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Full Length Research Paper

Effect of diverse ecological conditions on biomass production of *Themeda triandra* (Kangaroo grass) at various growth stages

Aamir Saleem[1], Sarwat N. Mirza[1], Irshad Ahmad Khan[1]* and Jennifer Franklin[2]

[1]Department of Forestry and Range Management, PMAS-Arid Agriculture University, Rawalpindi, Pakistan.
[2]Department of Forestry, Wildlife and Fisheries, University of Tennessee, USA.

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Due to heavy grazing of rangelands intolerable pressures on land, vegetation and its inhabitants has been observed. The main source of income in arid, semi arid and rain-fed areas of Pakistan is livestock rearing. The efficiency of rangelands has been adversely affected due to exploitation and centuries of overgrazing. Kangaroo grass native to Australia is known as the best grass to grow on different environmental and soil conditions. Biomass production of any grass is the key factor to estimate that if the grass could fulfill the animal requirements. Biomass production of kangaroo grass was estimated in this study at three growth stages on three different locations with different spacing treatments. Maximum dry matter biomass was observed at flowering stage followed by maturity stage and least was observed at vegetative growth stage. For all growth stages at closer spacing of 20 cm, maximum yield was observed while the least production was estimated for the spacing treatment of 40 cm. Maximum biomass production was observed at Rawalpindi, which is a high rainfall area, followed by Jhelum having medium rainfall while the least biomass production was observed at Talagang receiving the lowest rainfall among the selected range sites.

Key words: Kangaroo grass, biomass, dry matter, rangeland, growth stages.

INTRODUCTION

Heavy grazing over vast areas of rangelands has steadily put unbearable pressures on land, vegetation, and its inhabitants, such as wildlife, farm livestock and pastoral communities. The main causative factors are increase in human and livestock population. This has lead to an extension of dry land farming on marginal lands to satisfy the rising demand for food crops, and the cutting of shrubs and trees for domestic fuel consumption (Umrani et al., 1995). As a result, the more palatable species that previously covered the rangelands have been destroyed or thinned out, and it is now dominated by unpalatable low quality vegetation. Therefore every year, insufficient forage during the dry period, collective with drought years, causes serious losses of livestock (Grainger, 1990; Alvi and Sharif, 1995).

*Corresponding author. E-mail: irshaduaar@yahoo.com. Tel.: +92-51-9290151 or +92-51-9290169.

The chief source of income is livestock in arid, semi-arid, and rain-fed areas of Pakistan. Currently, 60% of the feed for sheep and goats comes from rangelands (Mahmood and Rodriguez, 1991), at the same time horses, donkeys, and camels obtain about half of their feed necessities from rangelands. The rest of their food comes from the feed resources derivative mainly from crops, fodder and agro-industrial byproducts. The basic rangelands types of the world are grasslands, desert shrub lands, savanna woodlands, forests, and tundra. The numerous plant associations in each group of rangelands usually exist that may perhaps vary from each other due to climatic, edaphic and human factors.

The efficiency of rangelands has been adversely affected due to exploitation and centuries of overgrazing. FAO (1987) has reported a dangerous stocking rate for low potential ranges. At present, only 10 to 15% of rangeland potential is being produced. This low productivity can be improved by adopting a variety of management practices such as periodic closures, re-seeding, and improved grazing management etc. and by introducing new forages and grasses. A fair percent of the rain-fed tract of the country is flabby for agronomic or forestry crops due to hostile soil or climatic conditions. These large areas of land generate grasses and bush. Livestock only are able of utilizing this wide and renewable natural resource. So there is a dire need to establish new forage grasses and legumes that can meet the range animal requirements and also enhance range forage productivity. For these reasons impact of environmental as well as soil conditions on the biomass production of Kangaroo grass (*Themeda triandra*) on dry matter basis is investigated in this study.

The Kangaroo Grass, native to Australia is one of the most recognizable members of the grass family (Poaceae). The species has particularly wide distribution in Australia (Hayman, 1960) and is often used as a forage species for domestic and wild animals. It is also found in some parts of Africa, Asia and the Pacific. It commonly grows in grassland and opens woodland communities. Kangaroo grass is a tufted perennial that can grow up to 1.5 m tall and 0.5 m across. Its roots enhance the soil health and soil structure by binding soil particles and aggregating them. Soil organic matter, soil porosity and nutrient cycling are also increased by kangaroo grass and it supports a large number of soil organisms, (Cole and Lunt, 2005). It is known to grow in full sun to partly shade on sandy to clay soils and utilize little moisture once established and germination improves as soil moisture approaches field capacity (Nolan, 1994). Because Kangaroo grass grows under a wide range of conditions, it has a wide distribution.

The objective of this study was to estimate the biomass production of kangaroo grass at three phonological growth stages (vegetative, flowering and maturity) under different soil and environmental conditions.

MATERIALS AND METHODS

In the experiment seeds of Kangaroo grass with awns were sown in a Randomized complete block design (RCBD) with four replications. The grass seeds were sown in a plot size 6 x 3.5 m. Seeds were sown by hand keeping plant to plant distance as 20, 30, 40 cm and row to row distance of 50 cm. Broad cast method was also used as a control treatment. Plant to plant distance was maintained by using the marker before sowing. The experiment was conducted to explore the effects of environmental and soil variations on the DM Biomass production of *T. triandra* (Kangaroo grass) at three phonological growth stages on three locations during 2005-06 and 2006-07. Locations include Pir Mehr Ali Shah Arid Agriculture University Rawalpindi (PMAS-AAUR) at the latitude 33° 36' N and 73° 05' E, range areas of Jhelum at 31° 20' N and 73° 44' E and Talagang 32° 55' N and 72° 25' E. These three experimental sites fall in different rainfall zone, Rawalpindi is high rainfall area, Jhelum is Medium rainfall area and Talagang is low rain fall area. These areas receive average annual rainfall of (1000 - 1200 mm/annum), (650 - 850 mm/annum) and (450 - 550 mm/annum) rainfall, respectively. Grass seeds were sown at three locations during the early part of monsoon season, in mid July, 2005-06 and for second year during mid July, 2006-07.

Soil analysis

Soil samples were collected from a depth of 0 - 15 cm and 15 - 30 cm. Soil samples were air dried in the laboratory, sieved through 2 mm stainless steel sieve and stored in plastic containers. Samples were analyzed for soil texture, pH, total nitrogen, phosphorous and potassium. After collecting the soil sample, 40 ml of 1% sodium hexa meta-phosphate and 150 ml of distilled water was added to 40 g of soil sample and suspension was kept for over night. After stirring for 10 min, the contents were shifted to cylinder and reading was recorded with Bouyocus Hydrometer method. Soil textural class was determined by using ISSS triangle (Gee and Bauder, 1986). Mechanical analyses were performed according to the method described by (Gee and Bauder, 1986).

Soil moisture

Soil samples were taken in metallic cans and weight was recorded. The samples were dried to constant weights at 105°C in the oven. Samples were removed from the oven and weight was recorded after cooling. Soil moisture was determined by the following formula:

$$\text{Soil Moisture (\%)} = \frac{\text{Loss in Weight}}{\text{Weight of oven dried soil}} \times 100$$

For determination of biological yield (total biomass), in each location two 1 m^2 Adjustable Decimal Collapsible (ADC) quadrates were used to harvest plant biomass at ground level in each plot (Khan, 1974). Harvested samples were oven dried at 55°C for 48 h to calculate forage production per ha on dry matter basis. Biomass production was determined during three phonological stages of growth, that is, vegetative, bloom (flowering) and maturity. Daily maximum and minimum temperatures (°C) and rainfall (mm) were recorded from nearby metrological stations at experimental sites during 2005-06 and 2006-07.

RESULTS AND DISCUSSION

Means for dry matter (DM) biomass (kg ha^{-1}) at vegetative stage presented in Figure 1 showed statistically significant differences for plant to plant spacing treatments at different locations (Rawalpindi, Jhelum, Talagang) during 2005-06 and 2006-07. Biomass during 2005-06 for plant to plant spacing of 20 cm at Rawalpindi was observed significantly different from rest of treatments, while broadcast method and 30 cm were statistically at par with each other, whereas, both were observed significant from 40 cm. At Jhelum similar results were observed. At Talagang treatment of 20 cm was observed significant with all other treatments, whereas, 30, 40 cm and broadcast method were statistically at par with each other. The maximum biomass 1,024.30 kg ha^{-1} (± 22.17) was recorded at Rawalpindi for 20 cm while the least 160.70 kg ha^{-1} (± 1.13) was observed for 40 cm at Talagang (Table 1). During 2006-07 biomass for plant to plant spacing of 20 cm and broadcast method at Rawalpindi were significant with each other and with rest of the treatments, whereas, 30 and 40 cm were statistically at par with each other. At Jhelum treatment of 20

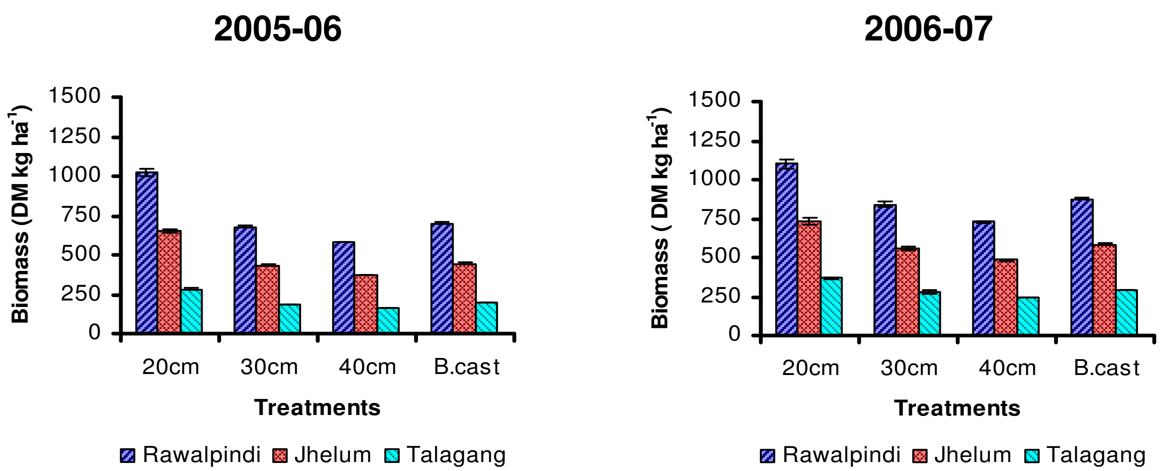

Figure 1. Effect of spacing and broadcast method on biomass production (DM kg ha^{-1}) at vegetative stage of Kangaroo grass at different locations (Rawalpindi, Jhelum and Talagang) during 2005-06 and 2006-07.

Table 1. Physical and chemical properties of the experimental sites.

Location	Depths (cm)	pH	ECe (dS/m)	O.M (%)	Avail. P (mg/kg)	Ext. K (mg/kg)	Avail. N (%)	Texture	Moisture (%)
Rawalpindi	0-15	8.2	0.24	0.82	5.8	40	0.041	Clay loam	16.7
	15-30	8.2	0.29	0.88	6.8	60	0.044	Clay loam	25.4
Jhelum	0-15	8.0	0.52	0.57	5.2	120	0.029	Sandy clay loam	13.9
	15-30	8.1	0.47	0.69	4.6	140	0.035	Sandy clay loam	21.3
Talagang	0-15	7.8	0.26	0.40	3.0	90	0.023	Sandy loam	5.2
	15-30	7.7	0.24	0.45	2.8	120	0.02	Sandy loam	9

cm was observed significant with other treatments, while, broadcast method and 30 cm were statistically at par with each other, whereas, both were observed significantly different from 40 cm. At Talagang, treatment of 20 cm was observed significant with other treatments, whereas, 30, 40 cm and broadcast method were statistically at par with each other. The maximum biomass 1,099.5 kg ha^{-1} (± 32.30) was recorded at Rawalpindi for 20 cm while the least 243.4 kg ha^{-1} (± 2.43) was observed for 40 cm at Talagang.

Means for dry matter biomass (kg ha^{-1}) at flowering stage presented in Figure 2 showed statistically significant differences for plant to plant spacing treatments at different locations (Rawalpindi, Jhelum, Talagang) during 2005-06 and 2006-07. Difference of DM biomass during 2005-06 for plant to plant spacing of 20 cm and broadcast method at Rawalpindi was statistically at par with each other, however, was significantly different from other treatments, whereas, 30 and 40 cm were statistically significant with each other. At Jhelum and Talagang similar results were observed. The maximum biomass 4,977.00 kg ha^{-1} (± 146.83) was recorded at Rawalpindi for 20 cm while the least 1,505.20 kg ha^{-1} (± 17.87) was observed for 40 cm at Talagang. During 2006-07, difference of DM biomass for plant to plant spacing of 20 cm and broadcast method at Rawalpindi was statistically at par with each other, however, significantly different from other treatments. The plant to plant spacing of 30 and 40 cm were observed significantly different with each other. Similar trends for DM biomass production were noticed at Jhelum and Talagang. The maximum biomass 5,449.0 kg ha^{-1} (± 190.27) was recorded at Rawalpindi for 20 cm while the least 1,718.10 kg ha^{-1} (± 7.30) was observed for 40 cm at Talagang.

Means for dry matter biomass (kg ha^{-1}) at maturity stage presented in Figure 3 showed statistically significant differences for plant to plant spacing treatments at different locations (Rawalpindi, Jhelum, Talagang) during 2005-06 and 2006-07. Production of DM biomass during 2005-06 for plant to plant spacing of 20 cm at Rawalpindi was significantly different from other treatments, however, broadcast method and 30 cm were statistically at par with each other, whereas, both were significantly different from 40 cm. At Jhelum and Talagang similar results were observed. The maximum biomass 4649.80 kg ha^{-1} (± 150.10) was recorded at Rawalpindi for 20 cm while the least 1321.90 kg ha^{-1} (± 22.07) was observed for 40 cm at Talagang. During 2006-07, at maturity bio-

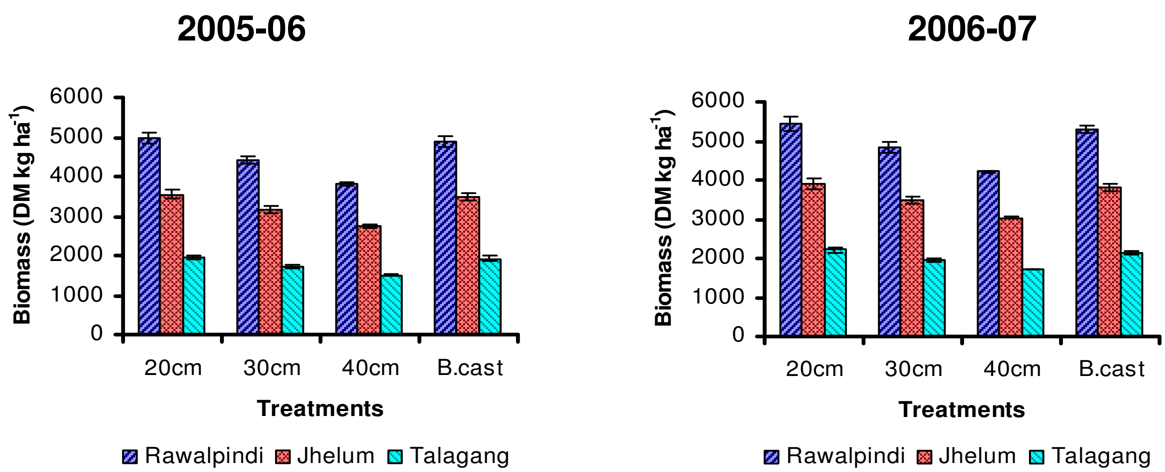

Figure 2. Effect of spacing and broadcast method on biomass production (DM kg ha^{-1}) at flowering stage of Kangaroo grass at different locations (Rawalpindi, Jhelum and Talagang) during 2005-06 and 2006-07.

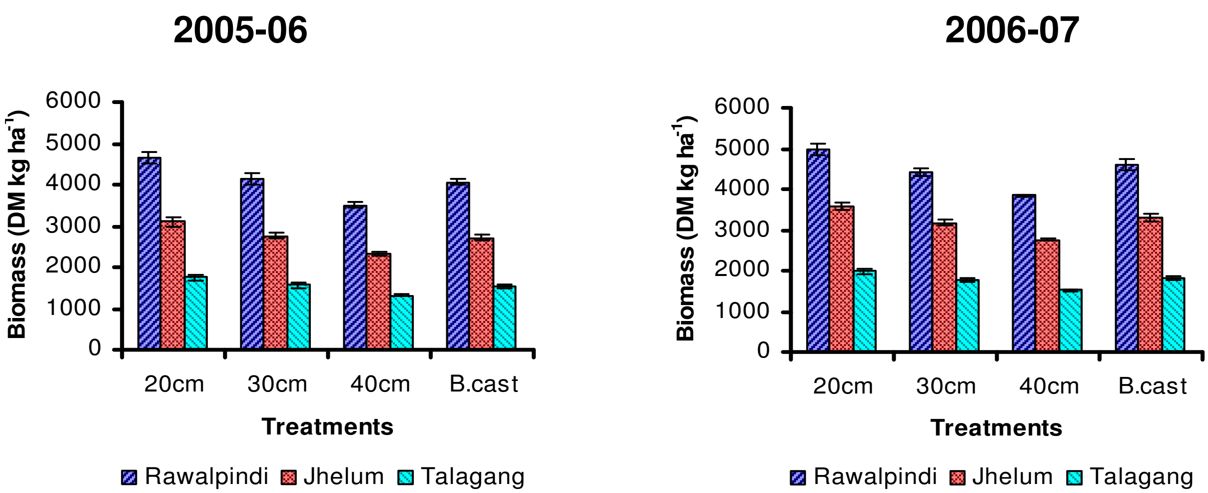

Figure 3. Effect of spacing and broadcast method on biomass production (DM kg ha^{-1}) at maturity stage of Kangaroo grass at different locations (Rawalpindi, Jhelum and Talagang) during 2005-06 and 2006-07.

mass for plant to plant spacing of 20 cm at Rawalpindi was observed significantly higher than other treatments, however, broadcast method and 30 cm were statistically at par with each other, whereas, both were significantly different from 40 cm. At Jhelum similar results were recorded. At Talagang treatments 20, 30 cm and broad-cast method were statistically at par with each other, however, all were significantly different from 40 cm. The maximum biomass 4,978.30 kg ha^{-1} (± 141.91) was recorded at Rawalpindi for 20 cm while the least 1,525.40 kg ha^{-1} (± 18.03) was observed for 40 cm at Talagang.

During the experimental periods at each location, the maximum biomass production was observed for the spacing treatment of 20 cm while the leaves drop started after drying which ultimately affected the total biomass yield. Whereas, at vegetative growth stage plants just started their growth, numbers of leaves were less and fleshy leaves and stem was present that is why enough plant moisture was present in plants, which reduced the dry matter biomass yield. Due to fleshy leaves and stems, plants were observed more palatable at vegeta-tive growth stage as compared to flowering and maturity stage. Daniel (1990) obtained similar results from an intercropping of Rhodes with alfalfa (*Medicago sativa)*. Similar conclusions on grass cereal-legume associations have been reported by Ibrahim et al. (1993), Munzur (1993), Soya (1994) and Qamar et al. (1999). Difference of biomass production at different locations might be due to difference in climatic conditions, rainfall pattern and soil conditions. It has been reported that the association between climatic conditions exists, of which rainfall is regarded as the most imperative (Rutherford, 1980).

Even though it is usually known that a good relationship exists between rainfall and biomass production (Rozenzweig, 1968; Strickland and Haydock, 1978; Carton et al., 1988; Smuts, 1989), it should, however, be emphasized that the production ability of ecotypes can be affected by environmental factors (especially rainfall). It appeared that loss of biomass due to weathering during the winter could, in some situations, be compensated for by harvesting near ground level to include the basal, which would usually be expected to be the heaviest internodes (Boe et al., 2000). Cassida et al. (2005) concluded that water availability from April to July was vital for switch-grass biomass production.

However, the most critical month differed amongst locations and genotype groups differed in their response to moisture availability. Similarly, Muir et al. (2001) reported switch-grass biomass yield was absolutely associated with precipitation during the growing season in Texas. Smart et al. (2005) also pointed out that it is commonly acknowledged that the amount of April through June precipitation is highly unpredictable and is a strong indicator of the current year's forage production in the northern mixed-grass prairie.

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