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Nutritive Value of Four Lucerne Cultivars Planted in Two Soil Types at Bathurst Research Station, Eastern Cape Province, South Africa

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Abstract

Medicago sativa (lucerne) is a widely used perennial fodder crop and ranked amongst the highly nutritive fodders globally. This study assessed the nutritive value (*i.e.* CP % and TDN %) of four lucerne cultivars under two soil types at Bathurst Research Station. A random grid (quadrant) sampling method was used for sampling and samples were submitted to the laboratory for analysis to determine forage quality. Data collection was carried out by separating harvested biomass for each cultivar using clean packs, weighed and dried at 70˚C for 48 hours then crude protein (CP %) and Total Digestible Nutrients (TDN %) were determined. The results of the study showed that soil type (site) had a significant ($P < 0.05$) effect on the overall quality of dry matter produced. In soil 1 (S1) the overall CP % content was 11.48% while it was 19.03% in soil 2 (S2). Cultivar 3 (KKS 9911) was the least nutritive cultivar in site 1, while the same cultivar was the most nutritive cultivar in site 2 pertaining CP content. Soil type also significantly affected ($P < 0.05$) the overall total digestible nutrient (TDN %) content of different lucerne cultivars. In S1, C4 (WL 525) had the highest ($P < 0.05$) TDN content in comparison to the rest of the cultivars while in the same soil type C1 (SA Std.) had the least TDN content. The four tested lucerne cultivars generally produced highly nutritive lucerne in S2 while they produced less nutritive lucerne in relation to both CP and TDN content in S1.

Keywords

Forage Quality, Nutritive Value, Fodder

1. Introduction

Lucerne is known as the "king of forage crops" due to its high forage quality, digestibility, palatability and dry matter (DM) production, especially under irrigation [1]. Globally, lucerne is one of the most grown forage crops [2]. Lucerne is regarded as the best and most commonly utilised pasture species in South Africa [1] [2]. In semi-arid areas where annual rainfall exceeds 500 mm, lucerne is cultivated as a rain-fed crop and used for grazing [3]. The protein content of lucerne hay is highly ranked and contains appreciable amounts of the essential amino acid lysine [4]. Amongst the most crucial roles of hay, quality is to enhance milk and meat production. Crude protein (CP) and total digestible nutrients (TDN) are some vital parameters measured to determine hay quality [5]. An average Lucerne plant is estimated to consist of 22% - 26% CP content when produced under optimal growing conditions. Ruminants have different CP requirements depending on their stage of growth. For instance, a dairy lactating cow weighing about 591 kg requires about 16% - 18% CP content to maintain its milk production [6]. In beef production systems a general recommended average TDN content is 60% [5]. Feeding with lucerne is also viewed as a "magic ingredient" for dairy cows as it complements grass and maize silages when fed at 2 - 3 kg a head a day. Inclusion of Lucerne in ruminant diets lifts rumen pH and increases scratch factor [5] [6].

Environmental and phenological factors, such as season, stage of growth, soil fertility and soil nitrogen status affect the nutritive characteristics of forages such as Lucerne [7]. Lucerne cultivar selection is one of the most important factors which determine the production potential in a particular environment. Its management is also key in bringing that potential to full fruition. The type of a selected cultivar also directly affects DM quantity, quality, pest/disease tolerance and stand life [8]. Stand persistence is also an important factor to consider when selecting a cultivar, particularly when Lucerne is to be produced for a number of consecutive growing seasons, as is the case for most producers [9]. The longer the stand persists seed and establishment cost becomes less important [8]. The aim of the study was to determine the effect of soil type on the nutritive value (*i.e.* CP and TDN %) of four lucerne cultivars planted at Bathurst Research Station in the Eastern Cape Province, South Africa.

2. Materials and Methods.

2.1. Study Area

The trial was done at Bathurst Research Station located at 33˚30'S and 26˚49'E with an altitude of 708 m, under Ndlambe Local Municipality in Sarah Baartman District. The area receives an average annual rainfall of 624 mm and has temperatures ranging between 13˚C - 29˚C. Bathurst falls under the kowie thicket veld (*i.e.* albany thicket biome). Kowie Thicket is characterized by herbaceous layer, succulent vegetation, shrubs and trees [10].

2.2. Experimental Procedure

The study assessed the nutritive value (*i.e.* CP % and TDN %) of four lucerne cultivars under two soil types namely Wesleigh and Oakleaf at Bathurst Research Station in March-April 2018. The treatments constituted of four cultivars (*i.e.* WL 711, WL 525 HQ, KKS 9911 and SA Standard). SA Standard was used as the control. The cultivars belong to four major dormancy groupings. The choice of cultivars was based on the dormancy groupings that were previously evaluated for performance in the Eastern Cape. All plots were 3 m × 3 m in size and were 12 meters apart. The trial was established in March-April 2018 as a 2 × 3 × 4 factorial design replicated three times.

Prior planting, soil samples were collected at random points from each site up to a depth of 15 cm to determine both chemical and physical properties of the soil. All soil samples were analysed at Döhne laboratory for soil pH, organic carbon (OC), total nitrogen (TN), exchangeable cations and available phosphorus using the Ambic-2 method [11] [12] and standard procedures described in soil science of South Africa (1990). Seeds were inoculated with a proper strain of commercially available inoculum (*rhizobium* bacteria). A pre-planting fertiliser (lime) was incorporated into the soil prior to the last seedbed preparation. Planting involved both row and broadcasting at a seeding rate of 5 $kg \cdot ha^{-1}$ and 15 $kg \cdot ha^{-1}$ respectively. Seed was rolled immediately after sowing for better contact between seed and soil [13] [14].

2.3. Nutritive Value Data Collection

For determination of dry matter quality (*i.e.* CP and TDN content) per cultivar in each treatment, a random grid (quadrant) sampling method (where a circular quadrant of 1 m^2 size adjusted to a 5 cm height was thrown on the plots randomly) was used and all biomass within that radius was cut to a 5 cm above the ground level in each plot. The harvested biomass for each cultivar was separated using clean packs, weighed and oven-dried at 70˚C for 48 hours then weighed for dry mass to determine the moisture content. A further laboratory test was done to determine biomass quality using a wet chemistry technique where a 250 g grab sample per plot was collected and analysed to determine forage quality [11] [12].

2.4. Data Analysis

All data collected was statically analysed by making use of both descriptive and inferential statistical techniques using the Statistical package for the Social Sciences (SPSS), version 25. Analysis of Variance (ANOVA), the repeated option of PROC GLM including Multifactor ANOVA where nutritive value per cultivar was a dependent variable while, cultivar and soil type were factors. Statistical significance was tested at 95% level with all results with $P < 0.05$ considered to be statistically significant.

3. Results

The findings of the study show that soil type had an effect ($P < 0.05$) on the overall crude protein (CP %) content of different lucerne cultivars. The overall CP content was higher in S2 than in S1 (**Figure 1**). In S1 C4 (WL 525) had the highest ($P < 0.05$) CP content (14.06%) in comparison with all other cultivars while in the same soil type C3 (KKS 9911) had the least CP content (8.85%). Cultivar 3 (KKS 9911) produced the highest ($P < 0.05$) CP content (21.24%) than the rest of the cultivars in S2 whereas C1 (SA Standard) had the least CP content (15.48%) in comparison with all other cultivars in the same site (**Table 1**). The results of the study also show that soil type also had an effect ($P < 0.05$) on the overall total digestible nutrient (TDN %) content of different lucerne cultivars. The TDN content was higher in S2 in comparison to S1 (**Figure 2**). In S1 C4

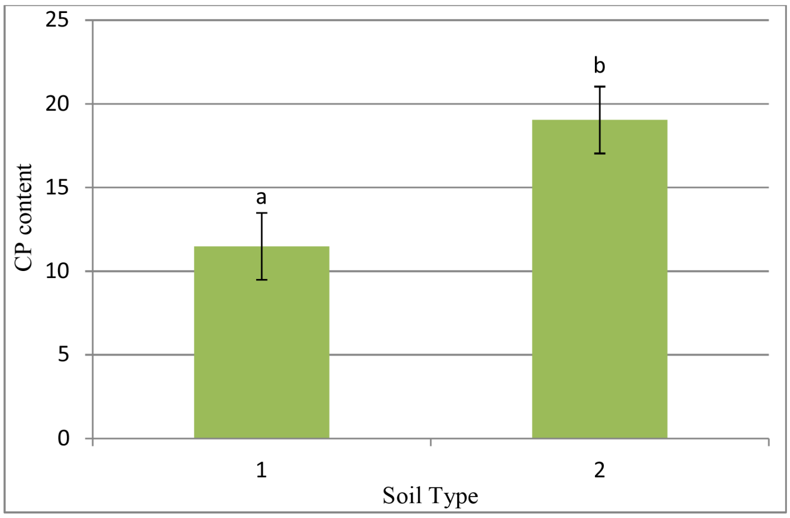

Figure 1. Overall CP % content of Lucerne per soil type.

Table 1. Effect of soil type on Lucerne CP % per cultivar.

Soil type	Cultivar	Mean	Std. error
Soil 1	C1 = SA Std.	11.01^{a}	0.710
	C2 = WL 711	12.00^{a}	0.710
	C3 = KKS 9911	8.85^{b}	0.710
	C4 = WL 525	14.06^{a}	0.710
Soil 2			
	C1 = SA Std.	15.48^{b}	0.710
	C2 = WL 711	19.61^{a}	0.710
	C3 = KKS 9911	21.24^{a}	0.710
	C4 = WL 525	19.80^{a}	0.710

Different small letter superscripts within the same column depict significant difference ($P < 0.05$) between soil type * cultivar while similar superscripts show no significant difference.

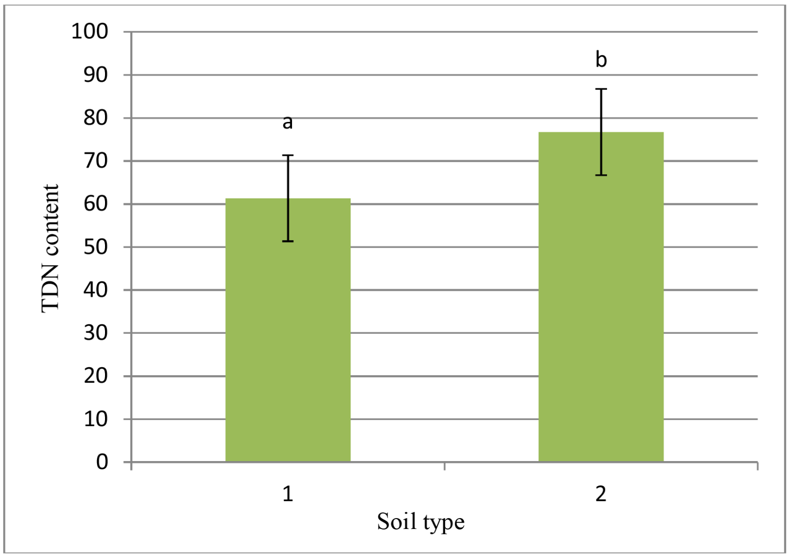

Figure 2. Overall TDN % content of Lucerne per soil type.

Table 2. Effect of soil type on Lucerne TDN % per cultivar.

Soil type	Cultivar	Mean	Std. error
Soil 1	C1 = SA Std.	57.08^{b}	2.574
	C2 = WL 711	57.25^{b}	2.574
	C3 = KKS 9911	58.75^{b}	2.574
	C4 = WL 525	72.33^{a}	2.574
Soil 2			
	C1 = SA Std.	76.80^{a}	2.574
	C2 = WL 711	76.17^{a}	2.574
	C3 = KKS 9911	77.07^{a}	2.574
	C4 = WL 525	76.98^{a}	2.574

Different small letter superscripts within the same column depict significant difference ($P < 0.05$) between soil type * cultivar while similar superscripts show no significant difference.

(WL 525) had the highest ($P < 0.05$) TDN content (72.33%) in comparison to the rest of the cultivars while in the same soil type C1 (SA Std.) had the least TDN content (57.08). Cultivar 3 (KKS 9911) produced the highest ($P < 0.05$) TDN content (76.98%) than the rest of the cultivars in S2 whereas C2 (WL711) had the least TDN content (76.17%) in comparison with all other cultivars even though the difference was not significant (Table 2).

4. Discussion

This study was aimed at determining the CP % and the TDN % content of different Lucerne (*Medicago sativa*) cultivars belonging to four dormancy groupings growing in two soil types. The results of the study showed that soil type had an effect on the overall crude protein (CP) content of different lucerne cultivars. In soil 1 (S1) the overall CP % content was 11.48% while it was 19.03% in soil 2 (S2). Regarding cultivar evaluation, the four tested lucerne cultivars produced highly nutritive lucerne in S2 while they produced less nutritive lucerne with regards to both CP and TDN content in S1. In S1 cultivar 4 (WL 525) had the highest CP (14.05%) content in comparison with all other cultivars while in the same soil type cultivar 3 (KKS 9911) had the least CP (8.85%) content. In S2, cultivar 3 (KKS 9911) produced the highest CP (21.24%) content than the rest of the cultivars while C1 (SA standard) produced the least CP (15.48%) content in comparison with all other cultivars. In relation to soil nutrient status S1 was a poor soil type while S2 was an average soil providing a favourable environment for optimal plant growth and development, this may translate to the evident superior nutritive value of the pasture consequently, produced. These findings are comparable to the results that were published by [15] [16] [17] [18], who indicated that soil type, which affects the ability of the soil to hold nutrients and water ultimately affects the quality of pastures produced.

The results of the study also showed that soil type had a significant effect on the overall total digestible nutrient (TDN %) content of different lucerne cultivars. In soil 1 (S1) the overall TDN % content was 61.35% while it was 76.75% in soil 2 (S2). In S1 cultivar 4 (WL 525) had the highest TDN (72.33%) content in comparison with all other cultivars while, in the same soil type cultivar 1 (SA standard) had the least TDN (57.08%) content. In S2, cultivar 3 (KKS 9911) produced the highest TDN (77.07%) content than the rest of the cultivars while C2 (WL 711) had the least TDN (76.17%) content in comparison with all other cultivars.

The two research sites are having different soil forms and soil physical characteristics; these differences may lead to significantly different levels of lucerne nutritive value. It is quite clear that S2 remains the better soil type. This is attributed to the fact that S2 is well drained and moderately deep therefore, provides a conducive environment for optimum lucerne development, growth and productivity. S1 was shallow in terms of soil depth, had signs of wetness and water logging. These characteristics are known to hinder optimum lucerne production and development. This is comparable to the finding of the studies conducted by [7], who indicated that Lucerne nutritive characteristics are greatly influenced by a number of environmental and phenological factors like soil nutrient status. Soil type also significantly influences the plant available water content (PAWC) and this ultimately affects the nutritive value of a pasture consequently produced [19].

With regards to TDN content in S1 cultivar 4 (WL 525 HQ) had the highest (72.33%) TDN of other cultivars while cultivar 1 (SA standard) had the lowest (57.08%) TDN. In S1 cultivar 4 (WL 525 HQ) had the highest CP (14.05%) content in comparison with all other cultivars while in the same soil type cultivar 3 (KKS 9911) had the least CP (8.85%) content. Both cultivar 3 and cultivar 4 are the highest ranked cultivars with regards to dormancy groupings and therefore their high performance was expected. Highly ranked dormant winter active cultivars are known to have abundance of soluble sugars and stress-related translation products, as well and differential accumulation of protein, DNA and RNA [20]. Such plants have a potential to yield up to 20% of their annual growth during winter through limiting the freezing occurring in extracellular spaces [21]. This finding is in line with the results published by [22] [23] [24] who concluded that a selected cultivar directly affects the quality of dry matter produced.

5. Conclusion

Outcomes of this study prove that Lucerne has the ability to provide forage of superior quality which is valuable for improving livestock productivity. It is also evident that soil type is a superseding factor influencing the ultimate nutritive value of the pasture produced in a particular area. Differences in the quality parameters measured between cultivars are also more pronounced in the poorer soil.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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