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# Production and Quality Evaluation of Millet (*Pennisetum typhoidum* L.) Germplasms for Fodder

M. Akmal and Zulfiqar
Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan

**Abstract:** Eight divergent genotypes of millet (NARC-5, Local Quetta, EXB ($D_2$) Bulk, NARC-1 DBR-3, local-Tandojam, Tift-383 and MB-87) were used to evaluate their fodder quality and production. Data revealed significant differences ($P< 0.05$) in millets genotypes right from emergence till the dry matter production. NARC-5 showed the highest emergence (165) rate per meter square, greater green leaf number (14/plant), specific leaf area (63.7 $cm^2/g$) and dry matter yield (19444kg $ha^{-1}$). On the mean fresh matter basis, genotypes NARC-1 yielded the highest (58331 kg $ha^{-1}$) with almost near about production of 52776 and 54165 kg $ha^{-1}$ for genotypes NARC-5 and Tift-83, respectively. Regarding forage quality of the millet's genotypes, differences ($P < 0.05$) were also observed for crude protein (CP), ether extracts (EE), mineral matter (MM), crude fiber (CF) and nitrogen free extract (NFE). Local Quetta yielded the highest CP in matter. NARC-5, NARC-1 and Tift-83 were nearly of the same range in tissue CP. EE mimicked similar order as explained for CP among the genotypes. NARC-1 showed the highest (8.84%) and MB-87 the minimum (8.16%) MM. CF of the genotypes was nearly the same and ranged from 31.77 to 31.39%. NFE among the genotypes ranged from 52.66 to 50.59% with minute differences.

**Key words:** *Pennisetum typhoidum*, divergent genotypes, fodder quality, crude protein, nitrogen free extract

## Introduction

Millet (*Pennisetum typhoidum* L.), a member of the family Poaceae, is highly drought resistant summer crop grown in rainfed beds of the North West Frontier Province (NWFP). It is locally known as Bajra and is a nutritious fodder source for livestock. Millet produces high quality grains than any other cereals under extreme conditions: like unfertile soil, intense heat, prolong drought etc. Besides Pakistan, millet is also commonly used as cereal crop for food in Africa, India and South Eastern Asia. Pearl millet is a coarse grass cultivated in dry regions under rainfed conditions. Millet is cultivated on 406.8 thousand hectares in the country and yields 161.5 thousand tons average green fodder (Agricultural Statistics, 1999). Likewise, in NWFP, millet is grown on 8 thousand hectares with 4.6 thousand tons production.

Fodder production is the major limiting factor of livestock production in Pakistan. In terms of fodder supply, Pakistan is short by about 200 million tones of dry matter and about 30-50% in terms of nutrient supply (Bhatti, 1996). The existing fodder deficiency is more than half of its demand in NWFP and reported much higher in the hilly as well as barani (Dry land) tracts of the province (Khattak, 1998). Among clovers, berseem and shaftal are the leading winter species that supply green-forage in the province and sorghum, millet as well as maize in the summer. Excluding grazing, on average basis the total availability of green forage from statistical data is estimated about 2.0 kg per animal per day which if assumed for the rainfed region is much less than the total average (Hatam *et al.*, 2001). Much attention is required for area where fodder supply situation is highly critical. Rainfed sectors of the province have potential as well as space for cultivating fodder in the cropping system. Demand and scope of fodder improvement in low supply regions should be of prime importance. Introduction and plant selection of high fodder varieties with quality fodder production is the shortest possible way to over come the existing deficiency-bridge of the province. Keeping the existing fodder importance and demand, the only possible way to over come the dry matter deficiency, new varieties introduction and selection is the possible shortest way to bridge the existing gap in a possible time frame. The present study was aimed to evaluate and select high yielding quality and quantity fodder growing the promising lines/varieties collected from different regions of the country and that fit well in the climatic conditions of Peshawar.

## Materials and Methods

The experiment was conducted at Agronomic Research Farm of the N.W.F.P. Agricultural University at Peshawar, Pakistan during summer 2000. The experiment was laid out in randomized complete block design using seed rate of 15 kg per hectare in 1.2 x 6.0$m^2$ sub-plots having 4 rows, 6.0m long and 0.3m apart. Fertilizer was applied at the rate of 60:60:00 (N:P:K) kg $ha^{-1}$ before sowing at the time of seedbed preparation. Irrigation was applied as per seasonal crop water demands.

Seedling emergence $m^{-2}$ was counted at about 2 weeks after sowing on randomly selected areas in each sub-plot. Seedling number in the two central rows each 0.5m in length was sampled and the emerged seedlings were counted manually. The sampling data was converted to estimate emergence on meter square. The fresh green leaves on 3 randomly selected plants at the start of flowering stage were manually counted. Likewise, the dead leaves on same plants were counted and averaged for mean fresh and dead leaf number per plant. The same green and dead leaves were weighed to estimate fresh and dead leaves mass. Stem remains after detaching the leaves, were weighed along with sheath and the material was dried in an oven at 60°C for 32-34 hours to estimate dry mass of fresh as well as dead leaves and stems of the plant. Specific leaf area was calculated by dividing area of all leaves of the plant measured through leaf area meter (LI-3100A) on dry mass of the corresponding leaves. The sample harvested for leaf and stem mass reading were used to calculate leaf to stem ratio of the germplasm. Height of the plant was taken in centimeters from the plant base to tip at full maturity stage of the crop. Height was measured on three representative plants and averaged for mean height of plant. Regarding tiller number per plant, three uniform representative plants were tagged and tillers were counted during the vegetative growth stage before flowering.

Two central rows each 2.0m in length and 0.3 m in width were harvested and weighed using a spring balance for fresh matter yield. The data obtained for each treatment was estimated on kg $ha^{-1}$ for the individual genotypes. A sample of the fresh matter was oven dried at 60°C for 30-34 hours to estimate the dry matter yield of genotypes.

After measuring the dry matter, the samples were ground and stored for further quality analysis. A sample of 250g-crushed material was sent to the Department of Animal Nutrition, Agricultural University, Faisalabad. The samples were analyzed for percentage of moisture, dry matter, crude protein, ether extract, mineral matter, crude fiber and nitrogen free extract.

## Results

**Fodder production:** The data (Table 1) indicated significant differences in emergence $m^{-2}$ among millet genotypes. The maximum emergence (165 seedlings per meter square) was

Table 1: Production parameters recorded on millets (*Pennisetum typhoidum* L.) genotype during the experiment at Agronomy Research Farm of the NWFP Agricultural University in the year 2000

| Genotypes | Emergence $m^{-2}$ | Leaf number/plant | | Leaf mass (g/plant) | | Stem mass (g/plant) | | Leaf :Stem ratio(%) | Plant height (cm) | Tillers/ plant (No.) | Specific leaf area ($cm^2$ $g^{-1}$) | Fresh matter (kg $ha^{-1}$) | Dry matter (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Green | Dead | Fresh | Dry | Fresh | Dry | | | | | | |
| NARC-5 | 165.3a | 13.9a | 1.6ab | 55.1c | 13.0c | 214.4ab | 34.6bc | 37.7b | 236.6bc | 3.7c | 63.68a | 52776b | 19444a |
| Local-Quetta | 145.0b | 11.3d | 1.4d | 44.1f | 9.0e | 166.0d | 35.8b | 25.0d | 223.7d | 4.1b | 50.6d | 30555e | 11111d |
| EXB($D_2$) Bulk | 121.3d | 13.1ab | 1.6ab | 59.0b | 14.3bc | 202.0bc | 43.9a | 32.7bc | 206.0e | 3.7c | 62.2ab | 47220cd | 12500c |
| NARC-1 | 136.7c | 13.6ab | 1.4b | 49.9d | 13.0c | 227.8a | 43.1a | 30.0cd | 247.4a | 3.7c | 54.2cd | 58331a | 13689b |
| DBR-3 | 134.7c | 12.0d | 0.9c | 45.9e | 11.1d | 190.8c | 36.2b | 30.7c | 239.5ab | 3.6c | 51.2d | 44443d | 8056d |
| Local-Tandojam | 146.7b | 12.8bc | 1.8a | 33.3g | 9.3e | 154.2d | 32.6bc | 29.0cd | 248.6a | 3.1c | 35.4e | 49998bc | 12500c |
| Tift-383 | 126.3d | 13.8a | 1.1c | 55.9c | 22.3a | 230.6a | 35.8c | 62.7a | 229.7cd | 3.6c | 55.6cd | 54165b | 13056c |
| MB-87 | 123.3d | 12.8bc | 1.0c | 68.9a | 15.3b | 151.0d | 23.4d | 65.7a | 143.6e | 8.6a | 58.1bc | 43054d | 12776c |
| CV | 3.33 | 4.12 | 12.62 | 1.81 | 5.89 | 5.19 | 3.85 | 8.238 | 2.56 | 5.67 | 5.41 | 5.82 | 10.68 |
| LSD (P < 0.05) | 8.008 | 0.932 | 0.298 | 1.635 | 1.368 | 17.45 | 2.406 | 0.0565 | 9.960 | 0.421 | 5.116 | 4875 | 2474 |

Means with the same letter are not significantly different (P < 0.05)

Table 2: Quality parameters recorded on millets (*Pennisetum typhoidum* L.) genotype during the experiment at Agronomy Research Farm of the NWFP Agricultural University in the year 2000

| Genotypes | Crude protein (%) | Either extract (%) | Mineral matter (%) | Crude fiber (%) | Nitrogen free extract (%) |
|---|---|---|---|---|---|
| NARC-5 | 7.12ab | 1.20ab | 8.71ab | 31.60ab | 51.37ab |
| Local-Quetta | 7.59a | 1.21a | 8.67abc | 31.59ab | 50.95ab |
| EXB($D_2$) Bulk | 7.03ab | 1.17abc | 8.56ab | 31.66ab | 51.59ab |
| NARC-1 | 6.72ab | 1.18ab | 8.84a | 31.54ab | 51.71ab |
| DBR-3 | 6.69ab | 1.16bc | 9.06a | 31.39b | 51.31ab |
| Local-Tandojam | 6.39b | 1.19ab | 8.22bc | 31.53ab | 52.66a |
| Tift-383 | 7.05ab | 1.17abc | 8.22bc | 31.59ab | 45.29b |
| MB-87 | 6.84ab | 1.13c | 8.16c | 31.77a | 52.09ab |
| CV | 7.36 | 2.25 | 3.51 | 0.487 | 8.20 |
| LSD (P< 0.05) | 0.894 | 0.046 | 0.091 | 0.269 | 7.310 |

Means with the same letter are not significantly different (P < 0.05)

recorded in NARC-5. Local Quetta and local Tandojam were non-significant from one another but significantly lower than NARC-5. NARC-1 and DBR-3 were non-significant from each other but significantly lower in emergence rate per unit area than both local Quetta and Tandojam. The genotypes MB-87, EXB($D_2$) Bulk and Tift-383 were the minimum yielding emergence rate per unit area in the groups and non-significantly different (P< 0.05) from one another. Green leaf number observed per plant in the eight genotypes showed a significant response. The genotypes could be classified into 4 groups on green leaf number basis. The maximum and non-significantly different green leaf number per plant was reported in genotypes NARC-5 (13.9) and Tift-383 (13.8), followed by NARC-1 (13.6) and DBR-3 (13.1). The genotypes local Tandojam and MB-87 yielded 12.8 green leaf per plant. Genotypes DBR-3 and local Quetta were significantly the lowest to have about 12 and 11 green leaf number per plant. Dead leaves (Senescence leaves) per plant of the genotypes also indicated significant (P< 0.05) differences (Column-4). The significantly maximum leaves per plant were reported in local Tandojam, followed by NARC-5 and EXB($D_2$) Bulk with 1.6 dead leaf number per plant. Both the local Quetta and NARC-1 showed 1.4 dead leaves per plant. The minimum (0.9) dead leaves were reported for genotype BDR-3.

Genotype NARC-5 and Tift-383 was non-significant from each other for fresh leaf matter production. Nevertheless, all other genotypes showed a significant response for fresh leaf matter per plant from one another. MB-87 has the maximum fresh leaf matter (68.9 g/plant), followed by EXB($D_2$) Bulk (59 g/plant), NARC-5 and Tift-383 (55 g/plant). The significantly lowest green leaf mass (33 g/plant) was reported for the genotype local Tandojam. Data regarding the dry leaf matter per plant do not mimic genotype order as observed for fresh leaf matter. However, significant differences among genotypes were found for dry leaf matter production. Genotype Tift-383 yielded significantly the highest (22.3 g) dry leaf matter per plant, followed by the genotypes MB-87 (15.3 g), EXB($D_2$) Bulk (14 g) and NARC-5 as well as NARC-1 (13 g), respectively. The minimum (5.0 g) dry leaf mass was observed for genotype Local Quetta and Local Tandojam, respectively.

Data showed a significant difference in fresh stem weight among the millet genotypes. Genotypes NARC-1 and Tift-383 yielded the non-significantly different but the maximum fresh stem weight (230 and 228g) on per plant basis, followed by NARC-5 (214g), EXB($D_2$) Bulk (202g), DBR-3 (191g) and Local Quetta (166g). The significantly lowest (151g) stem matter on single plant basis was recorded for genotype MB-87. MB-87 non-significantly differs from local Quetta for stem fresh matter production. Stem dry matter also differs significantly among genotypes. The maximum (43.9 and 43.1g) stem dry weight was observed for genotypes EXB($D_2$) Bulk and NARC-1, respectively. Followed by the non-significantly different fresh stem matter for the genotypes Local Quetta (35.8g), DBR-3 (36.3g) and Tift-383 (35.8g). The significantly lowest (23.4g) dry stem matter on single plant basis was observed for genotype MB-87.

Significant differences were observed for leaf stem ratio estimated for the genotypes. Genotype Tift-383 and Mb-87 did not significantly differ for leaf stem ratio but ranked on top than other genotypes. NARC-5 was significantly the next for leaf:stem ratio. NARC-5 and local Tandojam was of equal rank for leaf to stem ratio. The lowest leaf to stem was recorded for genotype local Quetta. The maximum height (248cm) was observed for local Tandojam and NARC-1, followed by DBR-3 (239cm), NARC-5 (236cm) and Tift-383 (230cm). The minimum (143cm) height was observed for genotype MB-87.

Tiller (modules/plant) showed a significant response for the genotypes (Column-11, Table 1). On the basis of tillers per plant, genotypes could be classified into three groups. MB-87 produced the maximum (8.6) and significantly the highest number of tillers per plant, followed by local Quetta (4.1). The rest of the genotypes produced non-significantly (P< 0.05) the lowest tillers per plant that ranged from 3.7 to 3.1 per plant. Specific leaf area of the genotypes showed a significant response from one another (column-12). Genotype NARC-5 ranked on top with maximum (62.7$cm^2$ $g^{-1}$) specific leaf area values, followed by the genotypes EXB($D_2$) Bulk (62.2$cm^2$ $g^{-1}$), NARC-1 and Tift-383 (55$cm^2$ $g^{-1}$). The minimum (35$cm^2$ $g^{-1}$) specific leaf area was observed for genotype local Tandojam.

NARC-1 was significantly the highest fresh matter producer with 58331kg $ha^{-1}$. NARC-5 and Tift-383 was the second with 52776 and 54165kg $ha^{-1}$ fresh-matter production, respectively. The local Tandojam ranked in position three with 49998kg $ha^{-1}$ fresh matter yield (Table 1). Genotype EXB($D_2$) Bulk with 47220-kg $ha^{-1}$ production of fresh matter ranked in category 4. MB-7 and DBR-3 yielded 44443 and 43054kg $ha^{-1}$ fresh matter respectively and

ranked in yielding group 5. The lowest (30555kg $ha^{-1}$) fresh matter yield was observed for genotype local Quetta. The genotypes dry matter data is presented in column-14 (Table 1). Data regarding dry matter production showed significant differences among different millet genotypes. NARC-5 with maximum dry matter (19444kg $ha^{-1}$) ranked on top among the genotypes, followed by NARC-1 (12500kg $ha^{-1}$). Genotypes EXB($D_2$) Bulk (12500kg $ha^{-1}$), local Tandojam (125000kg $ha^{-1}$), Tift-383 (13056kg $ha^{-1}$) and Mb-87 (12776kg $ha^{-1}$) were non-significant in dry matter production from each other. The minimum (8056kg $ha^{-1}$) dry matter was observed for genotype DBR-3.

**Fodder quality:** The results of the quality parameters for millet varieties of divergent genotypes are presented in Table 2. Crude protein had shown significant response to various genotypes. The highest ($P < 0.05$) crude protein (7.6%) content was observed for local Quetta, followed by the genotype NARC-5, EXB($D_2$) Bulk, NARC-1, DBR-3, and Tift-83 and MB-87 that ranged from 7.1 to 6.7%. The lowest ($P < 0.05$) crude protein content (6.4%) was found for genotype Local Tandojam. The data showed significant differences for ether extract among the millet genotypes. The maximum ether extract (1.21-%) was observed for Local Quetta, followed by NARC-5 (1.20%), NARC-1 (1.18%), Local Tandojam (1.19%), Tift-383 and EXB($D_2$) Bulk (1.17%). The minimum ether extract (1.13-%) was reported for MB-87. There were significant differences in percent mineral matter among the different millet genotypes (Table 2). The mineral matter was nearly the same for genotypes DBR-3 and NARC-1, NARC-5, EXB($D_2$) Bulk and Local Quetta and ranged from 8.56 to 9.06%. However, the minimum mineral matter (8.16%) observed for the genotype MB-87 was not different with the values for MB-87, Tift 383 and Local Quetta. Results revealed that crude fiber was influenced ($P< 0.05$) by genotypes. The highest crude fiber (31.77) was found for the genotype MB-87 and minimum (31.39) for DBR-3. Crude fiber was nearly the same among the genotypes NARC-5, Local Quetta, EXB($D_2$) Bulk, NARC-1, Local Tandojam and Tift-383 and was in the range of 31.60 to 31.53%. Significant differences were found in the nitrogen free extract of the millet genotypes. Local Tandojam showed the highest (52.66%) nitrogen free extract. Genotypes Tift-83 showed significantly the lowest nitrogen free extracts. All other genotypes did not significantly vary from one another for the nitrogen free extract percentage.

**Discussion:** Rate of seedling emergence per unit area was significantly affected by genotypes. The highest emergence per unit area was recorded for NARC-5. The uniform seed rate per unit area was used for different genotypes. Nevertheless, significant variation in emergence rate per unit area among genotypes was due to differences in the seed size. The relatively bigger seeds usually have to require the larger space and hence reflected the minimum emergence per unit area. NARC-5 has the smallest seed and hence reflected the highest emergence per unit area. Green leaf per plant is the most important character of a genotype that makes it suitable for forage and fodder yield. Leaf with respect to stem has the highest nitrogen content (Akmal, 1997) and hence has a positive impact on protein and intake of the herbage. The higher the leaf number of a genotype adversely affected the crude fiber content of the variety. Plant tallness of a genotype over the other fellow genotypes was also a positive character that favors the genotypes to yield significantly different leaves per plant. Kim (1990) reported that taller plants yielded more leaf number over the shorter types. Leaf of a cereal has a limited duration. After reaching the maximum age, leaf starts senescence. The process of senescence is usually found in the older leaves and starts from the bottom of a plant and proceeds upwards. On comparing the green and dead leaf number per plant of the genotypes, it was observed that genotypes having maximum green leaf did not mimic the statistical rating order for the dead leaves. This revealed that the process of senescence and leaf aging of the genotypes was different. The different genotypes had different leaf age and the process of senescence of a leaf of the genotypes varies from its other fellow genotype. Genotypes ranking order for the fresh leaf mass was not reflected as such for the dry leaf mass. This showed that moisture contents in leaf varied among genotypes. Genotypes having higher moisture in their fresh leaves lost more water and hence not maintain the ranking position for dry leaf mass. It has been reported that moisture content of the plant varies and ranged from 75-85% (Jones, 1988). Stem thickness as well as height of the genotypes were reported different and hence resulted different fresh matter of the fraction among different genotypes. Sorghum has solid nodes as well as internodes (filled with pith). Moreover, the stem is juicy and its concentration varies with different varieties of the same species (Chaudhry, 1994). Therefore the fresh stem sequence of the genotypes differs for the dry stem matter in this experiment. Nevertheless, assimilates partitioning within plant fractions varies with respect to plant types and different varieties of the same species (Shah and Akmal, 2002). Plant morphology and canopy structure that a genotype community develops on the ground surface may also be a factor that could force the plant to distributes assimilate in different rates in its components and may results different leaf and stem matter of the plant. Leaf to stem ratio is one of the most important character that could be take into consideration. The lowest leaf to stem ratio favors the genotypes for high leaf fraction than stem on per plant basis. Both the plant height and tiller number per plant is the character that can contribute for high forage and fodder production. Genotypes with tallest plant could reflect more leaves and can contribute for greater fresh and/or dry matter yield. Sharma and Adam (1984) and Kang and Yagya (1993) reported that plant height increased with increasing population density on unit area. Genotypes having higher emergence rate per unit area reflected the tallest plants over the other genotypes. Likewise, the increasing tiller per plant can also contribute for more biomass production. Genotypes fresh matter is the major forage fraction to be taken into consideration. Species major yield components for forage and fodder production are population per unit area, leaf number and weight per plant as well as stem mass. Genotypes having higher emergence per unit area with maximum leaf-number as well as leaf and stem masses were superior in fresh as well dry matter yield. Tiller number per plant could also be considered as a factor for the high yield. However, genotypes with more tillers may yield the shortest plants and that could adversely affect the total unit area production. Genotypes with greater leaf number, weight and area as well as height yields significantly the greatest and supports the findings of different scientists (Jiban *et al.*, 1998); Logasundari and Khan, 1996; Devanand and Das, 1996; Yogendra *et al.*, 1999).

Plant crude protein content is out comes of %N content. Leaves had 2-3 times higher %N than stem fraction. The greater leaf number, the higher weight of the plants and larger area were the probable reasons of the genotypes to response for higher CP and caused significant differences among genotypes for the CP values. CP reported for the genotypes were in the range of that reported by Johnson and Raymond (1993) and Anderson and Martin (1980). Rao and Swaminathan (1970) and Clerc and Baily (1989) reported relatively lower CP in millets. This could be due to many reasons for example, soil nutritional status, area's environment, plants population of the field and stage of the crop harvested for chemical analysis. These findings are lower than the findings obtained by Clerc and Baily (1989). Ether extract (EE) mimicked the CP order. This could also be associated with leaf fraction on the whole plant DM basis of the genotypes. Genotypes with higher leaf number and mass also responded for higher mineral matter than those had lower leaf-number, area and mass. Percent mineral in the DM was found within the range as reported by Johnson and Raymond (1993). As the stem fraction in plant exceeds its crude fiber concentration also increased. Stem is the richest source of fiber and its relatively higher proportion in the whole plant contributed to higher values. The values reported for millet

genotypes were within the range as reported by Johnson and Raymond (1993) and Anderson and Martin (1980) and lower than that reported by Clerc and Baily (1989). The difference in the values of CF content could be due to variable reasons: the selected genotypes stem thickness, plant height and inter-node's length of the genotypes as shown in the previous studies. However, the results of this study show that the millet plants of the divergent genotypes had also influenced CF contents. Nitrogen free-extract was not influenced by the genotypes. This might have been due to art fact of the laboratory procedure as a fraction. NFE was determined by subtraction in a fraction method "proximate analysis". Percent nitrogen free extract values were found close to the findings of Anderson and Martin (1980) and Johnson and Raymond (1993). On over all performance bases of the major yield components, fresh and dry matter production and nutritional status genotypes NARC-5 was found superior for general cultivation in Peshawar and similar climatic condition regions of the NWFP. Further study is needed to correlate chemical parameters with digestibility of the Millets genotypes. The use of regression equation for the prediction of digestibility from proximate composition is proposed as done with other forages grown in the region. However, the earlier attempts to predict forage digestibility on the basis of proximate principles were criticized by various workers (Van Soest, 1963; 1967). New parameters such as cell wall constituents (NDF) acid detergent fiber (ADF) and acid detergent lignin (ADL) were reported to be efficient predictors of forage digestibility (Van Soest and Moore, 1965; Gupta and Pradhan, 1974). Nevertheless, no reports are yet available about the predictability of these new parameters on local varieties of the Millet genotypes grown in the country and particularly in the province.

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