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Effect of *Bradyrhizobium* and Chicken Manure on Growth and Yield of Sorghum Intercropped with Soybean

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Abstract: A field experiment was carried out at Abu Usher for two successive seasons to study the effect of *Bradyrhizobium* and chicken manure (7 t/ha) on sorghum intercropped with soybean. Data were collected on shoot and root dry weights, nitrogen content, yield and land equivalent ratio (LER) of sorghum intercropped with inoculated soybean. The treatments significantly ($P \leq 0.05$) increased most of the parameters measured compared to the control (no inoculation, no manuring, no intercropping). Moreover, inoculation with the local isolate (isolate 2) plus manuring showed the highest values of the measured parameters of intercropped sorghum. Intercropping LERs were found to be 1. 68 and 1.79 for the first and second seasons, respectively.

Keywords: *Bradyrhizobium*; chicken manure; intercropping; LER; sorghum; soybean

INTRODUCTION

Farming in African countries is generally practiced under conditions of poor soil fertility. Increasing agricultural productivity with minimal inputs is an important economical, nutritional and environmental issue in these countries. Legumes can restore soil fertility by building up the soil nitrogen which would be available to the companion crops in intercropping systems. The degree to which an agricultural system really

benefits from leguminous crops depends upon the amount of nitrogen produced by the legume and remaining in its residues and utilization of these residues by other crops, as well as upon the amount of N_2 fixed (Ta *et al*. 1989; Akunda 2001).

Sorghum {*Sorghum bicolor* (L.) Moench.} is an important food grain in arid and semi-arid tropics. According to FAO (2008), sorghum is the fifth most important cereal in the world in terms of production and human consumption. The total production of sorghum in Sudan in 2006 was 110 000 ton/ha representing about 12% of world production (925 748 ton/ha). Sorghum is generally consumed as human food and as livestock feed. It is estimated that up to 97% of the protein and up to 75% of the calories in the diet of Sudanese people are derived from sorghum fermented forms (Ibrahim *et al*. 2005). Organic fertilizers improve soil properties. Chicken manure is a concentrated organic fertililizer containing all the basic nutrients necessary to plant growth, in available form. The aim of this work was to study the effect of *Bradyrhizobium* and chicken manure fertilization on growth, yield, LER and plant nitrogen content of sorghum intercropped with soybean.

MATERIALS AND METHODS

A field experiment was carried out at Abu Usher (Latitude 14˚55`N and longitude 33˚ll` E) for two successive seasons (1998/99 and 1999/00). The soil texture was 9.5% silt, 19.6% sand and 70.9 % clay, and the chemical composition was pH, 7.8; ECe, 1.58; N, 0.1% and P, 0.15 %.

Sorghum {*Sorghum bicolor* (L.) Moench.} seeds variety “Dabar” were obtained from the local market. Soybean {*Glycine max* (L.) Merr.} seeds of variety “Jupiter” were supplied by the Arab Corporation for Agricultural Investment and Development, Khartoum.

A *Bradyrhizobium* strain isolate 2 was locally isolated from nodules of soybean plants, whereas strain TAL 377 was supplied by NiFTAL Project, University of Hawaii, Paia, Hawaii, U.S.A. The strains were maintained at 4ºC on Yeast Mannitol Agar (YEMA) slopes. Charcoal-based inoculum was used to inoculate the seeds.

The experimental site was prepared by ploughing, harrowing, leveling and ridging. Phosphorus was applied as a basal dose in the form of triple super phosphate at the rate of 50 kg P_2O_5/ha. The land was divided into plots 3x4 m^2 with four 80 cm wide ridges. Chicken manure (pH=5.2, ECe=20.4, N=3.71% and P=0.003%) was added to the top soil at the rate of seven ton/ha. The plots were irrigated twice for two weeks before sowing. Soybean and sorghum were intercropped in alternative holes, three holes of soybean followed by three holes of sorghum, 20 cm apart. The experiment was arranged in split-plot design with four replicates. The following treatments were assigned to the main plots:

a) Control (no inoculation, no manuring),
b) inoculated with *Bradyrhizobium* strain TAL 377,
c) inoculated with isolate 2,
d) uninoculated plus 7 t/ha chicken manure,
e) inoculated with *Bradyrhizobium* strain TAL 377 plus 7 t/ha chicken manure, and
f) inoculated with isolate 2 plus 7 t/ha chicken manure.

The monocrops and the intercrops were arranged in the subplots. Three samples from each plot were taken at 8 and 10 weeks after sowing. Shoots and roots dry weight, yield and total nitrogen content of shoots were determined (Guebel *et al.* 1991). Land equivalent ratios (LERs) were calculated according to Willey (1979) using the following equation:

$$LER = L_A + L_B = \frac{Y_A}{S_A} + \frac{Y_B}{S_B}$$

where L_A and L_B are the LERs for the individual crops, Y_A and Y_B are the individual crop yield in intercropping, and S_A and S_B are their yields as sole crops .

Each sample was analyzed in triplicate. The data were subjected to analysis of variance and means were separated by the Duncan's multiple range test with a probability of ≤ 0.05.

RESULTS

Inoculating soybean with either strain of *Bradyrhizobium* significantly ($P \leq 0.05$) increased shoot dry weight of intercropped sorghum in the two seasons (Table 1). Chicken manure significantly ($P \leq 0.05$) increased shoot dry weight of monocropped and intercropped sorghum compared to the control plants in the two seasons. Application of chicken manure plus inoculation of soybean with either strain TAL 377 or isolate 2 showed more or less similar results (Table 1). Moreover, inoculation with isolate 2 and manuring resulted in the highest shoot dry weight of intercropped sorghum and they was significantly ($P \leq 0.05$) different from all other treatments.

Inoculating soybean with TAL 377 or isolate 2 significantly ($P \leq 0.05$) increased root dry weight of intercropped sorghum in the two seasons (Table 2). Inoculation with TAL 377 or isolate 2 and manuring significantly increased root dry weight of intercropped sorghum. There were no significant differences between the effects of the two strains.

Inoculation of intercropped soybean with TAL 377 or isolate 2 significantly ($P \leq 0.05$) increased shoot nitrogen content. There was no significant difference between the effect of the two strains (Fig.1). Application of chicken manure to monocropped or intercropped sorghum significantly increased the nitrogen content of sorghum compared to the control. However, there was no significant ($P \leq 0.05$) difference in nitrogen content between the monocropped and the intercropped plants. Addition of chicken manure to inoculated soybean with either TAL 377 or isolate 2 significantly enhanced the uptake of nitrogen by sorghum plants. Inoculation with isolate 2 and manuring increased the nitrogen content in the second season by 70.2 % compared to monocropped plants.

Chicken manure slightly increased the yield of intercropped sorghum, while significant increment was recorded for the monocropped sorghum. Inoculation of intercropped soybean with either strain TAL377 or isolate 2 increased the yield of sorghum in the first season, but the increase was not significant. However, in the second season, isolate 2 significantly ($P \leq 0.05$) increased the yield of intercropped sorghum (Fig.2). Sorghum yield was highest when the crop was grown in association with soybean inoculated with isolate 2 in the presence of manure. The percentage of increment was 69.8 in the first season and 64.9 in the second season compared to the intercropped control sorghum. Moreover, the increment was 22.2% and 27.7% in the first and second seasons, respectively, compared to monocropped control plants. Lower yields were obtained when sorghum was intercropped with uninoculated soybean.

All intercropping treatments proved to be efficient with land equivalent ratios of more than one (1.09-1.79). Soybean/ sorghum intercropping with chicken manure and inoculation with isolate 2 gave the highest LER values (Table 3).

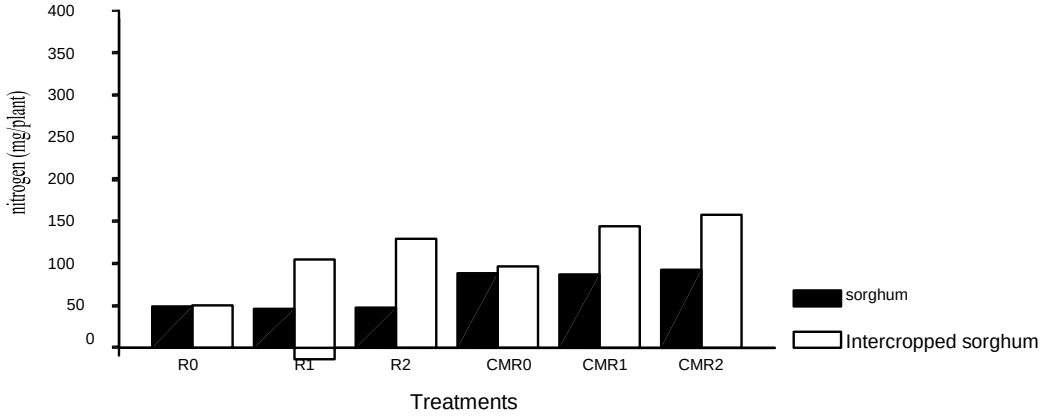
Table 1. Effect of intercropping (sorghum/ soybean), *Bradyrhizobium* inoculation and chicken manure (CM) on shoot dry weight of sorghum (g/ plant).

Treatment	Weeks after sowing			
	First season		Second season	
	8	10	8	10
	Monocropping System			
Control	25.85	65.43	39.35	69.82
TAL 377	26.55	63.81	35.90	65.60
Isolate 2	30.35	64.94	38.25	68.18
7 t/ha CM	60.37	121.75	81.73	103.0
7 t/ha CM +TAL 377	54.88	122.55	75.23	101.83
7 t/ha CM +Isolate 2	56.90	123.55	84.23	105.73
Mean	42.48	93.59	29.11	85.69
	Intercropping System			
Control	27.27	70.48	40.78	77.18
TAL 377	48.21	127.38	82.53	127.25
Isolate 2	60.32	137.03	90.88	139.73
7 t/ha CM	44.81	90.75	65.60	110.30
7 t/ha CM +TAL 377	53.84	150.93	96.85	157.23
7 t/ ha CM +Isolate 2	80.60	180.95	115.75	161.60
Mean	52.51	125.59	81.98	128.88
LSD (5%) for treatments	15.56	53.08	21.13	25.43
LSD (5%) for means	8.24	26.57	11.67	12.30

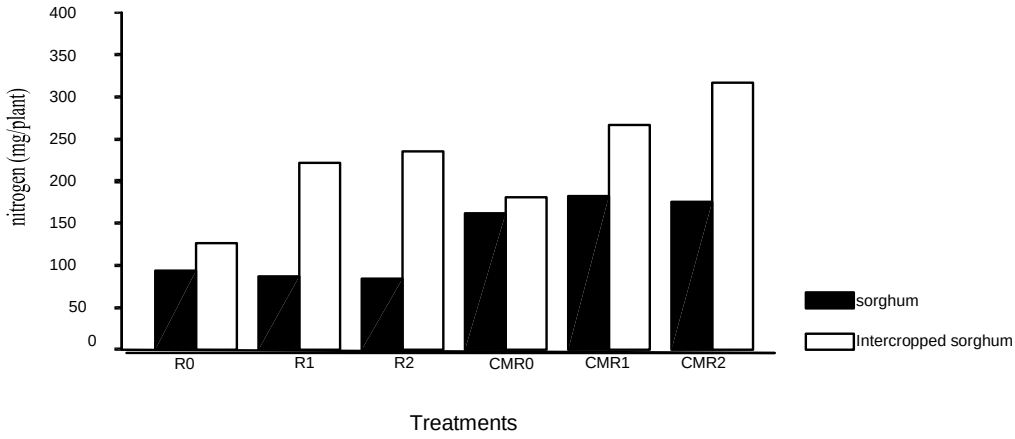
Table 2. Effect of intercropping (sorghum/ soybean), *Bradyrhizobium* inoculation and chicken manure (CM) on root dry weight of sorghum (g/ plant)

Treatment	Weeks after sowing			
	First season		Second season	
	8	10	8	10
	Monocropping System			
Control	4.28	12.52	11.05	15.53
TAL 377	4.97	13.33	9.05	16.93
Isolate 2	4.19	10.77	13.60	15.45
7t /ha CM	12.62	29.50	23.60	29.30
7t /ha CM +TAL 377	14.49	28.77	24.30	32.50
7t /ha CM +Isolate 2	13.30	29.55	22.08	30.85
Mean	9.03	20.74	17.28	23.43
	Intercropping System			
Control	4.79	12.10	12.05	16.45
TAL 377	15.28	31.53	34.05	38.58
Isolate 2	18.79	39.10	40.45	46.85
7 t/ha CM	12.25	20.70	23.08	35.45
7 t/ha CM +TAL 377	23.67	40.05	48.48	56.50
7 t/ha CM +Isolate 2	29.35	55.23	48.95	72.80
Mean	17.35	30.78	34.51	44.44
LSD (5%) for treatments	6.54	17.45	15.25	14.40
LSD (5%) for means	3.46	7.98	7.57	6.97

First season (1998/99)



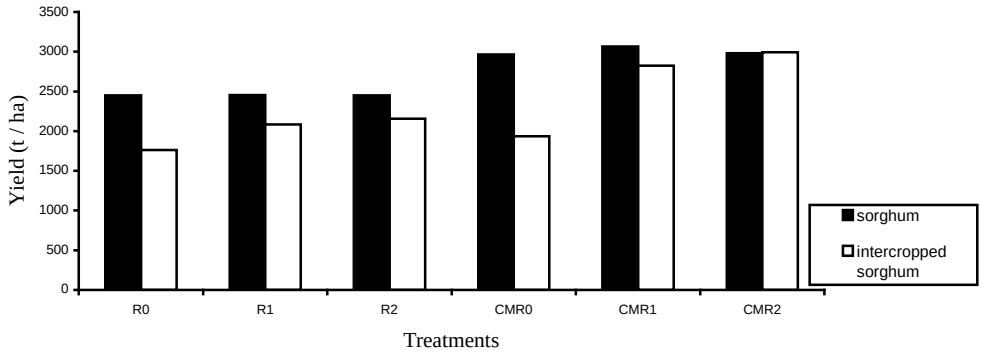
Second season (1999/00)



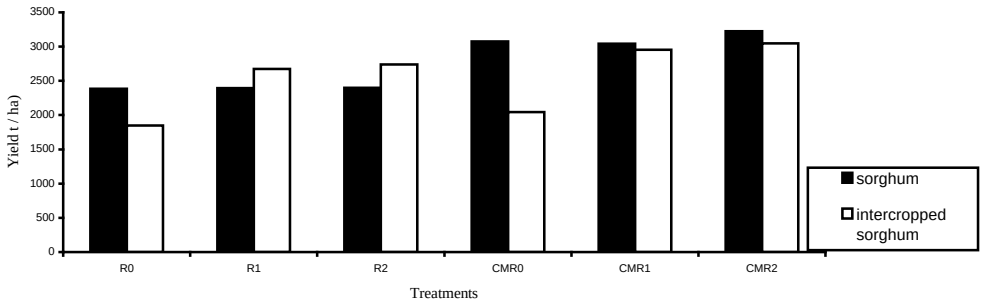
Ro=control, R1=TAL 377 ; R2=Isolate-2 ; CMR0=7 t/ha manure ; CMR1=7 t/ha manure+ TAL 377 ; CMR2=7 t/ha manure+ Isolate 2

Fig.1. Effect of intercropping (sorghum/soybean), *Bradyrhizobium* inoculation and chicken manure on nitrogen content of sorghum (mg/sorghum plant)

First season (1998/99)
LSD (5%) for treatments = 618.48



Second season (1999/00)
LSD (5%) for treatments = 836.92



Ro=control; R1=TAL 377; R2=Isolate 2; CMR0=7 t/ha manure; CMR1=7 t/ha manure+ TAL 377; CMR2=7 t/ha manure+ Isolate 2

Fig.2. Effect of intercropping (sorghum/ soybean), *Bradyrhizobium* inoculation and chicken manure on sorghum yield (t/ha)

Table 3. Land equivalent ratio (LER) of sorghum/soybean intercropping system

Treatment	First season	Second season
Control	1.09	1.16
TAL377	1.35	1.65
Isolate 2	1.44	1.70
7 t/ha CM	1.19	1.29
7 t/ha CM+TAL377	1.57	1.72
7 t/ha CM +Isolate 2	1.68	1.79
Mean	1.39	1.55

DISCUSSION

Intercropping, inoculation and manuring could be considered as an effective combination as they increased the nitrogen fixed by soybean. Sorghum plants benefited from the continuous supply of nitrogen from the associated soybean either by biological nitrogen fertilization or decomposition of nodules (Bandopadyay and De 1986) or by soybean sparing the soil nitrogen (Giller and Wilson 1993). The soil then became a useful nitrogen source for sorghum plants and that was reflected in increasing shoot dry weight, root dry weight, nitrogen content and yield of sorghum. This improvement in the intercropping system could be due to a better selection of infective and effective *Rhizobium* strains and the suitable combination of the legume and the cereal. The significant effect of chicken manure on sorghum yield could probably be attributed to its effect on increasing nitrate- nitrogen and organic matter of the soil and positive effect on soil texture, water and root penetration (El Tilib *et al.* 1993).

Intercropping of sorghum and soybean was efficient in utilizing the available resources than sole cropping resulting in higher productivity per unit area as can be judged from the LER values which were greater than 1.0 for all treatments. These results confirm the findings of Elijah (2001), Ghulam *et al*., (2003), Parasad and Brook (2005) and Ghosh *et al.* (2006). According to Ghosh *et al*. (2007), legumes contribute to maintaining the soil fertility via nitrogen fixation, which is increased in intercrops due to the more competitive character of the cereal for soil inorganic nitrogen. This leads to a complementary and more efficient use of nitrogen sources. Intercropping of grain legumes and cereals, therefore, offers an opportunity to increase the input of fixed nitrogen into agroecosystems without compromising cereal nitrogen use, yield level and stability. In this study, 79% more land planted by the sole crop is required to produce the yields achieved in intercropping. This indicates that this system will be beneficial to the farmers in terms of high yield for the food crop (sorghum) and the cash crop (soybean).

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تأثيرالبراديرايزوبيوم ومخلفات الدواجن على نمو وإنتاجية الذرة الرفيعه المحملة على فول الصويا

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موجز البحث: اجريت تجربة حقلية في أبوعشر لموسمين متتاليين لدراسة تأثير البراديرايزوبيوم ومخلفات الدواجن (7 طن/هكتار) على الذرة الرفيعه المحملة على فول الصويا . جمعت بيانات عن الوزن الجاف للمجموع الخضري والوزن الجاف للمجموع الجذري والمحتوى من النيتروجين والانتاجية ومعدل مكافي الارض (LER) لنباتات الذرة الرفيعه المحملة على نباتات فول الصويا الملقحة. ادت المعاملات الى زيادة معنوية ($P\leq 0.05$) عظم القياسات الماخوذة مقارنة بالشاهد (خالي من التلقيح ومخلفات الدواجن والزراع المحملة). ادى التلقيح بالسلالة المحلية Isolate 2 مع اضافة مخلفات الدواجن الى أعلى نتائج في كل القياسات الماخوذة مقارنة بالمعاملات الاخرى. بلغ معدل مكافيء الارض للزراعة المحملة 1.68 و 1.79 للموسمين الاول والثاني على التوالي.