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'Seeded-Yet-Sterile' Perennial Biofuel Feedstocks

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Acceptance and deployment of leading candidate cellulosic energy crops has been significantly inhibited by their lack of providing both inexpensive seeded establishment options and high first-year biomass production in perennial feedstocks with mitigated risk of crop invasiveness. Pearl Millet-Napier grass ('PMN'; *Pennisetum glaucum* R. Br. x *P. purpureum* Schumach) and King grass ('KG'; *P. purpureum* x *P. glaucum*), in comparison, are perennial biomass crops with immense potential to combine both the high yields of tropical perennial grasses such as energy cane (*Saccharum spp*.) and the integrated agronomics of large-seeded annual grasses such as sorghum (*S. bicolor* [L.] Moench). PMN and KG are further unique among energy grasses as 'seeded-yet-sterile' (SYS) feedstocks, in which fertile parents allow seeded production of hybrids that are subsequently sterile in biomass production fields [1,2]. PMN yields can equal or exceed that of sugarcane in tropical environments (20 Mg ha^{-1}) [3] and more than double that of switch grass (*Panicum virgatum* L.) in semiarid environments (10-15 Mg ha^{-1}) [1,4]. PMN seeds are comparatively large, and hybrid seed production can approach that of commercial forage sorghum [5]. PMN therefore provide comparatively inexpensive seed units, with seed:feedstock production acre ratios (2-400:1; direct seeded) versus energy cane (10:1; vegetative billets), switchgrass (40:1; broadcast seed), or *M. x giganteus* (10:1; vegetative rhizomes). Hybrid PMN and KG are polycultures, reducing risks of crop failure and environmental impacts due to monoculture. The presence of a common subgenome further provides a mechanism for capturing heterosis in PMN and KG hybrids [6]. Previous evidence of climbing legume intercrops' capacity to provide surplus nitrogen and increased overall biomass yields in napier grass [7,8] indicate a similar potential as a renewable source of nitrogen for PMN and KG. Within the genus Pennisetum, PMN and KG have several closely-related, apomictic species that provide potential to introgress this valuable trait [9]. Advantages of PMN and KG can be summarized upon comparison with current leading candidate energy grass feedstocks for desirable traits in biofuel ideotypes (Table 1).

	PMN: KG	Switchgrass	Energycane	Giant Miscanthus	Sorghum
Sterile F_1 Hybrid Seed	✓				
Large-Seeded	✓				✓
Year 1 Harvest	✓		✓		✓
Yield>10 Mg ha^{-1} yr^{-1}	✓		✓	✓	✓
Perennial	✓	✓	✓	✓	
Marginal Land Adaptation	✓	✓			✓
Low Establishment Costs	✓				✓
Polyculture	✓	✓			
Winter Standability	✓	✓	✓	✓	
Non-invasive (Seed)	✓		✓	✓	✓
Legume Compatibility	✓				
Apomixis Introgression	✓				

Table 1: Perennial cellulosic biofuel feedstock ideotype comparison.

PMN and KG possess a diverse natural range of carbohydrate composition [10,11], providing advantages towards optimizing biofuel yields. Biomass fractions not utilized by conversion platforms subsequently offer opportunities for biorefining high-value co-products. Napier grass, for example, possesses the highest leaf protein content among perennial grasses [12] and offers potential for large-scale production of plant protein-derived bioplastics [13]. Plant-based bioplastics have been commercially developed utilizing genetically-modified crops [14], and similar platforms based on non-transgenic plants would offer alternative technologies with vastly reduced developmental and regulatory costs. Further, incomplete hydrolysis derivatives of lignocellulosic material are common and provide a further process-based platform for production of xylo- ('XOS') & cello-oligisaccharides ('COS') with utility as functional foods, prebiotics, feed additives, and specialty chemicals [15]. XOS and COS commodity markets are expanding rapidly, providing additional economic incentives for PMN and KG producers and positive health impacts for society [16].

Through their highly efficient use of water and nutrients [17], perennial grasses such as PMN and KG are particularly promising crops with which the more than 1.1 billion acres of marginal, globally abandoned agricultural lands [18] could be brought into biomass production [19,20]. Such innovative application of perennial grasses in land use systems would enhance: 1) erosion mitigation, soil restoration, and carbon sequestration [21,22], 2) wildlife habitat [23], and 3) conservation agricultural practices [24]. As a result of such endeavors, sustainable strategies for biofuel systems with high energetic efficiencies, low food security trade-off risks, and significant environmental conservation impacts could be achieved. PMN and KG, moreover, therefore offer seed companies enhanced product ownership and control, growers inexpensive crop establishment costs and high biomass yields, feedstock customers economically viable value chains, co-product customers high-value commodities, and governments ecologically-optimized systems with little or no risk of crop invasiveness.

References

1. Burton GW (1944) Hybrids between napier grass and cattail millet. J Hered 35:227-232.
2. Hanna WW (1981) Method of Reproduction in Napier grass and in the 3X and 6X Alloploid Hybrids with Pearl Millet. Crop Sci 21:123-126.
3. Cuomo GJ, Blouin DC, Beatty JF (1996) Forage potential of dwarf napier grass and a pearl millet napiergrass hybrid. Agron J 88:434-438.

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4. Heaton E, Voigt T, Long SP (2004) Quantitative review comparing the yields of two candidate C4 perennial biomass crops in relation to nitrogen, temperature and water. Biomass Bioenergy 27:212–30.

5. Osgood RV, Hanna WW, Tew TL (1997) Hybrid seed production of pearl millet x napier grass triploid hybrids. Crop Sci 37:998-999.

6. Dujardin M, Hanna WW (1983) Meiotic and Reproductive Behavior of Facultative Apomictic BC1 Offspring Derived from Pennisetum americanum-P. orientale Interspecific Hybrids. Crop Sci 23:156-160.

7. Mureithi JG, Tayler RS, Thorpe W (1995) Productivity of alley farming with leucaena (Leucaena leucocephala Lam. de Wit) and Napier grass (Pennisetum purpureum K. Schum) in coastal lowland Kenya. Agroforestry Systems 31: 59-78.

8. Kavana PY, Kizima JB, Msanga YN, Kilongozi NB, Msangi BSJ, et al. (2005) Potential of pasture and forage for ruminant production in Eastern zone of Tanzania. Livestock Research for Rural Development.

9. Martel E, Poncet V, Lamy F, Siljak-Yakovlev S, Lejeune B, et al. (2004) Chromosome evolution of Pennisetum species (Poaceae): Implications of ITS phylogeny. Plant SystEvol 249:139-149.

10. Hanna, WW, Monson, WG (1980) Yield, quality, and breeding behavior of pearl millet x napier grass interspecific hybrids. Agron J 72:358-360.

11. Wadi A, Ishii Y, Idota S (2004) Effects of cutting interval and cutting height on dry matter yield and overwintering ability at the established year in Pennisetum species. Plant Prod Sci 7:88-96.

12. Urribarrí L, Ferrer A, Colina A (2005) Leaf protein from ammonia-treated dwarf elephant grass (PennisetumpurpureumSchum cv. Mott). ApplBiochemBiotechnol 121-124: 721-30.

13. Guilbert S, Morel M, Gontard N, Cuq B (2006) Protein-based plastics as smart green materials, in: JJ Bozell, MK Patel (Eds.), Feedstocks for the Future, ACS Symp. Ser., 921: 334-350.

14. Somleva MN, Snell KD, Beaulieu JJ, Peoples OP, Garrison BR, et al. (2008) Production of polyhydroxybutyrate in switchgrass, a value-added co-product in an important lignocellulosic biomass crop. Plant Biotechnol J 6: 663-678.

15. Pokusaeva K, O'Connell-Motherway M, Zomer A, Macsharry J, Fitzgerald GF, et al. (2011) Cellodextrin utilization by bifidobacteriumbreve UCC2003. Appl Environ Microbiol 77: 1681-1690.

16. Aachary A, Prapulla S (2011) Xylooligosaccharides (XOS) as an emerging prebiotic: Microbial synthesis, utilization, structural characterization, bioactive properties, and applications. Comp Rev Food Sci Food Safety.

17. Samsom R, Mani S, Boddey R, Sokhansanj S, Quesada D, et al. (2005) The potential of C4 perennial grasses for developing a global BIOHEAT industry. Crit Rev Plant Sci 24:461-495.

18. Campbell JE, Lobell DB, Genova RC, Field CB (2008) The global potential of bioenergy on abandoned agriculture lands. Environ SciTechnol 42: 5791-5794.

19. Cox TS, Bender M, Picone C, Van Tassel DL, Holland JB, et al. (2002) Breeding perennial grain crops. Crit Rev Plant Sci 21:59-91.

20. US DOE (2006) Breaking the biological barriers to cellulosic ethanol: A joint research agenda, DOE/SC-0095. U.S. Dep. of Energy, OS and OERE, Washington, D.C.

21. Adler PR, Del Grosso SJ, Parton WJ (2007) Life-cycle assessment of net greenhouse-gas flux for bioenergy cropping systems. EcolAppl 17: 675-691.

22. Lal R (2008) Crop residues as soil amendments and feedstock for bioethanol production. Waste Manag 28: 747-758.

23. Lemus R, Lal R (2005) Bioenergy crops and carbon sequestration. Crit Rev Plant Sci 24:1-21.

24. Follett RF (2001) Soil management concepts and carbon sequestration in cropland soils. Soil Tillage Res 61:77-92.

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