laboratory Association of Southern Africa [20]. Soil organic carbon [21] and pH were also analyzed. Grass species were sampled at maturity within a 10 cm radius of marked point intervals (1 m apart) for identification and determination of species density. All species along the transect were classified according to life form, palatability (high grazing value, medium grazing value, and low grazing value (%), ecological status (Decreasers, Increaser i, Increaser ii, Increaser iii and Invaders) as described by Van Oudtshoorn [22]. Van Oudtshoorn [22] describes decreaser species as those species that have high grazing value but decrease when veld deteriorates under high grazing pressure and trampling; Increaser I species as those that increase when the veld is underutilized; Increaser II species as those that increase with light to moderate grazing pressure and Increaser III species as those that increase with light to severe grazing pressure. The abundance of the species in the selected areas was also assessed as described by Moyo and Campbell [23], Jauworo et al. [24] and Ravhuhali [25], and Ravhuhali et al. [26]. With regards to abundance status, a grass species was classified as dominant (D), common (C), rare (R), or present (P) if its density was more than 13%, between 3 and 13%, between 1 and 3%, or less than 1%, respectively [22]. Above-ground biomass from transects was measured at 20 m intervals using a falling plate meter (disc pasture meter). Shoot height and diameter were measured using a ruler in centimeters. The plant species cover and the grazing index values (GIVs) were used to determine the grazing capacity according to Du Toit [27]. The grazing capacity, expressed as the number of hectares required to provide feed for a year for one head of cattle weighing 450 kg (hectares per livestock unit, LSU), was calculated as follows:

\[ Y = \frac{d \times \frac{[DM \times F]}{r}}{r} \]

where, \( Y \) = grazing capacity (ha/LSU), \( d \) = the number of days in a year, \( DM \) = dry matter yield (kg/ha), \( F \) = utilization factor (0.5), \( r \) = dry matter required daily by one livestock unit.
unit (LSU) (450 kg). Dry biomass production was rated as poor (500–2000 kg/ha), fair (2001–4000 kg/ha) and good (4001–6000 kg/ha).

2.3. Chemical Composition

Immediately after harvesting, grass samples were dried at 60 °C until at a constant weight. Dried samples were then milled through a 2 mm sieve and stored in a plastic container pending chemical analysis and in vitro ruminal fermentation. Samples were analyzed for dry matter (DM), organic matter (OM), and crude protein (CP) content [28,29]. Acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) were determined by using the ANKOM fiber analyzer (ANKOM Technology, New York, NY, USA) [30].

2.4. In Vitro Ruminal Dry Matter Degradability

The ANKOM Daisy incubator (ANKOM Technology Corporation, Fairport, New York) was used to determine the in vitro ruminal dry matter degradability of the common and dominant grass species. Milled grass samples were weighed (0.45–0.5 g) and transferred into ANKOM F57 bags, which were then heat-sealed and placed in four Daisy digestion jars. F57 bags without grass samples (controls) were also included in each jar. The jars were then filled with 1600 mL of warm (39 °C) buffer solution. A Bonsmara cow (fed a mixture of lucerne and buffalo grass) was used as a source of rumen fluid, which was collected through the cannula before morning feeding and squeezed into pre-warmed thermos flasks under a stream of carbon dioxide (CO₂) gas. The rumen fluid was homogenized in a blender and strained with a cheesecloth, before being used to inoculate the daisy jars (400 mL/jar). The jars were then purged with CO₂ gas and closed before incubation at 39 °C in the ANKOM chamber. ANKOM F57 bags were withdrawn after incubation at 12, 24, 36, and 48 h. Withdrawn F57 bags were washed with cold running water for about 20 min then dried in the oven for 12 h at 105 °C and dry matter degradability (DMD) was calculated as weight lost upon incubation.

2.5. Statistical Analysis

The general linear model (GLM) procedures of SAS [31] were used to analyze soil characteristics, sward palatability and biomass data. The following model was used:

\[ Y_{ij} = \mu + S_i + \epsilon_{ij} \]

where, \( Y_{ij} \) = dependent variable [soil characteristics], \( \mu \) = overall mean, \( S_i \) = site effect, \( \epsilon_{ij} \) = error linked to a random observation accepted as an independent and normal distribution. The means were separated and compared using the Least Significant Difference (LSD), calculated at \( p < 0.05 \) level.

The effect of grass species and soil type (site) on chemical composition and the in vitro ruminal dry matter degradability was analyzed using the GLM procedures of SAS [31], using the model:

\[ Y_{ij} = \mu + G_i + S_j + (G_i \times S_j) + \epsilon_{ij} \]

where, \( Y_{ij} \) = dependent variable, \( \mu \) = overall mean, \( G_i \) = grass species effect, \( S_j \) = soil type effect, \( G_i \times S_j \) = grass species and soil type interaction effect, \( \epsilon_{ij} \) = error linked to a random observation accepted as an independent and normal distribution.

The means were separated using the probability of difference (PDIDF) option of the lsmeans statement.

3. Results

Table 1 presents the properties of soils from the three communal rangelands. The Avalon soil type had higher \( (p < 0.05) \) pH (4.5) compared to Hutton (3.6) and Clovelly (3.5) soil types. No differences \( p > 0.05 \) between soil types were observed in terms of nitrogen-peroxynitric acid (N-NHO₄) concentration. Potassium (K) (110.7 mg/kg), calcium (Ca)
(486.7 mg/kg), and phosphorus (p) (102.3 mg/kg) levels were highest (p < 0.05) in Hutton, Avalon, Clovelly soils, respectively. Hutton (1.6%) and Clovelly (1.3%) soils had higher (p < 0.05) carbon (C) than Avalon soil. Clovelly soil had the highest iron (Fe) concentration (135.9 mg/kg) compared to Hutton and Avalon soils.

| Soil Properties          | Site                  | Breyten   | Davel     | Wesselton | SEM  |
|--------------------------|-----------------------|-----------|-----------|-----------|------|
| Type                     | Hutton soil           | Avalon soil| Clovelly soil|          |      |
| pH value                 | 3.6 b                 | 4.5 a     | 3.5 b     | 0.24      |
| Nitrogen nitrate (mg/kg) | 0.77 a                | 0.53 b    | 0.03 c    | 0.03      |
| Nitrogen-peroxynitric acid (mg/kg) | 4.8 a | 5.2 a | 5.2 a | 0.13 |
| Carbon (%)               | 1.6 a                 | 0.5 b     | 1.3 a     | 0.12      |
| Extractable acidity (%)  | 0.90 a                | 0.28 c    | 0.57 b    | 0.02      |
| Extractable alkalinity (%)| 0.70 a               | 0.30 c    | 0.33 b    | 0.02      |
| Sand (%)                 | 76.3 ab               | 74.3 b    | 77.7 a    | 0.88      |
| Silt (%)                 | 9.3 a                 | 9.0 b     | 9.0 a     | 0.61      |
| Clay (%)                 | 13.7 b                | 15.7 a    | 12.3 c    | 0.33      |
| Maco-minerals (mg/kg)    |                       |           |           |           |
| Potassium                | 110.7 a               | 91.3 b    | 79.0 c    | 3.50      |
| Calcium                  | 233.0 c               | 486.7 a   | 401.7 b   | 6.50      |
| Magnesium                | 91.3 b                | 107.7 a   | 112.7 a   | 2.80      |
| Phosphorus               | 3.3 b                 | 9.3 b     | 10.3 a    | 2.20      |
| Sodium                   | 3.7 b                 | 2.7 b     | 28.0 a    | 0.72      |
| Micro-minerals (mg/kg)   |                       |           |           |           |
| Iron                     | 74.6 b                | 53.3 c    | 135.9 a   | 5.50      |
| Copper                   | 2.8 a                 | 1.4 c     | 2.4 b     | 0.10      |
| Zinc                     | 1.6 c                 | 3.7 b     | 11.5 a    | 0.30      |
| Aluminium                | 54.6 a                | 9.4 c     | 27.7 b    | 0.48      |
| Manganese                | 25.3 b                | 28.5 ab   | 32.1 a    | 1.10      |

abc Means different lowercase superscripts in the same row are significantly different (p < 0.05); SEM: Standard error of the mean.

Life form, ecological status, palatability, biomass, and abundance of grass species found in the three study sites are presented in Tables 2 and 3. Thirty-one grasses composed of 28 turf perennials, two weak perennials and one perennial creeping grass were identified. Of the 31 grass species, 16%, 42%, and 32% were classified as highly palatable, moderately palatable, and unpalatable, respectively, while 10% of species could not be classified. Breyten (Hutton soil) had the highest proportion of highly palatable grass species while Davel (Avalon soil) had the least. *Andropogon schirensis*, *Harpochloa falx*, *Stiburus alopecuroides*, *Eliumurus muticus*, *Eragrostis planiculmis* and *Urochloa panicoides* grass species were common in Breyten (Hutton soil) and present in Davel (Avalon soil) and Wesselton (Clovelly soil). *Eragrostis plana* was common in Breyten and dominant in Davel and Wesselton. No significant (p < 0.05) difference was observed in terms of herbaceous biomass production (all with more than 4000 kg/ha) and grazing capacity across study sites.

Table 2. Life form, ecological status, grazing values, and abundance of grass species across different study sites.

| Grass Species         | Life Form 1 | Ecological Status 2 | Grazing Value 3 | HS | AS | CS |
|-----------------------|-------------|---------------------|-----------------|----|----|----|
| *Aristida congesta*   | WP          | Inc ii              | NP              | C  | C  | R  |
| *Andropogon schirensis*| TP         | Inc i               | MP              | C  | P  | P  |
| *Brachiaria serrata*  | TP          | Dec                 | MP              | P  | P  | P  |
| *Ctenium concinnum*   | TP          | Inc i               | NP              | R  | P  | P  |
| *Cynodon dactylon*    | CG          | Inc ii              | HP              | R  | C  | D  |
| *Diheteropogon amplectens*| TP    | Dec                 | MP              | R  | P  | P  |
Table 2. Cont.

| Grass Species       | Life Form 1 | Ecological Status 2 | Grazing Value 3 | HS  | AS  | CS  |
|---------------------|-------------|---------------------|-----------------|-----|-----|-----|
| Digitaria eriantha  | TP          | Dec                 | HP              | D   | R   | C   |
| Digitaria setifolia | TP          | Inc ii              | NS              | P   | P   | P   |
| Eragrostis capensis | TP          | Inc ii              | MP              | R   | P   | P   |
| Eragrostis chloromelas | TP       | Inc ii              | MP              | C   | C   | D   |
| Eragrostis curvula  | TP          | Inc ii              | MP              | C   | D   | C   |
| Eragrostis gammiflua | TP          | Inc ii              | NP              | R   | C   | C   |
| Eragrostis microantha | TP       | Inc ii              | NS              | R   | R   | P   |
| Elyonurus nuticus   | TP          | Inc iii             | MP              | C   | P   | P   |
| Eragrostis plana    | TP          | Inc ii              | NP              | C   | D   | D   |
| Eragrostis planiculmis | TP        | Inc ii              | NS              | C   | P   | P   |
| Eragrostis racemosa | TP          | Inc ii              | MP              | C   | P   | R   |
| Eragrostis rigidae  | TP          | Inc ii              | MP              | D   | P   | P   |
| Heteropogon contortus | TP         | Inc ii             | MP              | C   | P   | R   |
| Harpochloa falx     | TP          | Inc i               | NP              | C   | P   | P   |
| Hyparrhenia hitra   | TP          | Inc i               | MP              | P   | C   | R   |
| Microstola caffra   | TP          | Inc ii              | NP              | R   | P   | P   |
| Monocymbium ceresiiforme | TP      | Dec                 | MP              | R   | P   | P   |
| Paspalum dilatatum  | TP          | EG                  | HP              | R   | P   | C   |
| Stiburus alepecioides | TP         | CG                  | NP              | C   | P   | P   |
| Sporobolus africanum | TP        | Inc ii              | NP              | R   | R   | P   |
| Setaria spiculata   | TP          | Dec                 | HP              | P   | P   | R   |
| Trichomeura grandiglumis | WP      | Inc ii              | NP              | R   | P   | P   |
| Trisetachya leucotrix | TP         | Dec                 | MP              | C   | P   | R   |
| Themeda triandra    | TP          | Dec                 | HP              | C   | P   | C   |
| Urochloa panicodes   | TP          | Inc ii              | NP              | C   | P   | P   |

1 Life form: TP = Turfed perennial, WP = Weak perennial. 2 Ecological status: CG = Creeping grass, Inc I = Increaser i, Inc ii = Increaser ii, Inc iii = Increaser iii, Dec = Decreaser, EG = Exotic grass, CG = Climax grass. 3 Grazing value: NP = Not palatable, MP = Moderately palatable, HP = Highly palatable, NS = Not specified. 4 Abundance: D = Dominant (>13%), C = Common (>3–13%), R = Rare (1–3%), p = Present (<1%). HS = Hutton soil, AS = Avalon soil, CS = Clovelly soil.

Table 3. Palatability (proportion (%)) of common and dominant species per site), grazing capacity and biomass yield of grass species across soil types.

| Soil Type   | Parameters | Hutton Soil | Avalon Soil | Clovelly Soil | SEM |
|-------------|------------|-------------|-------------|---------------|-----|
|             | Highly palatable (%) | 9.63<sup>a</sup> | 4.83<sup>b</sup> | 6.27<sup>ab</sup> | 1.06 |
|             | Moderately palatable (%) | 3.83<sup>b</sup> | 13.60<sup>a</sup> | 5.06<sup>b</sup> | 0.358 |
|             | Unpalatable (%) | 3.50<sup>b</sup> | 6.87<sup>ab</sup> | 7.70<sup>a</sup> | 0.978 |
|             | Biomass (kg) | 5159.1 | 4110.7 | 5113.3 | 392.38 |
|             | Grazing capacity (Ha/LSU) | 1.6 | 2.0 | 1.6 | |

<sup>ab</sup> Means different lowercase superscript letters in the same row are significantly different (p < 0.05); SEM: Standard error of the mean.

A significant soil type x grass species interaction effect (p < 0.05) on herbage CP and ADF (Table 4) content and 36-h in vitro ruminal dry matter degradability (DMD36) (Table 5) was observed. Across all soil types, D. eriantha had the highest (p < 0.05) CP (106.5 g/kg DM) content. Eragrostis plana growing in Clovelly soil had a higher (p < 0.05) NDF concentration compared to the same species growing in Hutton soil. The Hutton soil promoted higher (p < 0.05) ADF content in A. congesta than Avalon and Clovelly soils. Eragrostis chloromelans harvested in Avalon soil had higher (p < 0.05) ADL concentration when compared to the same species in Clovelly and Hutton soils. However, in Avalon, A. congesta had a higher (p < 0.05) ADL value than D. eriantha, E. curvula, E. gammiflua and E. plana.
Table 4. Crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) (g/kg DM) in common and dominant grass species growing in Hutton (HS), Avalon (AS) and Clovelly (CS) soil types.

| Grass Species | CP | NDF | ADF | ADL |
|---------------|----|-----|-----|-----|
|               | HS | AS  | CS  | HS  | AS  | CS  | HS  | AS  | CS  | HS  | AS  | CS  | HS  | AS  | CS  |
| A. congesta   | 82.9 b | 78.3 b | 77.1 b | 779.8 ab | 814.9 a | 763.9 ab | 714.9 Aa | 576.3 Ba | 461.3 Cab | 174.0 a | 220.4 a | 179.2 a |
| D. eriantha   | 106.5 Aa | 94.6 Ba | 86.6 Ba | 688.2 c | 696.4 b | 684.7 c | 427.7 bc | 436.1 b | 392.4 b | 109.5 b | 116.9 c | 86.6 b |
| E. chloromelas | 67.1 c | 64.6 cd | 69.3 b | 715.7 c | 764.1 a | 732.1 bc | 400.2 Bc | 588.9 Aa | 467.7 Bab | 111.6 Bab | 189.3 Aab | 115.9 Bab |
| E. curvula    | 50.0 Bd | 64.8 Acd | 70.2 Ab | 813.0 a | 810.2 a | 806.5 a | 444.5 bc | 461.6 b | 392.4 b | 129.4 ab | 91.3 c | 130.7 ab |
| E. gummiflua  | 65.4 Ac | 57.2 Bd | 54.3 Bc | 774.0 abc | 781.8 a | 802.8 a | 362.9 Bc | 514.5 Aab | 525.4 Aa | 73.9 b | 103.7 c | 115.6 ab |
| E. plana      | 80.0 Ab | 65.8 Bc | 52.9 Cc | 728.1 Bbc | 771.9 ABa | 801.6 Aa | 508.0 b | 448.6 b | 477.5 ab | 117.1 ab | 127.0 bc | 109.7 b |

SEM 2.7 20.6 34.3 22.3

*ABC* Within chemical constituent, grass species means in the same row that do not share uppercase superscripts are significantly different (*p* < 0.05); *abc* Within each soil type, grass species means that do not share lowercase superscripts are significantly different (*p* < 0.05); CP = Crude protein, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ADL = Acid detergent lignin; SEM: Standard error of the mean.

Table 5. The effect of soil types and grass species on in vitro ruminal DMD degradability (g/kg) of common and dominant grass species from selected soil types.

| Grass Species | DMD12 | DMD24 | DMD36 | DMD48 |
|---------------|-------|-------|-------|-------|
|               | HS    | AS    | CS    | HS    | AS    | CS    | HS    | AS    | CS    | HS    | AS    | CS    |
| A. congesta   | 67.4 a | 102.1 b | 121.1 b | 152.5 a | 175.5 a | 169.6 b | 194.7 b | 253.9 abc | 229.1 c | 238.5 a | 328.7 Ab | 264.6 b |
| D. eriantha   | 105.3 Ba | 185.7 Abs | 202.1 Aa | 205.1 a | 252.2 a | 327.6 b | 288.0 ab | 293.8 ab | 381.0 b | 320.4 a | 390.9 a | 409.4 b |
| E. chloromelas | 98.8 Ba | 176.0 Aa | 95.9 Bb | 158.5 Ca | 253.0 Ba | 537.0 Aa | 229.6 Cab | 334.5 Ba | 649.3 Aa | 289.8 Ba | 373.8 Bb | 623.6 Aa |
| E. curvula    | 116.7 a | 85.2 a | 112.5 b | 164.5 a | 107.0 a | 211.4 b | 196.6 b | 168.4 bc | 256.3 bc | 245.1 a | 248.4 Ab | 287.2 b |
| E. gummiflua  | 122.7 a | 77.0 b | 112.8 b | 193.0 a | 140.6 a | 206.5 b | 331.5 Aa | 179.7 Bbc | 252.6 Abbc | 395.3 a | 231.0 Ab | 281.9 b |
| E. plana      | 105.0 a | 75.2 b | 130.7 b | 123.0 a | 124.1 a | 209.1 b | 182.0 b | 158.9 Cc | 289.1 bc | 241.7 a | 207.6 b | 364.6 b |
| SEM           | 22.6  | 56.2  | 45.6  | 60.7  | 60.7  | 60.7  | 60.7  | 60.7  | 60.7  | 60.7  | 60.7  | 60.7 |

*ABC* Within the incubation period, grass species means in the same row that do not share uppercase superscripts are significantly different (*p* < 0.05); *abc* Within each soil type, grass species means that do not share lowercase superscripts are significantly different (*p* < 0.05); Soil types: HS = Hutton soil type, AS = Avalon soil type, CS = Clovelly soil type; Degradability: DMD12 = Dry matter degradability at 12 h, DMD24 = Dry matter degradability at 24 h, DMD36 = Dry matter degradability at 36 h, DMD48 = Dry matter degradability at 48 h; SEM: Standard error of the mean.
For grasses harvested from Davel (Avalon soil), *E. chloromelas* had the highest (*p < 0.05*) DMD36 (334.5 g/kg DM) while *E. plana* had the least DMD36 value (158.9 g/kg DM). In Wesselton (Clovelly soil), the most degradable grass species was *E. chloromelas* (649.3 g/kg DM) while *A. congesta* was the least degradable (229.1 g/kg DM).

4. Discussion

4.1. Soil Parameters

Of major concern, soil pH (3.5–4.5) in the studied communal rangelands fell outside the recommended range of 5.2–8.0 (Table 1) [32,33]. The availability of soil nutrients and associated plant growth is influenced by soil parameters, such as pH [11,34]. Normally, plant growth is poor in acidic soils due to high levels of some trace elements [35]. Indeed, acidic soils tend to have high concentrations of micronutrients, such as aluminium and manganese that can be toxic to plants [36]. On the other hand, acidic soils tend to have lower levels of macronutrients, such as phosphorus [37]. In the current study, soils from the three study sites had similar pH, consequently, the sites had similar plant morphology and biomass yield. Soil nitrogen significantly affects the growth and diversity of conventional plant communities [18]. Lempesi et al. [38] reported that heavily grazed areas tend to have higher soil N concentrations compared to lightly grazed soil due to the deposition of manure and urine when animals are left to graze an area for a long period. All the studied sites were heavily grazed and had soils with similar concentrations of nitrogen-peroxynitric acid. However, in Breyten, the Hutton soil had the highest nitrate concentration (0.770 mg/kg), which could have been due to the high soil organic carbon. Indeed, Horwath and Kuzyako [39] reported that an increase in soil organic carbon is associated with higher soil nitrate. Soil organic matter concentration is essential for soil health and productivity [40] because it has been shown to directly influence moisture holding capacity, soil infiltration, soil nutrient availability, and the biological activity of microorganisms [41]. Soils from all three study sites had lower organic carbon than the recommended level of 3–6% [42]. As expected, the concentration of soil nutrients varied with soil types.

4.2. Grass Species Composition and Distribution

Information on the distribution of grass species is necessary to understand the flora biodiversity in specific areas [18]. Perennial grasses tend to be more dominant compared to the other life forms and are regarded as essential to the ecosystem [43]. The presence of perennial grass species has been reported to promote organic carbon and soil health [44]. Consequently, over or underutilization of dominant species, such as *Cynodon dactylon*, *E. chloromelas*, *E. curvula*, *E. plana*, and *E. rigidior* could result in poor veld condition in the studied communal rangelands. *Cynodon dactylon*, a creeping grass that is inaccessible to grazers [45], was dominant in all study sites. The dominance of this species suggests grazing cattle are unable to obtain sufficient forage in these communal rangelands. The grazing values obtained in this study indicate that there was a high proportion of highly palatable, moderately palatable, and unpalatable grasses in Breyten (Hutton soil), Davel (Avalon soil), and Wesselton (Clovelly soil), respectively. A high proportion of unpalatable grass species, such as the one recorded in Clovelly reduces nutrient supply to ruminants and negatively affects their productivity [46]. Species, such as *E. plana*, *E. gammiflua*, and *A. congesta* were either dominant or common in the study sites, clearly indicating poor rangeland health [22]. The low proportion of highly palatable grasses observed in Avalon and Clovelly soil types indicates preferential grazing, which if allowed to continue may result in local extinction of these desirable forage species [26]. Gusha et al. [47] also stated that the reduction of desirable species may be due to frequent defoliation under continuous grazing systems.
4.3. Biomass and the Species Grazing Values

Plant cover is important in preventing soil erosion, suppressing the growth of alien or unwanted plants, and also serving as available feed for herbivores [48,49]. There was no variation in biomass production across all the studied communal rangelands (Table 3). Though not statistically different, the biomass yield tended to be lower in the Avalon (4110.7 kg) soil compared to the Hutton (5159.1 kg) and Clovelly (5113.3 kg) soils. Abusuwar & Ahmed [50] recommended the practice of moderate grazing to maintain moderate plant growth, biomass and distribution. Changes in grazing pressure directly influence changes in vegetation structure, composition and productivity [51]. Although all areas fell within the same environmental conditions, abiotic and biotic factors, such as precipitation patterns, resource competition, environmental disturbances, and nutrient availability have also been found to influence vegetation structures and morphology [52].

Soil parameters are known to affect nutrient dynamics, species diversity [53], and plant growth [54]. This was evident in Hutton and Clovelly soils, which had higher nutrient concentration, a higher proportion of palatable species, higher biomass, and better grazing capacity than the rangeland with Avalon soil type. For these three communal rangelands, the information generated suggests that it is necessary to provide a policy framework and build institutional capacity to address the negative effects associated with heavy grazing [26]. These communal areas, if managed properly can self-rehabilitate, but this requires an understanding of how soils influence the herbaceous layer and vice-versa [55]. The introduction of community-based workshops on the proper utilization of rangelands could be a starting point in the capacitation of communal farmers in the art of sustainable rangeland management practices.

4.4. Chemical Composition of Common and Dominant Grass Species in Different Soil Types

Grasses were found to contain high fiber levels and these results were similar to the findings of Ravhuhali [25]. The highest CP content across all soil types was reported in D. eriantha (86.6–106.5 g/kg) and Aristida congesta (77.1–82.9 g/kg), suggesting the genetic superiority of this grass species [16]. While these CP levels are moderate, they are only just above the recommended CP levels (70 g/kg DM) for maintenance of rumen function [56]. Rambau et al. [57] reported that high lignin content reduces DM and CP degradability of forage, resulting in a nutrient deficiency in ruminants. Grass species in the study areas showed no differences in ADF and NDF content, which fell within the ranges of 363–715 g/kg and 684.7–814.9 g/kg, respectively. According to Kebede et al. [4], high ADF and NDF content, coupled with lower CP content indicate grass species of low nutritive value. Both ADF and NDF values in the current study fall within the range reported by Evitayani et al. [58] for mature grasses. Gargano et al. [59] reported similar results for D. eriantha (108 g/kg DM) and E. curvula (85 g/kg DM). Similar levels of ADL (73.9–220.4 g/kg DM) in grass species were observed across the studied soils. However, these levels were high enough to cause low in vitro ruminal fermentation of grass species. Forage palatability varies with grass species as influenced by compounds, such as fibers, lignin, volatile compounds, and crude protein. These compounds play a huge role in reducing the amount of forage material that can be consumed and digested by herbivores [60]. Herrero et al. [61] and Ravhuhali et al. [62,63] concur that nutritive value, palatability, and digestibility are important factors that affect feed intake and animal productivity. Based on these parameters, the feed value of available grass species in the study areas is low. The nutritive value of these low-protein and high-fibre grasses could be improved by providing rumen-degradable nitrogen supplements [64] to animals that use these three communal rangelands.

4.5. In vitro Ruminal Dry Matter Degradability

The grass species A. congesta, D. eriantha, E. chloromelas, E. curvula, E. gummiflua and E. plana had similar ruminal DM degradability across the studied sites (Table 5). The degradability of these grass species was moderate, but this was not surprising given that...
the protein content was low while the fiber and lignin contents were high. Indeed, grasses with low ruminal degradability are commonly found to have low levels of nitrogen and energy as well as higher fiber concentration, and thus cannot support optimum microbial protein synthesis necessary for higher animal performance [65]. The nutrients available to ruminants are crucially determined by the extent and rate of DM fermentation in the rumen [66]. Grass-based animal production is often compromised when grass DMD is low, which could be a consequence of a limited grass growing period [67]. This can be corrected by giving pastures sufficient time to rest and regrow.

5. Conclusions

Soils from the three study sites were found to be acidic. Hutton and Clovelly soils had better nutrient concentration such that both soil types had a numerically higher grazing capacity and a higher proportion of palatable species compared to the Avalon soil type. While soil type did not influence the quantity of grass forage production, it affected the chemical composition and nutritional value of the various grass species. Regardless of the harvesting site, most grass species were moderately fermentable in a simulated rumen due to high fiber and low protein content. Consequently, animals using these rangelands would require protein supplementation for better productivity. Better rangeland management strategies, such as reducing the stocking rate and introducing camps for rotational grazing could be used to permit vegetation recovery and improve rangeland health regardless of soil type. Grazers are known to exhibit selectivity in their foraging behavior thus they tend to make better use of rangelands than what is usually predicted from rangeland assessments alone. However, to allow this beneficial selective behavior in the studied rangelands, stocking density must be reduced.

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