Potential of C4 tropical grasses to contribute in carbon sequestration, environmental security and livelihood opportunities through increased fodder availability

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Introduction

- World grasslands ecosystems comprise 26% of earth's surface & supports > 38% of the population.
- By 2050, the agricultural sector challenge to produce 60% more food, feed and fibre (8.5 billion t/yr).
- Asia-Pacific region accounts to 1.2 billion ha grasslands.
- Grasslands an opportunity of *in-situ* conservation of flora and fauna.
- Diversity of grasslands a key element for sustainability in areas under high ecological and climatic stresses.
- Photosynthetic pathways affects productivity, resilience to climate, biomass decomposition and forage quality, hence play key role in sustainability.
- The global coverage of C4 vegetation 18.8 million km2; compared to 87.4 million km2 C3 vegetation. C4 species contribute ~25% of the primary productivity on earth.
- C4 plants dominate the grassland and savannah biomes of warm temperate to tropical latitudes.
- Brazilian *cerrado*, Argentinean *chaco*, tropical savannas in Africa, *Prairies* of North America, *pampas* and *campos* of South America, *grassvelds* of South Africa and Northern Australia represent such C3/C4 ecosystem.
- Some C4 species in cooler and drier climates such as *prairies* of North America and Mongolian *steppe*.
- Kangaroo grass, red grass and wire grass grasslands are referred as C4 grasslands.
- Tall grass *prairies* a diverse mix of C3 and C4 plant species but C4 grasses dominate the ecosystem.
- Photosynthetic use efficiency of the C4 plants is often higher leading to expansion in warm climates.

Indian grasslands/potential

- India supports 20 % of the world's livestock on only 2% of the world's geographical area. It has tropical, temperate as well as alpine grasslands.
- Ecological studies on the floristic compositions, dominant species and the climax/sub-climax stages over hundreds of years of ecological succession are ready prescriptions for developing and rejuvenating the grazing resources.
- Fast degrading rangelands in dry areas is causing a threat to huge amount of carbon stored in the top soil on earth in addition to threat to global hotspots for biodiversity.
- Ecologically important, Indian grasslands, viz. Shola grasslands of Nilgiris; Sewan grasslands of arid Rajasthan; semi-arid grasslands of southern part; Rollapadu grasslands in the semi-arid Andhra Pradesh; Banni grasslands of Gujarat; and Alpine grasslands of Sikkim and Western Himalaya, are in various stage of degradation - have very high ethnic value; livelihood for many communities and reservoir of huge biodiversity
- In the context of fast changing climate, the grazing lands can play a significant role.
- High water use efficiency and productivity of most C4 tropical grasses (such as *Panicum*, *Dichanthium*, *Heteropogon*, *Sehima, Cenchrus, Pennisetum*) make them suitable for coping with climate change along with quality fodder.
- Productivity of grasslands in arid and semiarid region is from 0.5 to 1.0 t/ha dry matter. Even if 75% of the area under *Sehima- Dichanthium* cover is improved by controlled grazing and reseeding, the fodder availability will increase from 83 million tons to 224 million tons.
- A large number of fauna species are threatened due to habitat degradation and anthropogenic pressures.
- Managing grasslands outside protected area has been major constraint.

C3/C4 grasslands: climate change, carbon sequestration and the environment

- Species with the C3 and C4 modes of photosynthesis coexist in grasslands.
- Balance between the two vegetation types affects productivity, water use efficiency and quality of forage, animal productivity, carbon storage and nitrogen.
- The grassland ecosystems have faced severe stresses including temperature, moisture and edaphic factors affecting the C3/C4 balance. Hence, the C3/C4 balance moved during the last 50 years.
- C3 and C4 plants differ for light, water and nitrogen use efficiencies, digestibility and decomposability.
- Under elevated CO2 increase in sugars, starch and fructan were reported among C3 grasses with reduction in protein content, however, among most C4 grasses protein content was least affected.
- Less digestible species are left ungrazed, leading to increased frequency and density.
- Grazing pressure important factor in climate change studies and effects on the C3/C4 balance.
- Ungrazed C3/C4 grassland showed tall grasses replacing short ones but overall dominance of tall C4 such as *Brachypodium sylvaticum and Miscanthus sinensis* remains unchanged.
- High regenerative capacity important trait in order to minimize the overgrazing effect.
- *Leymus chinensis* (C3) and *Chloris virgata* (C4) show major change in their competition magnitude and productivity as per precipitation and nitrogen availability.
- C4 grasses need to grow rapidly and survive under natural resource stress.
- Emissions by various livestock production cycles on grasslands can be reduced by adopting free animal grazing on rangeland – indirectly affecting balance between C3 and C4 in responsive to climate change.
- C4 grasses such as *Cenchrus*, *Panicum*, and *Chrysopogon* increase TOC by 77 to 91%.
- Along with C4 species, CAM plants, such as cacti, also contributing to grassland productivity because of their evolutionary advantage for adaptation to hot climates.

Prospects and strategies

- The high biomass C4 or C3/C4 grasslands can play vital role in future to cope with climate change.
- Such ecosystems maintain other infrastructure sustainable by checking silting process.
- C3/C4 intermediate climate smart species like *Panicum maximum* are most suitable candidate for making grasslands climate resilient in auto mode.
- The high biomass producing C4 grass biomass can be potential source for lignocellulosic ethanol production or combustion energy production.
- There is need to identify desirable stages of succession, based on ecological principles, for sustainability of the system in context of coexistence of the C3/C4 balance in grasslands.
- As a major source of forage from the C3/C4 grasslands and savannas, efficient recycling of natural resources and carbon sequestration need to studied.
- Recent advancement in C4 pathway and its evolution may open up further possibilities for introducing C4 pathway among some C3 species by using the new C4 model species *Setaria viridis*.