Pak. J. Bot., 41(2): 519-527, 2009.

SEASONAL VARIATION IN CURRENT SEASON AND DEAD BIOMASS OF *CHRYSOPOGON AUCHERI* (BOISS) STAPF. AND *CYMBOPOGON JWARANCUSA* (JONES) SCHULT. IN HIGHLAND BALOCHISTAN, PAKISTAN

SARFRAZ AHMAD[1], MUHAMMAD ISLAM[1], GUL BANO[2], SOHAIL ASLAM[1] AND SHAISTA KOUKAB[1]

[1]Arid Zone Research Centre, Quetta, Pakistan
[2]Department of Botany, University of Balochistan, Quetta, Pakistan.
E-mail: s_ahmadazrc@yahoo.com

Abstract

Aboveground current season growth biomass and dead accumulated biomass of *Chrysopogon aucheri* (Boiss) Stapf., and *Cymbopogon jwarancusa* (Jones) Schult., were evaluated during 2001 and 2002 in a protected site of Hazarganji-Chiltan National Park in highland Balochistan. *Cymbopogon jwarancusa* current season biomass ranged from 27 kg/ha in April to 51 kg/ha in June whereas *Chrysopogon aucheri* current season biomass production ranged from 2 kg/ha in April to 54 kg/ha in June. Above ground dead biomass of *Cymbopogon jwarancusa* ranged from 77 to 310 kg/ha whereas the dead biomass of *Chrysopogon aucheri* ranged from 50 to 320 kg/ha. In both years the dead biomass remained more than 70% in the growing season. The protected site had a higher accumulation of aboveground dead material and limited new growth. Accumulated dead materials reducing the productivity of these grasses and planned grazing or clipping may improve the productivity and quality of these grasses.

Introduction

The spatial and temporal productivity of grasses is highly variable due to climatic variability, grazing pressure and nutrients (Olson & Richard, 1989). *Chrysopogon aucheri* and *Cymbopogon jwarancusa* are the dominant perennial C_4 bunchgrasses and occur over a wide range of elevation and soil types in Balochistan (Ahmad *et al*., 2000a). The productivity of rangeland of Balochistan is declining due to overgrazing, over exploitation and soil erosion (Hussain & Durrani, 2007). Water availability is the most important environmental factor controlling survival, production of range plants, germination, abundance and subsequent growth (Brown, 1977, Pitt & Heady, 1978). Water availability exerts an important role on structure and function of many rangeland ecosystems. Plant production in deserts is largely limited by water (Noy-Meir, 1973). However, a direct relationship between precipitation and plant production is not frequently observed (Charley, 1972, Webb *et al*., 1978), the reasons may be due to depletion of available nutrients, timing, duration, intensity of precipitation and changes in biomass allocation patterns (Fisher *et al*., 1988).

Herbivory and other processes destroy biomass or reduce productivity in grasslands and may also increase or decrease the production of litter (Facelli & Pickett, 1991). Decomposition rates vary greatly among ecosystems. Decomposition is negligible in deserts areas due to lack of water that limits microbial activity on the soil surface but in grassland, decomposition is faster by cattle trampling or snow packing (Knapp & Seastedt, 1986). Standing dead material may be transformed faster into litter in semiarid and moist grasslands than in sub-humid areas (Hunt, 1978). Litter alters both physical and chemical environment either directly or indirectly and releases both nutrients and phytotoxic substances into the soil (Facelli & Pickett, 1991). Variable results in grasslands productivity have been reported by removing the standing dead plant material or litter. Forage yields decreased while tiller densities of *Festuca hallii* and *Agropyron spicatum* increased in the first year after removing mulch and standing dead plant litter (Willms *et al*., 1980). However, yields were marginally greater and tiller densities of *Festuca hallii* were substantially increased after two consecutive years of removing standing dead plant litter (Sinton, 1980).

Knowledge of forge production and species production potential under variable environmental conditions is vital for better utilization and management of grasslands of Balochistan. Estimation of the proportion of live and dead materials from vegetation is essential for accurate determination of forage production (Johnson, 1986). Ahmad *et al*., (2000a,b,c) studied the re-generation potential of *Cymbopogon jwarancusa* and *Chrysopogon aucheri* in a protected site. However, information is lacking on the impact of long-term protection of grasses from grazing. The objective of this research work was to evaluate the seasonal grassland productivity in term of current season growth and accumulated dead biomass of two major species (*Chrysopogon aucheri* and *Cymbopogon jwarancusa)* in a protected National Park in highland Balochistan.

Materials and Methods

Study site: The experiment was conducted in Hazarganji-Chiltan National Park located approximately 20 Km south- west of Quetta, Balochistan (30° 07’N, 66° 58’E). The elevation of the park ranges from 1680 m to 3313 m. The soil of the experimental area varies from sandy to sandy loam in texture with a pH of 7.3 to 8.5 (Marwat *et al*., 1992). The area has a Mediterranean climate and long-term average rainfall is about 250 mm (Kidd *et al*., 1989). Rains mostly occur in winter season from Nov-March. Summer rains are very rare but if occurs provide sufficient moisture and better range vegetation. The average minimum winter and maximum summer temperatures are 6°C in January and 39°C in June, respectively. As a National Park, the area has been protected from livestock grazing since 1964. The main vegetation of the park includes *Cymbopogon jwarancusa*, *Chrysopogon aucheri*, *Bromus tectorum*, *Artemisia quettensis, Astragalus stocksii*, *Caragana ambigua*, *Ferula oopoda*, *Ferula costata*, *Sophora mollis* ssp., *Griffithi*, *Ebenus stessata*, *Pistacia khinjak* and *Fraxinus xanthoxyloides*.

Experimental procedures: In March 2001, 3 parallel blocks (100 x 100 m) at a distance of 10-m apart were established at a representative site dominated with *Chrysopogon aucheri* and *Cymbopogon jwarancusa*. In each block 10 quadrats ($1m^2$) were harvested from April to September 2001 and April to November 2002 for estimation of above ground biomass. The plants rooted within $1m^2$ were harvested. Areas disturbed by previous sampling were avoided during quadrat placement. Plant materials were hand separated into current seasonal growth (C.S.G) and dead biomass (D.B). All the plant samples were dried at a constant temperature of 70°C for 48 hours. Monthly current season growth and dead material data were analyzed separately in each year in a two-way factorial randomized complete block design.

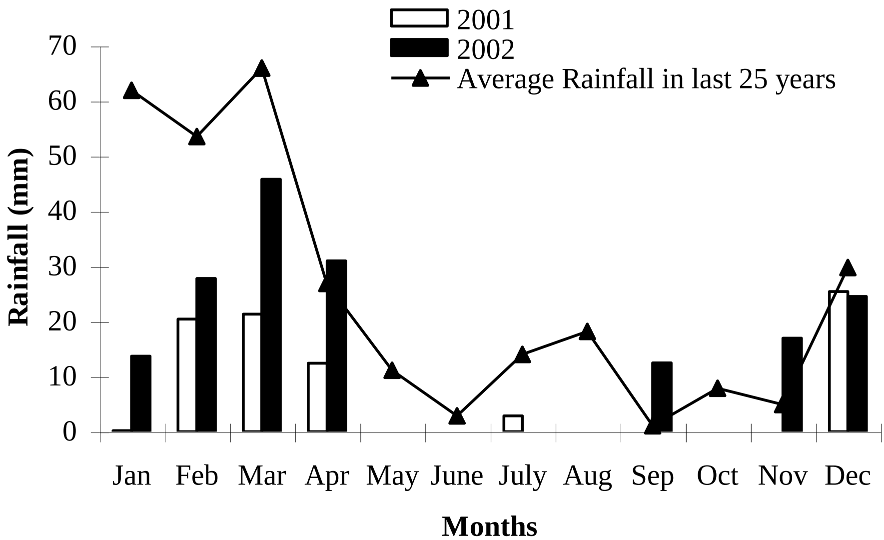


Fig. 1. Total monthly rainfall during 2001, 2002 and average rainfall of 25 years.

Soil samples at two depths (0-10cm and 10-20cm) were also collected from each established block at three different places during the experiment for the determination of soil moisture content by gravimetric method. Soil moisture data were analyzed in a two-way factorial randomized complete block design.

Results

Total annual rainfall during 2001and 2002 was only 82.8 mm and 172.3 mm respectively, compared to long-term average of 250 mm. Optimal growing season rainfall (February to May) during 2001 and 2002 was 54.4 mm and 104.6 mm respectively, while the long term average is 158 mm (Fig. 1). Rainfall in 2001 was at least 77% less than long-term average while the rainfall during 2002 was slightly better than 2001. Absolute maximum and minimum temperatures of 35 and -6°C were recorded in July and January, respectively. During 2001, in April 12.4 mm of rainfall was received, however; the later months were dry without any rain except a light shower of 2.8 mm received in July 2001. Similarly, the year 2000 was also very dry and a total rainfall of 75.1 mm was received with more than 50% in the month of December 2000, which might have contributed to the spring growth of the grasses during 2001.

Soil moisture contents for 2001 and 2002 are presented in Fig. 2a&b. Moisture content was significantly ($p<0.05$) different among months during 2001 and during 2002. In 2001, soil moisture was comparatively better in April and in later months a sharp decline in the stored soil moisture occurred (Fig. 2a). During 2002 season, the soil moisture content at various depths was comparatively better than the 2001 season. However, the soil moisture declined from April to August and in September 2002, there was an increase in soil moisture content due to rainfall (10 mm) in early September 2002 (Fig. 2b).

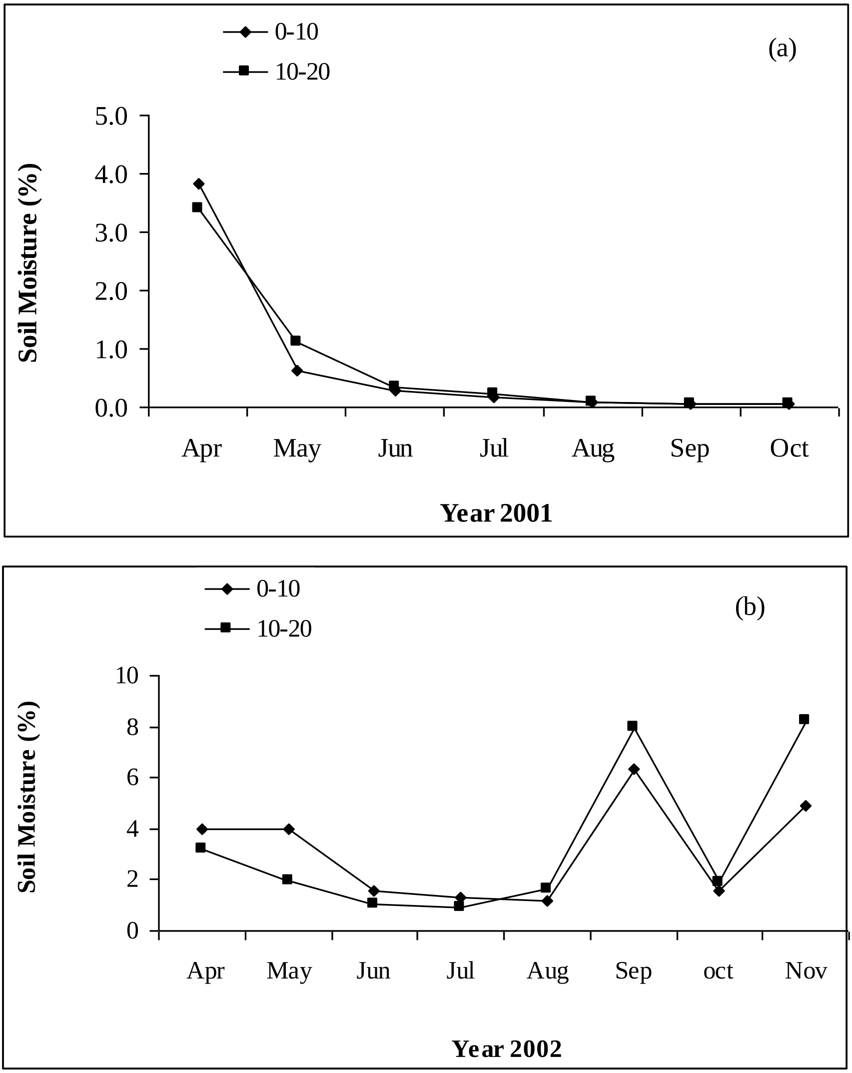
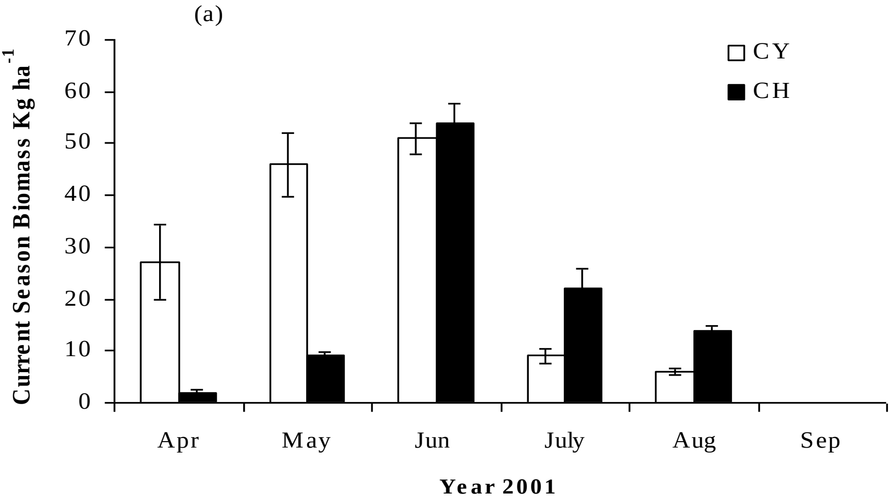


Fig. 2. Soil Moisture content at 0-10 and 10-20 cm depths during 2001 (a) and 2002 (b).

The above ground biomass (current season growth and dead biomass) of both species showed a pronounced seasonal pattern (Fig. 3a & b). In 2001, current season growth (CSG) biomass production was significantly different among months ($p<0.05$) and species x month interaction was also significant ($p<0.05$). Above ground current season growth of both species was peaked in June and then showed a decline trend. In *Cymbopogon jwarancusa* current season growth ranged from 27 kg/ha in April to 51 kg/ha in June whereas *Chrysopogon aucheri* current season biomass production ranged from 2 kg/ha in April to 54 kg/ha in June. The trend of current season growth in 2002 was also similar as 2001 except slight increase in biomass due to better rainfall and availability of soil moisture (Fig. 4a & 4b).



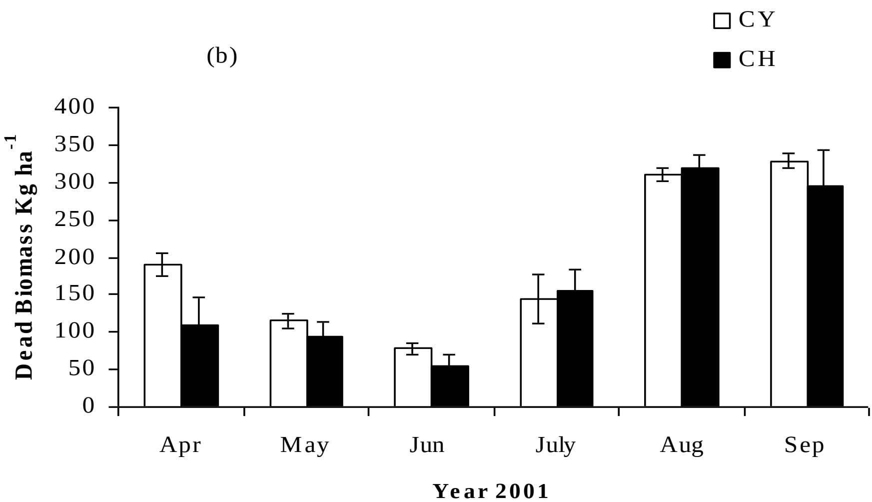


Fig. 3. Current season growth (a) and dead biomass (b) of *Chrysopogon aucheri* (Ch) and *Cymbopogon jawarancusa* (Cy) during growing season of 2001.

In both years the dead biomass remained more than 70% in growing season except in June where the fresh material increased up to 50%. In 2001, above ground dead biomass was significant ($p<0.05$) among months but no significant ($p>0.05$) differences were observed between species and species x month interaction. Above ground dead biomass of both species showed a similar trend of gradual decrease as the current season growth increases up to mid June and then increases as the grasses enters towards maturity. Above ground dead biomass of both species was peaked in August to November as the grasses approached towards dominant period (Fig. 4b). Above ground dead biomass of *Cymbopogon jwarancusa* ranged from 77.75 to 310 kg/ha whereas the dead biomass of *Chrysopogon aucheri* ranged from 50 to 320 kg/ha in August (Fig. 3b & 4b).

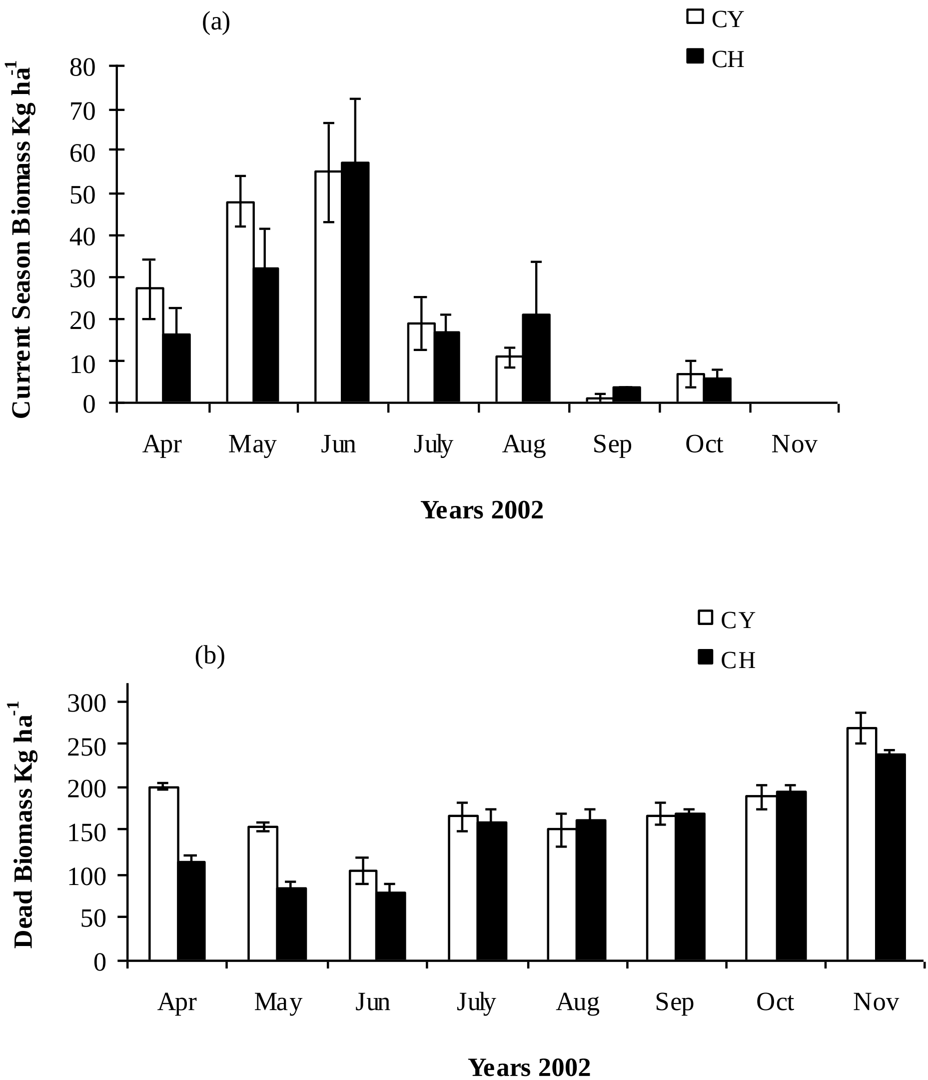


Fig. 4. Current season growth (a) and dead biomass (b) of *Chrysopogon aucheri* (Ch) and *Cymbopogon jawarancusa* (Cy) during growing season of 2002.

Discussion

The temporal variation in rainfall is an inherent characteristic of semiarid grassland production (Behuke *et al*., 1993, Dahlberg, 2000). Soil moisture and the environmental conditions (high or low temperature) significantly affect the biomass production. The productivity of grassland fluctuates in time and space as water and nutrient availability varies (Olson & Richards, 1989). The annual above ground biomass of both *Chrysopogon aucheri* and *Cymbopogon jwarancusa* was considerably affected by rainfall fluctuation between the two consecutive years. The biomass production of both species significantly increased during 2002 as compared to 2001, which was almost certainly due to higher rainfall and its better distribution. In highland Balochistan, it is observed that the net primary production mainly depends on stored soil moisture from winter rains, rains in spring season, and occasional summer rains prolong the growth period of grass species.

Cymbopogon jwarancusa is a dominant species and covers more than 50% of the total area and its dominance may be due to its higher seed production, viability and better germination rates than *Chrysopogon aucheri* (Ahmad *et al*., 2000a). *Cymbopogon jwarancusa* completes its life cycle earlier than *Chrysopogon aucheri* and this capability may be due to its establishment early in the season and growth at low temperature (Saleem, 1990). *Chrysopogon aucheri* remain active for a longer period of time may be due to its higher number and length of primary and seminal roots (Saleem, 1990). Moreover, *Chrysopogon aucheri* has the ability to produce biomass late in the growing season at high temperature subject to the availability of soil moisture as also observed by Mott (1978) in *Chrysopogon fallax* and *Chrysopogon latifolius*. Grassland species may also differ considerably in their abilities to tolerate drought conditions (Bassiri *et al*., 1988). The investigated soil moisture (0-10 cm and 10-20 cm) in the present study is inadequate to compare the biomass production and soil moisture availability. It seems that both species rely on water stored in the deeper soil layers. Therefore, further investigations are required to study the soil moisture content below 20 cm along with patterns of root distribution of *Cymbopogon jwarancusa* and *Chrysopogon aucheri*.

In both years the dead material was more than 50%, which reduced the quantity of current season growth as well as quality of both the grasses. The very long protection of these grasses reduces their current season biomass production. Enhanced growth rate of grasses in response to grazing, fire and disturbance under favorable environmental have been observed due to replacement of dead plant material and better photosynthetic ability (Chapin & McNaughton, 1989). The plant growth of *Cymbopogon jwarancusa* and *Chrysopogon aucheri* is also affected as a result of dead material accumulation due to low tillering ability. Tiller height, number and size of leaves are growth components that may contribute to the re-establishment of a photosynthetic surface area (Becker *et al*., 1997). The sustainability of grasses and grasslands depends on successive tiller initiation from auxillary buds of previous tiller generation. Perennial bunchgrasses are relatively long lived however, individual tiller longevity does not exceed two years in most temperate species (Briske, 1991). Tiller initiation must occur annually to offset mortality and maintain plant productivity, size and competitive ability (Murphy & Briske, 1992). Therefore, some planned grazing or clipping (removal of dead plant material) may improve the productivity and quality of these grasses at protected site of Hazarganji National Park. However, further field studies are required to monitor the impact of removal of standing dead plant material on growth and forage production under variable environmental conditions.

Acknowledgment

The authors are highly thankful to Professor Dr. Mufakhirah Durrani, Department of Botany, University of Balochistan, Quetta for the technical assistance and manuscript review. The financial support of Agriculture Linkages Programme (ALP), Pakistan Agricultural Research Council (PARC) and Arid Zone Research Centre (AZRC), Quetta is also highly appreciated for conducting this research work in Balochistan.

References

Ahmad, S., C.A. Call and E.W. Schupp. 2000a. Regeneration ecology of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* in upland Balochistan. 1. Morphology, viability and movement of seeds (Spikelets). *Pak. J. of Biol. Sci*., 3(10): 1583-1587.

Ahmad, S., C.A. Call and E.W. Schupp. 2000b. Regeneration ecology of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* in upland Balochistan. 1I. Dispersal, predation and soil reserves of seeds (Spikelets). *Pak. J. of Biol. Sci*., 3(11): 1880-1883.

Ahmad, S., C.A. Call., E.W. Schupp and S.N. Mirza. 2000c. Regeneration ecology of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* in upland Balochistan. III. Effects of precipitation and seedbed microhabitat on seedling recruitment. *Pak. J. of Biol. Sci*., 3(12): 2041-2047.

Bassiri, M., A.M. Wilson and B. Grami. 1988. Root excision and dehydration effects on water uptake in four range species. *J. of Range Manag*., 41(5): 378-382.

Becker, G.F., C.A. Busso, T. Montani, A.L. Orchansky, R.A. Brevedan, M.A. Burgos, A.C. Flemmer. 1997. Effects of defoliating *Stipa tenuis* and *Piptochaetium napostaense* at different phonological stages: tiller demography and growth. *J. Arid Envir*., 35: 251-268.

Behuke Jr. R.H., I. Scoones and C. Kewen. 1993. In: *Range ecology at disequilibrium*. New models of natural variability and pastoral adaptation African savannas. pp. 248. Overseas Development Institute, London.

Briske, D.D. 1991. Developmental morphology and physiology of grasses, p.85-108. In: Grazing management: An ecological perspective. (Eds.): R.K. Heitschmidt and J.W. Stuth. Timber Press, Portland, Ore.

Brown, R.W. 1977. Water relations of range plants. Ch. 4 In: *Rangeland Plant Physiology*. (Ed.): R.E. Sosebee. Range Sci. Series No. 4. Doc. For Range Manage., Denver, Colo.

Chapin, F.S. and S.J. McNaughton. 1989. Lack of compensatory growth under phosphorus deficiencies in grazing adapted grasses from the Seregeti plains. *Oecologia*, 79: 551-557.

Charley, J.L. 1972. The role of shrubs in nutrient cycling, Pp. 182-203. In: *Wildland shrubs-their biology and utilization*. (Eds.): C.M. McKell, J.P. Blaisdell and J.R. Goodwin. USDA Forest Serv. Gen. Tech. Rep. INT-I, Washington, DC.

Dahlberg, A.C. 2000. Vegetation diversity and change in relation to land use, soil and rainfall: A case study from North East District, Bostswana. *J. of Arid Envir*., 44: 19-40.

Facelli, J.M and S.T.A. Pickett. 1991. Plant litter: Its dynamics and effects on plant community structure. *Bot Rev*., 57:2-32.

Fisher, F.M., J.C. Zak, G.L. Cunningham and W.G. Whitford. 1988. Water and nitrogen effects on growth and allocation patterns of creosotebush in the northern Chihuahuan Desert. *Journal of Range Management*, 41(5): 387-391.

Hunt, H.W. 1978. A simulation model for decomposition in grasslands. pp 155-183 In: *Grallsland simulation models*. (Ed.): G. Innis. Springer, New York.

Hussain, F and M. J. Durrani. 2007. Forage productivity of arid temperate Harboi rangeland, Kalat, Pakistan. *Pak. J. Bot*., 39(5): 1455-1470.

Johnson, Marrk, K. 1986. Estimating ratios of live and dead plant material in clipped plots. *J. of Range Manag*., 39(1): 90-91.

Kidd, C.H.R., D.J. Rees, J.D.H. Keating, F. Rehman, A. Samiullah and S.H. Raza. 1988. Meteorological data analysis of Balochistan. *MART/AZR Research Report No. 19. Arid Zone Research Institute, Quetta*.

Knapp, A.K. and T.R. Seastedt. 1986. Detritus accumulation limits productivity of tallgrass prairie. *Bio. Sci*., 36: 622-668.

Marwat, Q.U.D., M.S. Nisar and F. Hussain. 1992. Vegetation studies of Chilton National Park Hazarganji, Quetta. *Pak. J. Agri. Res*., 13: 71-79.

Mott, J.J. 1978. Dormancy and germination in five native grass species from savannah woodland communities of the Northern Territory. *Australian J. of Botany*, 26: 621-631.

Murphy, S. and David D. Briske. 1992. Regulation of tillering by apical dominance: chronology, interpretive value, and current perspectives. *J. of Range Mang*., 45(5): 419-429.

Noy-Meir, I. 1973. Desert ecosystems: environment and producers. *Annu. Rev. Ecol. Sys*., 5: 25-51.

Olson, Bret E. and J.H. Richards. 1989. Crested wheatgrass growth and replacement following fertilization, thinning, and neighbor plant removal. *J. of Range Mang*., 42(2): 93-97.

Pitt, M.D. and H.F. Heady. 1978. Response of annual vegetation to temperature and patterns in Northern California. *Ecology*, 59: 336-350.

Saleem, M. 1990. *Autecological characteristics of Chrysopogon aucheri and Cymbopogon jwarancusa dominant rangeland grasses in Balochistan*. PhD dissertation Utah State University, Logan, Utah, USA.

Sinton, H.M.M. 1980. *Effect of burning and mowing on Festuca hallii (Vasey) Pipe, Festuca scabrella Torr*. M.Sc Thesis, Univ. of Alberta, Edmonton.

Webb, W., S. Szarek, W. Lauenroth, R. Kinerson and M. Smith. 1978. Primary productivity and water use in native forest, grassland and desert ecosystems. *Ecology*, 59: 1239-1247.

Willms, W., A.W. Bailey and A. McLean. 1980. Effects of clipping or burning on some morphological characteristics of *Agropyron spicatum*. *Can J. Bot*., 58:2309-2312.

(Received for publication 25 March 2008)