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Performance of Various Forage Grasses Under Spring and Monsoon Seasons at Pothowar Plateau (Pakistan)

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ABSTRACT

A long term field experiment was conducted to investigate the performance of various warm season forage grass species under rain-fed conditions at National Agricultural Research Centre, Islamabad during 1998 - 2003. The maximum fresh and dry biomass was obtained from *Pennisetum purpureum* (Elephant grass) followed by *Pennisetum purpureum* (Mott grass). *Eragrostis superba, Panicum maximum, Bothriochloa pertusa* and *Cenchrus ciliaris* cultivars produced similar fresh and dry biomass and were next to the *Pennisetum purpureum*. Among the various grasses under study the average lowest biomass was obtained from *Digitaria diversinesis and Digitaria swazilandensis*, while *Eragrostis curvula, Vetiveria zizynoides, Digitaria decumbens* and *Chloris gayana* produced statistically similar and slightly higher biomass than that of *Digitaria swazilandensis* and *Digitaria diverersinesis*. Forage yield of all the grasses was higher in monsoon compared to spring season due to prolong growing season. Maximum percent moisture contents were observed during spring season.

Key Words: Tropical grasses; Biomass production; Performance; Rain-fed conditions; Pakistan

INTRODUCTION

More than 60% of the area of Pakistan has categorically been declared as rangeland, which is the biggest land use of the country. Total area of rangelands is 50.88 m ha (Mohammad, 1987). This vast area/natural resource of the country is not being managed on scientific basis and at present only 10 - 15% of their actual potential is being realized (Ali *et al.*, 2001). Pakistan is mostly arid to semiarid and more than 80% of the area receives less than 300 mm rainfall (Zafaruddin, 1983). Like most of the arid countries, Pakistan is also facing the problem of degradation of its rangelands as a result of poor grazing, mismanagement in utilization of water resources and deforestation (Mohammad, 1989).

The carrying capacity of the highly depleted rangelands of Pakistan could be increased manifold by reseeding with palatable grass species. In addition to the meager availability of forage the area is overstocked 2 - 3 times of the carrying capacity and livestock are under-fed to their low performance. Some areas even receive even more grazing pasture, as grazing animal are not evenly distributed over the entire area of grazing. Under these bad conditions, the pool of livestock feed is deficit by 21% forage dry matter, 29% energy and 33% crude protein requirements (Qureshi, 1992) Apart from the forage available from the rangelands about 2.7 m ha of the cultivated commanded area is under fodder production, which is not sufficient even to feed the maintenance requirements of livestock (Younas *et al.*, 1993). This area cannot be increased due to competition with other commodity crops. The re-growth of a forage species depends upon many plant environmental variable such as species, ecotype, age of the stand, temperature, radiation, water supply, soil fertility, leaf area display, previous management level of reserve carbohydrates and other organic constitutes and presence of growing points (Qamar, 1997). The stage at which the plants are harvested is very critical in determining the forage yield and quality.

Forages when harvested at early stages of their development have relatively higher crude protein content, other extract and ash content, but crude fibre, acid detergent lignin, hemicellulose and cellulose increase with later harvesting resulting in decreased dry matter digestibility (Mirza *et al.*, 2002). Higher dry matter intake is associated with the better nutritive quality of early rather than late cut forage, exemplifying the appropriate harvest treatment. For grass and cereal forage, it has been established that dough stage is the most appropriate stage to make a compromise between dry matter yield and forage quality (Qamar *et al.*, 1997) In many countries, improved ecotypes of forage grasses have increased the range productivity of the native and naturalized grass lands (Walmsley *et al.*, 1978).

Keeping in view the prevailing circumstances of the rangelands, it is the need of the time that conduction should be removed to increase forage productivity of the degraded rangelands. It is the paramount importance that high yielding and palatable grass species should be established in their suitable eco-sites (Muhammad & Naqvi, 1987). Therefore, the present study was conducted to determine a) effect of climate on the performance of grass species/ecotypes after ten years of their establishment in the Pothowar area b) re-growth ability in both spring and monsoon season c) succulence in the grass species.

MATERIALS AND METHODS

The experiment was carried out at research area of National Agricultural Research Centre, Islamabad, Pakistan. The climate is characterized by very hot summers and cold winters. It is situated in the subtropical sub-humid continental Pothowar plateau. The mean annual rainfall may exceed 1000 mm, which is received mostly during the summer season. The hottest month June has mean annual temperature of June and the coldest month of January may receive a few frost events. Climatic data of the study period is given in Table I, which was collected from the Water Resources Research Station, NARC, Islamabad. The soil is slightly alkaline with pH = 8.0, non-saline loamy in texture, low in organic matter (0.51%) and deficient in N (0.042%) and P (5.4 ppm) except for available K = 78.5 ppm (Qama, 1997). During 1974 - 75, approximately 27 species/ecotypes of forage grasses and legumes were obtained from different regions of the world as shown in Table II.

These strains were tested for their adaptability for six years at Rangeland Research experimental area, NARC, Islamabad. Fourteen strains of forage grasses were selected for the study. Row to row distance was 50 cm and plot size was 3 x 4 m^2. For Mott grass row to row distance was 1 m. The experiment was planned in a randomized complete block design factorial (RCBD). All the species were raised from seed (1988) except Elephant grass and Mott grass because these grasses do not breed true from bed and must be propagated vegetatively to obtain true to type plant population (Hoveland & Moson, 1980; Rushland *et al.*, 1993). Elephant grass and Mott grass were planted from tufts (1990), which composed of root and shoot material. The tufts were irrigated only at the time of planting. Grasses were maintained without irrigation and fertilizer application. Weeding and hoeing was done manually whenever needed.

Data on fresh and dry matter yield were collected from the same plots in spring and monsoon season of 1998 to 2003. Data were collected during the last week of April (Spring season) and of monsoon during the first week of September. Three quadrats were harvested randomly for fresh and dry matter determinations (Khan, 1966). The fresh biomass was measured by using the formula as under:

$$\text{Fresh biomass (t ha}^{-1}) = \frac{\text{Fresh biomass weight}}{\text{Area in m}^2} \times \frac{10000}{1000}$$

Table I. Meteorological data of the study period (1998-2003)

Year	Rainfall		Temperature	
	Spring	Monsoon	Spring	Monsoon
1998	122.31	222.00	15.00	28.25
1999	49.72	151.50	15.75	28.62
2000	52.75	173.30	15.75	28.25
2001	9.50	222.95	16.25	29.25
2002	23.42	182.20	16.20	28.57
2003	77.45	224.80	15.38	28.35

All the plots in one square meter were clipped close to the ground level and fresh biomass was weighed and the samples were oven dried to a constant temperature at 70°C for 72 h. The data were subjected to analysis of variance (ANOVA) and means were separated using least significant difference (LSD) (Steel & Torrie, 1980). To study the effect of different climatic factors e.g. temperature and rainfall with relation to fresh and dry biomass was done.

RESULTS AND DISCUSSION

The Mott grass produced highest dry matter yield (24.66 $t.ha^{-1}$) in spring during 1998 - 2003 (Table III). After mott grass, elephant grass obtained 13.89 $t.ha^{-1}$ and 20.78 $t.ha^{-1}$ in spring and monsoon season, respectively. The dry matter yield of *Panicum maximum* was near to elephant grass. In case of dry matter yield in spring season *Cenchrus ciliaris, Eragrostis superba, Bothrichloare pertusa* and *Digitaria diversinesis* were at par with each other. *Digitaria diversineruis, Chloris gayana, Setaria anceps* were similar in dry matter yield during spring season. *Digitaria swazilandensis, Vetiveria zizynoides, Erograstis curvula* were closest to each other during spring season.

During monsoon season Mott grass produced the highest dry matter yield of 32.44 $t.ha^{-1}$ followed by the elephant grass and *Bothriochloa pertusa* 2.78 $t.ha^{-1}$ and 15.30 $t.ha^{-1}$, respectively. *Panicum antidotale* and *Panicum maximum* during this season were at par. The dry matter yield of *Cenchrus ciliaris* and *Sataria anceps* was approximately similar. *Digitaria diversineruis* gained the lowest position during monsoon season. Significant differences were observed among different species. The dry matter of the species is generally dependent upon the genetic potential of the respective species interacting with the prevailing environmental conditions.

Dry matter yield was more in monsoon season compared to spring season in almost all species/ecotypes because of more rainfall on the yield of grasses is quite visible as is evident from the rainfall data and the yield data. During this period the average rainfall was 55.86 mm in spring season and 196.04 mm in monsoon season as compared to dry matter yield was 8.26 $t.ha^{-1}$ in spring and 12.29 $t.ha^{-1}$ in monsoon season. Differences (25 - 50%) were also marked between the yield of spring and monsoon season with higher yield during monsoon season as compared to spring season. This can also be attributed towards the rain-fed nature of the grass species under study and the higher rainfall during July-September as compared to spring rains (Table I).

In addition to higher yield, digestibility is one of the main qualities of forage. Apart from other factors, it also depends upon succulence of the forages. Mott grass was the most succulent forage grass among all the grasses as it contained about 74% moisture contents (Table IV). Mott grass is also an excellent grass used for silage purpose and

Table II. A brief history of the grasses selected for study

S. No.	Botanical Name	Common Name	Source	Brief description
1	*Panicum antidotale*	Blue panic grass	Pakistan	Vigorous, profusely branched stem upto 2.5 m high, long blue green leaves, stems soon become hard, can acquire bitter taste due to accumulation of oxalic acid.
2	*Panicum maximum*	Green panic grass	Tanzania	Tufted perennial upto 3.5m tall, very succulent and nutritions, suitable for mix seeding with legumes.
3	*Cenchrus ciliaris*	Buffel grass	Tanzania	Tufted tussock forming grass, stems upto 1.5m tall, large strong root system high protein and digestibility
4	*Pennisetum purpureum*	Elephant grass	Tanzania	Tall, erect, thick stems upto 4.5m high. It is planted like sugarcane the culms having three nodes are cut into pieces and are buried in the soil upto two nodes and 3rd above ground.
5	*Eragrostis superba*	Love grass	Kenya	Tufted grass, upto 30-75 cm high highly palatable for cattle and used for reseeding denuded land in dry areas.
6	*Eragrostis curvula*	Weeping love grass	Kenya	Strongly tufted grass with flowering stem upto 1.5m high. Remains green in summer, palatable when young easy to establish from seeds
7	*Bothriochola Pertusa*	Pilled blue stem	India	Tufted grass upto 1m tall spreads though rhizomes and stolons, grows in dry areas, good pasture grass with stands grazing and drought.
8	*Digitaria decumbense*	Pangola grass	West Indies	Semi-erect, stems upto 1m tall, forms open turf, pasture grass, with stands trampinga grazing, nutritions but quality declines sharply with age.
9	*Digitaria swazilandensis*	Finger grass	Zimbabwe	Profusely branches stem upto 60 cm high, grows on poor soils, tolerates drought, low yielding less palatable, good soil binder.
10	*Digitaria diversineruis*	Blue couch	Zimbabwe	Stoloniferous, forms low densemats, aggressive, replaces other grasses, 2-15cm high, flowering stem 10-45cm high, and produces reasonably good forage.
11	*Chloris gayana*	Rhodes grass	Kenya	Fine stemmed leafy prostate to ereet turf forming upto 1.5m high, palatable for hay not for silage, drought and grazing resistant, salt tolerant.
12	*Setaria anceps*	Setaria grass	Kenya	Tufted perennial, stem upto 2m high, compressed lower part leaves upto 40cm long, white glabrous, panicle dense cylindrical, nutritions and highly palatable.
13	*Vetiveria zizynoides*	*Vetivar grass*		Profusely branches stem upto 60cm, *Panicle dense*, suitable for mix seeding with legumes.

Table III. Fresh and Dry biomass (t. ha^{-1}) of various Grass species (Average of 6 years 1998 - 2003)

Grasses	Spring		Monsoon		Mean
	Fresh	Dry	Fresh	Dry	
Panicum antidotale (Blue panic)	17.00 ef	6.78 de	24.52 ef	12.72 d	15.26 D
Cenchrus cilliaris	21.98 de	7.83 cd	32.62 de	10.68 e	18.28 CD
Pennisetum purpureum cv. Elephant grass	43.57 b	13.89 b	106.78 b	20.78 b	46.26 B
Pennisetum purpureum cv. Mott grass	78.43 a	24.66 a	118.49 a	32.44 a	63.51 A
Eragrostis superba	28.72 c	7.69 cd	31.86 de	9.98 e	19.56 C
Panicum maximum	28.32 c	9.32 c	34.45 d	14.22 c	21.58 C
Bothriochloa pertusa	23.15 d	7.51 d	41.87 c	15.30 c	21.96 C
Digitaria decumbens	16.57 ef	7.19 d	26.78 de	7.41 g	14.49 DE
Digitaria diversineruis	15.25 ef	5.21 e	17.70 f	4.91 h	10.77 E
Chloris gayana	19.55 e	6.34 de	23.96 ef	8.17 f	14.51 DE
Setaria anceps	17.45 e	5.83 de	26.65 e	10.06 e	15.00 D
Digitaria swazilandensis	11.79 f	4.40 e	18.27 f	6.60 g	10.27 E
Vetiveria zizynoides	13.35 f	4.85 e	25.60 ef	10.71 e	13.63 DE
Erogrostis curvula (schart) Nees	13.87 f	4.12 e	19.72 f	8.02 f	11.43 DE
Mean	24.93 B	8.26 CD	39.23 A	12.29 C	
LSD	3.46	1.71	6.36	1.69	

Values followed by same letter(s) are statistically similar at P=0.05.

digestibility of Mott silage has been reported to be higher than that of corn silage (Rusland *et al*., 1993). Many other grasses like pangola grass, love grass and buffel grass were also succulent. Their succulence showed that these were good for feeding animals because they are likely to have better palatability and digestibility.

Forage production capacity of the affected rangelands can be increased manifold if the affected rangelands are reseeded with the high yielding grass perennial species suited to this ecological zone, provided the livestock are grazed according to the carrying capacity of the pasture for sustained use of this vast natural land/resource (Sharma & Verma, 1983). Mott grass having the high green fodder yield and good palatability can be successfully grown in high rainfall northern areas, where single cropping system is occurring/prevailing. It can also be grown along water channels and on borders of cash crops in irrigated areas. Buffel grass has a wide range of adaptability of various ecological situations. It has been sown/reseeded successfully over 5000 ha in Thal, Cholistan, D.G. Khan, Kohistan, Pothwar and dry lands of Kohat and Peshawar districts. *Blue panic* is grown in the tropical arid and semi arid rangelands of the country. It is also a very promising species of the Pothwar region (PARC, 1984). Buffel grass is grown better in sandy loam soils, while *Blue panic* is easily adapted in sandy loam dunes (Mohammad & Naqvi, 1987). Buffel grass has been recommended for Rajasthan deserts by the Government of India (1981). *Blue panic* is also a good

Table IV. Moisture contents (%) of various grass species during spring and monsoon

Grasses	Spring	Monsoon
Panicum antidotale (Blue panic)	74.26 a	75.18 a
Cenchrus ciliaris	71.21 b	74.68 a
Pennisetum purpureum cv. Elephant grass	70.98 b	69.39 b
Pennisetum purpureum cv. Mott grass	70.64 b	67.23 b
Eragrostis superba	69.38 bc	66.49 bc
Panicum maximum	68.18 bc	65.73 c
Bothriochloa pertusa	68.07 c	65.09 c
Digitaria decumbens	67.84 c	64.29 c
Digitaria diversineruis	67.58 c	64.19 c
Chloris gayana	67.03 c	61.94 d
Setaria anceps	63.24 d	59.57 d
Digitaria swazilandensis	62.19 d	58.58 d
Vetiveria zizynoides	61.72 d	57.26 e
Erogrostis curvula (schart) Nees	57.30 e	51.41 f
Mean	72.14 A	64.29 B
LSD	1.26	2.79

Values followed by same letter(s) are statistically similar at P=0.05

specie in sandy rangelands. However it should be grazed at relatively earlier stages because at late phenological stage it seems become highly lignified hence becomes un-palatable (Ali *et al.*, 2001). Different species of *Digitaria* can also be used for soil conservation (Mohammad, 1989) *Chloris gayana* is a salt tolerant grass and it is recommended for saline rangelands (Mohammad *et al.*, 1987; Ali *et al*., 2001).

CONCLUSIONS AND RECOMMENDATIONS

It could be concluded from this study that the carrying capacity of the highly depleted arid/semi-arid rangelands of Pakistan can be raised manifold by reseeding Buffel and the blue panic grass, green panic grass etc as range areas are producing only 10 - 50% of their potential. From the Table III it is clear that Mott grass performed better followed by Elephant grass under rain-fed conditions in Pothowar. So these grasses can make a big impact if grown in the most areas of northern Punjab and NWFP. As grasses are comparatively high yielding as compared to legumes but legumes are more nutritious in terms of crude protein content and digestibility. Legumes also leave beneficial effects on the soil and produce higher biomass in mixture (Qamar *et al.*, 2000). Therefore, it is suggested that studies on grass legume mixture may be conducted in order to improve forage yield and sustainability.

REFERENCES

Ahmad, S.D., M. Hammad and S.A. Majid, 2001. Exotic Lolium perenne varieties, their forage value and soil cover potential in Himalayan region. *On line J. Biol. Sci*., 1: 815–7

Ali, M., I.A. Qamar, A. Ali, M. Arshad and J. Iqbal, 2001. Evaluation of tropical grasses for forage yield and crude protein content in the Pothowar plateau of Pakistan. *On line J. Biol. Sci*., 1: 466–7

Government of India, 1981. Report of the working Group on Arid Zone Research and Development of Sciences and Technology. P: 231, India

Hoveland, C.S. and W.G. Monson, 1980. *Genetic and environment effect of forage quality, storage and utilization*. Pp: 139–68. American Society Agronomy and Crop Science Society America Madoson, WI

Khan, C.M.A., 1966. New adjustable, decimal, collapsible quadrate versus three old quadrates and evaluation. *J. Range Mgt*., 27: 71–5

Mirza, S.N., N. Mohammad and I.A. Qamar, 2002. Effect of growth stages on quality of forage grasses. *Pakistan J. Agric. Res*., 17: 145–7

Mohammad, N., 1987. *Pakistan's experience in Rangeland Rehabilitation and Improvement*. P: 70. Food and Agriculture Organization of the United Nations, Rome

Mohammad, N., 1989. *Rangeland Management in Pakistan*. P: 198. International centre for Integrated Mountain Developmen, Kathmandu, Nepal

Mohammad, N., B.H. Niazi and I.A. Qamar, 1987. Effect of salt stress on growth and ion uptake in Rhode grass (*Chloris gayana* kunth). *Biologia*, 33: 183–9

Mohammad, N. and A.H. Naqvi, 1987. Dry matter yield of promising grasses in the arid rangeland of Sindh, *Pakistan. Trop. Agric. (Trinidad)*, 64: 70–1

PARC, 1984. Annual report (1983 - 84) Range Research Pothowar, p. 40. Pakistan Agricultural Research Council, Islamabad

Qamar, I.A., 1997. The effect of defoliation of vetch, barley of their mixtures on forage yield quality of residual effects on the succeeding crops in rainfed areas of Pakistan. *Ph.D. Thesis*, Department of Agriculture, University of Reading, UK

Qamar, I.A., G. Akbar and M. Asif, 2000. Performance of summer grasses in arid rangelands of Dhabiji (Sindh). *Sci. Technol. Develop.*, 19: 45–7

Qureshi, M.S., 1992. *An overview of livestock of poultry production in Pakistan*. A paper presented at Pakistan Poultry Feed Technology Seminar, Lahore, Pakistan

Rushland, G.A., L.E. Scollenberger and C.S. Jr. Jones, 1993. Nitrogen fertilization effects on planting stock and characteristics and establishment performance of elephant grass. *Agron. J.*, 85: 857–61

Sharma, S.K. and C.M. Verma, 1983. Performance of Cenchrus ciliaris Lin. Strains in arid rangelands of Western Rajasthan. *Annals of Arid Zone*, 22: 23–7

Steel G.D. and J.H. Torrie, 1980. *Principles and procedures of statistical of Biometrical Approach*. 3rd edition, P: 182. Mc Graw Hill Book Company, New York

Sultana, F., I.A. Qamar, M.I. Sultani, A. Ali and M. Arshad, 2000. Determination of carrying capacity of a sown pasture in the Pothwar plateau of Pakistan. *Pakistan J. Biol. Sci*., 3: 2077–8

Walsmsley, D.V., A.L. Sergeant and M. Dookeran, 1978. Effect of fertilizer on growth and composition of elephant grass (*Pennisetum purpureum*) in Tobago, West Indies. *Trop. Agric. (Trinidad)*, 55: 329–34

Younas, M.A.R., J.I. Iqbal and M. Yaqoob, 1993. The need, importance and future strategies of the rural livestock production. *Pakistan Sci. Inst.*, 2: 13–7

Zafaruddin, C., 1983. Improvement of rangelands. *Progressive Farming*, 3: 27–31

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