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Environmental Impact on Biomass and Allelopathic effect of *Cenchrus ciliaris.L*

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Abstract:

The study was conducted at the GEER foundation, Gandhinagar, India to evaluate environmental impact on biomass production of Cenchrus ciliaris.L (buffel grass) and its allelopathic effect on Dichanthium annulatum and Sehima nervosum. These grasses were grown in separate plots and also in combination. Growth parameters which were studied for all sets were Shoot length, Above Ground Biomass (AGB), Below Ground Biomass (BGB) and number of leaves and meteorological data were also recorded. It was observed that C.ciliaris could survive through extreme climate and Dichanthium annulatum and Sehima nervosum could not flourish in the presence of Cenchrus ciliaris, which resulted in the maximum biomass of Cenchrus ciliaris. The effect of different seasons on biomass of Cenchrus ciliaris was observed over a year. Statistical analysis of the data showed significant variation in biomass.

Key words: Cenchrus ciliaris, buffel grass, biomass, allelopathic effect

Introduction

Plants have many diverse uses, which have a direct or indirect bearing on the civilization of human society. It has been said that "He who make two blades of grass grow where one grew before is the benefactor of mankind [….] he who obscurely works to find the laws of such growth is the greater benefactor of mankind" (Henry Augustus Rowland, 1848-1901).

When there is constant soil moisture on the upper layer of the soil for a considerable time of the year, the grassland formation tends to be dominant, while when there is an interval between upper water and ground water table reaches the surface, as in the arid zone where the tree growth is not found. Under such circumstances, short grasslands are developed in the temperate belt of the world, known as 'steppes' and tall grasslands of 'prairies'. 'Savannah' is a typical grassland found in the tropics, in the conditions of a humid climate, where rain falls for 3 to 8 months. In the frigid zones like the alpine meadows, the grasses are much more capable to exist and survive against severe cold climate.

Range lands or grazing lands are extensive tracts of arid and semi-arid lands that are essentially unsuited to rain-fed crop cultivation, industrial forestry, protected forests or urbanization. The best use of range lands is for livestock and wild life production, excluding irrigation systems or other technology. Range lands are those renewable resources, which require little or no commercial energy input to produce milk, meat, wool hides and other animal products (Cf. Dennis 1984). More than 200 million people use range lands over the world for some pastoral production, whereas 30 to 40 millions of these people are wholly dependent on livestock. Although no comprehensive global assessment of the extent of rangeland exists, the best estimates are from U.N.

The grasses assume importance not only as livestock feed, but also as soil builders and binders and aid in soil conservation. In their principal role, the tropical grasses stand as the highest potential yielder of starch and proteins equivalent to any other crop plants and further being the dominant component of tropical pastures, as the cheapest sources of animal feed (Rajora 2002). Perennial grasses are major components of tropical pastures providing bulk of herbage to animals. The grass and grazing are important constituents of fodder resources in India. Out of the total land area of 3.2 million sq. km of this country, about one-third falls under arid and semiarid zone (Vora et al., 2003).

Perennial grass species like *Cenchrus ciliaris, Cenchrus setigerus, Lasiurus sindicus, Dichanthium annulatum, Panicum antidotale, Sehima nervosum* are grouped as 'High Perennial' species as they give high forage yield under natural rain fed conditions. *Cenchrus ciliaris* is a valuable tufted perennial grass in arid and semi-arid areas characterised by severe drought, high temperature, low rainfall and sandy soil. It is an excellent grazing perennial suited to pasture and rangelands. Its high soil binding capacity is due to its clustered root system in the upper 8 to 10 cm layer of soil. It survives extreme and prolonged drought but grows vigorously when favourable conditions set in *S. nervosum* and *D.annulatum* are major components of *Sehima - Dichanthium* grass cover of India. *Cenchrus ciliaris, Dichanthium annulatum* and *Sehima nervosum*, when grown alone or in combination, show significant variation in biomass productivity. Buffel grass (*Cenchrus ciliaris* Linn.), a perennial pasture grass species, has wider adaptability in varied edaphic habitats all over the country. It is one of the prominent species of *Dichanthium-Cenchrus-Lasiurus* grass cover type of tropical India.

Materials and Methods

The experimental site was located at the Botanical Garden of GEER Foundation, Gandhinagar, Gujarat, India (latitude 23˚ 13'00" and longitude 78˚42'00"). Gandhinagar, the 'Greenest Capital City' of Asia, and the Second Greenest City in the Nation has an average elevation of 81 meters (265 feet). The city sits on the banks of the river Sabarmati, in north-central-east Gujarat. The 20,543 km² area around Gandhinagar is defined by Gujarat capital territory and it spans over an area of 205 km² (79.15 square miles). Gandhinagar has a monsoon climate with three main seasons: summer, monsoon and winter. Except during the monsoon, the climate is generally dry and hot. The weather is very hot from March to June, when the maximum temperature stays in the range of 36ºC (97ºF) and 42 ºC (108ºF), and the minimum in the range of 19ºC (66 ºF) and 27ºC (81 ºF). It is cool but never really cold from November to February, the average maximum temperature is around 29ºC (85ºF), the average minimum is 14ºC (57ºF), and climate is extremely dry. The southwest monsoon brings a humid climate from mid-June to mid-September. The average annual rainfall is around 803.4mm (32 inches). The soil of Gandhinagar is mainly alluvial, formed due to silting by the Indus river system in Gujarat. This soil is loamy and suited to irrigation farming and it is suitable to raise crops throughout the year. The water is suitable for irrigation as its electroconductivity is 0.98; pH is 7.8 and Ca+Mg is 5.57 M.e/L.

The experimental site is in the South East part of Gandhinagar. The study was conducted during the year 2006-2007. The soil of the experimental site was sandy loam and slightly alkaline (pH 7.5) with 0.36% organic carbon, electrical conductivity - 0.16mmho, available nitrogen – 285 kg/ha, available phosphorus - 24 kg/ha, available potash - 356 kg/ha. The palatable fodder grasses which were selected for the experiment were *Cenchrus ciliaris, Dichanthium annulatum* and *Sehima nervosum*. The material was sown in the experimental plots laid down at the Botanical Garden (Indroda Park), GEER Foundation, Gandhinagar, India, in randomized block design, in five replications. The plots size was 3m×3m and distance between the adjacent plots was 2 m and a hundred tussocks were planted in each plot according to the row method, where row-to-row spacing was 30 cm and plant to plant spacing was 25 cm. All the three grasses were sown individually and in combination of two and all three together in separate plots. Routine agronomic practices of fertilizer and irrigation were followed. The meteorological data, namely average maximum temperature, minimum temperature, humidity, photoperiod and rainfall were noted during the field experiment. Ten plants were randomly selected and growth data was recorded at monthly interval from all sets. Three cuts of grasses were taken and the growth data included number of leaves per plant, length of shoot, Above Ground Biomass (fresh and dry) and Below Ground Biomass (fresh and dry) weight per plant.

Also an experiment was performed, namely to grow *Cenchrus ciliaris* grass in the month of September and its seeds were sown in the late September. In spite of irrigation and fertilization, the seeds took very long to get established. Growth data of the individual C*enchrus ciliaris* plant was calculated in different seasons. Data on height of plant, number of tillers, fresh weight of shoot and fresh weight of roots on individual *Cenchrus ciliaris* plant was calculated. The maximum roots generally occur in upper 30cm, depth of soil. Therefore, from the base of each plant 20cm radius was formed and each plant was excavated up to 30cm, depth with ball of earth with a shawl. The individual plants were kept in polythene bags and labelled. Below ground biomass was assessed after washing thereby the excavated roots with a fine jet of water to remove the soil particles. The shoot portion was clipped up to ground level and green weight recorded in grams. This was recorded as fresh above ground biomass and fresh below ground biomass. All the above ground and below ground samples so collected were dried in oven at 80˚C till the weight remained constant. The oven dried weight of shoot and roots were recorded in grams by using electronic balance. This was recorded as Dry-Above Ground Biomass and Dry- Below Ground Biomass respectively.

Results

It was observed that *Cenchrus ciliaris* grows well in a pure patch as well as in a mixed patch. The growth data (Table 1 &2) shows the gradual increase in height, number of leaves, fresh weight and dry weight in all samples. The average height of *Cenchrus ciliaris* at the end of 90 days was 82.8 cm, whereas in mixed patch it was 91.8 cm. The average number of leaves/plant was 28.3 and 31.2 in pure and mixed patch respectively. Mean fresh Above Ground Biomass (AGB/plant) in pure and mixed patch was 100.6gm and 99.6gm respectively after 90 days of sowing. The data reveals almost similar biomass of *Cenchrus ciliaris* in a mixed patch. Biomass productivity of *Cenchrus ciliaris* was not affected when grown with *Dichanthium annulatum*. As shown in Table 2, the average height of *Dichanthium annulatum* after 90 days was 72.3 cm, whereas in mixed patch it was 51.6 cm. The average number of leaves per plant also decreased in the mixed patch. Average Above Ground Biomass (AGB/plant) was 110.4gm and 94.8gm in pure and mixed patch respectively. Thus it was observed that *Cenchrus ciliaris* almost dominated over *Dichanthium annulatum*. *Cenchrus ciliaris* did not allow

Dichanthium annulatum to flourish in its presence. *Sehima nervosum* could not grow in the warm environment and so no data could be collected. *Dichanthium annulatum* grows well in pure patch but when *Dichanthium annulatum* is grown in combination with *Cenchrus ciliaris*, its growth is affected due to profusely growing *Cenchrus ciliaris. Cenchrus cilaris* is a warm season grass and sprouts in February and becomes dormant at the end of September after seed dispersal (Umar Farooq et al. 2003). The average height of the *Cenchrus ciliaris* plant at the end of summer, monsoon and winter season is shown in Table 3. As *Cenchrus ciliaris* is a warm season grass the average height of the plant in the winter season is less, due to less growth vigour. The *Cenchrus* plant in summer and monsoon season exhibits greater height as compared to same in winter. Similarly, the number of tillers decreases from summer to monsoon to winter.

Crop growth in buffel grass peaked at the time when both high temperature and important precipitation events or sufficient soil moisture coexisted. Buffel grass grows at a slower rate during cooler weather than many other tropical grasses (Humpreys 1967). Cool weather has a negative impact on growth in buffel grass; in addition, buffel grass will enter a dormancy stage (little or no growth) under low soil humidity/no rainfall conditions. The root biomass of *Cenchrus ciliaris* plant in summer, monsoon and winter season is shown in Table 3. In winter, the root biomass is less, as the growth of the plant is restricted due to unfavourable season. The shoot biomass at the end of the summer was higher than the root biomass. This difference in shoot and root biomass may be due to the fact that most of the reserve food material in root was used for the start of new shoots. The shoots gained less height in the beginning of the growing season and thus the shoot biomass was significantly less than the root biomass. The non-significant differences between shoot and root biomass in monsoon season are attributed to the growth of both shoots and roots due to enhanced photosynthetic in shoot and allocation of more photosynthetic to the roots for storage and re-growth. The shoot - root ratio of an individual *Cenchrus ciliaris* plant was calculated by: shoot - root ratio = Average weight (gm) of the shoot / Average weight (gm) of the root. The shoot weight increased more than the root of an individual *Cenchrus ciliaris* plant during the growing season and reached the maximum in October. At the end of the growing season, the shoot and root biomasses were at maximum. Re-growth of foliage and continued maintenance of the individual *Cenchrus ciliaris* plant after dormancy depend initially on the reserved food material in the roots. Reserved food material in the roots was used for the re-establishment of tillers/shoots (photosynthetic surfaces). Therefore a sustainable decrease may occur in shoot biomass.

At the end of the growing season, more photosynthates were allocated to the shoots and the roots to increase food reserves for future use, for daily function i.e. respiration. Apparently the *Cenchrus ciliaris* plant allocated more photosynthates to increase the photosynthetic surface (leaf area).The shoot - root ratio of *Cenchrus cilaris* plant substantially increased due to prolonged growing season in monsoon. The results are in agreement with Heady (1975) and Cook et al (1986).This study showed that both shoot and root biomasses of individual *Cenchrus ciliaris* are higher at the end of the growing season than in the beginning of the growing season. The numbers of reduced tillers/shoots were less in October in comparison with May. Shoot - root ratio increased with the progression of the growing season and an increase in shoot biomass, because the shoot height was maximum. It can be concluded that the number of tillers was higher in summer followed by monsoon and winter. Similar results were obtained in the *Cenchrus ciliaris* plant by Umar Farooq (2003).

Discussion

In the present study Above Ground biomass productivity of *Cenchrus ciliaris* as a pure patch is 9.5 t/ha while as a mixed patch with *Dichanthium annulatum* is 9.4 t/ha. This herbage yield has a potential of increasing with various biotic and abiotic factors. Under irrigation and optimum fertilization conditions, a close relationship exists between temperature and dry matter production. The rate of leaf appearance in stems of graminaceous plants increases with high temperatures. Crop growth in buffel grass peaked at the time both high temperature and important precipitation events or sufficient soil moisture coexisted. Buffel grass grows at a slower rate during cooler weather as compared to many other tropical grasses (Humpherys 1967). Cool weather exerts a negative impact on growth in buffel grass; in addition, buffel grass will enter a dormancy stage (little or no growth) under low soil humidity/no rainfall conditions. The yield was reduced by 25% when water was excluded during vegetative growth, whereas yield was reduced by 59% when water was imposed at flowering stage (Thomas et al. 2004). It is observed that *Cenchrus ciliaris* can grow well even in the mixed patch and dominates over *Dichanthium annulatum*. Severe warm conditions of summer could not affect the growth of *Cenchrus ciliaris*, which kept on flourishing well in such conditions. *Cenchrus ciliaris* has been considered as a highly drought resistant grass species.

Cenchrus ciliaris is a particularly aggressive grass, by virtue of its extensive root system competing with associated species for water and nutrients. It also appears to be allelopathic (suppression of other species by exudation of phytotoxic chemicals that inhibit germination and growth of other plants). Evidence of possible allelopathy was determined by Nurdin and Fulbright (1990). Allelochemicals increasing in the roots exude and cause inhibition or arrest of growth of other plants (Vora 2003). These interactions mainly in the rhizosphere thus result in the better establishment of *Cenchrus* as against *Dichanthium* and *Sehima*. This observation needs to be further explored and experimented, with an understanding of the allelopathic interactions among various grasses.

There is a non-significant difference in root biomass in summer and monsoon season due to the allocation of more photosynthates to root by the end of the growing season to enhance reserved food material for respiration during dormancy and its re-growth during growing season. Similar results were obtained in *Cenchrus ciliaris* grass (Umar Farooq 2003). The root biomass decreases, when re-growth occurs in the early growing season. The reserved food in the root is used for shoots re-growth and there is decline in root biomass. After the formation of 8-10 leaves on stem the reserved food of root is not used for shoot re-growth. As the growing season progresses, the leaves manufacture sufficient photosynthates and send extra food material for day to day life requirement to the root, to enhance the reserve food material. Health of an individual plant depends upon its ability to synthesise food in leaf area and enhance food reserves in the roots that decrease in the beginning of the growing season because it is used for shoot growth. At the end of the growing season, both shoots and roots have maximum biomass because of the maximum photosynthetic activity accumulated during the prolonged growing season. All grasses produce more abundantly during the wet season, but the variation in productivity according to season differs among plant species (Lemeziene et al. 2004).

Conclusion

It was observed that *Cenchrus ciliaris* could grow well in the mixed patches as well, and it dominates over *Dichanthium annulatum*. Severe warm conditions of summer had no effect on the growth and biomass of *Cenchrus ciliaris*, which kept on flourishing under such adverse climatic conditions while *Sehima nervosum* could not sustain harsh summer climate and failed to grow - as a result, no data could be collected. *Cenchrus ciliaris* has been considered as a highly drought resistant grass species. *Dichanthium annulatum* grows well in the pure patch but, when along with *Cenchrus ciliaris,* its growth and biomass were affected due to profusely growing *Cenchrus ciliaris*. During the seasonal study it was observed that crop growth in *Cenchrus ciliaris* peaked at the time when both high temperature and important precipitation events or sufficient soil moisture coexisted. Buffel grass (*Cenchrus ciliaris*) grows at a slower rate during cooler weather than many other tropical grasses. Thus seasonal changes in biomass were observed in *Cenchrus ciliaris* over a year (2007) and significant seasonal variations in biomass were noticed.

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Table 1 Growth parameters of *Cenchrus ciliaris* in pure and mixed patch

Name	Days	Average height (cm)	Average number of leaves	Fresh Weight (gm)		Dry Weight (gm)	
				Shoot	Root	Shoot	Root
C. ciliaris (pure patch)	30	26.7	8.3	72.9	25.8	14.6	6.58
	60	72.6	24.5	244.7	52.3	37.52	19.4
	90	82.8	28.3	476.1	101.6	110.5	25.8
Name	Days	Average height (cm)	Average No. of Leaves	Fresh Weight (gm)		Dry Weight (gm)	
				Shoot	Root	Shoot	Root
C. ciliaris (mixed patch)	30	25.3	7.2	70.12	24.2	9.7	5.66
	60	70.4	22.1	240.7	50.2	32.13	18.1
	90	91.8	31.2	470.1	99.6	107.4	25.1

Table 2 Growth parameters of *Dicanthium annulatum* in pure and mixed patch

Name	Days	Average height (cm)	Average number of leaves	Fresh weight (gm)		Dry weight (gm)	
				Shoot	Root	Shoot	Root
D.annulatum (pure patch)	30	12.4	4.2	16.3	6.5	4.31	2.05
	60	52.6	9.1	83.2	20.3	20.13	6.3
	90	72.3	12.3	110.4	24.1	30.2	8.2
Name	Days	Average height (cm)	Average number of leaves	Fresh weight (gm)		Dry weight (gm)	
				Shoot	Root	Shoot	Root
D.annulatum (mixed patch)	30	7.8	3.2	6.65	5.62	2.2	2.33
	60	32.3	7.7	61.51	15.4	17.14	5.58
	90	51.6	9.3	94.8	21.4	23.6	7.2

Table 3 Growth parameters of *Cenchrus ciliaris* during different seasons

Parameters	Summer (February-May)	Monsoon (June-September)	Winter (October-January)
Height of plant (cm)	129	154	95.25
Number of tillers / plant	32.25	24.5	18.25
Above Ground Biomass (gm)	154.5	255.75	114.5
Below Ground Biomass (gm)	62.25	75.75	54.5