GROWTH POTENTIAL AND BIOMASS PRODUCTION OF RESEEDED RANGE GRASSES IN KHERIMURAT SCRUB FOREST

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ABSTRACT

Rangelands are pivotal renewable natural resource and grazing is an efficient way of its utilization. Presently these rangelands are desecrated continuously because of high human impact. Contemporary necessity is to reinstate the forage potential by increasing the efficacy of forage species in rangelands by employing various rehabilitation techniques such as reseeding etc. The present study was designed to assess the growth performance and biomass production of reseeded grasses in scrub rangelands of Kherimurat scrub forest of Barani Livestock Production Research Institute, during summer 2010 to spring 2011. Five grass species included *Bothriochloa pertusa* (palwan), *Pennisetum purpureum* (Napier), *Cynmbopogan distans* (Chita), *Cenchrus ciliarus* (Dhaman) and *Themeda anathera* (Loondar) were reseeded by broadcast method during summer, 2009. Data collected for morphological parameters including number of leaves per plant, plant height, number of inflorescence and number of tillers per plant at three different growth stages i.e., vegetative, flowering and maturity of grasses was analyzed statistically by ANOVA using RCBD. Significant results were observed among selected grass species in terms of biomass production and growth potential and revealed that *Cynmbopogan distans* (Chita) grass showed higher morphological growth in comparsion to other grasses at all growth stages however *Cenchrus ciliarus* (Dhaman) grass showed minimum growth. While, *Pennisetum purpureum* (Napier) showed maximum fresh and dry biomass production in all seasons followed by *Cynmbopogan distans* (Chita) and is highly recommended for reseeding under rain-fed conditions of Pothowar.

INTRODUCTION

In Pakistan more than 60 percent of area has been declared as rangeland, which accounts major land use of the country. The total area coverage of rangeland reported in Pakistan is 50.88 m ha (Mohammad, 1987). The rangelands in the country are a key natural resource that extensively supports livestock and wild life population (Habib *et al*., 2015). Rangelands are principally accredited to scanty and erratic rainfall but during normal wet seasons, most of the land ropes large volumes of forage of relatively high quality (Mbatha and Ward, 2010). But due to over utilization, poor management and lack of enough resources this massive area of natural resource is being

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neglected hence at present only 10-15 percent of their definite potential is being attained (Ali *et al*., 2001). Most of the area in Pakistan is Arid to Semiarid and more than 80 percent of the area receives less than 300mm rainfall (Zafaruddin, 1984). Pakistan, likely other arid countries is also facing the challenge of rigorous rangeland degradation as a result of deforestation, poor grazing and mismanagement and utilization of water resources leading to decline in its potential of forage production (Mohammad, 1989). Also climate change is drastically exacerbating the rangeland degradation (Han *et al*., 2008). Hence, the need of time is to restore its potential for forage production by creating high diversity of forage species in these natural resources of the country (Butt and Ahmad, 1994). Rangeland reseeding has been recommended as a possible management practice to improve forage production and carrying capacity of degraded rangelands, when coupled with proper stocking, provided natural conditions favor both seed germination and seedling establishment (Chaudhry *et al*., 2010). In Pakistan, reseeding may be a feasible range remediation practice for rangelands with low forage production and unpalatable plants vegetation (Mohammad, 1984). For long grazing season a continuous supply of good quality forage on regular basis is necessary. Artificial and natural reseeding of range vegetation in small covers is also a desirable practice. Reseeding has been demonstrated as the best option to improve forage condition in range areas (Mnene, 2006). Reseeding improves existing ground cover and enhances biomass production by manifolds. This can be accomplished by: (a) over-sowing into existing vegetation with a superior species, (b) establishing a completely new pasture, with or without irrigation, and (c) reseeding denuded land (Pratt and Gwynne, 1977).

Despite the existence of appropriate technologies for reseeding, adoption rate has remained low over the years. One of the most limiting factors is inadequate supply of quality grass seeds (Mbogoh and Shaabani, 1999).

Keeping in view the prevailing circumstances of the rangelands, it is the need of time to increase forage productivity of the degraded rangelands by utilizing various techniques. Also it is of paramount importance that high yielding and palatable grass species should be established in their suitable eco-sites by reseeding (Muhammad and Naqvi, 1987).

MATERIALS AND METHODS

Experimental site

The experiment was carried out at Kherimurat scrub forest of Barani Livestock Production Research Institute, District Attock. Kherimurat lies in Pothohar Plateau at 330 North latitude and 720 East longitudes. The elevation of area from sea level varies from 460-1067 m. The temperature ranges from 10-

38°C and humidity is 50 percent and more. Total area of Kherimurat scrub forest is 5074 ha (12533 acres) and total reseeded area 20x20 m. The research site basically consist of a range area in Kherimurat scrub forest having many species of trees such as *Olea ferrugenia, Acacia modesta and Acacia nilotica*, grasses like *Cenchrus ciliarus, Cynodon dactylon* and shrub species *Adhatoda vesica* etc.

Selection of suitable species

Five different grass species has been reseeded in Kherimurat scrub forest during summer, 2009 for studying growth parameters at three different phonological stages i.e., vegetative, flowering and maturity. The selected grass species comprised of *Bothriochloa pertusa* (Palawan), *Pennisetum purpureum* (Napier), *Cynmbopogan distans* (Chita). *Cenchrus ciliarus* (Dhaman) and *Themeda anathera* (Loondar) and have been reseeded with broadcast methods on a plot size of 4 x 20 m, during summer 2009. This study was conducted to check the growth performance and biomass production of these reseeded range grasses.

GROWTH PERFORMANCE

Morphological Data

Morphological data regarding number of leaf per tiller, plant height, number of tillers per plant and number of inflorescences per tiller was recorded at different phonological stages like vegetative, flowering and maturity of all the selected grass species. Growth parameters were studied for five randomly selected plants from each plot of different plant species. Plant height (cm) was determined from ground to the end of the tallest tiller (Butt *et al*., 1992).

Fresh and dry biomass production

Data on fresh and dry mater yield for summer season 2010 was collected in the first week of September. Similarly, dry matter yield was also being taken during the last week of October, 2010. Spring season data was collected in the last week of April, 2011. Three quadrates of 1 m^2 size were harvested randomly from each plot of each species for fresh and dry matter determinations (Khan, 1974). Palatable matter of each grass species was clipped close to the ground level and fresh biomass was weighed and the samples were oven dried to at a constant temperature of 70ºC for 72 hours in Laboratory of Forestry and Rangeland Management Department in Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi. The oven dried weight was recorded to estimate annual yield of selected reseeded grasses.

The fresh biomass was measured by using the formula as under:

$$\text{Fresh Biomass (Kh/ ha}^{1}) = \frac{\text{Fresh biomass weight (g)}}{\text{Area in m}^2} \times \frac{10000}{1000}$$

Statistical Analysis

The experiment was planned in randomized complete block designs (RCBD) and means were compared using least significant difference test (LSD) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Mean values of grasses showed that maximum no. of leaves were obtained at vegetative stage of *Cynmbopogan distans* grass (G3) and minimum no. of leaves per plants in *Cenchrus ciliarus* (Dhaman) grass. Pennusetum purpureum (G2) was at par to Cynmbopoan distans grass (G3) followed by *Bothriochloa pertusa* (G1) grass and *Themeda anathera* (G5) (Table. 1). At flowering stage *Cynmbopogan distans* grass (G3) showed maximum average no. of leaves per plants and *Cenchrus ciliarus* grass (G4) again showed minimum average. *Bothrichloa pertusa* G1 and *Pennisetum purpureum* (G2) showed balance however *Themeda anathera* (G5) stood nearby *Cenchrus ciliarus* (G4). Maturity stage data revealed that *pennisetum purpreum* (G2) showed maximum no. of leaves at this stage. Mean values at maturity stage showed a little different value as compared to vegetative and flowering stage. *Pennisetum purpureum* (G2) has maximum and *Themeda anathera* (G5) minimum no. of leaves. At this stage grasses showed low values as compared to other stages because plants shed their leaves at maturity and this difference is also due to advancing plant maturity.

Findings of Mislevy *et al*. (1989) and Khan *et al*. (1999) are also quite similar to present conclusions, who have reported upto 10 times more forage production in the reseeded area in comparison to the native range area vegetation. Decreased leaves ratio with advancing plant age may be attributed to synthesis of more cell wall contents with advancing maturity. Similar results were also reported by Crowder and Chheda (1982), Dabo *et al*. (1988) and O' Reagain *et al*. (1996) that a short vegetative period resulted in decreased leaf to stem ratio with advancing age. Comparison of all stages data regarding to No. of leaves has shown in graph No. 1.

Table 1. Mean values of Plant Height, No. Tillers per plant, No. of Leaves per tiller and No. of Inflorescence at Vegetative, Flowering and Maturity Stages of sleceted five grasses

Grasses/ Growth Stages	Vegetative				Flowering				Maturity			
Traits	NL	NT	PH	NI	NL	NT	PH	NI	NL	NT	PH	NI
G1	4.80	14.20	62.40	2.40	7.60	11.40	92.60	3.60	5.40	13.60	101.40	6.00
G2	6.00	14.80	78.80	0.00	7.60	14.20	100.20	0.00	8.20	18.20	113.40	0.80
G3	6.20	19.20	92.20	2.60	8.60	24.80	128.80	10.80	7.20	22.20	128.60	9.00
G4	2.80	7.20	40.60	0.60	5.00	8.80	61.80	0.80	4.80	10.40	70.20	1.00
G5	4.20	11.80	55.60	2.00	5.40	17.20	74.60	5.00	4.00	18.60	70.80	6.20

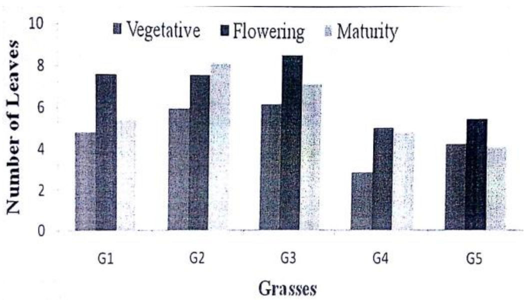
Legends: NL*: no. of leaves,* NT*: no. of tillers,* PH*: plant height,* NI*: no. of inflorescence*

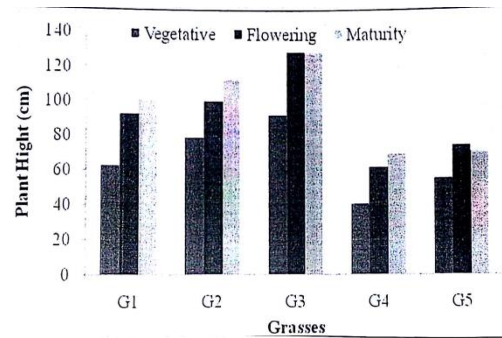
The mean value of plant height at vegetative, flowering and maturity stage resulted that *Cynmbopogan distans* (G3) has maximum growth potential regarding plant height (116.53 cm) followed by *Pennisetum purpureum* (97.46 cm) while minimum plant height (57.53 cm) was recorded in *Cenchrus ciliarus* (G4) of all grasses. The plant height in these grasses increased with increasing plant maturity due to longer vegetative growth period. Habib *et al*. (2015) also reported that plant height increased throughout the experimental period but maximum increase was observed after monsoon. Findings of the study are also consistent with those reported by Mislevy *et al*. (1989). Similar findings were reported by Butt *et al*. (1992), Mushtaque *et al*. (2010) and Arshadullah *et al*. (2009). Comparison of data related to plant height is shown in graph No. 2.

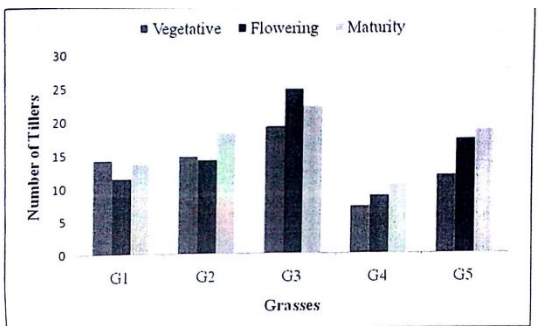
Mean values of grasses at different growth stages showed that maximum no. of tillers per plant were obtained in *Cynmbopogan distans* (G3) grass and minimum no. of tillers per plant were observed in *Cenchrus ciliarus* (G4) followed by *Bothriochloa pertusa* (G1), *Pennisetum purpureum* (G2) and *Themeda anathera* (G5). The results indicated that number of tillers per plant increased with advancing plant maturity. The rate of increase in tiller density was faster during vegetative growth and increased number of tillers per plant with advancing growth resulted in increased basal circumference. The results were in conformation with the findings Habib *et al*. (2015) who also observed maximum number of tillers in *Panicum antidotale* during vegetative growth of the plants however the tiller density declined with advancing maturity. The findings of

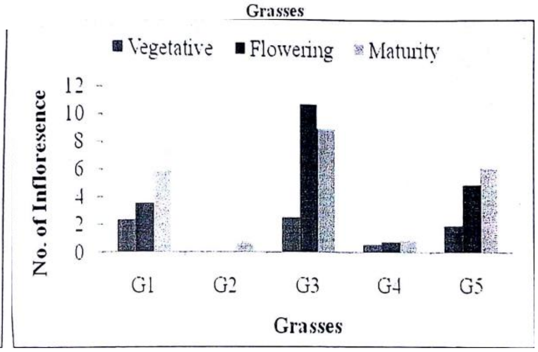
Madakadze *et al.* (1999), Butt *et al*. (1992) and Arshadullah *et al*. (2009) and Koech *et al*. (2016) are also in agreement with present results. Comparison of data related to number of tillers per plant is shown in graph No. 3.

Comparison of number of leaves (Graph-1), plant height (Graph-2), number of tillers (Graph-3) and number of inflorescence (Graph-4) at vegetative, flowering and maturity stages of reseeded range grasses at research area of Kherimurat scrub forest.





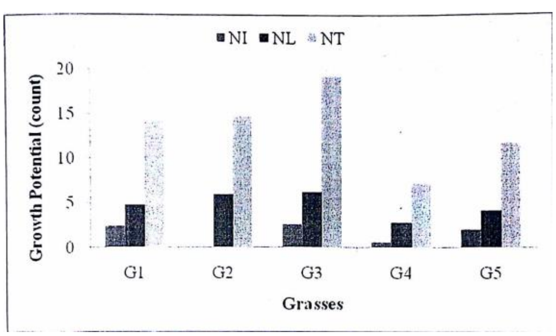


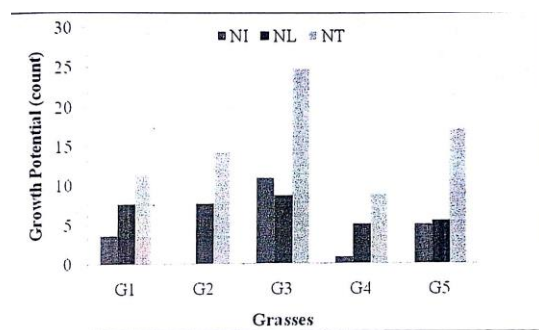


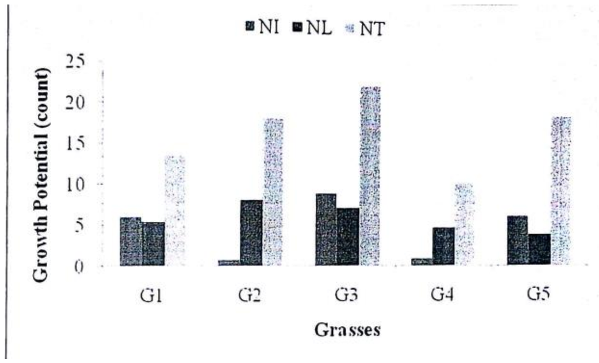
Cynmbopogan distans (G3) again showed maximum no. of inflorescence (7.46) and *Pennisetum purpureum* (G2) indicated minimum inflorescence (0.26) at different growth stages of grasses. The no. of inflorescence in these grasses increased with increasing plant maturity and after getting a specific maturity no. of inflorescence started decreasing. As compared to other stages, inflorescence production was higher at flowering stage however after getting maturity plants started to defoliate that resulted into a decline in inflorescence density. Similar findings were reported by Butt *et al*. (1992) and Mushtaq *et al*. (2010). Hussain and Durrani (2009) also reported that seasonal availability of forage, palatability and animal preference varied in terms of botanical composition throughout the year. Hence, maximum number of inflorescence resulted in higher palatability of grazing animals. Comparison of all stages data regarding to no. of inflorescence has been elucidated in graph No. 4.

By comparing all growth parameters at vegetative, flowering and maturity stage the growth potential of *Cynmbopogan distans* (G3) was found maximum followed by *Pennisetum purpureum, Bothriochloa pertusa* and *Themeda anathera* as compared to *Cenchrus ciliarus* (G4) that revealed minimum growth potential in all parameters. However, plant height increased rapidly from seedling to vegetative stage as compared to vegetative to flowering stage and declined with advancing maturity. After maturity, stunted plant growth has been observed leading to defoliation. Whereas, an increase in plant height was observed with advancing plant maturity but after attaining certain maturity the further plant growth stunted leading to defoliation. This result indicated that reseeding arid rangeland with these species improve the growth potential of rangeland area as compared to native rangeland grasses and ultimately help to increase forage production by extensively supporting livestock production. Our results are in line with the findings of Jehanzeb *et al*. (2016) who also reported significant differences in forage yield at various growth stages of different grass species. Comparison of vegetative, flowering and maturity stage data regarding all growth parameters has graphically shown in graph no. 5, 6 and 7 below.

Comparison of maturity stage data regarding all growth parameters graphically has shown in graph No. 7. All growth parameters showed varied response during maturity stage where, no. of inflorescences were higher in *Cynmbopogan distans* (G3) and lower in *Pennisetum purpureum* (G2) whereas, *Themeda anathera* (G5) was found in the middle of all grasses in case of no. of inflorescence. While no. of leaves were maximum in *Pennisetum purpureum* (G2) and minimum in *Themeda anathera* (G5) however, no. of tillers were higher in *Cynmbopogan distans* (G3) followed by *Pennisetum purpureum* (G2) and lower in *Cenchrus ciliarus* (G4) (Table 1). So *Cynmbopogan distans* showed higher morphological potential at this stage.



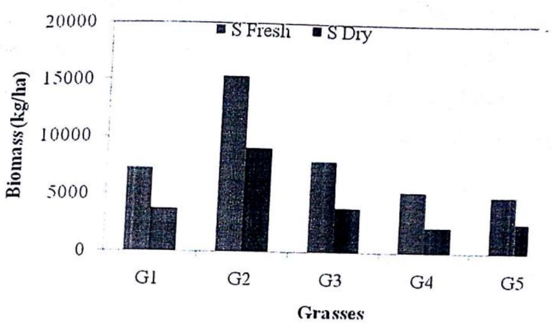


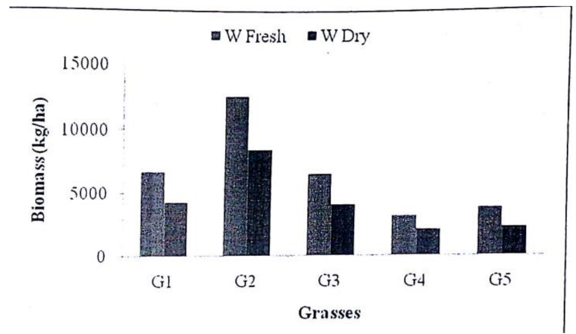


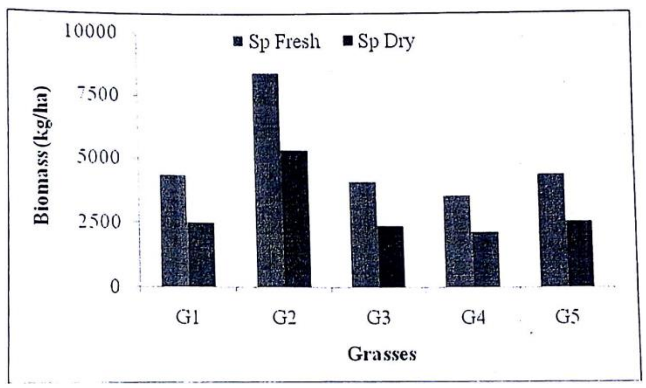
Comparsion of growth potential of five reseeded range grasses at vegetative (Graph-5), flowering (Graph-6) and maturity stage (Graph-7) in research area of Kherimurat scrub forest.

Data collected on fresh and dry matter yield of grasses revealed that *Pennisetum purpureum* (Napier) 9376.66 kg/ha produced maximum fresh and dry matter yield followed by the *Cynmbopogan distans* (Chita) 8083.33 kg/ha and 4033.33 kg/ha. *Cenchrus ciliarus* (Dhaman) produced minimum fresh and dry matter yield 5466.66 kg/ha and 2423.33 kg/ha in summer season. *Themeda anathera* (Loondar) produced fresh and dry matter yield little high than Cenchrus ciliarus. These results were consistent with research conducted by Khan *et al*. (1999).

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. Fresh and dry matter yield was more in monsoon season as compared to winter and spring season, in almost all species because of more rainfall during monsoon season of 2010. Laden (2016) also reported similar results and found significant differences among quality and agronomic characteristics of all plant species and environmental conditions. Nippert *et al*., 2006 also demonstrated a significant positive correlation between precipitation variability and productivity, independent of precipitation amount, in a long term Research Program. Many other studies (Mohammad, 1989; Durrani *et al*., 2005 and Farooq, 2003) have also shown that the amount of rainfall severely affects the productivity of rangelands and our findings a quite in line with them. Comparison of fresh and dry biomass production of different grasses in summer season has graphically shown in graph no. 8.







Comparsion of fresh and dry forage yield (kg/ha) of five reseeded range grasses in summer (Graph-8), winter (Graph-9) and spring (Graph-10) in research area of Kherimurat scrub forest.

All five grasses showed maximum biomass production during the end of summer season due to the high monsoon rain fall which increased the total potential of the grasses. *Pennisetum purpureum* grass had maximum biomass production due to high production of stem to leaf ratio. It has very high productivity as a forage grass for livestock. Other grasses also produced good quantity of biomass in this range area. Dry biomass production of these grasses was also calculated. Dry biomass was also found maximum in *Pennisetum purpureum* grass as compared to other reseeded range grasses during this season. Similar observations have been made by Koech (2014) who evaluated six indegeous grasses for pasture production under varying soil moisture content in Kenya and found significant results in terms of water use efficiency to biomass production.

Fresh and dry yield data for winter season was taken in early winter at the maturity of grasses during the last week of October. At this stage, Napier grass again produced the highest fresh and dry matter yield of 12566.66 kg/ha and

8383.33 kg/ha) followed by the *Cynmbopogan distans* (G3) 6450 kg/ha and 4043.33 kg/ha) where, *Cenchrus ciliarus* (G4) produced minimum fresh and dry matter yield 3100 kg/ha and 2046.33 kg/ha). *Themeda anathera* (G5) produced fresh and dry matter yield (3733.33 kg/ha and 2200 kg/ha) little high than *Cenchrus ciliarus* while *Bothriochloa pertusa* stood in the middle of all grasses. Fresh biomass production of these reseeded range grasses was low as compared to monsoon data. This difference was due to the dryness of grasses at their maturity and defoliation of leaves of grasses. Comparison of fresh and dry biomass production of different grasses at maturity has been graphically shown in graph no. 9. The low production of biomass during this season is due to dryness of grasses at maturity and dry condition of this season. At maturity all growth process in plants stopped and their biomass production reduced as compared to vegetative and flowering stage biomass. Our results mirror the findings of Koech (2014) who also demonstrated decline in WUE with advancing maturity in all the selected species.

In spring season Napier grass produced the highest fresh and dry matter yield of (8446.66 kg/ha and 5406.66 kg/ha) followed by the *Themeda anathera* (Loondar) (4440 kg/ha and 2593.33 kg/ha). *Cenchrus ciliarus* (Dhaman) produced minimum fresh and dry matter yield (3603.33 kg/ha and 2173.33 kg/ha) in spring season. *Bothriochloa pertusa* (Palwan) was similar to *Themeda anathera* (Loonder) in terms of production. Griffin and Jung (1983) reported similar findings and revealed increase forage dry matter yield with increasing maturation. Similarly, Madakadze *et al*. (1999) reported that dry matter yield increased with increasing plant maturity and attributed it to increase in tiller density with advancing plant age. Dry matter yield was more in monsoon season compared to winter and spring season in almost all species because of high rainfall in monsoon of 2010. Our results are in conformation with the findings of Laden (2016) who also revealed a significant difference in the performance of the selected species during two consecutive years due to variable environmental conditions. This can also be attributed towards the rain-fed nature of the grass species under study and the higher rainfall during July-September, 2010 as compared to spring rains in 2011. Findings of Nippert *et al*. (2006) also support our findings in term that variability in annual rainfall pattern has a significant effect on above ground cover and biomass production of range grasses. Comparison of fresh and dry biomass production of different grasses in spring season has graphically shown graph No.10.

CONCLUSION

Based on the results, it could be concluded from this study that rangeland reseeding may be recommended as a possible cost efficient management practice to improve forge production. The degraded rangelands could be reseeded with these grasses to enhance biomass productivity accompanied with carrying capacity of arid / semi-arid rangeland of Pakistan. Recommended grasses for reseeding included *Cynmbopogan distans* (Chita), *Pennisetum purpureum* (Napier) grass followed by *Bothriochloa pertusa* (palwan), *Cenchrus ciliarus* (Dhaman) and *Themeda anathera* (Loondar) grass under rain-fed conditions in Pothowar. So these grasses can turn in high yields if reseeded in most areas as compared to legumes but legumes are more nutritious in terms of crude protein content and digestibility. By comparing three season data it was concluded that monsoon data was high in terms of production due high rain fall during monsoon season. *Pennisetum purpureum* (Napier) grass produced maximum fresh and dry biomass production followed by *Cynmbopogan distans* (Chita) in all three season as compared to other reseeded range grasses and is highly recommended for reseeding under rainfed conditions. However, *Cenchrus ciliarus* (Dhaman) produced minimum biomass production.

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