Sesbania rostrata (Bremek and Oberm.) as Biological Nitrogen Fixator for Sustainable Lowland Rice Production

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ABSTRACT

Nitrogen plays a crucial role in rice cultivation. It is usually supplied as chemical fertilizer (urea). However, rice monocropping without fallow and loss of urea-N through leaching, often lead to soil fertility decrease, decline in soil organic matter and environmental pollution, which negatively affect rice yield. Climate change is expected to worsen this situation. All this may affect food security especially against the backdrop of increasing population levels, particularly in Sub-Sahara Africa. New and alternative N resources should be explored to sustainably supply rice crop needs and thus reduce the adverse environmental effects of current urea-N use in rice. Biological Nitrogen Fixation (BNF) by legumes is a promising and environment-friendly mechanism that can be used to convert atmospheric di-nitrogen into fertilizers for agriculture. As such, BNF could increase the sustainability of traditional rice production systems. In this respect, *Sesbania rostrata*, which is native to Africa and frequently used as a green manure in lowland rice production systems, is one of the best N-fixating plant species because its N-fixing bacteria nodulate on both stem and roots, whereas the plant itself grows fast, has high N-fixation rates and tolerates waterlogged soils. The plant, when plowed under at 34-42 days after sowing, can add 90 to 150 kg N ha^{-1} and 7.4 t ha^{-1} of biomass to the soil. It has been found that *S. rostrata,* supplied as a green manure, can double rice yields after one rice cultivation cycle. Findings further reveal a 35% residual effect on yield of the same green manure application on grain yield in a second rice cultivation cycle. It is probably the cheapest alternative N source to smallholder farmers.

1-INTRODUCTION

N is one of the major factors limiting global rice production (Choudhury and Kennedy 2004). In Africa, Asia and Latin America, rice is the staple food of more than three billion people (Ganapathi et al. 2014). Currently, urea-N is unaffordable for the majority of smallholder farmers in Africa. For this reason, new, alternative N-sources should be explored to sustainably supply rice N needs. Leguminous plant species can be such an alternative N resource. Among these, *Sesbania rostrata* (Bremek and Oberm.) (Fabaceae) is one of the best known (Ndoye et al. 1996). The objective of this presentation is to highlight the potential and prospects of *S. rostrata* as green manure in rice fields in order to prepare for future research.

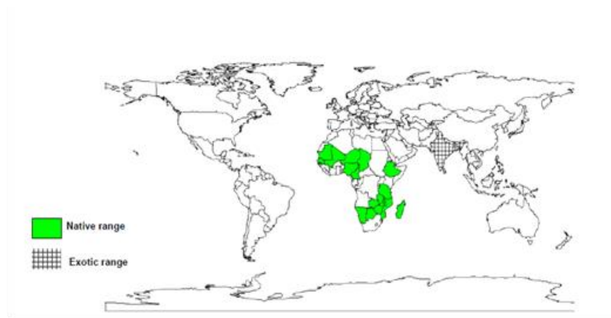

Figure 1 African countries where *Sesbania rostrata* has been planted (Source: Orwa et al. 2009)

Figure 2 Stem nodulation of *S. rostrata* (Source: Wabi 2015)

2-METHODOLOGY AND SOURCE OF DATA

We did a literature review of articles dealing with (keywords): biological nitrogen fixation (BNF), *Sesbania rostrata*, N fertilization in rice cultivation, soil fertility, soil organic matter, integrated soil fertility management and climatic conditions sourced from Web of Science (WoS) and Google scholars.

3- BIOLOGICAL NITROGEN FIXATION (BNF) AND *SESBANIA ROSTRATA*

- N-fixing nodules are formed both on stems and roots of *S. rostrata* (Den Herder et al. 2006);
- N-fixing nodules of *S. rostrata* can be used to convert atmospheric di-nitrogen through biological means into fertilizers for agriculture (Ndoye et al. 1996);
- stem nodules of *S. rostrata* can continue to fix di-nitrogen even when the plant grows in waterlogged soils (Latt et al. 2009);
- BNF is the best alternative to supply N to crops grown in developing countries.

4- AGRONOMIC AND ECONOMIC ISSUES OF *SESBANIA ROSTRATA* AS A GREEN MANURE IN LOWLAND RICE

- *S. rostrata* green manure can add 90 to 150 kg N ha^{-1} and 7.4 t ha^{-1} of biomass to the soil (Bhuiyan and Zaman 1996; Ndoye et al. 1996);
- incorporation of *S. rostrata* can provide 60 kg urea-N in rice fields (Ndoye et al. 1996);
- rice yield can double after one incorporation of *S. rostrata* green manure; 35% residual effect on grain yield is obtained in a second rice crop following this first incorporation (Ndoye et al. 1996);
- *S. rostrata* can be a low-cost N-fertilization alternative for rice smallholders (Latt et al. 2009).

5- *SESBANIA ROSTRATA* FOR A SUSTAINABLE LOWLAND RICE PRODUCTION SYSTEM

- *S. rostrata* as green manure can compensate for N losses and reduce environmental pollution from chemical fertilizers;
- regular incorporation of *S. rostrata* can be both an ecological source of N as well as of soil organic matter which is essential in maintaining adequate soil quality;
- *S. rostrata* can use renewable sources of energy instead of non-renewable sources for higher nitrogen-fixation rates;
- *S. rostrata* as green manure can increase nutrient cycling to rice plants and reduce the use of chemical fertilizer for the long-term sustainability.

6-CONCLUSION AND CHALLENGES

Green manure of *S. rostrata*:

i. can provide N to rice and improve soil structure and microbial activity;
ii. can increase the profit margin of rice farmers by reducing imports of urea-N.

However, the relationship between agronomic performance and financial profitability in West Africa lowland rice cultivation systems has not been fully investigated. As a result, it is important to:

a) assess both agronomic performances and financial profitability of *S. rostrata* as a green manure in rice fields;
b) promote and facilitate mainstreaming of *S. rostrata* as a green manure.

ACKNOWLEDGMENTS

This work was supported by the Special Research Fund (BOF, Bijzonder Onderzoeksfonds) from Ghent University (UGENT) (scholarship code: 01W00414).

REFERENCES

Bhuiyan NI, Zaman SK (1996) Use of green manuring crops in rice fields for sustainable production in Bangladesh agriculture. In: Rahman M, Podder AK, Van Hove C, Begum ZNT, Heulin T, Hartmann A (Eds.) *Biological nitrogen fixation associated with rice production*, Book series: Developments in plant and soil sciences, 70, pp 51-64.

Choudhury ATMA, Kennedy IR (2004) Prospects and potentials for systems of biological fixation in sustainable rice production. Biol Fertil Soils 39:219-227.

Den Herder G, Schroeyers K, Holsters M, Goormachtig S (2006) Signaling and gene expression for water-tolerant legume nodulation. Crit Rev Plant Sci **25**:367-380.

Ganapathi Dr, Vishwanath Shetty Y, Pradeep S, Chidanandappa HM, Noor Nawaj, Dhananjaya BC (2014) Organic farming on productivity of rice and soil fertility under alfisols of southern transition zone of Karnataka, India. In: Rahmann G, Aksoy U (Eds.) *Building Organic Bridges*, Johann Heinrich von Thünen-Institut, Braunschweig, Germany, 3, Thuenen Report, no. 20, pp 635-638.

Latt YK, Myint AK, Yamakawa T, Ogata K (2009) The effects of green manure (*Sesbania rostrata*) on the growth and yield of rice. Journal of the Faculty of Agriculture Kyushu University 54 (2):313-319.

Ndoye I, Dreyfus B, Becker M (1996) *Sesbania rostrata* as green manure for lowland rice in Casamance (Senegal). Tropic. Agric. (Trinidad) 73 (3):234-237.

Orwa C, Mututa A, Kindt R, Jamnadass R, Anthony S (2009) Agroforestry Database: a tree and selection guide, version 4.0. http://www.worldagroforestry.org/treedb/AFTPDFS/Sesbania_rostrata.PDF. Accessed 09 February 2015.

Wabi MA (2015) Field work and data collection in Benin.