Rejuvenation of Rangelands – Role of Diversity and Improvement Strategies of Range Grasses

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Abstract

In India, a major part of the rural economy is dependent on the grazing-based livestock husbandry which is unique integration of agriculture and livestock coupled with rich traditional knowledge. Ecosystems of common property resources had been a mainstay in rural economy and livelihood. The traditional grazing forage resources in arid and semi-arid regions have deteriorated a lot due to various factors including heavy grazing pressure, climate change and dominance of invasive species, thus, needs rejuvenation. Additionally, these are causing serious economic and ecological problems such as poor productivity, soil and water erosion and reduced carbon sequestration.

The genetic improvement of these grasses encounters various problems such as polyploidy, apomixis, seed shedding and shattering and poor seed to ovule ratio. Transfer of desirable traits from donor germplasm becomes difficult due to the existence of apomixis. The breeding objectives are also multifold including herbage yield, forage nutritional quality, abiotic stress tolerance etc. Identification of sexual lines is prerequisite for transfer of traits. Mutation attempts are also not effective due to polyploidy. ICAR- Indian Grassland and Fodder Research Institute, Jhansi has collected rich genetic diversity in these range grasses especially *Dichanthium-Bothriochloa* complex, *Heteropogon, Chrysopogon, Sehima, Panicum*, *Cenchrus, Pennisetum etc.* from different parts of the country as well as procurement from gene banks of the world. These germplasm were evaluated for morphological traits which indicated the existence of wide variation for various morpho-agronomic traits. The paper deals with reporting the extent of variability among the potential range grasses; with prospects of utilizing the diversity in rejuvenating the degraded rangelands of India and other places with isoclimatic conditions.

Introduction

Grazing based livestock husbandry is the backbone of rural livelihood and rural economy in India and is continuing since the dawn of civilization. The traditional ecosystem and indigenous knowledge based grazing management and grassland rejuvenation is now under stress due to various factors like overgrazing, climate change, and anthropogenic interference. As per recent estimate, there is a shortage of green and dry forage in India (Roy et al. 2019a).

Range grasses and legumes are important components of Indian grasslands. The edible flora for the grazing animals in the rangelands or grassland comprises both annual and perennial species. While annuals grow with onset of the monsoon from the seeds already shed from the previous year's plants, perennials survive in the form of clumps during the dry season and grow again with the availability of water. The rangelands are now less productive and unable to provide nutritious fodder to the livestock owing to heavy grazing pressure. The productivity of grasslands can be increased if improved high yielding genotypes with desirable traits such as persistence, stress tolerance, quality and high water use efficiency are seeded in the grasslands .

Genetic improvement of forage range grasses is extremely difficult due to various reasons such as small flowers, asynchronous flowering, little understanding of floral biology and pollination mechanism. It is further complicated by the presence of apomixis in most of the tropical perennial range grasses which hampers the transfer of desirable traits by hybridization. Polyploid nature of these tropical grasses also restricts use of breeding tools like mutation (Roy et al. 2019b).

The prominent tropical range grasses genera of the Indian rangelands include *Bothriochloa, Dichanthium, Cynodon, Panicum, Pennisetum, Cenchrus, Lasiurus, etc*. These have good fodder value and are reported to have high genetic variability (Roy et al., 2019b). India also has some ethnic grasslands such as Banni Grasslands, Shola grasslands, Sewan grasslands, Terai Grasslands, Kangeyam grassland etc. Many tropical and arid/semi-arid perennial and annual grass species are natural flora of these grasslands. These grasslands are under stress due to various factors and various stages of degradation can be seen.

Several factors have been assigned as reasons for degradation of these grasslands. Primarily such factors include excessive grazing pressure much beyond the carrying capacity, social factors, policy issues, climate change, dominance of invasive species, anthropogenic pressure etc. Such degradation is leading to serious concerns such as low fodder availability, reducing biodiversity, extinction of characteristic flora and fauna, soil erosion, increased water runoff and poor carbon sequestration. The eco-services rendered by these grasslands are also adversely affected. Hence, a multi-pronged approach is needed for their rejuvenation. However, in this paper we will be discussing only the role of genetic diversity in the preservation and improvement of Indian grasslands, especially the tropical ones. To limit the scope of this paper, we present here the extent of genetic diversity of the four grasses i.e. *Sehima nervosum* (Sen grass), *Dichanthium annulatum* (Marvel grass)*, Heteropogon contortus* (Black spear grass) and*Megathyrsus maximus* (Guinea grass).

Genetic diversity the source of variation

Wide diversity for metric traits such as plant height, tiller number/tussock, leaf length, leaf width, number of leaves/ tiller etc exists across the genus both at intraspecies and interspecies level. Similarly, considerable variation also occurs for the non-metric traits include habit (such as creeping, erect, prostrate and semi-erect nature), node colour or anthocycnin pigmentation on node, nodal hairiness, internodal colour of the culm, leaf colour, leaf blade attitude, flag leaf attitude etc. These non-metric traits contribute to many quality indicators along with some traits which make the genotype suitable for specific conditions. Although these grasses are largely apomictic, many forms show facultative apomictic types. Such variation might have been created in nature through intraspecific, interspecific and intergeneric crossing. It is also possible that more sexual plants occur in natural conditions in this region which allows recombination to occur in this predominantly apomictic grass.

Several species and races along with various intermediate introgressed derivatives of *Dichanthium* and *Bothriochloa* are reported. The presence of wide variability may be the result of such introgression which got fixed due to apomixis. Earlier studies involving fewer accessions of *D. annulatum* indicated a wide range of diversity independent of their geographical distribution (Agarwal et al. 1999). Similar studies in other tropical perennial grasses also indicated occurrence of wide variability independent of geographical collection in *Sehima nervosum* (Roy et al. 1999); in *Heteropogon contortus* (Roy 2004; Bhat and Roy 2014) and in Guinea grass (Jain et al. 2003, 2006, Roy et al. 2020), morphotypes among guinea grass *(*Malaviya et al 2006). Diversity among these grasses has been reported to be linked with geographical distribution where some other studies indicated presence of wide diversity independent of geographical origin. The collected germplasm were from several agro-ecological regions of the country which included low hills, arid and semi arid parts, humid and sub humid parts as well as eastern and western Himalayan zones. Exploiting the variability, several high yielding varieties have been developed in these grasses which include IGS 9901 (*Sehima nervosum*), Bundel Guinea grass 1, 2, 4, Co-3, PGG-9, PGG-616 (for Guinea grass), Marvel -09-4, JHD 2013-2, Marvel -8 (for *Dichanthium*). These varieties are being popularized by different agencies for enhancing fodder resources in the country. Guinea also exhibits diversity for photosynthetic pathways, thus making it suitable for different ecological niches.

Nutritional Diversity

Dichanthium genotypes exhibit crude protein content variation from 5 to 11% and for IVDMD from 38 to 66%. Among Heteropogon genotypes CP varied from 2 to 10% whereas IVDMD varied from 31 to 59%. In guinea grass CP ranged from from 3.7 to 7.4% and the IVDMD ranged from 26 to 50%. In Sehima nervosum these values for CP ranged from 4 to 13% and IVDMD from 32.7 to 52.25. This establishes that enough variability for nutritional parameters is present in nature and a suitable selection of genotypes, either in sole culture or in mixture of genotypes, can improve the total digestible matter output from the grasslands.

Ways and prospects of diversity utilization for improving grasslands

This variability can be exploited to get high yielding superior types with desirable traits which can be introduced in grasslands or pasturelands to get high yield. The seeds of better high yielding genotypes of these grasses can be seeded in the grasslands in seed pellet form or other forms using seed priming techniques to increase the germination and establishment. It will lead to higher productivity and better sustenance of such grasslands. Another approach could be putting a mixture of genotypes with distinct morphological traits and identified desirable agronomical or nutritional features, and then leaving such grasslands exposed to varying level of grazing pressure for long periods with regular observation on dominance of distinct genotypes in different periods. This allows the natural selection at one hand and identification of genotypes with persistence under variable grazing pressure. The core subset development is prerequisite for such work because a large number of genotypes can not be taken to field condition, hence representatives of different morphotypes of core subset can be identified for such an objective. Further, such core development also allows evaluation of such genotypes in target environments for abiotic stresses such as shade, salinity and moisture.

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