Soybean (*Glycine Max* (L) Merill) Promiscuity Reaction To Indigenous Bradyrhizobia inoculation In Some Ghanaian Soils

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ABSTRACT: For many tropical countries particularly in Africa, Biological Nitrogen Fixation (BNF) continues to be the most promising alternative or supplement to the use of chemical Nitrogen fertilizers for sustainable Agriculture. In contrast to cowpea that nodulate profusely in tropical soils with the naturally occurring bradyrhizobia, nodulation and nitrogen fixation in the American-type soybean in similar environments has largely depended on inoculating bradyrhizobia into the soil. The development of the Tropical Glycine Cross (TGx) soybean varieties by IITA has made it possible for these promiscuous varieties to nodulate with the naturally occurring strains belonging to the cowpea *Bradyrhizobium* spp. The Most Probable Number (MPN) technique was used to determine the bradyrhizobial population in these soils. Eighty four *Bradyrhizobium* is olates obtained from randomly selected nodules on soybean were assessed for effectiveness in nitrogen fixation. Three of the most effective isolates were used in inoculation studies carried out in the greenhouse at the University of Ghana-Legon on three promiscuous soybean varieties, Anidaso (TGx 813-6D), TGx 1903-8F and TGx 1448-2E and a non- promiscuous genotype, Davis, in three Ghanaian soil series, Toje (Chromic cambisols), Chichiwere (Dystricfluvisol) and Bekwai (Ferric acrisols). There were tremendous inoculation responses in these soils for both the promiscuous and non-promiscuous cultivars, with even the promiscuous ones responding better to inoculation than the non-promiscuous Davis. Inoculation gave rise to significant increases in nodule number, nodule dry weight, shoot dry weight and total nitrogen accumulation compared to the uninoculated control even in the Chichiwere soil series which harboured the highest population of indigenous bradyrhizobia, suggesting that the populations of the naturally occurring bradyrhizobia in these soils were either not highly competitive or sufficient for optimum nodulation and nitrogen fixation. For all the symbiotic or growth parameters assessed, the four soybean varieties were ranked as Davis<TGx1448-2E<TGx1903-8F<Anidaso (TGx 813-6D).

Key words: *Bradyrhizobium japonicum Effectiveness. Inoculation.Non-promiscuous soybean. Promiscuous soybean.*

INTRODUCTION

Nodulation of soybean by effective bradyrhizobia results in substantial amounts of N_2 being fixed by the symbiosis (Henson and Heibel, 1984). As an introduced crop, however, soybean often nodulates poorly in many tropical soils, and inoculation with selected *Bradyrhizobium japonicum* strains is frequently necessary for N_2 to be fixed (Ayanaba, 1980). Between the late 1970s and the early 1880s IITA soybean scientists had two different approaches to improving biological nitrogen fixation (BNF) to meet the demand for N in soybean. The first was to breed promiscuous soybean varieties that should nodulate with indigenous soil rhizobia to make inoculation unnecessary (Kueneman *et al*., 1988). The second was to encourage the production and uses of inoculant in soybean production (Sanginga *et al.*, 1997). Even though there were yield response by non-promiscuous soybean to inoculation, this was not significant in the promiscuous soybean lines (Pulver *et al*., 1982; Rao *et a*l., 1981). This raised the question of the effectiveness of the bradyrhizobia used as inoculants by these authors. It was important to find out whether inoculants, if available can be used on promiscuous soybean varieties to promote rapid nodulation or whether indigenous bradyrhizobia will outcompete the inoculant strains. Recent studies with these promiscuous soybean lines, however, have shown considerable variability in the effectiveness and population communities of indigenous bradyrhizobia in a given location (Sanginga *et al*., 1999; Fening and Danso, 2002). Sanginga *et al*., (1995) also found a direct relationship between bradyrhizobia cell counts and promiscuous soybean response. Thus promiscuous soybean may also need inoculation with exotic bradyrhizobia depending on effectiveness and indigenous bradyrhizobia in the locality (Okereke *et al.,* 2000), as well as the degree of promiscuity of the soybean variety (Sanginga *et al*., 1999). There is therefore the need to examine the response of promiscuous soybean lines to inoculation in more soil series using different types of soybean varieties to assess whether effective bradyrhizobia strains capable of nodulating promiscuous soybeans occur in Ghanaian soils. Our objective of this study is to isolate bradyrhizobia from promiscuous and non- promiscuous soybean genotypes and to determine their effectiveness in nodulation and nitrogen fixation (as measured by total nitrogen accumulation in the plant).

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MATERIALS AND METHODS

Three soil series, namely Toje,Chichiwere and Bekwai, were sampled from fields that had no history of soybean cultivation. Soil samples were collected from 0-15cm depth. Three promiscuous soybean varieties, namely Anidaso TGx 1903-8F and TGx 1448-2E, obtained from Tropical Soil Biology and Fertility (TSBF) program in Kenya and a non-promiscuous genotype Davis, obtained from the IITA Ibadan-Nigeria were used. Soil pH was determined in both distilled water and in 0.01M $CaCl_2$ using pH meter. Available P was determined using a spectrometer (Chapman, 1965). Total soil N was estimated using Kjeldahl method (Bremner, 1996). The Most Probable Number (MPN) count was used to determine the number of infective rhizobia in soils (Woomer *et al*., 1990). Bradyrhizobia were isolated from randomly selected soybean and a loopful of the suspension was then streaked on yeast extract mannitol (YEM) agar plates and incubated at 28^{0}C to assess their growth (Somasegaran and Hoben, 1985). The bradyrhizobial isolates were assessed for their effectiveness on sand obtained from the Densu river bed using soybean cultivar Anidaso as a reference crop described by (Ferreira and Marques, 1992). There were three replicate jars for each Bradyrhizobial isolate. Uninoculated seedlings grown in jars supplied with nitrogen (70ugml^{-1} KNO_3) (Somasegaran and Hoben, 1994) and without nitrogen served as control. The inoculated plants and the uninoculated ones without nitrogen were supplied with N-free nutrient solution (Broughton and Dilworth, 1970). Plants were harvested 42 days after planting and nodule number was counted, nodule dry weight and shoot dry weight were also recorded. Shoots were severed from their roots at the collar, put in labelled envelopes and oven-dried at 70°C for 72 hours after which their dry weights were taken. The `equation below was used to calculate the effectiveness index (Ej)

$$E_J = \frac{X_J - X_{TO}}{X_{TN} - X_{TO}} \times 100$$ (Ferreira and Marques, 1992)

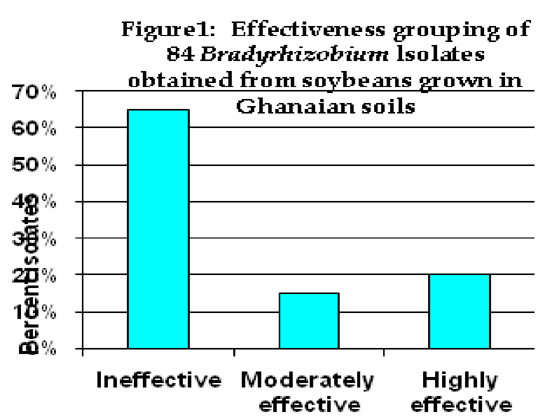
Where, X is the mean dry weight of shoot with subscripts J, TO and TN representative of the shoot dry weight of inoculated test strain, the uninoculated control and the nitrogen control respectively. Plant dry weight value of each inoculation treatment was compared with those of the N-controls and the LSD at P = 0.01 level was used to delineate isolates significantly different from the N control (Bell *et al*., 1994). Classes of effectiveness were defined from comparison with the N controls. Thus as criteria for grouping isolates, isolates with effective index more than 80% were classified as highly effective, effective index between 50% and 80% was classified as moderately effective and isolates with effective index less than 50% were classified as ineffective. Three most effective indigenous bradyrhizobial isolates (Isolates 19, 37 and 57) were used for the inoculation. Each soil type was air-dried and the soil aggregates were gently crushed in a mortar using pestle to pass through a 2mm mesh sieve. The experiment was conducted in the Greenhouse of the Ecological Laboratory within the Geography department of University of Ghana with maximum and minimum day and night temperatures being 35^{0}C and 23^{0}C respectively. For inoculation, a 1ml, washed rhizobial suspension (containing about 10^8 cells) was diluted to 50 ml in sterile distilled water and mixed thoroughly with 1.5 kg soil contained in plastic pots (18cm high, 15cm wide at the top and 12cm at the base). Each pot was therefore inoculated with about 6.0 x10^4 cells g^{-1} soil. Uninoculated soil served as control. All soils were fertilized with essential macro and micro-nutrients except N (Owiredu & Danso, 1988). Four surface–sterilized soybean seeds (Vincent, 1970) were planted in each pot, and thinned to two after germination. The treatments were replicated four times in a completely randomized split-block design with soils as the main blocks. Plants were watered daily with distilled water and were harvested six weeks of growth. The shoots were oven dried for 70^{0}C for 48hrs and Kjeldahl N analysis (Bremner, 1965) was done on ground samples (<0.2mm). Nodules were sun-dried and stored in serum bottles. Statistical analysis was done using Genstat statistical software version 6.1 (Genstat, 2000). Significant differences were assessed at 5% level. Mean separation was carried out by Least Significant Difference (LSD) procedure.

RESULTS

Table 1. *Some physical and chemical properties of three soils used for growing inoculated soybean*

Soil Series	pH(in H_20)	% N	Available P(mgkg-^{1})	Potassium Me/100g	Magnesium Me/100g
Toje	5.3	0.32	6.08	0.64	3.0
Chichiwere	5.2	0.33	9.49	1.28	4.8
Bekwai	4.8	0.23	4.40	1.28	8.2

Most Probable Number (MPN): The assessments of indigenous bradyrhizobial cell densities based on the MPN method were: Bekwai (4.0 x 10^1/gsoil) <Toje< (8.0 x 10^2/gsoil) <Chichiwere (6.6 x10^3/gsoil). Effectiveness grouping of 84 bradyrhizobial isolates: Of the 84 bradyrhizobial isolatesexamined,55 (65%) were ineffective, 12 (15%) moderately effective,and 17 (20%) were highly effective (Fig.1). The highest effectiveness index (128%) was scored by isolate number 37 and whose inoculation resulted in the accumulation of the highest amount of nitrogen (177.85mgN) in soybean, followed by isolate 57(114%) and 19 (111%)



Nodulation, nitrogen fixation and dry matter yield

Without inoculation, both the promiscuous and non-promiscuous soybean varieties failed to nodulate in the Bekwai soil and allthough all four varieties formed nodules in the Toje and Chichiwere soils, the range of nodules formed by Davis (1.3-2.7/plant) in these soils was far lower than the 8.3-23.0 nodules/plant formed by the indigenous bradyrhizobia in these two soils (Table 2). Significantly fewer nodules developed on the uninoculated soybean in both promiscuous and non-promiscuous varieties in all the soil series tested than on the inoculated ones, but with the application of the inoculants strain nodulation occurred with the non- promiscuous variety Davis recording the highest value (30 plant-^{1}) compared to the promiscuous soybean varieties in Bekwai soil. (Table 2).Even in the Bekwai soil, abundant nodules were formed on all varieties, and ranged from 20 nodules formed by isolate 57 on TGx 1903-8F to 33.7 formed by the same isolate on Davis. In general, inoculation response was better for Davis in the Bekwai soil than in the Chichiwere soil, while being lower than the Toje soil. Significant differences in numbers of nodules formed by the different isolates on different varieties occurred in the Chichiwere soil. For example, while the inoculation of isolates 57 and 37 resulted in the formation of the highest number of nodules on soybean grown in the Chichiwere soil and isolate57 was the best for TGx 1903-8F, inoculation with isolate 19 resulted in Anidaso forming the highest number of nodules in the same Chichiwere soil. Among the promiscuous varieties, the varieties could overall be ranked as TGx 1903-8F >Anidaso> TGx-1448 2E in terms of nodulation with inoculation. On average, inoculation with the three isolates resulted in similar nodulation of the four varieties in the Toje soil as in the Chichiwere soil. However, some similarities as well as individual treatment differences occurred, as evident in Table 2. For example, while inoculation with isolate 57 and 37 resulted in highest nodulation amongst all the inoculation treatments and were the best strains for TGx 1903-8F grown in the Toje soil, Anidaso and Davis gave the highest nodulation when isolate 37 was inoculated into Toje soil grown to the four varieties. Davis in particular formed far more nodules when inoculated with any of the three isolated strains in the Toje soil than in any other soil. There were significant differences ($P<0.05$) among *Bradyrhizobium* isolates used with isolate 57 effecting the production of high nodule number in Bekwai soils (29.3 nodules plant^{-1}).There was significant difference ($P<0.05$) among the soybean varieties in Chichiwere soils in terms of nodulation. Chichiwere soils produced the highest nodulation in both uninoculated and the inoculated soils. TGx 1903-8F recorded the highest nodule value (44 nodules^{-1}) compared to lowest value recorded by Davis (25). Surprisingly, Davis formed the highest mean nodules (38 nodule-^{1}) alongside TGx 1903-8F in Toje soils. The inoculums 57 confirmed its superiority by producing the highest nodule number in all the three soils Toje (36 nodules plant-^{1}), Chichiwere (36.6 nodules plant^{-1}) and Bekwai (29.3 nodules plant^{-1}). Nodule dry weights of inoculated soybean plants were significantly ($P<0.05$) greater than for the uninoculated counterparts (Table 3). With the exception of Bekwai soil, TGx 1903-8F appeared a better

Table 2: *Effect of inoculation with indigenous Bradyrhizobium japonicum isolates on nodule number per plant of four varieties of soybean in three different soils*

Soil Series	Varieties	No Inoculation	*Inoculum*			
			Isolate 19	Isolate 37	Isolate 57	Mean
Toje	Anidaso	13.3	37.0	31.3	35.0	34.4
	TGx 1448-2E	8.3	36.0	31.0	31.0	32.7
	TGx 1903-8F	20.7	29.3	41.0	43.0	37.8
	Davis	2.7	37.0	33.3	35.3	35.2
	Mean	11.3	34.8	34.2	36.1	-
Chichiwere	Anidaso	17.3	42.7	39.7	44.3	42.2
	TGx 1448-2E	16.3	35.0	31.0	31.3	32.4
	TGx 1903-8F	23.0	37.7	45.0	48.7	43.8
	Davis	1.3	29.0	23.3	22.0	24.8
	Mean	14.5	36.1	34.8	36.6	-
Bekwai	Anidaso	0.0	30.3	27.7	31.7	29.9
	TGx 1448-2E	0.0	28.3	27.7	30.6	28.9
	TGx 1903-8F	0.0	21.3	20.7	20.0	20.7
	Davis	0.0	29.3	27.0	33.7	30.0
	Mean	0.0	27.3	25.8	29.0	-

LSD ($P < 0.05$); Soil =1.8, Variety =2.04, Inoculant= 2.04 Soil ×Variety = 3. Soil x variety x inoculants = 7.07

nodulator and produced greater nodule mass thanAnidaso (Table 3). Even though Davis nodulated very well in the inoculated Bekwai soil, its nodule dry weight was lower (268 mg plant^{-1}) than the other two promiscuous soybean varieties (Anidaso and TGx 1448-2E). TGx 1903-8F appeared better in terms of nodule dry weight production in

Toje (174 mg plant^{-1}) and Chichiwere soil (386 mg plant-^{1}). Even though Anidaso produced more nodules than TGx 1448-2E in Chichiwere soils, its corresponding nodule dry weight is lower (262.2 mg plant-^{1}) thanTGx 1448-2E (333.3 mg plant^{-1}). In exception of Bekwai soils that inoculum 57 produced the highest nodule dry weight (288 mg plant-^{1}) this did not happened in Toje and Chichiwere soils as inoculum 37 outcompeted inoculum 57 for nodule dry weight in these soils that is Toje (158 mg plant^{-1} as against 156.7 mg plant^{-1}) and Chichiwere soils (344.2 mg plant^{-1} as against 342.5 mg plant^{-1}). Shoot dry weight of inoculated soybean plants also showed a greater and significantly higher yield (P<0.05) than the uninoculated controls.TGx 1903-8F produced the highest shoot dry weight in Toje soils (3.83 g plant^{-1}) and Anidaso also recorded the highest shoot dry weight in Chichiwere soils (5.40 g plant^{-1}) (Table 4). Interestingly, Davis superseded Anidaso in mean shoot weight production in one out of the three soils. This was recorded in Bekwai (3.74 g plant^{-1} as against 3.44 g plant^{-1}).Inoculum 57 produced more shoot dry weight in two out of the three soils. These soils are Chichiwere (4.97 g plant^{-1}) and Bekwai soils (4.97 g plant^{-1}). However in Toje soil, inoculum 19 topped in terms of shoot dry weight production (3.73 g plant^{-1}). Inoculation generally increased the total N fixation by way of nitrogen accumulation by soybean plants in all the three soils. Significant differences (P<0.05) existed among soil, variety and inoculant and in soil and variety interaction. However, soil, variety and inoculant interactions were not significant at the same probability level. The three promiscuous soybean varieties fixed more nitrogen in Chichiwere soil compared to the rest two. Anidaso fixed more nitrogen (200.3 mgN plant^{-1}) in Chichiwere soil than Toje and Bekwai soils. (Table 6) Interestingly Davis, a non-promiscuous soybean fixed the highest nitrogen in Bekwai soil (150.3 mgN plant^{-1}) with TGx 1903-8F performing poorly recording the lowest value (128.2 mgN plant^{-1}). Soybean in Toje soils fixed sub-optimal nitrogen with TGx 1448-2E fixing the highest nitrogen (101.0 mgN plant^{-1}) and Davis fixing the lowest nitrogen (79.8 mgN plant^{-1}). Inoculum 57 fixed the highest N in all the three soils- Toje (94.4 mgN plant^{-1}), Chichiwere (170.1 mgN plant^{-1}) and Bekwai (155.3 mgN plant-^{1})

Table 3: *Effect of inoculation with indigenous Bradyrhizobium japonicum isolates on nodule dry weight in mg per plant of four varieties of soybean in three different soils*

Soil Series	Varieties	No Inoculation	*Inoculum*			
			Isolate 19	Isolate 37	Isolate 57	Mean
Toje	Anidaso	83.3	180.0	163.3	156.7	166.7
	TGx 1448-2E	63.3	163.3	150.0	153.3	155.5
	TGx 1903-8F	96.7	180.0	173.3	193.3	182.2
	Davis	6.7	126.7	146.7	123.3	132.2
	Mean	62.5	162.5	158.3	156.7	-
Chichiwere	Anidaso	203.3	353.3	340.0	393.3	362.2
	TGx 1448-2E	136.7	260.0	406.7	333.3	333.3
	TGx 1903-8F	206.7	423.3	316.7	420.0	386.7
	Davis	146.7	293.3	313.3	223.3	276.6
	Mean	173.4	332.5	344.2	342.5	-
Bekwai	Anidaso	0.0	266.7	276.7	303.3	282.2
	TGx 1448-2E	0.0	243.3	273.3	316.7	277.8
	TGx 1903-8F	0.0	233.3	260.0	290.0	261.1
	Davis	0.0	323.3	240.0	243.3	268.9
	Mean	0.0	266.7	262.5	288.3	-

Source

LSD (P < 0.05); Soil =16.6 Variety =19.2, Inoculant= 19.2 Soil ×Variety = 33.3 Soil x variety x inoculants = 66.5

Table 4: *Effect of inoculation with indigenous Bradyrhizobium japonicum isolates on shoot dry weight (g) per plant of four varieties of soybean in three different soils*

Soil Series	Varieties	No Inoculation	*Inoculum*			
			Isolate 19	Isolate 37	Isolate 57	Mean
Toje	Anidaso	2.39	7.51	7.31	6.97	7.26
	TGx 1448-2E	3.94	6.91	6.81	7.27	7.00
	TGx 1903-8F	2.79	7.50	7.70	7.42	7.54
	Davis	1.83	7.51	6.89	7.12	7.17
	Mean	2.74	7.36	7.18	7.20	-
Chichiwere	Anidaso	4.02	9.78	9.46	13.20	10.81
	TGx 1448-2E	3.56	9.11	9.58	10.23	9.64
	TGx 1903-8F	4.16	9.43	9.51	8.95	9.30
	Davis	3.14	6.08	8.11	7.35	7.18
	Mean	3.72	8.60	9.17	9.93	-
Bekwai	Anidaso	3.54	6.60	7.01	7.02	6.88
	TGx 1448-2E	3.51	7.33	6.95	6.60	6.96
	TGx 1903-8F	4.43	6.73	7.25	7.28	7.09
	Davis	5.07	7.45	7.56	7.72	7.58
	Mean	4.14	7.03	7.19	7.16	-

LSD ($P < 0.05$); Soil =0.21 Variety =0.21, Inoculant= 024 Soil ×Variety = 0.42 Soil x variety x inoculants = 0.83

Table 5: *Effect of inoculation with indigenous Bradyrhizobium japonicum isolates on %N per plant of four varieties of soybean in three different soils*

Soil Series	Varieties	No Inoculation	*Inoculum*			
			Isolate 19	Isolate 37	Isolate 57	Mean
Toje	Anidaso	2.39	2.33	1.56	3.10	2.33
	TGx 1448-2E	1.30	3.28	2.44	2.67	2.80
	TGx 1903-8F	1.46	2.71	1.98	2.63	2.44
	Davis	1.59	2.38	2.37	2.14	2.30
	Mean	1.69	2.68	2.09	2.64	-
Chichiwere	Anidaso	2.25	3.51	3.45	3.89	3.62
	TGx 1448-2E	1.62	3.75	3.76	4.00	3.84
	TGx 1903-8F	2.86	3.47	4.25	2.71	3.48
	Davis	1.96	2.57	2.22	2.53	2.44
	Mean	2.17	3.33	3.42	3.28	-
Bekwai	Anidaso	1.18	3.98	4.37	4.07	4.14
	TGx 1448-2E	0.57	2.50	4.01	4.80	3.77
	TGx 1903-8F	1.03	2.88	4.20	3.72	3.60
	Davis	0.51	3.98	3.29	4.73	4.00
	Mean	0.82	3.34	3.97	4.33	-

LSD ($P < 0.05$); Soil =0.45 Variety =0.51, Inoculant= 0.51 Soil ×Variety =0.89 Soil x variety x inoculants = 1.78

Table 6: *Effect of inoculation with indigenous Bradyrhizobium japonicum isolates on Nitrogen fixation in mg N per plant of four varieties of soybean in three different soils*

Soil Series	Varieties	No Inoculation	*Inoculum*			
			Isolate 19	Isolate 37	Isolate 57	Mean
Toje	Anidaso	29.4	86.9	57.1	109.1	84.4
	TGx 1448-2E	25.6	124.5	83.6	95.0	101.0
	TGx 1903-8F	19.5	105.3	76.4	98.5	93.4
	Davis	14.3	82.1	82.1	75.1	79.8
	Mean	18.6	99.7	74.8	94.4	-
Chichiwere	Anidaso	44.4	173.8	162.8	264.4	200.3
	TGx 1448-2E	26.3	171.0	180.1	204.5	185.2
	TGx 1903-8F	59.0	160.3	202.0	118.7	160.3
	Davis	29.6	87.4	90.5	92.8	90.2
	Mean	39.8	148.1	158.9	170.1	-
Bekwai	Anidaso	20.8	133.3	153.5	109.1	132.0
	TGx 1448-2E	10.2	92.4	137.2	95.0	108.2
	TGx 1903-8F	22.8	94.8	151.3	98.5	114.9
	Davis	13.8	148.4	120.3	75.1	114.6
	Mean	16.9	117.2	140.6	94.4	-

LSD ($P < 0.05$); Soil =17.7 Variety =20.4, Inoculant= 20.4 Soil ×Variety = 35.4 Soil x variety x inoculants = 70.7

DISCUSSION

The fact that Bekwai contained less than 50 bradyrhizobia cells per gram of soil supports the views expressed by Cuttelan and Hungria (1994) that where soybean has not been previously grown, there is generally a response to inoculation with bradyrhizobia especially for the non-promiscuous cultivars. The present study revealed that large bradyrhizobial counts occurred in soils such as Chichiwere (6600cell/gsoil) which also supported the highest nodulation (33 per plant) in this study. This is supported by the suggestion by Danso (1992) that population range of 10^3 to 10^4 rhizobia per gram of soil should by most standard be adequate for high nodulation. There were high increases in nodulation after inoculation for both the promiscuous (Anidaso, TGx 1448-2E, TGx 1903-8F) and non-promiscuous (Davis) soybean varieties. Similar responses to inoculation by cowpea bradyrhizobia have been reported in the literature (Fening and Danso, 2001). Nodulation of both promiscuous and non-promiscuous soybean varieties by indigenous bradyrhizobia was rather low and could not be supportive of high yield. Similar findings have been reported for promiscuous soybeans grown in the moist savanna of West Africa (Okereke*et al*., 2000). Kumaga and Etu-Bonde (2000) from pot studies, demonstrated that nodulation and N_2 fixation of promiscuous soybean may be increased by inoculation with effective bradyrhizobia. The current results on nodulation agree with the findings of Fening & Danso (2002) that bradyrhizobia numbers and effectiveness vary considerably among locations. In their study they found out that indigenous cowpea bradyrhizobia were effective enough for inoculants production, a situation which is similar to this study that show soybean bradyrhizobia being effective for inoculants production. Sanginga *et al*., (1999) found that need for inoculation for some elite promiscuous soybean breeding lines depended on effectiveness of indigenous bradyrhizobia in a given locality. However the good nodulation obtained by Nangju, (1980) and Pulver *et al*., (1982) on promiscuous soybean cultivars without inoculation in contrast to this study may support the evidence that West Africa bradyrhizobial populations may vary in number and effectiveness from one location to another and that promiscuous soybeans show considerable site-specific nodulation (Pulver, *et al*., 1985). Many authors reported that non-promiscuous soybean varieties nodulate more than the promiscuous ones when they are inoculated. (Kumaga & Ofori 2004; Djagbletey, 1995, Gyau, 2001). These findings disagree with the findings in this experiment where Davis nodulated poorly in both uninoculated and inoculated soils compared to the promiscuous variety (not true when you look at the relative response to inoculation of Davis and the other varirties in Bekwai). However the ability of Davis to produce more nodules upon inoculation than the promiscuous ones in more of the soils in those experiment may be due to the fact that the exotic bradyrhizobia inocula used by those authors (Kumaga and Ofori, 2004; Djagbletey, 1995; Gyau, 2001) performed better (Pulver *et al*., 1982) than the indigenous ones used in this experiment. Even though soil series like Chichiwere harbored a lot of indigenous bradyrhizobia, during the most probable number MPN count, it still responded to inoculation perhaps due to the fact that the introduced bradyrhizobia strains were more competitive than the indigenous strains in the soil. Poor nodulation of TGx 1448-2E was a confirmation of work done by Okogun & Sanginga, (2003) who reported that thislate maturing variety nodulated poorly when screened in Nigeria with other TGx lines for two years. In this study, the low pH coupled with low available P in Bekwai soil might have accounted for no nodulation in these soils unless inoculated. This is in agreement to some extent with available report that soil deficient in P limit the extent of nodulation and N_2 fixation (Isreal, 1993). Singleton *et al*

(1992) also reported that phosphorus apart from its effect on the nodulation process and plant growth has been found to exert some direct effects on soil rhizobia.

CONCLUSION

It is concluded that inoculation of promiscuous and non-promiscuous soybeans with effective bradyrhizobia may be a more important strategy for increasing nodulation, nodule dry weight, %N, and Total N accumulation in soybean plants. However, the advantage with promiscuous nodulation is that where inoculants are absent or difficult to get, it gives an advantage over the non-promiscuous ones. The results indicate that in spite of the numerous bradyrhizobia in the soils there was still inoculation response by the soybeans suggesting that we can sometimes rely on indigenous bradyrhizobia strains instead of the foreign ones as inoculants for growth and yield

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