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# Forage Production and Pattern of Forage Quality Indices During Reproductive Development of Millet Genotypes

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**Abstract:** The forage yield and quality constituents vary greatly depending upon harvesting time and varieties. A field experiment was conducted for better understanding the effect of different harvesting times and genotypic variation in forage yield and quality indices. Three millet varieties i.e. FB-786, MB-87 and AF-POP-2005 were used in the experiment, and were harvested at three different timings i.e., 60, 70 and 80-days after sowing. In the beginning of reproductive development, all the three varieties produce quality fodder, however significant decline in fodder quality was observed due to delay in harvesting. Among the genotypes tested, FB-786 gave the outstanding performance in connection with forage yield, quality and feeding value. A close association in quality components was also found like varieties rich in protein had simultaneously accumulated low crude fibre. The differences produced by harvesting dates for leaf to stem ratio, fresh and dry matter yield were more pronounced even than varietal differences. The dry matter collected at 70 and 80-days after sowing was 43.5% and 68.1% higher than 60-days after sowing but low in quality. The crude protein at 70 and 80-days was 7.21% and 11.23% and ash was 7.08% and 10.63% less than harvesting at 60-days. Therefore, harvesting at 70-days after sowing is better compromise between forage yield and nutritional value. The compromise between forage yield and quality is intricate and it is upto forage producer which one is preferable. The variety with better performance i.e., FB-786 can be used for future forage improvement for narrowing the gap between achieved and required quality.

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## 1. Introduction

In domestication of animals, the grazing systems were replaced with cut and carry feeding system where livestock depends on chopped fodder. Green forages are the cheapest source of animal's nutrition (Mohajer et al., 2013) and it is prerequisite for owner of livestock farming to be a grass producer to ensure seasonal availability of quality food in sufficient quantity for profitable farming. Recently a major portion of animal feed is obtained from green forages along with some cereal and legume based concentrates as food supplement. The livestock in Pakistan is often remain under fed (Akmal et al., 2010; Sarwar et al., 2002) mainly by squeezing the cultivated area under fodder coupled with continuous degradation of rangeland. Cultivating more land for forage crops had no longer a realistic approach for the motive behind which is higher human population pressure on cultivated land for grains production (Naveed et al., 2014; Iqbal et al., 2015). The highest return from the livestock is achievable only by reducing the complete reliance on costly animal feeds.

Quality forage production is key concern of forage growers to get a higher return (Ball et al., 2001) and it has become second most important factors followed by crop yield. The determination of forage composition is also essential to determine the probable deficiencies in livestock nutrition being fed with these forages. We have subset of analysis which is important to predict the forage value for crude protein, ash, digestibility, intake and palatability potential etc. The forage value of crop does not remain similar during the whole growth season but it goes on changes with respect to age of plant. The plant composition and morphological structure (leaves, stem and spike etc.) changes with growth and development cycle (Glamočlija et al., 2011). Therefore, it is most important to identify the plant stage at which the nutrients are optimal. A thorough study of forage mass at various harvesting will encourage the farmer to take advantage of market trend. The final forage composition is the function of photosynthates and nutrients distribution in plants.

The millet is source of food for poor farmers and fodder for livestock in arid ecologies (Vetriventhan et al., 2008). Pearl millet is relatively drought tolerant, palatable to livestock and occasionally has been found to be problematic especially in low moisture availability like sorghum. It possesses a wide variability for vegetative and spike traits (Khairwal et al., 2007) and it is an emerging need that the parental diversity should be explored to abridge the gap between required and available forage quantity through the development of genotypes with higher forage production potential. Most of studies regarding the forage mass and its composition under the range of harvesting times compared the feeding value at vegetative and reproductive development stages (Mohajer et al., 2011; Tabosa et al., 1999; Valencia et al., 2000; Tielkes and Gall, 1998) but there is paucity for these information regarding on pattern of nutritive changes within period of reproductive development. Therefore, the present study was carried out to evaluate the varietal potential and their consumption time for ensuring sustainable and quality forage to livestock.

## 2. Materials and Methods

The three millet cultivars i.e. FB-786, MB-87 and AF-POP-2005 were tested for green forage quality in a range of harvesting dates i.e. 60, 70 and 80-days after sowing. Field experiment was conducted at Agronomic Research Farm, University of Agriculture; Faisalabad (31.26°N, 73.06°E and Altitude 184 m), Pakistan during kharif 2011, on sandy loam soil previously occupied with spring maize. The soil was thoroughly prepared one week before sowing under the package of general cultivation practices and seed was sown on 6$^{th}$ August at field capacity in 30 cm apart rows with single row hand drill by using a seed rate of 15 kg ha$^{-1}$. All of phosphorus (60 kg ha$^{-1}$) and half of nitrogen (30 kg ha$^{-1}$) was incorporated in soil in the form of single super phosphate (16 % $P_2O_5$) and urea (46 % N), respectively during land preparation. The second dose of 30 kg N ha$^{-1}$ was top dressed at 25 days after the complete removal of weeds along with first irrigation. The plots were irrigated by flood method and irrigation intervals were scheduled according to local climate.

Experiment was consisted of 27 experimental units, each of 1.8 m × 6.0 m plot and the treatments set was arranged in factorial based randomized complete block design (RCBD) in three repeats. All the operations in production package were kept similar for all plots except treatment factor. However, no particular pest and diseases incidence was noted during the whole period of experimentation. The onset of reproductive development was considered on the appearance of 50 % spikes and all the tested varieties attain it during 50 to 60days after sowing. The standard methods for recording data on agronomic traits and chemical composition were used. The yield supporting attributes like plant height, leaf area and leaf to stem ratio was taken by randomly selecting ten plants from individual plot at harvest time.

The green plants were harvested according to their treatment schedule and were soon weighed for fresh weight. The dry matter percentage was estimated by keeping the sun dried chopped material in electric oven at 70$^{o}$C for 72 hours (Martin et al., 1990) and it was taken as basis for estimation of dry matter yield. The composite samples were dried and used for chemical composition. The small size sample (350 g) was also derived from oven dried mass and it was subjected to milling (2mm) in electric grinder. The well grind material was preserved in polythene bags to subject it for chemicals composition.

The feed sample was analyzed for protein by Kjeldahl method (Kacar and Inal, 2008), crude fibre (Van Soest et al., 1991) and ash (AOAC, 1990) in forage laboratory. The N value obtained, got multiplied with 6.25 (AOAC, 1980) to provide crude protein. The ash contents in dry matter were based on burning at 550 $^{0}$C in a muffle furnace for 5 hours. The collected data was analyzed by standard ANOVA procedures using computer operated programme Statistix 8.1 and the significance of treatments means were evaluated at 5 % probability level by using LSD test (Steel et al., 1997).

## 3. Results

The forage yield, morphological yield supporting attributes and forage quality showed a strong relation with time of harvest (Table 1). The plants continue to grow and every successive delay in harvesting significantly increased the plant height, fresh and dry matter yield, dry matter % age and at the same time it produced the dry matter with higher crude fibre fractions.

However, the trend was reversed for leaf to stem ratio, crude protein and ash mass and hence, it can be concluded that late harvesting deteriorated the forage value by the combined effects of nutritional components. The protein value from dried mass obtained at 60- days after sowing was significantly higher than from 70 and 80- days after sowing. The close association among nutritional components was noticed. For example, the increase in crude fibre was concomitant with decrease in crude protein and ash contents. The close relationship between traits specifying the forage value like crude protein, crude fibre and ash has also been declared from the results of studies by (Panahi et al., 2012). The reduced forage material in case of earlier harvesting was however compensated by dry matter concentrated with more protein and ash. The crude protein fraction in whole plant dry matter was 7.21 % at 60-day, 6.69 % at 70-day and 6.40 % at 80-day after sowing with an average decline of 0.04 % per day during the sampling period.

The tested varieties exhibited inherited variations for yield and chemical composition except dry matter percentage and variety FB-786 produced the tall and leafy plants. The dry matter from FB-786 and its composition was also optimum over the given varieties. The variety MB-87 was poor performer for fresh forage and it had dry matter with inferior quality. The forage quality at earlier stages was the highest than at later stages irrespective of cultivar influence. By quantifying the relative contribution of harvest dates and varieties for producing differences in recorded data, it was realized that harvesting factors outcome the varieties for leaf to stem ratio, fresh and dry forage yield. Whereas the plant height and dry matter composition was likely to be more influenced by varieties than harvest treatment.

## 4. Discussion

The significant increase in forage yield against each consecutive delay in harvesting showed the continuity of growth between first and last harvest. The variety FB-786, MB-87 and AF-POP-2005 had accumulated 13.30, 15.05 and 15.88 %, respectively of total biomass in last ten sampling days. The higher dry matter production by the end of harvesting is mainly attributed by availability of time for growth completion and better utilization of natural resources.

The poor protein gains at later growth stages is primarily from imbalance leaves production and stem elongation rate and secondarily, leaf loss from senescence with advancing the age of plant. Hence, it gave the lower value for leaf to stem ratio. The reduction in leaf mass with maturity is remarkable loss in forage composition as leaves had more N (1.65%) than stems (0.43%) (Bidinger and Blummel, 2007). The poor protein value in dry matter harvested at 80-days after sowing would require a backup protein supplement for maintaining animal performance. Its value addition through protein rich supplement is not a cost effective solution for the reason behind is higher prices. The protein deficit forages are major limiting factor for gaining the full genetic potential of animals. Increasing the protein yield will require a modification in genetic constitution for either leaf to stem ratio and control of cell wall lignification. Provided that a major portion of millet forage yield is from stem, the alteration of stem composition through breeding techniques will bring a significant change in forage quality.

**Table 1. Yield attributes and dry matter composition of three millet genotypes**

| Treatment | Plant Height | Leaf to stem ratio | Forage yield | Dry matter | Dry matter yield | Crude fibre | Crude protein | Ash |
|---|---|---|---|---|---|---|---|---|
| **Harvesting** | (cm) | | **(t ha$^{-1}$)** | **(% age)** | **(t ha$^{-1}$)** | **(%)** | **(%)** | **(%)** |
| 60DAS | 166.97 c | 0.49 a | 67.52 c | 27.17 c | 18.44 c | 36.57 c | 7.21 a | 9.03 a |
| 70 DAS | 189.87 b | 0.37 b | 76.23 b | 34.78 b | 26.47 b | 37.20 b | 6.69 b | 8.39 b |
| 80 DAS | 230.12 a | 0.24 c | 82.18 a | 37.68 a | 31.00 a | 38.32 a | 6.40 c | 8.07 c |
| LSD | 4.007 | 0.0240 | 1.010 | 0.998 | 0.660 | 0.240 | 0.1600 | 0.165 |
| **Varieties** | | | | | | | | |
| FB-786 | 224.76 a | 0.41 a | 87.98 a | 33.80 | 29.97 a | 35.71 c | 7.67 a | 9.50 a |
| MB-87 | 157.34 c | 0.32 c | 62.71 c | 33.03 | 21.07 c | 39.26 a | 6.03 c | 7.27 c |
| AF-POP-2005 | 204.86 b | 0.37 b | 75.24 b | 32.80 | 24.87 b | 37.13 b | 6.5 b | 8.71 b |
| LSD | 4.007 | 0.0240 | 1.010 | Ns | 0.660 | 0.240 | 0.1600 | 0.165 |
| H | *** | *** | *** | *** | *** | *** | *** | *** |
| V | *** | *** | *** | Ns | *** | *** | *** | *** |
| V×H | *** | * | ** | *** | *** | *** | Ns | ** |

The means indicated with small letter differed significantly at 0.05 % probability level.

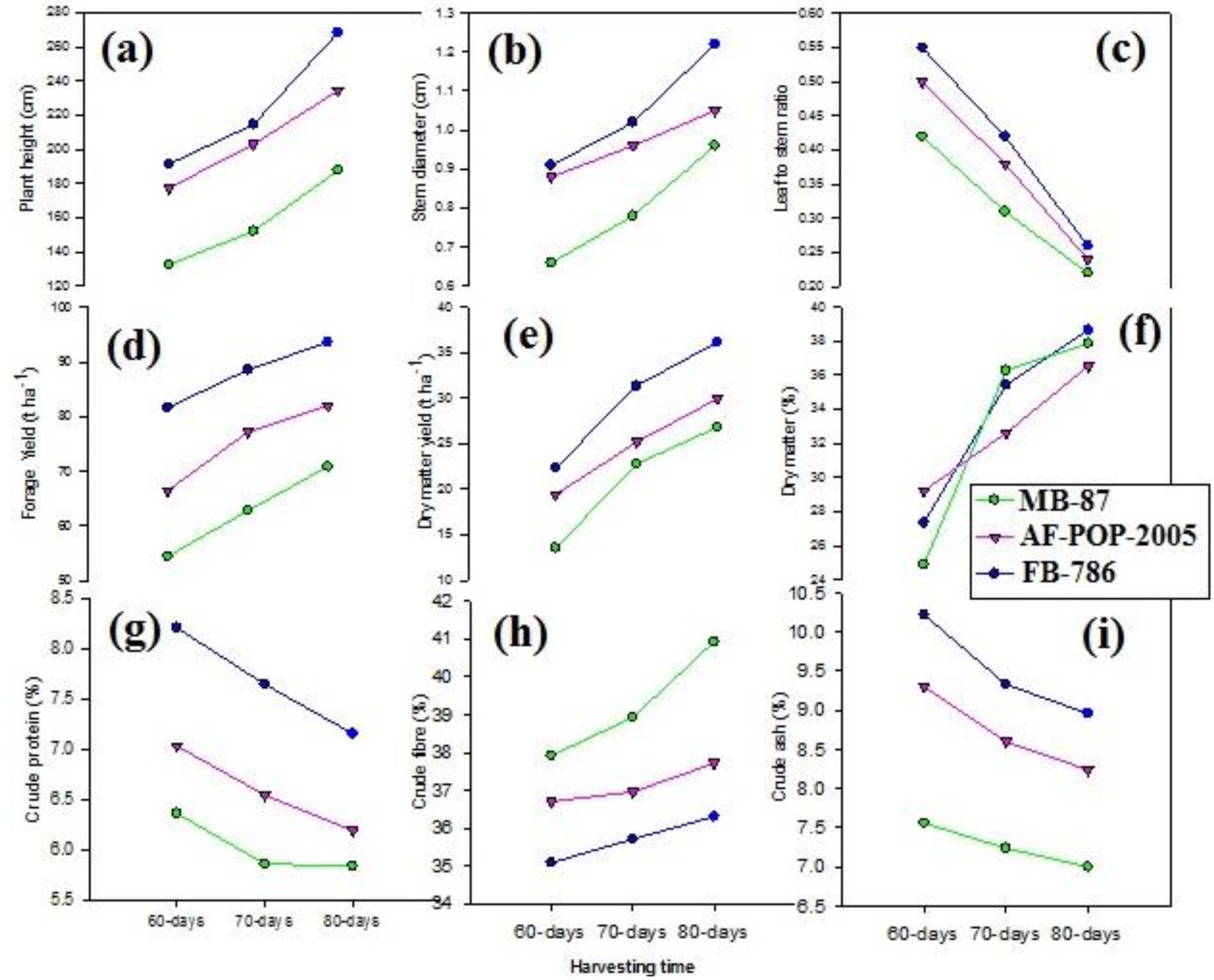


**Fig. 1. Varietal behavior yield and quality attributes of millet genotypes** plant height (a), stem diameter (b), leaf to stem ration (c), forage yield (d), dry matter yield (e), dry matter %age (f), crude proten (g), crude fiber (h), and crude ash (i)

The leaves, being a major contributor to total protein yield may be relative proportionality base explanation of low protein gains from the plants with maturation (Tariq et al., 2011). The variety having better leaf to stem ratio is obviously characterized with high density crude protein in dried sample (Table 1). The mineral substances (ash) deposited in vegetative plant parts are diverted to seed forming tissues and apparently, the steady decline in ash contents was recorded from sample obtained at first and last harvesting. During the growth cycle, likewise pheno-phases, certain anatomical changes happen particularly deposition of lignin (non-carbohydrate material) in cell wall with the basic function of improving the strength, thickness and rigidity through cementing and increases crude fibre proportion in dry matter (Fahey, 1994, Ates et al. 2010). The pattern of crude fibre accumulation and ash reduction with maturity has been confirmed in several crops (Ayub et al., 2002; Ashraf et al., 1995; Jafari and Rezaeifard, 2010). A moderate level of crude fibre in dry matter is important for maintenance of rumen pH through saliva production in chewing process.

The varieties were differentiated for plant height and leaf to stem ratio and these yield supporting traits contributed for fresh and dry matter yield. The variety FB-786 not only led in agronomic and forage yield but also provided superior quality forage over the rest of varieties. This showed that breeding in fodder crops not only focused the yield improvement but also made an equal contribution for nutritional prospective. The tested varieties could not make remarkable differences over each other for dry matter percentage. The variety MB-87 had the shortest plants, the lowest forage mass rich in stems and dry matter concentrated with crude fibre and therefore cannot be sown for forage value. Its poor performance may be lack of adoption to prevailing environment. The differences from genetic constitution have also been reported earlier (Akmal and Zulfiqar, 2002; Imran et al., 2010; Beck et al., 2007). The intensity of undesirable changes in forage value accompanied with consecutive harvesting dates was modified to some extent with varietal factors (Fig. 1 a-i). The variety FB-786 was less severely affected with bad effects of late harvesting and it sustained the growth with respect to plant height, leaf to stem ratio and even deteriorated the forage quality at much lower rate with late harvesting when compared with other two varieties. The significant variations among the tested varieties for the evaluated traits translated the prevalence of genetic variability.

**5. Conclusion**

The harvesting regimes of three millet varieties brought significant variations in forage mass and value. This is one of way for estimating the level of success in crop improvement. The contradictory behavior of fresh biomass and forage quality, make it difficult to decide the harvest time. Therefore, it the forage producer who is going to make decision which one is important. In the recent investigation, the harvesting at 70- days after sowing and cultivation of FB-786 could be taken as precise choice for forage yield and quality.

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