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The Effects of Bradyrhizobium Inoculation on Yield and Yield Components of Hyacinth Bean (*Dolichos hyacinth* L.)

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Abstract: Field experiments were conducted at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat, Sudan, to find out the effect of *Bradyrhizobium* inoculation and chicken manure or sulphur fertilization on shoot, root, nodulation, yield and yield's components of hyacinth bean. The results showed that inoculation, chicken manure, sulphur and their interaction improved the dry weight of shoots and roots, nodulation, grain yield and yield's components of hyacinth bean.

Key words: Bradyrhizobium, inoculation, chicken manure, hyacinth bean,

INTRODUCTION

The importance of legumes as food lied primarily in their high protein content (20-25%). Hyacinth bean (*Dolichos hyacinth* L.) is an Asia origin crop and was probably domesticated in India as a cultivated grain legume. The crop is widespread in India, Egypt and Sudan as well as in Madagascar and Ethiopia. Hyacinth seed contains an average of 17% protein with *in vitro* protein digestibility of 80% (Murphy and Colucci, 1999).Leiner (1976) found that the calcium content of hyacinth bean was ranged from 167.4 to 231.1, magnesium from38.7 to 48.6, potassium from 185.3 to 214, sodium from 6 to 9, iron from 11.7 to 18.1, copper from 1.4 to 2.5, manganese from 2.5 to 3.0 and zinc from 3.6 to 4.5m/100g. These nutritional characteristics coupled with the other environmental benefits make hyacinth bean a suitable food and fodder crop for the tropics. Hyacinth is an old established irrigated crop in Sudan. The crop is used for shifting cultivation or shorter rest periods of one or a few years for the usual method of maintaining soil fertility and organic matter (English *et al.*, 1999). Grain legumes generally fix about 15-210 kg/ha/y (Dakora and Keya, 1997). It has been found that inoculation of soybean by *Bradyrhizobium japonicum* significantly increased nodulation, yield and seed quality (Okereke and Onochie, 1996). Efforts throughout the world are directed towards improving the quality of food crops by increasing the nutritional value of the grains and decreasing the anti nutrients level. Breeding, fertilization programme sand genetic engineering are directed towards improving seed quality. *Rhizobium* inoculation of faba beans was reported to increase yield and protein content (Babiker *etal.*, 1995). Therefore the objective of the present work is to examine the effect of Bradyrhizobium inoculation on yield and yield components of Dolichos *hyacinth* L.

MATERIALS AND METHODS

Materials:

Hyacinth bean (Dolichos *hyacinth* L.) cultivar used in this study was supplied kindly by Arab Corporation for Agricultural Investment and Development, Khartoum, Sudan. Bradyrhizobium (TAL 109) was obtained from the Biofertilization Department, Environment and Natural Resources Institute, National Centre for Research,

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Khartoum, Sudan. The Yeast Extract Manitol (YEM) medium was prepared according to Cleyet-Marel method.Chicken manure was obtained from The Top Farm of Faculty of Agriculture, University of Khartoum, Shambat, Sudan. Elemental sulphur was obtained from El Geneed Sugar Industry, Sudan. Strains of Bradyrhizobium were preserved by streaking on YEM agar ,mixed with 3.0 g of calcium carbonate per litre, in slants in screw –caps test tubes and kept in the refrigerator at 4º C. Seeds were inoculated by mixing with a thick suspension of charcoal based Bradyrhizobium inoculums ,with average count of 1×10^9 c fu/g .Arabic gum solution(40%) was added for good adhesion .Seed inoculation was carried out in the soil and irrigated .Unless otherwise stated all chemicals and reagents used in this are of reagent grade.

Field Experiments:

Three field experiments were conducted during three successive seasons (2000/01,2001/02 and 2002/03) at the Demonstration Farm of the Faculty of Agriculture, Shambat, University Khartoum, Sudan (Latitude 15º 40 N and Longitude 32º 32 E) with the following soil composition : 23% sand, 32% silt, 45% clay, 0.05 total N,0.033% P,1.40% organic matter, 8.0 PH value, Ece 0.52(dS/m) and cations (meq/l) 0.12K,4.50 Na,1.90 Ca and 0.70 Mg.

Chicken Manure and Sulphur Application:

Two separate experiments were conducted, for one experiment chicken manure was applied at different levels (0, 2.5, 5.0, 7.5 and 10.0 t/fed), distributed along the ridges and mixed with the soil and then the soil divided into plots. Thereafter, the plots were irrigated twice for two weeks before sowing. For the other experiment elemental sulphur was applied at different levels (0, 25, 50, 75 and 100 kg/fed). The soil was divided into plots and the plots were irrigated twice before sowing for two weeks.

Treatments:

The treatments were replicated three times in a split-split plot design. The treatments used during the first and second seasons were divided into groups as follows:

Un inoculated:

Only chicken manure was applied at different levels (0, 2.5, 5.0, 7.5 and 10.0 t/fed).

Inoculated:

The seeds were inoculated and the soil was amended with manure at different levels (0, 2.5, 5.0, 7.5 and 10.0 t/fed).

Un inoculated:

Only elemental sulphur was applied at different levels (0, 25, 50, 75 and 100 kg/fed).

Inoculated:

Only elemental sulphur was applied at different levels (0, 25, 50, 75 and 100 kg/fed).In the third season the residual effect of either chicken manure or elemental sulphur in the presence or absence of Bradyrhizobium inoculation was investigated.

Sampling:

Four samples from each plot were taken at 4 and 8 weeks after sowing to determined the number of nodules per plant and at 12 weeks to determine the dry weights of shoots and roots. At harvesting five plants were taken to determine plant height (cm), number of pods per plant, 100-seed weight (g), grain yield (g) per plant and total yield per unit area (kg/ha) .

Statistical Analysis:

Data were analyzed statistically using analysis of variance according to Gomez and Gomez (19984) procedure for a split-split plot design. The differences of means were identified by least significant differences (L.S.D) at $P \geq 0.05$.

RESULTS AND DUSCUSSION

Weight and Number of Shoots,roots,nodules and Pods:

Bradyrhizobium inoculation significantly ($P< 0.05$) increased dry weights, number of nodule / plant and pod /plant of hyacinth bean cultivar (Highworth) compared to the uninoculated control in all seasons (Tables 1, 2, 3, 4 and 5). Chicken manure and sulphur treatments significantly increased the dry weights of shoots and

roots in all seasons after 12 weeks and 4 and 8 weeks, the significance increased with the level of treatments. Interactions between treatments significantly increased the dry weights of shoots, roots, nodules and pods in all seasons. These results are in agreement with those reported by (Elsheikh, 1998), Okereke and Unaeglu (1992), Salih (2002) , Penfold *et al.,* (1995), Pankhurst *et al.* (1997) and Schawarz *et al.,* (1999). Forage legumes have likewise yielded valuable information when treated with rhizobial inoculants: hyacinth bean cultivars were reported to nodulate and were able to fix nitrogen and responded positively when inoculated with competent rhizobial strains (Mahdi and Atabani, 1992).

Yield and Yield Components:

Bradyrhizobium inoculation, incorporated and interacted with chicken manure and sulphur significantly increased the number of pods/plant in all seasons (Table 5) and increased grain yield per plant (Table 7) and improved final yield (t/ha) as represented in table 8. The presence of indigenous *Rhizobium*, soil nitrogen availability, soil physiochemical constrains and climatic conditions were reported to influence the ability of the crop to achieve maximum nitrogen fixation through inoculation (Bergerson *et al.,* 1995) and consequently improved the crop yield. Moreover, chicken manure and sulphur were showed to enrich the soil physical and chemical properties and plant growth and yield. The number of pods/plant is one of the important yield components in hyacinth bean. It was found to be positively correlated with grain yield of legume crops, in faba bean (Abdelmula *et al.,* 1993), hyacinth bean (Rajput *et al.,* 1991; Ishag, 1994; Abdel-Hafeez, 2001), fenugreek (Abdelgani *et al.,* 2003) and soybean (Salih, 2002).

The effect of inoculation with *Bradyrhizobium* on the 100-seed weight and grain yield/plant of hyacinth bean was not significant (Table 6). However, chicken manure, sulphur , significantly increased the 100-seed weight of hyacinth bean. The effects of 10 t chicken manure/fed and 100 kg sulphur/fed significantly increased 100-seed weight of hyacinth bean compared to all other treatments. Similar findings were reported by Alzidany (1995) in faba bean and Abdelgani (1997) in fenugreek.These results agreed with the findings of many workers in faba bean (Rahman *et al.,* 1988), in hyacinth bean (Abdel-Hafeez, 2001) and in soybean (Salih, 2002)., results were reported for the residual effects of triple super phosphate and phosphate rock in improving grain yield in groundnut (Elsheikh, 2003).

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Table 1: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on shoot dry weight (g) after 12 weeks of hyacinth bean grown for three consecutive seasons.

Seasons	1st season			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
					Chicken Manure				
Control	27.40	32.20	29.80	25.60	27.10	26.35	22.90	25.10	24.00
2.5t/fed	33.10	39.30	36.20	32.80	37.40	35.10	26.50	32.70	29.60
5.0t/fed	36.90	42.10	39.50	39.10	45.70	42.40	35.30	34.90	35.10
7.5t/fed	38.90	44.50	2.70	52.50	53.90	53.20	46.80	49.40	48.10
10 t/fed	48.80	54.60	52.70	58.70	60.70	59.70	58.90	63.90	61.40
Means	37.02	42.54		41.74	44.96		30.08	41.20	
Overall			39.78			43.35			35.64
					Sulphur				
Control	25.40	29.00	27.20	23.70	26.50	25.10	23.70	26.50	25.10
25kg/fed	26.80	34.80	30.80	31.50	34.90	33.20	26.90	32.30	29.60
50kg/fed	34.40	45.60	40.00	37.10	42.70	39.90	34.80	39.80	37.30
75kg/fed	39.30	47.50	43.40	49.40	54.80	52.10	39.30	41.70	40.50
100kg/fed	51.50	57.30	54.40	52.20	59.60	55.90	53.00	59.80	56.40
Means	35.48	42.84		38.78	43.70		35.54	40.02	
Overall			39.16			41.24			37.78

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	1.84	2.31	0.63
Inoculated	0.90	0.74	0.48
Amendments × Inoculated	2.80	3.01	0.90
Amendments × Level	4.43	4.76	1.42
Amendments × Inoculated × Level	6.12	6.73	2.00

Table 2: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on root dry weight (g) after 12 weeks of hyacinth bean grown for three consecutive seasons.

Seasons	1st eason			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
				Chicken Manure					
Control	1.17	1.27	1.22	0.58	0.70	0.64	2.12	2.16	2.14
2.5t/fed	1.62	1.72	1.67	0.68	0.88	0.78	2.32	2.38	2.35
5.0t/fed	1.76	1.86	1.81	1.04	1.60	1.32	3.10	3.16	3.13
7.5t/fed	1.94	2.04	1.99	1.18	1.70	1.44	3.52	3.48	3.50
10 t/fed	2.11	2.17	2.14	1.72	1.79	1.76	3.88	3.70	3.79
Means	1.72	1.82		1.04	1.32		2.99	2.99	
Overall			1.77			1.18			2.99
				Sulphur					
Control	1.06	1.16	1.11	0.71	0.75	0.73	0.98	1.24	1.11
25kg/fed	1.08	1.22	1.15	0.79	0.85	0.82	1.26	1.42	1.34
50kg/fed	1.19	1.33	1.22	0.88	1.56	1.22	1.48	1.80	1.64
75kg/fed	1.30	1.68	1.49	1.02	1.54	1.33	1.79	2.01	1.90
100kg/fed	1.53	1.71	1.63	1.68	1.76	1.73	2.15	2.39	2.27
Means	1.22	1.42		1.01	1.32		1.52	1.78	
Overall			1.32			1.16			1.65

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	0.06	0.09	0.10
Inoculated	0.0	0.05	0.03
Amendments × Inoculated	0.11	0.16	0.12
Amendments × Level	0.25	0.31	0.18
Amendments × Inoculated × Level	0.37	0.48	0.26

Table 3: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on number of nodules per plant after 4 weeks of hyacinth bean grown for three consecutive seasons.

Seasons	1st eason			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
				Chicken Manure					
Control	3.13	4.87	4.00	3.55	5.15	4.35	4.25	6.91	5.58
2.5t/fed	5.00	7.66	6.33	5.24	8.20	6.72	7.17	10.25	8.71
5.0t/fed	9.83	10.97	10.40	8.96	11.32	10.14	10.24	15.30	12.77
7.5t/fed	13.33	15.67	14.50	12.80	16.30	14.55	15.31	18.55	16.93
10 t/fed	4.50	5.84	5.17	3.89	4.91	4.40	5.20	7.32	6.26
Means	7.16	9.00		6.88	9.18		8.43	11.67	
Overall			8.08			8.03			10.05
				Sulphur					
Control	3.50	5.16	4.33	4.11	6.19	5.15	5.00	8.24	6.62
25kg/fed	6.24	8.66	7.45	7.37	10.41	8.89	7.35	12.41	9.88
50kg/fed	10.86	12.34	11.60	11.80	15.46	13.63	11.72	18.20	14.96
75kg/fed	15.19	17.27	16.23	17.51	20.37	18.94	17.09	23.45	20.27
100kg/fed	18.00	23.42	20.71	20.80	28.00	24.40	19.21	29.23	24.22
Means	10.75	13.37		12.32	16.08		12.07	18.31	
Overall			12.06			14.20			15.19

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	0.42	0.39	0.60
Inoculated	0.27	0.21	0.42
Amendments × Inoculated	0.64	0.58	0.84
Amendments × Level	1.10	1.00	1.33
Amendments × Inoculated × Level	1.60	1.42	1.88

Table 4: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on number of nodules per plant after 8 weeks of hyacinth bean grown for three consecutive seasons.

Seasons	1st eason			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
				Chicken Manure					
Control	8.04	10.84	9.44	8.04	10.84	9.44	9.09	11.25	10.17
2.5t/fed	11.13	16.21	13.67	11.13	16.21	13.67	14.20	17.64	15.92
5.0t/fed	16.47	23.83	20.15	16.47	23.83	20.15	18.78	24.14	18.21
7.5t/fed	25.20	34.56	29.88	25.20	34.56	29.88	27.19	37.03	39.03
10 t/fed	7.03	9.51	8.27	7.03	9.51	8.27	10.24	13.20	11.72
Means	13.57	18.99		13.57	18.99		15.91	20.65	
Overall			16.28			16.28			18.28

Table 4: Continue

				Sulphur					
Control	8.55	11.47	10.01	8.55	11.47	10.01	8.80	10.88	9.84
25kg/fed	11.73	17.65	14.69	11.73	17.65	14.69	13.94	17.42	15.68
50kg/fed	17.41	25.77	21.59	17.41	25.77	21.59	16.99	25.67	21.33
75kg/fed	25.84	36.04	30.94	25.84	36.04	30.94	28.00	36.80	32.40
100kg/fed	28.00	40.40	34.20	28.00	40.40	34.20	30.61	41.37	35.99
Means	18.31	26.27		18.31	26.27		19.66	26.42	
Overall			22.29			22.29			23.04

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	0.51	0.51	1.00
Inoculated	0.30	0.30	0.75
Amendments × Inoculated	0.73	0.73	1.37
Amendments × Level	1.16	1.16	2.08
Amendments × Inoculated × Level	1.64	1.64	3.00

Table 5: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on number of pods per plant of hyacinth bean grown for three consecutive seasons.

Seasons	1st eason			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
				Chicken Manure					
Control	36.08	44.84	40.46	55.83	58.12	56.98	36.38	41.28	38.83
2.5t/fed	39.67	43.59	41.63	58.56	66.22	62.39	42.50	48.06	45.28
5.0t/fed	48.83	58.75	53.79	70.83	79.89	75.36	50.59	59.65	55.12
7.5t/fed	54.17	67.75	60.96	80.85	87.87	84.36	55.56	60.42	57.99
10 t/fed	61.83	78.51	70.17	67.70	96.44	82.07	62.92	73.16	68.04
Means	48.11	58.69		66.75	77.71		49.59	56.51	
Overall			53.40			72.23			53.05
				Sulphur					
Control	36.58	41.26	38.92	49.67	51.57	50.62	41.61	42.61	42.11
25kg/fed	37.67	43.17	40.42	53.83	62.25	58.04	42.39	49.55	45.97
50kg/fed	47.75	56.75	52.25	58.58	68.76	63.67	49.78	53.72	51.75
75kg/fed	51.50	63.78	57.64	72.00	78.08	75.04	56.43	63.23	59.83
100kg/fed	60.42	74.32	67.37	76.73	84.61	75.04	61.82	75.14	68.48
Means	46.78	55.86		62.16	69.06		50.41	56.85	
Overall			51.32			65.61			53.63

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	2.26	2.59	2.00
Inoculated	1.39	1.60	1.07
Amendments × Inoculated	2.69	3.66	4.31
Amendments × Level	4.48	5.78	6.88
Amendments × Inoculated × Level	6.14	8.18	9.28

Table 6: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on 100-seed weight (g) of hyacinth bean grown for three consecutive seasons.

Seasons	1st eason			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
				Chicken Manure					
Control	20.52	20.94	20.73	21.06	21.12	21.09	19.46	20.16	19.81
2.5t/fed	20.88	20.98	20.93	21.20	21.24	21.22	19.90	20.26	20.08
5.0t/fed	21.68	21.98	21.83	21.64	21.92	21.78	20.51	20.49	20.50
7.5t/fed	22.20	22.12	22.16	21.66	21.74	21.70	20.76	21.46	21.11
10 t/fed	22.97	23.03	23.00	21.45	22.35	21.90	21.13	21.69	21.41
Means	21.65	21.83		21.41	21.67		20.35	20.81	
Overall			21.74			21.54			20.58
				Sulphur					
Control	19.19	20.61	19.90	19.69	20.71	20.20	19.46	19.98	19.72
25kg/fed	19.44	20.80-	20.12	19.75	20.81	20.28	19.90	19.96	19.93
50kg/fed	20.46	20.94	20.70	20.45	22.29	21.37	20.16	20.22	20.19
75kg/fed	20.74	21.22	20.98	20.85	22.93	21.89	20.46	20.32	20.19
100kg/fed	21.04	22.18	21.61	21.13	23.91	22.51	21.02	21.24	21.13
Means	20.17	21.15		20.37	22.13		20.00	20.14	
Overall			20.66			22.25			20.07

Table 6: Continue

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	0.56	0.49	0.55
Inoculated	0.39	0.28	0.31
Amendments × Inoculated	0.86	0.69	0.78
Amendments × Level	1.20	1.10	1.24
Amendments × Inoculated × Level	2.09	1.56	1.75

Table 7: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on grain yield per plant (g) of hyacinth bean grown for three consecutive seasons.

Seasons	1st eason			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
				Chicken Manure					
Control	44.74	49.74	47.25	36.76	48.54	42.65	52.24	58.48	55.36
2.5t/fed	48.69	55.45	52.07	56.80	53.07	54.95	57.04	69.00	63.02
5.0t/fed	53.67	64.81	59.24	63.51	75.69	69.60	64.43	76.59	70.51
7.5t/fed	60.75	69.07	64.91	74.80	81.92	78.36	73.00	85.92	79.46
10 t/fed	63.18	74.68	68.93	61.23	90.55	75.89	88.53	94.23	91.38
Means	54.21	62.75		58.62	69.96		67.04	76.84	
Overall			58.48			64.29			71.94
				Sulphur					
Control	56.13	65.37	60.75	50.42	56.44	53.43	48.18	54.66	51.42
25kg/fed	61.41	69.07	65.24	55.79	67.03	61.41	52.21	64.47	58.34
50kg/fed	64.25	75.95	70.10	62.25	74.37	68.31	59.89	71.95	65.92
75kg/fed	68.98	77.86	73.43	80.00	86.46	88.43	70.38	84.16	77.27
100kg/fed	71.25	79.65	75.45	78.38	90.82	84.60	86.63	98.35	92.49
Means	64.40	73.58		65.36	75.02		63.45	74.71	
Overall			63.74			70.19			69.08

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	1.26	2.04	1.39
Inoculated	1.72	1.01	0.87
Amendments × Inoculated	1.78	3.30	1.92
Amendments × Level	2.82	5.81	3.05
Amendments × Inoculated × Level	3.98	8.63	4.12

Table 8: Effect of Bradyrhizobium inoculation and chicken manure or sulphur fertilization on yield (kg/ha) of hyacinth bean grown for three consecutive seasons.

Seasons	1st eason			2nd season			Residual(3rd season)		
Treatment	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means	Uninoculated	Inoculated	Means
				Chicken Manure					
Control	1065.7	1185.0	1125.3	1807.3	2115.7	1961.5	1636.2	1706.4	1671.3
2.5t/fed	1159.3	1320.7	1240.0	2069.7	2113.0	2091.3	1647.2	1981.6	1814.4
5.0t/fed	1278.0	1542.7	1410.3	2050.0	2103.7	2077.8	1824.7	1679.9	1752.3
7.5t/fed	1446.7	1644.0	1545.3	1917.0	2139.0	2028.0	1714.5	1611.9	1663.2
10 t/fed	1521.0	1778.0	1649.5	2123.0	2161.0	2142.0	1875.1	1527.3	1701.2
Means	1294.1	1494.1		1993.8	2126.5		1739.5	1701.4	
Overall			1394.1			2060.1			1720.5
				Sulphur					
Control	1336.0	1556.7	1446.3	1753.3	1811.7	1782.5	1438.4	1654.0	1546.2
25kg/fed	1462.3	1644.7	1553.5	1816.7	1866.0	1841.3	1456.8	1685.2	1571.0
50kg/fed	1529.7	1800.3	1665.0	1895.3	1868.0	1881.7	1482.3	1701.5	1591.9
75kg/fed	1642.7	1853.7	1748.2	1795.3	1836.0	1818.8	1523.1	1745.7	1634.4
100kg/fed	1696.3	1896.7	1796.5	1907.7	1904.3	1906.0	1594.0	1896.4	1745.2
Means	1533.4	1750.4		1831.7	1857.2		1498.9	1736.6	
Overall			1641.9			1844.5			1617.8

Treatment (s)	LSD (5%)		
	1st season	2nd season	Residual(3rd season)
Amendments	21.55	42.10	19.23
Inoculated	30.48	59.40	26.45
Amendments × Inoculated	43.11	84.01	35.67
Amendments × Level	68.15	98.83	49.08
Amendments × Inoculated × Level	96.39	107.85	72.36

Conclusion:

Based on the results obtained, the Chicken manure and sulfur and *Bradyrhizobium* inoculation are recommended to improved growth and yield of hyacinth bean in Sudan.

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