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Forage productivity and nutritive value of *Stylosanthes humilis* (Kunth) harvested at different Phenological stages

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Abstract— *Using local feed was hampered primarily by overlooking the proper growing period of hay harvesting. The objective was to determine the stage of Stylosanthes humilis (Kunth) should be harvested in order to maximize dry matter and provide higher-quality hay. The six treatments were before to flowering (BF), 10, 25, 50, 75, and 100% flowering stages were tested for yield and nutritional quality using a randomized complete block design with three replications. The findings demonstrated that the evaluated morphological features and quality indicators had different interaction effects. Hay harvested at 10% flowering stage had the highest leaf proportion, and the CP content varied significantly (p<0.01) between treatments; hay harvested at 10% flowering stage had a higher IVDMD value (66.9%), while hay harvested before flowering had a higher value (20.9, 20.8, and 20.6%, respectively). Plant height had a negative correlation with LSR, CP, ash, NDF, ADF, and IVDMD, but a positive and significant (P<0.001) correlation with DM% and dry matter yield t/ha. NDF was uncorrelated with LSR, DMY t/ha, and IVDMD, while it was positively and significantly correlated (p<0.001) with ADF and DM% and negatively connected with CP. Determine that the 25% flowering stage was the best time to harvest Stylosanthes humilis (Kunth) hay, leading to a higher dry matter yield and better nutrient quality. This was highly advised in order to improve the usage of Stylosanthes humilis (Kunth) hay in farmers' technological demonstrations.*

Keywords— ***flowering, morphological, in vitro digestibility, nutritional quality, season***

I. INTRODUCTION

The country feed resources fall into the following categories: hay, agro-industrial by-products, crop residue, natural pasture, improved pasture, and forages, which are 37, 33, 14, 10, 5, and 1%, respectively (CSA, 2021). According to Alemayehu Mengistu et al. (2017), the main sources of feed for cattle in the nation are natural pasture, crop residues, and stubble grazing. According to Shapiro et al. (2015) and CSA (2019), these feed resources are of low quality and are not easily available all year round. Over the past five years, foreign invasive plants and cropping land invasions have caused a significant reduction in grazing land. The primary factor contributing to Ethiopian smallholder farmers' livestock's subpar production performance is a lack of feed. In order to address this issue, various studies aim to strategically supplement with cultivated improved forages and agro-industrial by-products. Since legumes generally have a relatively high feeding value, adding legume forages improves the diet of animals. This is especially true for mature fodder, when regulated legumes can retain a higher nitrogen content than grasses (Mariyappan et al., 2009).

The shrubby perennial legume Stylosanthes scabra is indigenous to South America's tropical regions (Schultze et al., 1984). In tropical and subtropical climates with variable soil fertility and acidity, shrubby stylo thrives (Pathak et al., 2004). Because it grows in areas with 325 mm of annual rainfall, reaches a height of 1.2 m, and yields 1 to 10 and 2 to 7 tons of dry matter (t/ha-1 DM) annually as pure pasture or when interplanted with grasses, respectively, Shrubby Stylo is a crucial legume for drier regions (Pathak et al., 2004; Akinlade et al., 2008; https://www.tropicalforages.info). *Stylosanthes humilis*, sometimes known as Kunth, is a perennial improved farmed legume fodder that can be utilized as hay or cut as feed in lowland settings. An annual herbaceous legume with a broad geographic and ecological range, *Stylosanthes humilis* is indigenous to Central and South America. It can be found in both semi-arid and locations with up to 3000 mm of annual rainfall in Brazil (Williams et al., 1984). Aside from these traits, it is regarded as a significant pasture legume for the tropics and an intriguing species for genetic and ecological research. The right hay harvesting stage hasn't been thoroughly understood, nevertheless, particularly in the Metekel Zone of Benishangul Gumuz Regional State in North West Ethiopia. Finding the precise stage of *Stylosanthes humilis* (Kunth) hay harvest for the best fodder yield and nutritional quality was the goal of the study.

II. MATERIALS AND METHODS

Experimental site

The experiment was conducted for three consecutive years during the 2019 to 2021 cropping season at Pawe Agricultural Research Center on-station in Metekel Zone of Benishangul Gumuz Regional State, Ethiopia, it is at a distance of 567 km northwest of Addis Ababa. The elevation of the area is 1150 meters above sea level and the annual rainfall ranges from 900 to 1450 mm with annual minimum and maximum temperatures of 20 and 35°C, respectively. The experiment was undertaken on loam sandy soil and the PH value was 5.51 and 3.45 organic matter 0.15 total nitrogen percentage (Habtie *et al.*, 2020). The rainfall distribution, maximum and minimum temperature and relative humidity of experimental years are shown in (Fig 1 and 2).

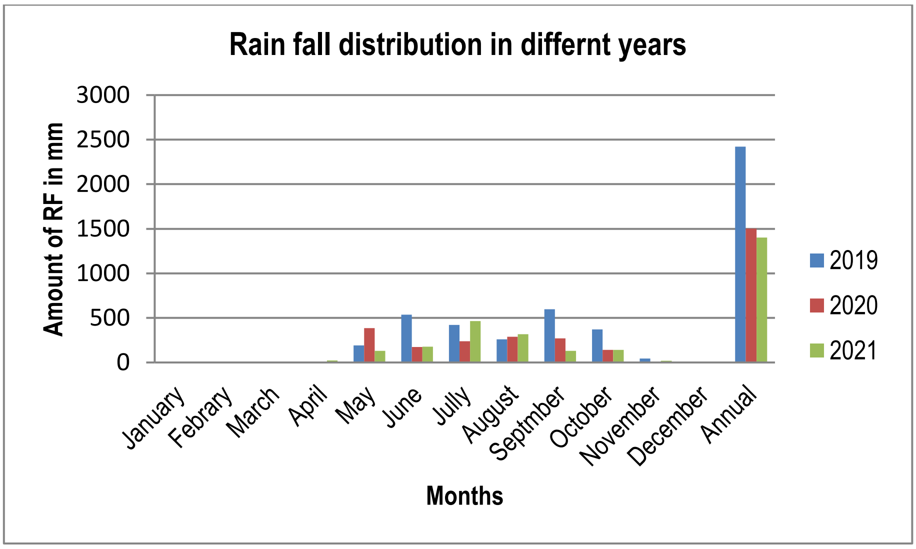

Fig.1 Annual distribution of rainfall in different experimental years

Treatments and experimental design

Six treatments were considered by using the flowering phenology of *Stylosanthes humilis* (Kunth), while the treatments were harvested at the blooming stage (T1), 10% flowering (T2), 25% flowering (T3), 50% flowering (T4), 75% flowering (T5) and 100% flowering (T6). The seed rate of *Stylosanthes humilis* (Kunth) was 10kg/ha in a 3mx4m (12m^2) plot size using a randomized complete block design (RCBD) with three replications in the main rainy season of mid-June.

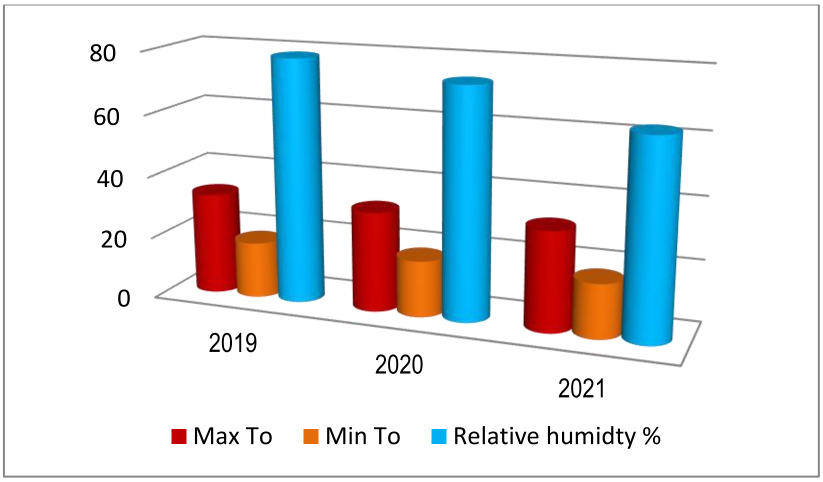

Fig.2 Pattern of temperature and relative humidity in different experimental years

Land preparation, planting, and management practices

The land was plowed and prepared using a tractor and leveled manually. The recommended amount of seed rate for *Stylosanthes humilis* (Kunth) is 10kg per hectare; 12g per 12m² plot was used. The spacing between rows was 40cm and seeds were drilled at a depth of about 3cm, and lightly covered with soil to ensure adequate emergence. 100kg/ha nitrogen, phosphorus, and sulfur (NPS) fertilizer was uniformly applied during sowing. Plots of *Stylosanthes humilis* (Kunth) were weeded manually at different times during the experimental period and furrows were made to prevent water logging.

Field data collection and fodder sampling

Five plants were randomly selected from each plot (counted from the main stem at the bottom), to measure the average values of the number of tillers per plant, plant height using a steel tape from the ground level to the highest leaf, the weight of the total fresh biomass yield (FBY) was recorded from one m² quadrant sample in each plot harvested at 5cm above the ground and converted to the hectare. A fresh biomass yield representative sample weighing 300g was manually fractioned into leaf and stem. The leaf-to-stem ratio (LSR) was estimated based on the fresh basis of each component on the field by measuring sensitive balance. After measuring leaf and stem fresh weight, the sample was pooled and put into paper bags and oven at 65°C to constant weight to measure the dry matter content and calculate dry matter yield (DMY).

Fodder chemical composition and in vitro digestibility analyses

The nutritional quality analysis of the forage sample was done at Holetta Agricultural Research Center Nutrition Laboratory. The dried fodder samples were ground to pass through a 1mm Wiley mill sieve size and labeled for easy identification and stored at ambient temperature pending quality analyses. Dry matter (DM), Ash, and Organic Matter (OM) were done according to the procedures of AOAC (1995). Neutral detergent fiber (NDF), Acid Detergent fiber (ADF) and Acid detergent lignin (ADL) were determined by the method of Van Soest and Robertson (1985). In vitro, dry matter digestibility (IVDMD) of the sample was determined according to the procedure outlined by Tilley and Terry (1963). Hemicellulose and cellulose were calculated as NDF-ADF and ADF-(ADL+ADF ash), respectively. The nitrogen content of the samples was determined by the Micro Kjedhal method crude protein (CP) was calculated by multiplying the N value by 6.25.

Statistical analysis

The mean DM yield components, growth parameters and chemical composition data for different treatments of *Stylosanthes humilis* (Kunth) were used for the statistical analysis. The General Linear Model (GLM) procedure of SAS system computer software was employed for the analysis of variance SAS version 9.4. (SAS, 2019). The least significant difference (LSD) at a 5% significance level was used for the comparison of means. We analyzed the data using the following model: Yijk = μ + Ti + Yj + (TY)ij + Bk + eijk; Where Yijk =measured response of treatment i in block k of year j; μ = grand mean; Ti = effect of i^{th} treatment Yj = effect of j^{th} year; TY= effect because of interaction between i^{th} treatment and j^{th} year; Bk (j)= effect of k^{th} block; eijk =random error effect of treatment i in block k of year j.

III. RESULTS AND DISCUSSION

Analysis of variance

The combined analysis of variance in morphological characteristics and in vitro quality attributes measured the number of tillers per plant (NT), plant height (PH), leaf-to-stem ratio (LSR), FBY DM, Ash, CP, NDF, ADF, ADL and IVDMD is presented in (Table 1). The effect of year was highly significant ($p<0.0001$) differences for the number of tillers per plant (NT), plant height (PH), dry matter yield (DMY), and contents of Ash, CP, NDF, ADF significant ($p<0.05$) differences for FBY. Treatments differed significantly ($p<0.01$) for FBY, DMY, CP NDF, ADF and ADL whereas NT, PH and Ash were significant ($p<0.05$). But, LSR, DM% and IVDMD were not significant ($p>0.05$) by year and treatment. The year*treatment interaction did not affect ($p>0.05$) all parameters measured except the CP and ADL contents ($p<0.05$) (Table 1).

Table: The combined mean square for morphological characteristics and nutritional quality parameters of different treatments evaluated over years for Stylosanthes humilis (Kunth)

S.V	DF	NT	PH	LSR	FBY	DMY	DM	Ash	CP	NDF	ADF	ADL	IVDMD
Year	2	974***	838.9**	0.05	100.76*	331.86*	0.03	44.38***	139.6***	248.7***	476.22***	16.56***	11.34
Rep	2	5.3	437.8*	0.02	41.34	18.28*	0.09	0.62	0.06	3.8	2.2	0.04	4.5
Trt	5	19.5*	206.5*	0.07	106.6**	35.75**	0.04	0.65*	1.85**	8.2**	7.3**	0.42**	4.1
Trt*Yr	10	9.6	103.3	0.05	19	2.24	0.01	0.1	0.7*	2	1.79	0.17*	3
Error	34	4.8	74.4	0.05	19.88	19.88	0.03	0.22	0.31	1.9	1.78	0.07	7.9
GM		13.4	98	0.59	40.2	36.5	90.8	7.27	20.4	55.59	34	6.57	65.9
CV		16.38	8.7	39.7	11.09	11.3	0.19	6.4	2.76	2.47	3.9	4.27	4.26
Sig		**	*	ns	**	**	ns	ns	**	**	**	**	ns
R2		0.92	0.64	0.34	0.59	0.42	0.35	0.92	0.96	0.89	0.94	0.93	0.24

*=significant at 5% **=significant at 1%, ***=significant at o.1%, Rep=replication, Trt=treatment, NT= number of tiller; PH=plant height LSR= leaf stem ratio FBY=fresh biomass yield; DMY= dry matter yield DM=dry matter OM=organic matter CP=crud protein NDF=neutral detergent fiber ADF=acid detergent fiber ADL= acid detergent lignin and IVDMD=invitro dry matter digestibility.

Morphological characteristics over the year

Morphological characteristics provide supportive information for the quality traits' efficiency, and the performance of treatments over the year shown in (Table 2). Plant height, leaf-to-stem ratio and dry matter yield were significantly ($p<0.05$) different in the first year, not a statistically significant difference was observed in year two, while except number of tillers per plant and leaf-to-stem ratio showed a significant effect resulting in the third year. This variation may be the inconsistency of rainfall, temperature and relative humidity in different years.

Table 2: The morphological characteristics of Stylosanthes humilis (Kunth) at different harvesting stages over a year

TRT	NT			PH in cm			LSR			DMY t/ha			DM%		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
BF	13.8^{b}	6.7	11	83.2^{c}	95.7	99.2^{d}	0.6^{a}	0.59	0.57	29.76^{b}	32	30^{b}	90.8	90.79	90.8
10%	16.5^{ab}	6.8	11.8	86.6^{bc}	93.6	101.4^{bc}	0.53^{ab}	0.64	1	36.53^{ab}	35.5	36.57^{ab}	90.7	90.6	90.8
25%	19.2^{a}	7	12.6	98.8^{ab}	95.6	103^{cd}	0.57^{ab}	0.6	0.52	41.38^{a}	35.97	34.04^{ab}	90.8	90.88	90.7

50%	19.6^{a}	7	12.8	106^{a}	94	105.3^{cd}	0.58^{ab}	0.7	0.63	42.89^{a}	36.32	34.08^{ab}	90.8	90.78	90.9
75%	19.9^{a}	7	12.9	106.9^{a}	94.3	108.3^{b}	0.47^{ab}	0.68	0.48	39.6^{a}	37.55	37.89^{a}	90.8	90.73	90.9
100%	21.6^{a}	7.4	14.2	104.7^{a}	98	113^{a}	0.41^{b}	0.57	0.41	43.57^{a}	37.49	36.01^{ab}	90.9	90.89	90.9
GM	18.4	6.98	12	97.7	95.2	105	0.53	0.63	0.6	38.96	35.8	34.77	90.8	90.78	90.8
CV	12.7	6.7	19	7.9	13.6	2.3	16.6	19.6	64.6	11.4	9.19	10.6	0.15	0.26	0.1
LSD	5.7	0.83	4.1	13.8	22	4.5	0.16	0.22	0.7	8.11	5.99	6.7	0.26	0.44	0.27
Sig. level	**	*	NS	*	NS	**	*	NS	NS	*	NS	*	NS	NS	NS

This means that a column with different superscripts is significantly different. NS=non significant; BF=before flowering; NT= number of tiller, PH=plant height LSR= leaf stem ratio FBY=fresh biomass yield DMY=dry matter yield.

Forage yield components

Plant height

The mean plant height of *Stylosanthes humilis* (Kunth) on different harvesting stages was significantly (P<0.05) different across all testing years except the 2020 cropping season (Table 2). The result indicated that the highest mean plant height was recorded in the 2021 cropping season (113 cm) followed by year one (2019) (104.7 cm) and year two (2020) (98 cm) at 100% flowering harvesting stage during the experimental years. Combined analysis for plant height also differed significantly (P<0.05), which ranged from 105.2 to 92.7 cm with a mean of 98.35 cm. Generally, the (T6) 100% harvesting stage gave the highest mean plant height followed by 50%, 75%, and 25% while the lowest plant height was recorded at 10% flowering and before the blooming stage. This difference could be due to differences in moisture content and soil fertility conditions of the experimental periods and when the plant develops a full phenological stage the height of the plant also increases. These values correlate well with Karal. A. Hernandez (2020) on the concept of plant growth and development described plant growth as the increase of plant biomass, which varies over time and depends on the life cycle of the plant, environment and management but, development is the passage over the life cycle phases like vegetative, elongation, boot, flowering stages, anthesis, and seed ripening.

Number of tillers per plant

There is a significant difference observed among the harvesting stage (p<0.05) on the number of tillers per plant. *Stylosanthes humilis (*Kunth*)* harvested at 100% flowering stage gave the highest tiller number per plant (21.6), which was followed by harvesting at 75% flowering (19.9). The highest tiller density per plant observed at the late stages of harvesting which was significantly different from the number of tillers harvested at the early days of growth of the plant indicated that the number of tillers per plant increased with an increase in the stage of harvesting days. This result shows that the plant clipped at the early development stage had a few tillers per plant. There is a difference among different experimental years, a higher tiller number was recorded in 2019 followed by 2021, this may be due to the difference in intensity and the extent of precipitation in each year.

Leaf-to-stem ratio

As indicated in (Table 2) the leaf-to-stem ratio for the *stylosanthes humiles* (Kunth) hay harvesting stage was significantly different (p<0.01) was found over the years. The results indicated that the highest mean leaf-to-stem ratio at the forage harvesting stage was recorded in the first year (2019). This may be due to better precipitation that promotes the plant growth responsible for the attainment of higher leaf proportion. There was highest leaf proportion was recorded in10% flowering harvesting stage, whereas the other five treatments BF, 25, 50, 75 and 100% flowering stage recorded similar values. As the stages of growth of *stylosanthes humiles* enlarged, LSR became reduced, this indicated that there was an inverse relationship between the growths of plant to leaf to stem ratio. This might be due to the reason that old leaves fall when a plant increased reversely the stem of the plant was enlarged. Our result was analogous to the findings of Malede (2006) and Berihun (2005).

Table 3 The Nutritional quality parameters of Stylosanthes humilis (Kunth) at different harvesting stages over a year

TRT	Ash%			CP%			NDF%			ADF%			**IVDODM**		
	2019	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**	**2019**	**2020**	**2021**
BF	20.96^{a}	23.3	18.6^{a}	6.97^{b}	5.51	8.4	53.76^{b}	58.95	48.6	32.23	38.57	25.9^{b}	66.76	66.5	66.9^{a}
10%	20.03^{bc}	22.57	17.4^{b}	7.1^{ab}	5.44	8.8	56.33^{a}	59.98	52.7	34.4	39.66	29.1^{a}	66.93	68.7	65.1^{ab}
25%	20.46^{abc}	23.2	17.7^{ab}	7.1^{ab}	5.57	8.6	56.26^{ab}	59	53.4	34.4	38.72	30^{a}	65.4	66.4	64.3b
50%	20.76^{ab}	23.25	18.2^{ab}	7.43^{ab}	5.87	9	55.66^{ab}	59.2	52.1	34.16	39	29.2^{a}	65.06	64.7	65.2ab
75%	20.46^{abc}	23.32	17.6^{ab}	7.33^{ab}	5.45	9.1	55.8^{ab}	59.89	51.8	34.6	40.27	28.9^{a}	65.63	65.7	65.4ab
100%	19.76^{c}	23.46	16^{c}	7.73^{a}	6.39	9	55.66^{ab}	58.77	52.5	34.36	38.72	29.9^{a}	65.83	67.9	63.7b
GM	20.41	23.19	17.6	7.2	5.7	8.85	55.94	59.31	51.88	34.02	39.17	28.88	65.9	66.72	65.1
CV	2.02	3.05	3.6	5.7	9.7	4.47	2.24	2.54	3.18	2.72	4.4	4.67	3.08	6.2	1.79
LSD	0.75	1.28	1.15	0.75	1.01	0.72	2.26	2.74	3	1.68	3.16	2.4	3.7	7.52	2.13
P-value	0.04	0.7	0.009	0.31	0.32	0.25	0.22	0.87	0.058	0.08	0.8	0.035	0.83	0.88	0.08

This means that a column with different superscripts is significantly different. NS=non-significant BF= before flowering, CP=crude protein ; NDF= neutral detergent fiber; ADF= Acidic detergent fiber; IVDMD=In vitro dry matter digestibility

Forage yields

Forage dry matter yield of *Stylosantus humilis* (Kunth) showed a significant (p<0.001) variation among the treatments indicated in (Table 2). Dry matter yield obtained from (2019-2021) years varied from 29.76 t/ha to 43.57 t/ha among treatments with a mean of 38.96 t/ha. A high dry matter yield was attained from the 100% flowering stage (43.57 t/ha) followed by (42.89 t/ha) from the 50% flowering harvesting stage while the least dry matter yield was got (29.76 t/ha) from ready to flowering stage, the other was had intermediate value. This might be because of the high number of tillers per plant, height and reduction of moisture content when plant maturity advanced. This agrees with previous findings of Silva *et al.* (2021); and Dida *et al.* (2021) that the tiller number and maturity stage of the forage plant directly affect dry matter yield. This supports previous findings of Chiphwanya *et al.* (2021) plants develop physiologically from vegetative to reproductive phases, there is an increased stem fraction compared to the leaf fraction. Stem elongation is accompanied by an accumulation of hemicellulose, cellulose and lignin, which provide strength to the plant.

Forage nutritional quality and In-vitro quality parameters

Except for IVDMD the other nutritional quality parameters were a significant (p<0.05) difference at different clipping stages of hay for *Stylosantus humilis* (Kunth) presented in (Table 3). The higher DM value was recorded at 100% followed by 75, 50 25% and before the flowering stage, whereas lower DM was shown at the 10% flowering stage of mowing. The current result emphasized that when the plants are mature the dry matter content is higher. As indicated in (Table 3) significant differences between treatment groups on CP content, greater CP content was observed in hay harvested before flowering, 10 and 25% of flowering 20.9 and 20.8 and 20.6% flowering stage, and the other was intermediate values, respectively. The studies reported by Singh *et al.* (1997); and Mahala *et al.* (2009) indicated that the crude protein content of herbaceous species is higher at a young stage of growth than at a maturity stage. According to Lonsdale (1989) feeds that have <120,120-200 and >200gCP/kg DM and <9, 9-12 and >12 MJ ME/kg DM are classified as low, medium and high protein and energy source, respective order, based on this the current result was grouped under a medium level of protein feed. Therefore, the CP content obtained from our study for all treatments is above the maintenance requirement for ruminant livestock and enough to satisfy the protein requirement for dairy cows to produce 10-15kg milk/cow/day. These results offer crucial evidence among treatments on NDF, ADF and ADF value, except ready for flowering stage all treatments attained higher NDF, ADF and ADL. From this result, we observed that when the plant matured, the value of all fibers like NDF, ADF and ADL also increased, but the CP value was inversely dropped. Our experiments emphasize the previous results of Enoh *et al*. (2005) stage of maturity is the most important of all the factors affecting hay quality and the one in which the greatest progress can be made. There were no significant differences between treatments in terms of IVDMD. The forage nutritive value is affected most by variations in forage genotype, maturity, season, and management (Mahala *et al*., 2009; Solomon, 2001).

Correlation between morphological characteristics and nutritional parameters

The results of the Pearson correlation among plant height, leaf-to-stem ratio, dry matter yield t/ha, DM%, chemical composition and IVDMD were presented in Table 4. The current result of plant height was positively and strongly correlated (p<0.001) with dry matter yield t/ha and DM%, but negatively correlated with LSR, CP, ash, NDF, ADF and IVDMD. The negative correlation between these factors might be due to the enhanced plant height which leads to reduced leaf area as well as important nutrients if plants are harvested at full heading. The current result was inline with the prevous study of Mulisa (Faji *et al*., 2019). LSR was negatively correlated with DMY t/ha, DM% and CP, but not correlated with ash, NDF, ADF and IVDMD. Dry matter yield t/ha was positively correlated with DM%, but negatively correlated with CP and IVDMD and not correlated with Aash, NDF, and ADF. Crude protein was negatively correlated with ash, DMy t/ha, DM%, NDF, and ADF not correlated with IVDMD. NDF was positively and strongly correlated (p<0.001) with ADF, and DM% and not correlated with LSR, DMY t/ha, and IVDMD but, negatively correlated with CP.

Table 4: different harvesting stages of Stylosanthes humilis (Kunth) hay on the correlation between morphological characteristics and nutritional parameters

	PH	LSR	**DMY**	DM%	CP	Ash	NDF	ADF	IVDMD
PH	1	-0.11*	0.323*	0.335*	0.437**	-0.51***	-0393**	-0.392**	-.0313*
LSR		1	-0.206	-0.04	-0.061	0.137	0.0031	-0.028	0.081
DMY			1	0.307*	-0.003	0.001	0.22	0.21	-0.10
DM %				1	0.212	0.191	0.274*	0.187	-0.396**
CP					1	-0.894***	-0.82***	-0.89***	-0.117
Ash						1	0.76***	0.833***	0.318*
NDF							1	0.97***	0.173
ADF								1	0.089

*** Significant correlation at alpha 0.001, ** significant correlation at alpha 0.01, * significant correlation at alpha 0.05; NS: non-significant; NT; number of tiller; PH: plant height; LSR: leaf to stem ratio; FBY: fresh biomass yield; DMY: dry matter yield; DM%: dry matter percentage; CP: crude protein; NDF: neutral detergent fiber; ADF: Acidic detergent fiber; ADL: Acidic detergent Lignin; IVDMD: invitro dry mater digestibility

IV. CONCLUSION

Stylosanthes humilis (Kunth) exhibited different morphological and quality parameter variations among the tested treatments and years. The number of tillers, height of the plant, fresh biomass yield, NDF, ADF, and ADL of the plant are higher when plant maturity is advanced, while the CP, ash content and IVDMD of the plant are reversely condensed. Plant height was correlated positively and strongly (p<0.001) with dry matter yield t/ha and DM%, but negatively correlated with LSR, CP, ash, NDF, ADF and IVDMD. Dry matter yield t/ha was positively correlated with DM% but negatively correlated with CP and IVDMD. NDF was positively correlated (p<0.001) with ADF, DM% but, negatively correlated with CP. We observed a higher leaf proportion when the hay was harvested at 10% of the flowering stage of cutting. Hay harvesting for *Stylosanthes humilis (*Kunth) at the 25% flowering stage attained higher dry matter yield, protein content, and feed digestibility. Hence, to improve the utilization of *Stylosanthes humilis (*Kunth*)* hay in technology user's demonstration of technology was highly recommended.

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AUTHOR CONTRIBUTION

All authors contributed to research conceptualization, experimental design, data collection and data curation, analysis, and final draft manuscript writing.

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