COMPARATIVE FORAGE PRODUCTION AND IN-VITRO DRY MATTER DIGESTIBILITY OF THREE PERENNIAL FORAGE SPECIES OF *PANICUM* GRASS AT DIFFERENT CLIPPING STAGES

Ashar Farooq[1]*, Mohammad Salim[2], Muhammad Tahir Khan[3], Zahid Rauf[1], Ahmed Hussain[2] and Muhammad Bilal Zia[1]

ABSTRACT

The research was conducted to find out the relative performance of three perennial forage species of *Panicum* grass subjected to different clipping stages at Range Research Garden, Pakistan Forest Institute, Peshawar. Randomized Complete Block Design with Factorial arrangement having four replications was used for layout of the experiment. Treatment combinations consisted of three species i.e. *Panicum antidotale, Panicum coloratum* and *Panicum maximum* and three clipping stages viz. Pre-boot; full flowering and Seed Ripe stage. Fresh forage yield was determined immediately after clipping. The samples were oven dried to determine dry matter yield and In-Vitro Dry Matter Digestibility. The data were subjected to Analysis of Variance (ANOVA) for Factorial arrangement. Significant difference between individual means was separated using Tukey's HSD test. The results of the study for comparison of species indicated that fresh forage yield (t/ha) and In-Vitro Dry Matter Digestibility (%) of *Panicum maximum* was higher significantly ($P< 0.05$) followed by *Panicum antidotale* and *Panicum coloratum*. Dry matter (%) of *Panicum antidotale* was higher significantly ($P< 0.05$) than that of *Panicum maximum* and *Panicum coloratum.* The results of the study for comparison of clipping stages revealed that the fresh yield at Full Flowering stage was higher significantly ($P< 0.05$) than pre-boot and Seed ripe clipping stages. Analysis of data showed that Dry Matter (%) increased significantly as grasses grew from pre-boot stage till seed ripe stage. Keeping in view the highest forage yield and IVDMD, *Panicum maximum* was found to be the best species to meet the forage demand and nutritional requirements of livestock. Intermediate stage between Pre-boot and Full flowering stage was found to be the best stage for harvesting to maximize forage yield and nutritive value.

Keywords: Clipping stages, Fresh yield, Dry Matter (DM), In-vitro dry matter digestibility (IVDMD)

INTRODUCTION

Panicum is considered as one of the largest genus of Poaceae family having approximately 450 species. The species of the genus are widely distributed throughout the world in different ecological zones. Many species are found in sub-tropical regions. However, the genus is also well represented in

[1] Pakistan Forest Institute, Peshawar, Pakistan
[2] Department of Forestry and Wildlife Management, University of Haripur
[3] Department of Animal Nutrition, University of Agriculture, Peshawar
* Correspondence author's email: asharfarooq1973@gmail.com

temperate regions. *Panicum g*enera comprises of several species that have high forage potential. Blue panic (*Panicum antidotale*), Guinea grass (*Panicum maximum*) and Coloured Guinea grass *(Panicum coloratum*) are some of the better used and well known species (Aliscioni *et al*., 2003). Livestock sector is the largest sub-sector in agriculture during the past years. It contributes to foreign exchange income and accounts for about 3.1 % of total exports accounting for 11.70% to the Gross Domestic Product during the financial year 2019-20 (Anonymous, 2020). Rangelands are the largest natural resource of Pakistan having about 45.2 million hectare area. (Mohammad, 1989). For improving forage production and its utilization, it is essential to have awareness of nutritive value of range species and their impact on livestock production (Islam and Adams, 2000). Good nutritive value of forages and sustainable pasture management strongly contribute to high levels of animal performance and health in terms of production of milk, multiple births, growth rate or disease resistance. Forage grasses with high yielding production and having better nutritive value play an important role in meeting the nutritional requirements of livestock. Such perennial forages have an effective use in feeding programs of livestock. The forage grasses can be stored as hay & for making silage and are used in fodder shortage periods during winter (Anonymous, 2001). Introduction and cultivation of high-quality forages with high yield and wider adaptability to environmental stresses is demand of the situation. This could coup the shortage of quality feed and subsequently increase livestock productivity (Jamil *et al.,* 2018). Keeping in view the shortage of fodder and low rangeland productivity in Pakistan, the most important thing is to establish high yielding and more palatable grass species in their suitable eco-sites. The comparative study for yield and nutritional value of three *Panicum* grass species namely *Panicum antidotale*, *Panicum maximum* and *Panicum coloratum* species have never been explored in Pakistan. In this context, the present study was designed.

Objectives of the Study

The proposed study was focused to achieve the following objectives.

- Comparing the forage yield of *Panicum antidotale*; *Panicum coloratum* and *Panicum maximum* grass species at three different clipping stages

- Evaluating the In-Vitro Dry Matter Digestibility of *Panicum antidotale*; *Panicum coloratum* and *Panicum maximum* grass species at three different clipping stages

MATERIAL AND METHODS

Experiment was carried out in experimental area at Range Research Garden, Pakistan Forest Institute, Peshawar. The site of the experiment is

situated at 34.017113° North, 71.4809949° East with an altitude of 335 meters.

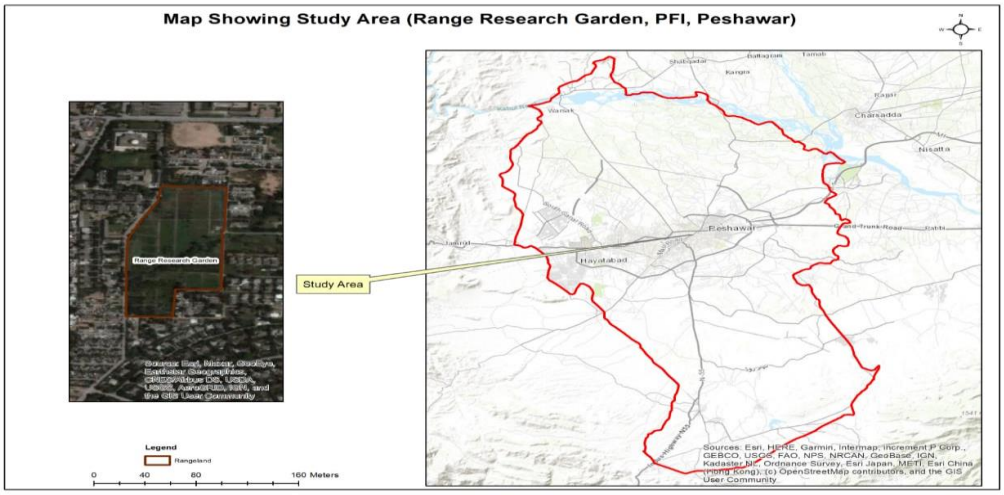

Fig. 1 Showing map of study area

Data of soil samples collected from the experimental site showed a sandy loam texture, pH (7.64), EC (0.19 dSm^{-1}),bulk density (1.53 gcm^{-3}), moisture (7.8%), organic matter content (0.53%), phosphorus (0.36 $mgKg^{-1}$) and low sulphur (0.027$mgKg^{-1}$) at 0-15 cm depth. Rainfall during the study period was 485 mm.

The layout of experiment was designed using Randomized Complete Block Design (RCBD) with Factorial arrangement having four replications. Root slips of forage grasses namely *Panicum antidotale*, *Panicum maximum* and *Panicum coloratum* were planted in March, 2020 in 3m x 3m plots at a spacing of 50 cm between rows and root slips. Irrigation was provided at the time of planting and two irrigations in June and July, 2020. The experiment was carried out from March, 2020 to November, 2020.

The forage species were manually harvested at three stages of growth viz. a. viz. Pre-boot (CS_1), Full Flowering (CS_2) and Seed ripe stage (CS_3). Green fodder yield per hectare was recorded for all the three clipping stages. One square meter (1^2m) quadrat was used to in each sample plot to harvest the grasses for fresh forage yield determination. For air-dried forage yield, grass samples were air dried until the weight of dry matter became constant.

For forage quality study, the grass samples were got analyzed from the Forage Nutrition Laboratory, Department of Animal Nutrition, University of Agriculture, Peshawar. According to the method of AOAC (2007), the grass samples were put to analysis for DM (method ID 934.01.ISO 900). IVDMD was determined by the technique Telly and Terry (1960). Forage analysis was carried

out with three (03) replications.

All data were analyzed with Analysis of Variance (ANOVA) technique for Factorial arrangement. SPSS Software package (Version 20.0) was used for data analysis. Significant difference between individual means was separated using Tukey's HSD test.

RESULTS AND DISCUSSIONS

1. Forage yield (fresh/green) of *Panicum* grasses at different clipping stages

The freshly cut forage yield of three *Panicum* grasses is presented below in Figure 2.

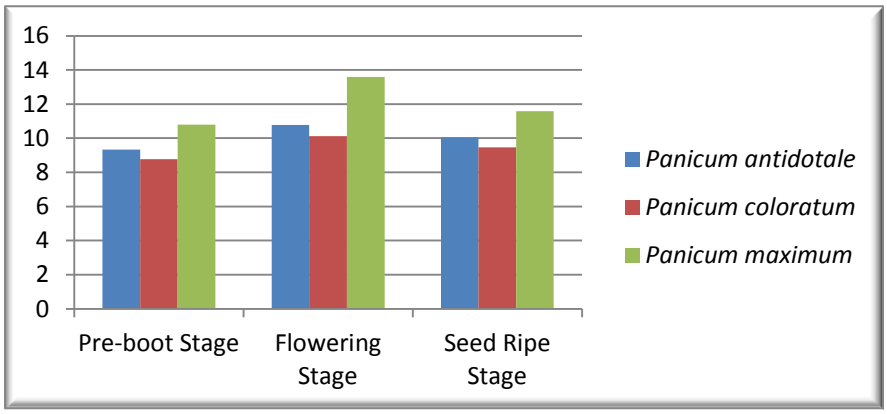

Fig. 2. Fresh/Green Forage Yield (t/ha) of three *Panicum* species at three different clipping stages

It is clear from the figure above that fresh forage yield of all the three species increases from pre-boot stage till seed ripe stage. *Panicum maximum* had the highest fresh forage yield at all clipping stages followed by *Panicum antidotale* and *Panicum coloratum*.Forage yield was maximum at full flowering stage followed by seed ripe stage and pre-boot stage. In all the three clipping stages, *Panicum coloratum* had the minimum production.

Statistical Analysis

Results of statistical analysis are presented below:

Comparison between Species

A comparison between species is shown in table 1:

Table 1. Showing results of statistical analysis for comparison between species

Dependent Variable	(I) species	(J) species	Mean Difference (I-J)	Sig.
Fresh Forage Yield	*Panicum antidotale*	*Panicum coloratum*	.5942	.331
		Panicum maximum	-1.9358*	.000
	Panicum coloratum	*Panicum antidotale*	-.5942	.331
		Panicum maximum	-2.5300*	.000
	Panicum maximum	*Panicum antidotale*	1.9358*	.000
		Panicum coloratum	2.5300*	.000

* 5% significance level

The results reveal that there is no significant difference between fresh yields of *Panicum antidotale* and *Panicum coloratum* while fresh yield of *Panicum maximum* is significantly higher than *Panicum antidotale* and *Panicum coloratum.*

Comparison between three Clipping Stages

A comparison between three clipping stages is shown in table 2.

Table 2. Showing results of statistical analysis for comparison between clipping stages

Dependent Variable	(I) Stage	(J) Stage	Mean Difference (I-J)	Sig.
Fresh Forage Yield	Pre-boot	Flowering	-1.8633*	.000
		Seed Ripe	-.7283	.197
	Flowering	Pre-boot	1.8633*	.000
		Seed Ripe	1.1350*	.026
	Seed Ripe	Pre-boot	.7283	.197
		Flowering	-1.1350*	.026

* 5% significance level

Interaction of species and clipping stages

Table 3. Results of statistical analysis for interaction of species and clippingstages

Source	Dependent Variable	Mean Square	F	Sig.
species * Stage	Fresh	.858	.850	.506

The results presented in above table show that interaction effect of species and clipping stages is non-significant.

Panicum maximum had the highest fresh yield followed by *Panicum antidotale* and *Panicum coloratum*. Afzal *et.al.* (2007) reported that aboveground fresh production of Green panic (*Panicum maximum* var. Gatton) was significantly higher than that of Blue panic grass (*Panicum antidotale*) in the rainfed conditions of National Agricultural research Center (NARC), Islamabad. Arshadullah *et al.* (2009) also concluded that fresh biomass of *Panicum maximum* was more (28.32 t/ha) than *Panicum antidotale* (17.0 t/ha) in Pothwar plateau.

Yield was lowest in pre-boot stage and was maximum in Full flowering stage. The findings are in line with the findings of Mirza *et al.* (2002); Sarwar *et al.* (2002); Mushtaque *et al.* (2010); Ahmad *et al.* (2012) and Lounglawan *et al.* (2014). The increase in yield is due to the fact that the fiber content also increases with increase in maturity which supports the yield.

Dry Matter (DM %) of *Panicum* Grasses at three different clipping stages

The dry matter yield of three *Panicum* grasses is presented in figure 3.

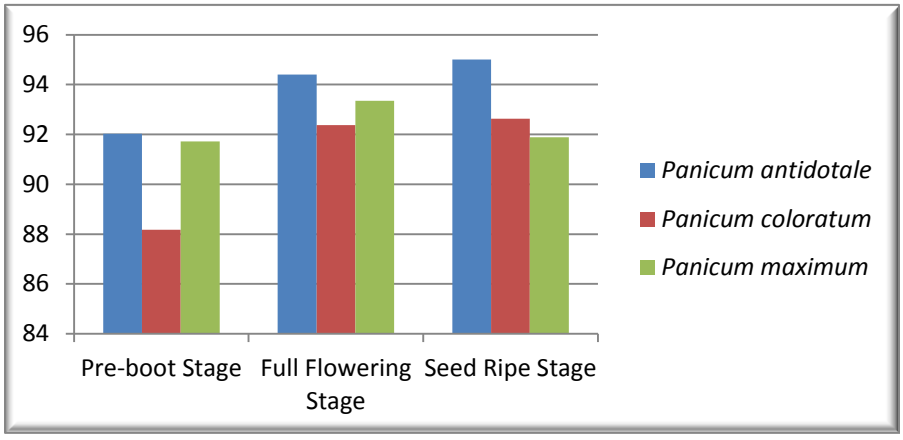

Fig. 3. Dry Matter (%) of three *Panicum* species at three different clipping stages

It is clear from the figure above that Dry Matter content of all the three species increases from pre-boot stage till seed ripe stage. *Panicum antidotale* had the highest DM content followed by *Panicum maximum* and *Panicum coloratum*.

Statistical Analysis

Results of statistical analysis are presented below:

Comparison between Species

A comparison between species is shown in table 4.

Table 4. Showing results of statistical analysis for comparison between species

Dependent Variable	(I) species	(J) species	Mean Difference (I-J)	Sig.
Dry Matter	*Panicum antidotale*	*Panicum coloratum*	2.7511*	.000
		Panicum maximum	1.4833*	.001
	Panicum coloratum	*Panicum antidotale*	-2.7511*	.000
		Panicum maximum	-1.2678*	.005
	Panicum maximum	*Panicum antidotale*	-1.4833*	.001
		Panicum coloratum	1.2678*	.005

* 5% significance level

The results reveal that there is a significant difference between all the three species of *Panicum*. Based on homogeneous sub-sets (Tukey HSD), Dry matter (%) of *Panicum antidotale* is significantly higher than the other two species of *Panicum.* Dry matter (%) of *Panicum coloratum* is the lowest.

Comparison between three Clipping Stages

A comparison between three clipping stages is shown in table 5.

Table 5. Showing results of statistical analysis for comparison between clipping stages

Dependent Variable	(I) Stage	(J) Stage	Mean Difference (I-J)	Sig.
Dry Matter	Pre-boot	Flowering	-2.7389*	.000
		Seed Ripe	-2.5400*	.000
	Flowering	Pre-boot	2.7389*	.000
		Seed Ripe	.1989	.834
	Seed Ripe	Pre-boot	2.5400*	.000
		Flowering	-.1989	.834

* 5% significance level

Interaction of species and clipping stages

Table 6. Showing results of statistical analysis for interaction of species and clipping stages

Source	Dependent Variable	Mean Square	F	Sig.
species * Stage	Dry Matter	3.860	7.226	.001

The results presented in above table show that interaction effect of species and clipping stages is non-significant.

Analysis of data revealed that dry matter (%) increased as grasses grew from pre-boot stage to Full flowering stage. The results support the findings of Mirza *et al.* (2002); Sarwar *et al.* (2006); Mushtaque *et al.* (2010); Ahmad *et al.* (2012); Lounglawan *et al.* (2014) and Chiphwanya *et al.* (2017). The increase in the yield is a result of the fact that as the grasses reach towards maturity, the fiber content (cell wall contents) also increases which supports the yield.

Panicum antidotale had the highest dry matter followed by *Panicum maximum* and *Panicum coloratum.* Arshadullah *et al.* (2006) found that *Panicum maximum* showed 9.32 t/ha dry biomass whereas *Panicum antidotale* showed 6.78 t/ha dry biomass respectively. On the contrary, Arshadullah *et al.* (2009) reported that the DM yield of *Panicum antidotale* (Blue panic) was better than *Panicum maximum* (Guinea grass).

In-Vitro Dry Matter Digestibility (IVDMD) composition of *Panicum* Grasses at three different clipping stages

IVDMD contents composition of three *Panicum* grasses is presented below in figure:

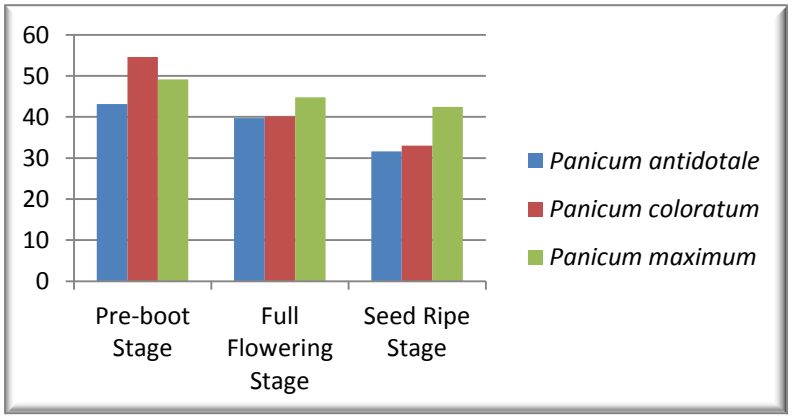

Fig. 4. In-Vitro Dry Matter Digestibility (IVDMD) of three

Panicum species at three different clipping stages

Statistical Analysis

Results of statistical analysis are presented below:

Comparison between Species

Table 7. Showing results of statistical analysis for comparison between species

Dependent Variable	(I) species	(J) species	Mean Difference (I-J)	Sig.
IVDMD	*Panicum antidotale*	*Panicum coloratum*	7.4067*	.000
		Panicum maximum	13.2567*	.000
	Panicum coloratum	*Panicum antidotale*	-7.4067*	.000
		Panicum maximum	5.8500*	.000
	Panicum maximum	*Panicum antidotale*	-13.2567*	.000
		Panicum coloratum	-5.8500*	.000

* 5% significance level

Comparison between three Clipping Stages

A comparison between three clipping stages is shown in table 8.

Table 8. Showing results of statistical analysis for comparison between clipping stages

Dependent Variable	(I) Stage	(J) Stage	Mean Difference (I-J)	Sig.
IVDMD	Pre-boot	Flowering	-4.4100*	.000
		Seed Ripe	-7.2933*	.000
	Flowering	Pre-boot	4.4100*	.000
		Seed Ripe	-2.8833*	.005
	Seed Ripe	Pre-boot	7.2933*	.000
		Flowering	2.8833*	.005

* 5% significance level

Interaction of species and clipping stages

Table 9. Showing results of statistical analysis for interaction of species and clipping stages

Source	Dependent Variable	Mean Square	F	Sig.

species * Stage	IVDMD	52.019	18.480	.000

The results presented in above table show that interaction effect of species and clipping stages is non-significant.

Panicum maximum had the highest IVDMD (%) followed by *Panicum coloratum* and *Panicum antidotale.* IVDMD content of grasses was the highest at pre-boot stage followed by Full flowering stage and was the lowest at seed ripe stage. IVDMD content of grasses decreased with phenological development of stages. These results resemble with the findings of Tessema *et al.* (2010); Bora *et al.* (2011); Reddy *et al.* (2012); Agza *et al.* (2013) and Chiphwanya *et al.* (2017) who reported the decrease in IVDMD with increase in maturity. The reason for this decrease is that lignin is deposited in the cell wall as the maturity increases, and the proportion of stems increases and ultimately the digestibility decreases when compared with early stages.

Research work by some researchers on three *Panicum* species is presented in table 10.

Table 10. Showing research work done on the yield and nutritive value of three *Panicum* species by researchers

Grass Species	FY (t/ha)	DM (t/ha)	Reference
Panicum antidotale	30	4.25	Heuze *et al.* (2016)
	10.50	3.88	Arshadullah *et al.* (2009)
Panicum coloratum	-	4.23	Heuze *et al.* (2017)
	29.25	9.28	Anwar *et al.* (2012)
Panicum maximum	-	7.0	Heuze and Tran (2020)
	17.09	5.72	Arshadullah *et al.* (2012)
	16.38	5.54	Anwar *et al.* (2012)
	2.08	0.71	Arshadullah *et al.* (2009)

In Pakistan, very little information is available on the three *Panicum* species for forage yield and nutritive value. No literature is available on the comparative performance of *Panicum* species in question. Few isolated studies have been conducted by some researchers. As depicted in the above table, Arshadullah *et al.* (2009) reported that P*anicum antidotale* had better fresh matter yield and dry matter yield as compared to *Panicum maximum* forage production. In another study, Anwar *et al.* (2012) reported better fresh and dry matter yield of *Panicum coloratum* as compared to *Panicum maximum.* Heuze *et al.* (2016); Heuze *et al.* (2017) and Heuze and Tran (2020) have reported separately the yield and quality parameters of three *Panicum* grasses. While comparing each other, it is found that *Panicum maximum* had significantly more DM yield than *Panicum antidotale* and *Panicum coloratum.* These results coincide with the findings of this study. However, the research work by Pakistani

researchers differ from this study.

CONCLUSION

It is concluded from the results that forage yield and nutritive value of *Panicum maximum* is significantly higher than *Panicum coloratum* and *Panicum antidotale*. Forage yield and quality at Full flowering stage is better than as compared to pre-boot and seed ripe stage. Full flowering stage is the best stage for harvesting these grasses. As for nutrition, good nutrient is IVDMD which is higher in early stages of growth and decrease with maturity.

RECOMMENDATIONS

Based on the results, the following recommendations are made:

1. *Panicum maximum* is recommended for use as a cultivated fodder crop and for hay & silage purposes in sub-tropical semi-arid zone, Peshawar.

2. In-vivo dry matter digestibility as well as livestock production should be further evaluated.

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