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Why is Bambara groundnut able to grow and fix N_2 under contrasting soil conditions in different agro-ecologies?

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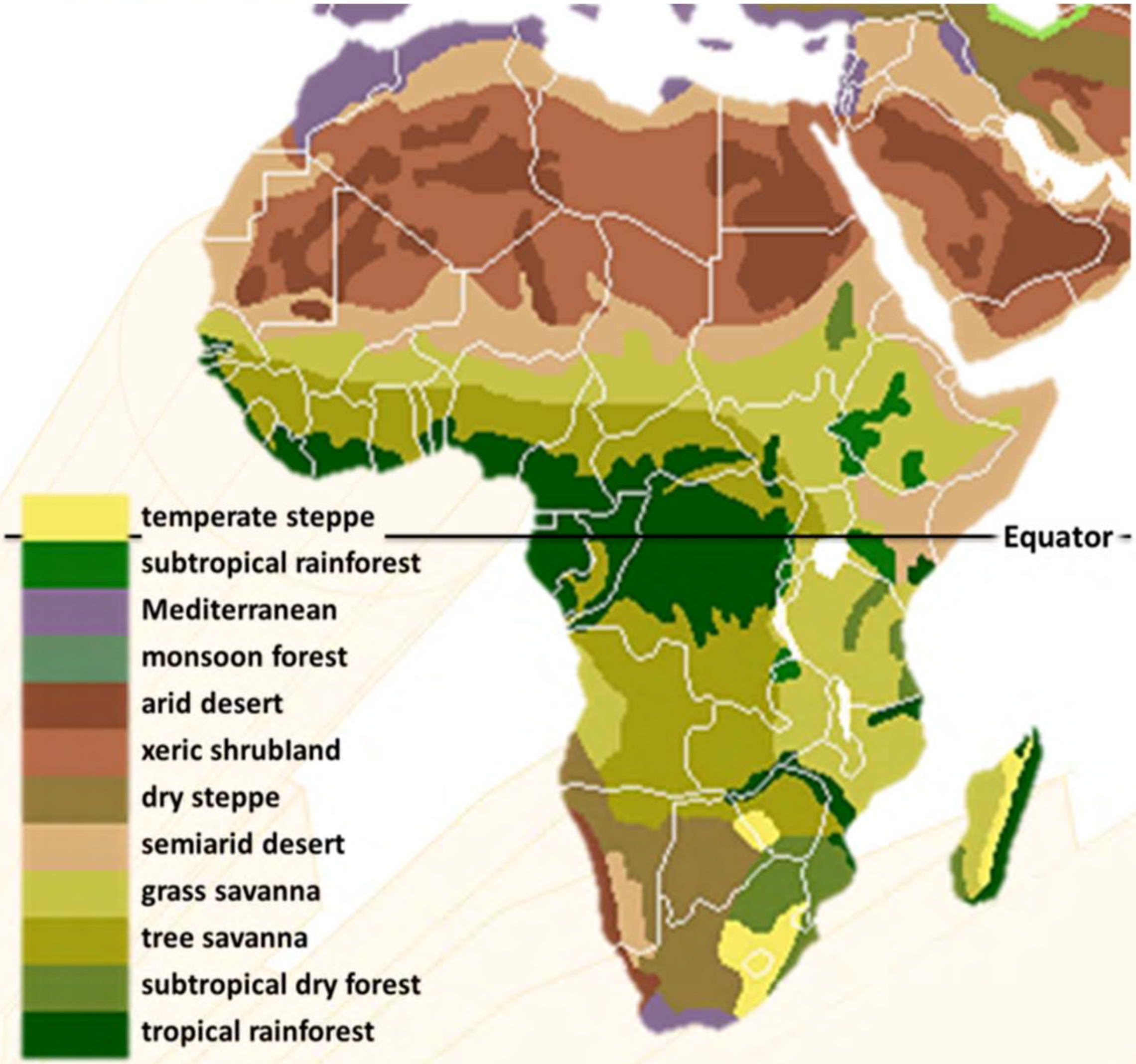
Introduction

- Bambara groundnut (*Vigna subterranea* L. Verdc) is the 2nd most important African indigenous food legume crop after cowpea (Azam-Ali et al. 2001)
- Grown mainly for human consumption and its grain makes a complete meal with 14–24 % **protein**, 60 % **carbohydrate**, and 6–12 % **oil** (Mahala & Mohammed 2010)
- Has high levels of fibre, **Ca**, **K**, **Mg**, **P** and **Fe** in the grain
- The potential of neglected and underutilized crops such as Bambara groundnut could be exploited for overcoming food deficits in the continent (Padulosi et al. 2002)

Distribution



- It is widely distributed to as far as India, Sri Lanka, Indonesia, the Philippines, Malaysia, Thailand, the Papuan region of Southeast Asia New Caledonia and South America and (Baudoin & Mergeai, 2001; Somta et al. 2013)

Source: exploringafrica.matrix.msu.edu

Adaptability

- Bambara groundnut is well adapted to a wide range of environmental conditions
- Better yields of Bambara groundnut were obtained even under low rainfall, in poor nutrient soils or high soil temperatures, compared to other grain legumes (Doku & Karikari, 1971)
- The ability of the crop to grow in these different agro-ecologies including drought prone environments has been investigated (Berchie et al. 2012; Mabhaudhi & Modi, 2013)

Nitrogen fixation

- Bambara groundnut form N_2-fixing symbioses with soil bacteria belonging to the genera *Rhizobium, Bradyrhizobium, Ensifer, Azorhizobium* and *Mesorhizobium* (Sprent, 2009)

- These rhizobia converts atmospheric N_2 into NH_3 after infecting and establishing themselves inside root-nodules of legumes

- Incorporating N_2-fixing legumes into cropping systems is the sustainable way of tapping atmospheric N_2 for increased crop yields, improved soil N fertility (Peoples et al. 2008)

N_2 fixation in Bambara groundnut

- Various studies evaluated N_2 fixation in other legumes (i.e groundnut, soybean, cowpea) in Africa (Belane and Dakora 2009; Pule-Meulenberg & Dakora 2009)

- However, there are very few on N_2 fixation in Bambara groundnut (Kishinevsky et al. 1996; Nyemba and Dakora 2010)

- In South Africa , Bambara groundnut is still neglected and under-reseached , no improved cultivars and no studies conducted on N_2 fixation and assessing this' species potential as a biofertilizer

Farmer’s fields in Mpumalanga, South Africa

Intercropped maize without fertilizer in South Africa

Table 1 %Ndfa and N fixed of Bambara groundnut sampled from 26 farmers' fields of Mpumalanga Province, South Africa

Location	Farm	Ndfa	N-fixed
		Pods +shoots	
		%	$Kg.ha^{-1}$
Village			
Machipe	1	83bc	36f
	2	69e	48e
	3	82bc	28g
	4	60fg	128b
	5	85b	25gh
Majakaneng	6	73d	21h
	7	69e	72cd
Dikgwale	8	62f	90c
	9	70e	75cd
Malekutu	10	33i	19h
	11	77cd	46ef
	12	98a	4j
	13	62f	38f
	14	79c	6i
	15	70e	58de
	16	80c	144b
	17	88ab	48e
	18	90ab	200a
Phameni	19	76cd	94c
	20	90ab	49e
	21	77cd	6i
	22	90ab	92c
Skhwahlane	23	66ef	116bc
	24	54g	143b
	25	43h	135b
	26	52g	66d
F-statistics		14.3**	20.8**

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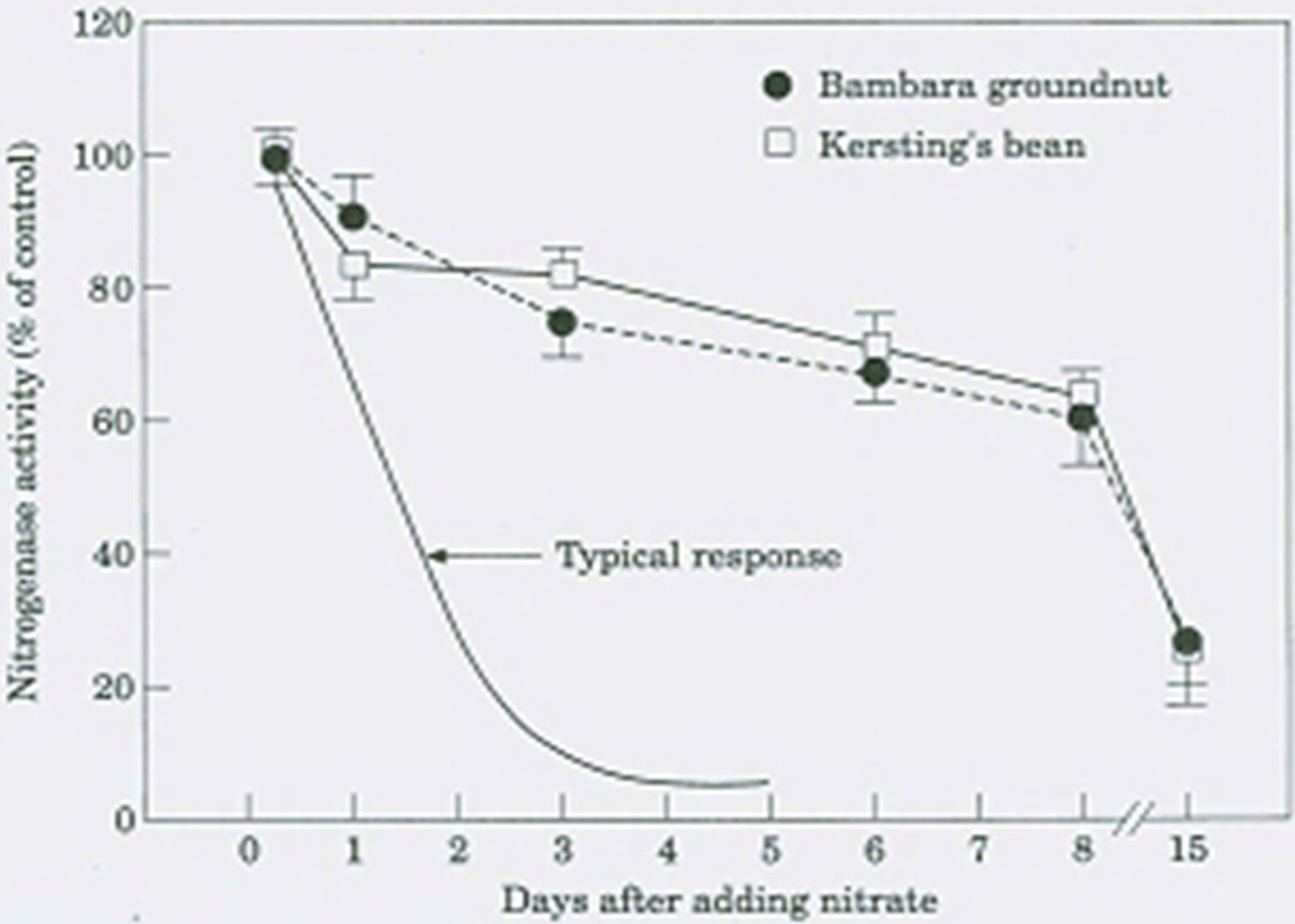
Nitrate tolerance

- Bambara groundnut obtained more N from soil than symbiosis e.g. 173 kg N from soil vs. 135 kg $N.ha^{-1}$ from symbiosis on farm 25 at Skhwahlane, and 116 kg N from soil vs. 143 kg $N.ha^{-1}$ from symbiosis on farm 24 at Skhwahlane
- Although these high levels of N uptake might have inhibited nodule functioning in Bambara groundnut to some extent (Streeter 1988; Ayisi et al. 2000)
- Earlier studies have shown that some accessions of the species are tolerant of mineral N in the rhizosphere (Dakora et al. 1992; Dakora 1998)


Bambara groundnut
Kersting's bean
Typical response
Nitrogenase activity (% of control)
Days after adding nitrate
0
20
40
60
80
100
120
0 1 2 3 4 5 6 7 8 15

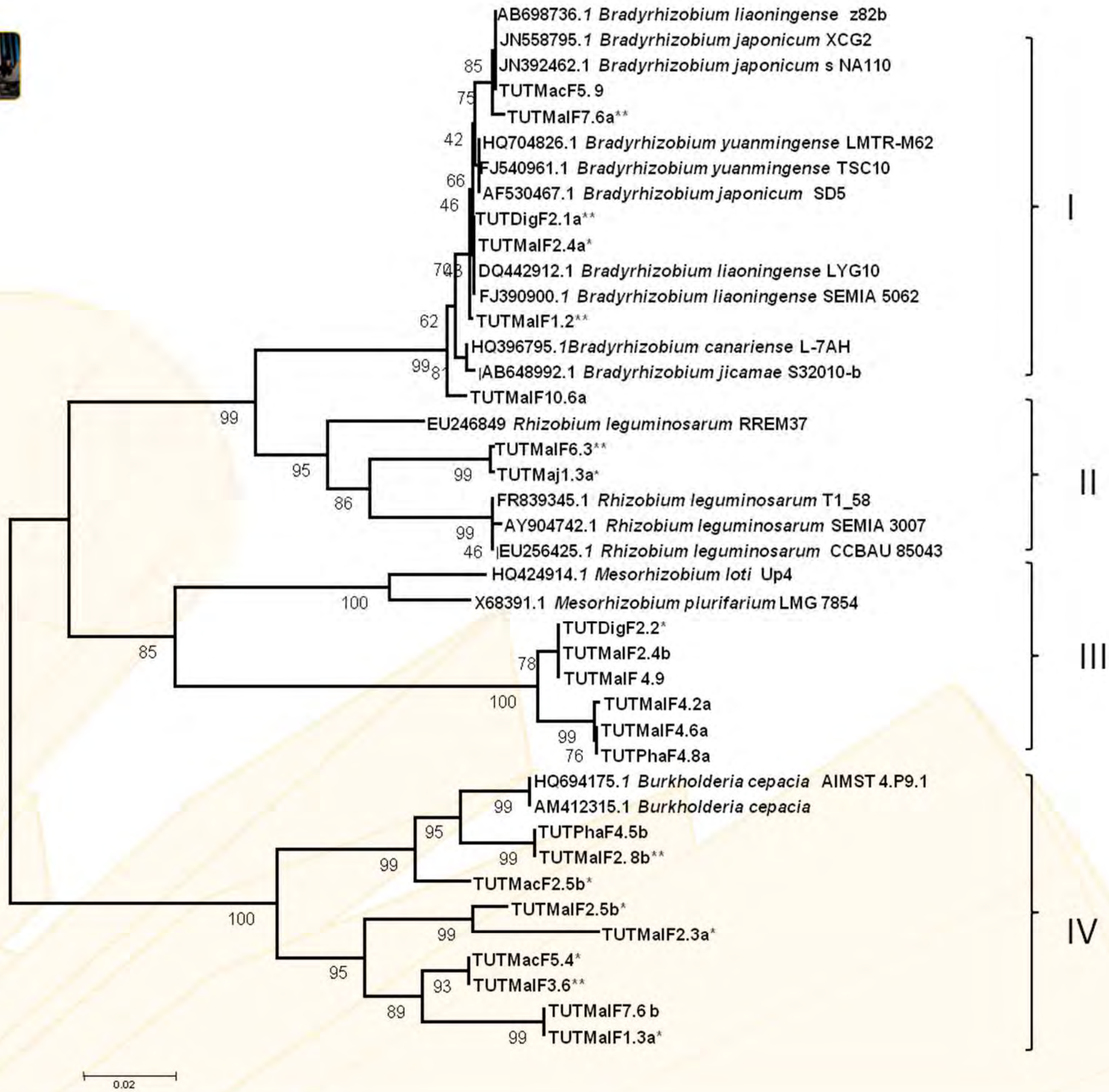
Promiscuicity in Bambara groundnut

- An earlier study (Doku, 1969) showed Bambara goundnuts to be non-selective in its rhizobial requirements
- Later studies however found that inoculating Bambara groundnut with suitable strains of *Bradyrhizobium* spp. can significantly increase grain yield and symbiotic N (450kg N fixed.ha^{-1}) (Kishinevsky et al. 1996; Gueye et al. 1998)
- However, at farm level, yield of Bambara groundnut is often low partly due to little understanding of its diverse microsymbionts and their symbiotic efficacy

Characterization of rhizobia

- Root nodules were randomly harvested from plants collected from farmers' fields
- Isolations and phenotypic characterization were done according to Vincent (1970)
- 98 single-colony isolates tested for their ability to nodulate Bambara groundnut
- The DNA extraction procedure was according to Wilson (1994)
- Strains were sequenced at Inqaba Biotechnological Laboratory in Pretoria

Comparison of inoculated and uninoculated Bambara groundnut



Phylogenetic relationships among 16SrDNA sequences of Bambara isolates

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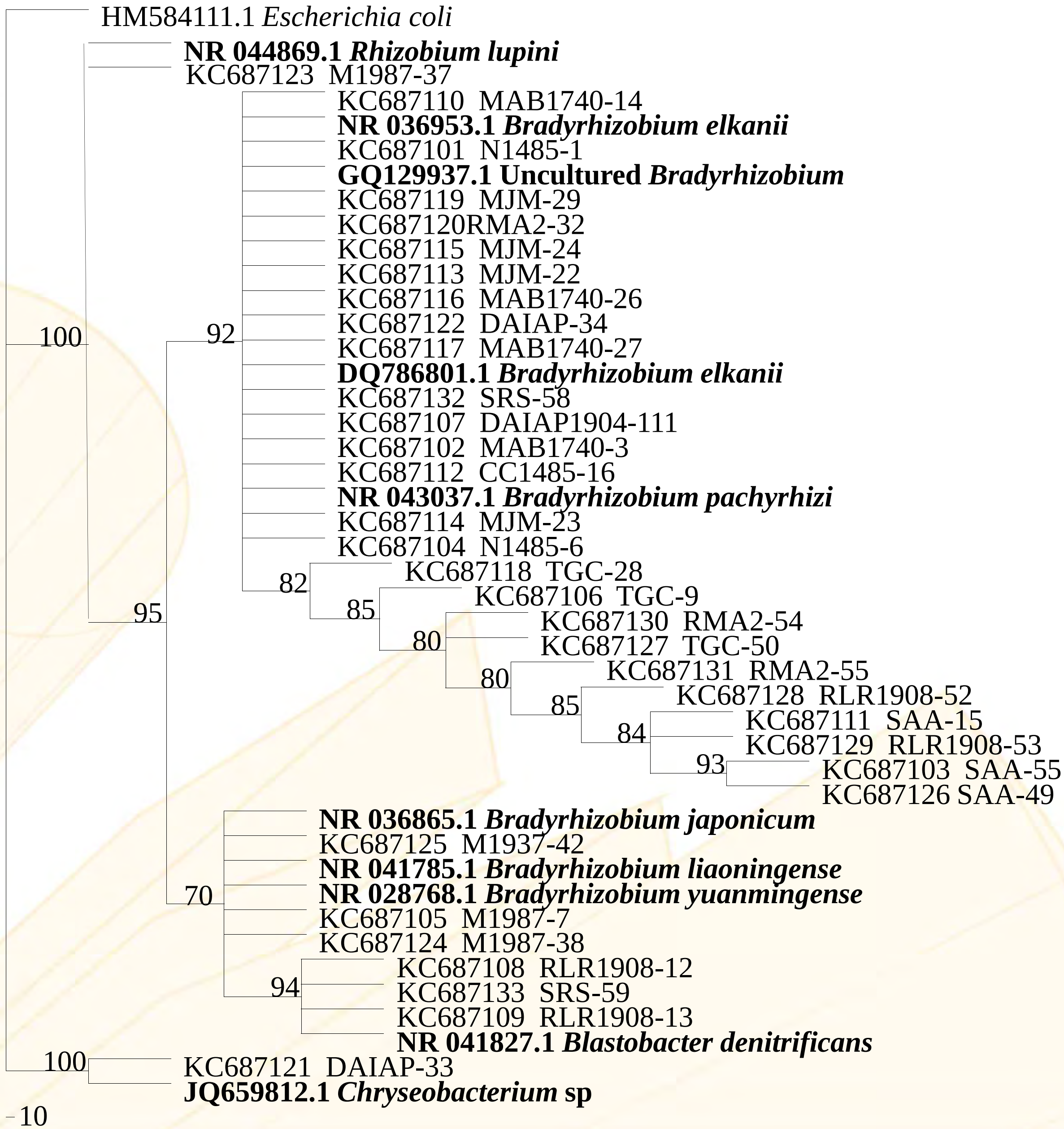

Phylogenetic relationships among 16SrDNA sequences soybean isolates

Conclusions

- This legume has the potential to become a significant food security crop, and a bio fertilizer in cropping systems of resource-poor farmers in Africa
- Furthermore, it is important to screen and identify Bambara groundnut landraces with superior symbiosis for increased food security in a climate change scenario
- Superior strains can be used for development of inoculants to improve yields of Bambara groundnut and other grain legumes

Policy implications

- As a food security crop Bambara groundnut deserves increased research and research funding
- There is need to increase research on microsymbionts of NUL (Neglected underutilized Legume) species

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