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RESEARCH TITLE

EFFECT OF INOCULATED COWPEA, NITROGEN AND PHOSPHORUS FERTILIZERS ON GROWTH OF SORGHUM UNDER RAINFED CONDITIONS

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Abstract

Afield experiment was carried out at the experimental field of Faculty of Agriculture (Abu Naama)- University of Sinnar for two successive seasons to study the effect of *Bradyrhizobium*, N and P fertilizers on growth of sorghum intercropped with cowpea. Parameters were studied leaf numbers, leaf area, plant height and shoot dry weight. Intercropping with inoculated cowpea, N and P significantly increased leaf area, plant height and shoot dry weight of sorghum in two seasons compared with the control, where the number of leaves were not significantly affected by all treatments compared with the control.

Key Words: *Bradyrhizobium*; Nitrogen; Phosphorus; intercropping; sorghum, cowpea; rainfed

عنوان البحث

تأثير التسميد النتروجيني والفسفوري واللوبيا حلو الملقحة ببكتيريا العقد الجذرية *Bradyrhizobium* علي نمو الذرة الرفيعة

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المستخلص

أجريت تجربة حقلية بالمزرعة التجريبية لكلية الزراعة (أبونعامة) – جامعة سنار لموسميين متتالين لدراسة تأثير الزراعة البينية والتلقيح ببكتيريا العقد الجذرية (*Bradyrhizoium*) والتسميد النتروجيني والفسفوري علي نمو الذرة الرفيعة. أظهرت نتائج الدراسة أن الزراعة البينية وتلقيح اللوبيا حلو ببكتيريا العقد الجذرية (*Bradyrhizoium*) والتسميد النتروجيني والفسفوري أدى إلي زيادة معنوية في مساحة الورقة وطول النبات والوزن الجاف للساق ، كما لم يتأثر عدد الأوراق بكل المعاملات في الموسمين مقارنة بالشاهد.

Introduction:

Intercropping is becoming more important to increase crop productivity, through effective use of water, nutrients and solar energy compared to monoculture cropping (Willey, 1990)

The rainfed areas in Sudan are distributed in the west, central and southern parts, it is about 12.1 million hectare represents more than 80% of the total agriculture area in Sudan, and it lies to the south of the rainfall line 300 mm/year. More than 80% of the total sorghum in Sudan was produced under rainfied conditions.

According to FAO (2008), sorghum (*Sorghum biocolor* L. Monech) is the fifth important crop among the cereals in the world, it is a principal cereal that forms an important staple diet throughout the semi- arid Asian and African regions (Ahmed,2000). Sorghum is generally consumed as human food and as livestock feed.

In rainfed agriculture fertilizers are not routinely applied due to the following reasons: (i) it is not possible to determine when to fertilize, as it may rain at any time before or after application (ii) to minimize the production cost in risky agriculture system due to rain fluctuation (iii) high cost of chemical fertilizers and low prices of the crop.

Therefore, it is important to provide a cheap source to increase the chemical content of soil through intercropping system. The main objectives of this study was to determine the effect of inoculation with *Bradyrhizobium* strain, intercropping, nitrogen and phosphorus fertilization and their interactions on growth of sorghum under rainfed conditions.

Materials and Methods:

Afield experiment was carried out at the experimental field of Faculty of Agriculture (Abu Naama) - University of Sinnar (Latitude 12◦ 44 N and Longitude 34◦ 7 E) for two successive seasons (2014and 2015). The soil of the experimental site is characterized by 11.5% sand, 19.6% silt. 68.9% clay. pH=8.1.Ece= 0.9, N= 0.06% and P=5.3%.

Sorghum (*Sorghum biocolor* L. Monech) seeds of variety tabat were obtained from the Sudanese Arabian company, cowpea (*Vigna unguiculata* L. Walps) seeds were obtained from the local market of Abu Naama, and *Bradyrhizobium* strain was obtained from Environment and Natural Resources Research Institute, National Centre for Research.

The experimental site was prepared by ploughing, harrowing, then leveling and ridging. The land was divided into plots, each of 4X6 m, 70 cm between ridges, and six

north- south ridges per plot. P and N fertilizers were added at sowing. The experiment was arranged in split split plot design with six replicates. The following treatments were assigned to main plots:

1- Uninoculated (Control)

2- Inoculated with *Bradyrhizobium* strain.

The following cropping systems were assigned to the sub plots:

1- Cowpea (monocropping system)

2- Cowpea/sorghum (intercropping system)

3- Sorghum (monocropping system)

The following fertilizers were assigned to the sub sub plots:

1- No fertilizers (control)

2- 20 Kg N/ha

3- 50 Kg P/ha

At sowing, seeds of cowpea were wetted using 40% gum Arabic solution and mixed thoroughly with the charcoal based inoculums of *Bradyrhizobium*, inoculated seeds were left to dry for few minutes in shade. Five seeds of inoculated or uninoculated cowpea in conjunction with sorghum were sown by hand on the ridges in holes 30 cm apart, which were later thinned to three plants per hole for both crops. The crops were grown in alternate, single rows. The plots were irrigated immediately after sowing. There after rainfall was the main source of irrigation.

Three samples from each plot were taken at 4, 6, 8 and 10 weeks after sowing. The parameters which were measured are leaves number, plant height, and leaf area and shoot dry weight (determined after drying in an oven at 70°C for 48 hours).

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 probability of $P \leq 0.05$.

Results:

All treatments did not significantly (P≤ 0.05) affected the leaf numbers of sorghum compared with the untreated control in the two cropping system in the two seasons (Tables 1 &2).

Application of N or P significantly (P≤ 0.05) increased the leaf area of sorghum. However, this effect is more pronounced during the 8th and 10th weeks compared with untreated control in the two seasons (Tables 3 &4).

Inconsistent results were observed on plant height of sorghum by treatments, where the application of both *Bradyrhizobium* strains and 50 Kg P/ha in one treatment significantly (P≤ 0.05) increased it compared with the untreated control in both seasons (Tables 5 &6).

The shoot dry weight of sorghum was significantly (P≤ 0.05) increased by *Bradyrhizobium* strain, application of N or P and their combination with *Bradyrhizobium* strain compared with the untreated control (Tables 5 &6).

Table 1: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on number of leaves in sorghum (leaf/plant) in season 2014

Treatments	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	6.0[a]	6.4[a]	7.7[a]	8.7[a]
20 Kg N/ha	6.4[a]	6.5[a]	8.2[a]	9.6[a]
50 Kg P/ha	6.3[a]	6.6[a]	8.5[a]	9.5[a]
TAL 169	6.2[a]	6.4[a]	7.8[a]	8.6[a]
TAL 169+20Kg N/ha	6.3[a]	6.6[a]	8.2[a]	9.6[a]
TAL 169+50Kg P/ha	6.3[a]	6.6[a]	8.4[a]	9.5[a]
Mean	6.3	6.5	8.1	9.3
	Intercropping system			
Control	6.2[a]	6.3[a]	7.5[a]	8.7[a]
20 Kg N/ha	6.2[a]	6.5[a]	8.3[a]	9.4a
50 Kg P/ha	6.3[a]	6.4[a]	8.3[a]	9.2[a]
TAL 169	6.5[a]	6.5[a]	7.7[a]	8.7[a]
TAL 169+20Kg N/ha	6.3[a]	6.5[a]	8.2[a]	9.1[a]
TAL 169+50Kg P/ha	6.4[a]	6.5[a]	8.4[a]	9.3[a]
Mean	6.3	6.5	8.1	9.1
LSD (5%) treatment	0.46	0.58	0.90	1.0
LSD (5%) means	0.08	0.10	0.15	0.1

Table 2: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on number of leaves in sorghum (leaf/plant) in season 2015

Treatment	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	5.8[a]	6.3a	7.6[a]	8.9[a]
20 Kg N/ha	6.3[a]	6.6[a]	7.6[a]	9.2[a]
50 Kg P/ha	6.2[a]	6.6$_a$	7.7[a]	9.3[a]
TAL 169	5.7[a]	6.3[a]	7.6[a]	8.8[a]
TAL 169+20Kg N/ha	6.2[a]	6.5[a]	7.9[a]	9.4[a]
TAL 169+50Kg P/ha	6.2[a]	6.5[a]	8.0[a]	9.4[a]
Mean	6.1	6.5	7.7	9.2
	Intercropping system			
Control	5.8[a]	6.4[a]	7.6[a]	8.9[a]
20 Kg N/ha	6.3[a]	6.3[a]	8.0[a]	9.3[a]
50 Kg P/ha	6.3[a]	6.3[a]	8.1[a]	9.3[a]
TAL 169	5.8[a]	6.4[a]	7.6[a]	8.9[a]
TAL 169+20Kg N/ha	6.3[a]	6.3[a]	8.1[a]	9.4[a]
TAL 169+50Kg P/ha	6.1[a]	6.4[a]	8.2[a]	9.3[a]
Mean	6.1	6.4	7.9	9.2
LSD (5%) treatment	0.56	0.40	0.70	0.76
LSD (5%) means	0.09	0.07	0.12	0.13

Table 3: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on leaf area of sorghum (cm2/plant) in season 2014

Treatment	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	25.50[a]	43.20[a]	218.86[a]	229.25[a]
20 Kg N/ha	50.35[bcd]	57.59[bc]	328.70[bcd]	354.00[c]
50 Kg P/ha	48.91[bc]	69.68[c]	400.00[d]	409.07[de]
TAL 169	25.78[a]	43.56[a]	215.14[a]	231.11[a]
TAL 169+20Kg N/ha	49.55[bcd]	57.58[bc]	329.99[cd]	374.20[cde]
TAL 169+50Kg P/ha	49.25[cd]	66.81[c]	399.71[d]	417.40 [d]
Mean	41.56	55.77	315.40	335.88
	Intercropping system			
Control	28.45 [a]	50.36[ab]	224.38[ab]	258.92[ab]
20 Kg N/ha	53.36[bcd]	58.62[bc]	340.46[d]	354.83[cd]
50 Kg P/ha	61.90[cd]	64.68[c]	343.07[d]	361.29[cd]
TAL 169	29.19[a]	57.02[bc]	241.27[abc]	283.78[b]
TAL 169+20Kg N/ha	47.93[b]	65.22[bc]	344.14[d]	359.90[cd]
TAL 169+50Kg P/ha	62.38[d]	66.99[c]	353.64[d]	374.75[cd]
Mean	47.20	60.48	307.83	332.25
LSD (5%) treatment	6.58	8.44	83.04	29.12
LSD (5%) means	1.10	1.41	13.84	4.58

Table 4: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on leaf area of sorghum (cm2/plant) in season 2015

Treatment	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	23.19^{a}	39.28^{a}	199.16^{a}	208.87^{a}
20 Kg N/ha	45.77^{bc}	52.35^{bc}	313.29^{d}	322.14^{c}
50 Kg P/ha	44.47^{c}	59.71^{c}	364.04^{d}	372.26^{d}
TAL 169	23.43^{a}	39.60^{a}	195.78^{a}	210.38^{a}
TAL 169+20Kg N/ha	45.04^{cd}	52.53^{b}	300.29^{bcd}	340.52^{cd}
TAL 169+50Kg P/ha	44.67^{cd}	60.74^{c}	363.74^{d}	379.84^{d}
Mean	37.70	50.70	289.30	305.60
	Intercropping system			
Control	25.86^{ab}	45.78^{ab}	204.18^{ab}	235.62^{ab}
20 Kg N/ha	47.14^{cd}	53.29^{bc}	315.33^{d}	322.90^{cd}
50 Kg P/ha	56.27^{d}	58.80^{c}	312.20^{cd}	328.78^{cd}
TAL 169	26.54^{ab}	51.84^{bc}	219.55^{abc}	258.24^{b}
TAL 169+20Kg N/ha	43.58^{bc}	59.29^{c}	313.17^{d}	327.67^{cd}
TAL 169+50Kg P/ha	56.71^{d}	60.90^{c}	321.81^{d}	333.01^{cd}
Mean	42.60	54.90	281.00	301.04
LSD (5%) treatment	6.06	10.90	75.60	26.50
LSD (5%) means	1.01	1.82	12.60	4.42

Table 5: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on plant height of sorghum (cm/plant) in season 2014

Treatment	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	33.73^{a}	44.55^{a}	69.67^{a}	83.17^{a}
20 Kg N/ha	39.08^{ab}	57.03^{bc}	87.17^{bc}	91.56^{ab}
50 Kg P/ha	46.11^{c}	58.39^{bc}	102.50^{d}	95.22^{b}
TAL 169	35.40^{a}	46.39^{ab}	69.72^{a}	83.50^{a}
TAL 169+20Kg N/ha	43.42^{bc}	56.86^{bc}	86.56^{bc}	93.05^{ab}
TAL 169+50Kg P/ha	45.72^{c}	57.39^{bc}	100.00^{cd}	94.50^{b}
Mean	40.50	53.40	85.90	90.10
	Intercropping system			
Control	35.78^{a}	45.86^{a}	79.22^{ab}	86.83^{ab}
20 Kg N/ha	46.22^{c}	57.33^{bc}	89.67^{bc}	92.11^{ab}
50 Kg P/ha	49.11^{c}	55.00^{b}	94.61^{bcd}	95.50^{b}
TAL 169	35.56^{a}	46.56^{ab}	78.56^{ab}	89.89^{ab}
TAL 169+20Kg N/ha	44.28^{bc}	57.28^{bc}	86.50^{b}	92.17^{ab}
TAL 169+50Kg P/ha	46.00^{c}	60.83^{c}	90.06^{bc}	95.11^{b}
Mean	42.81	53.82	86.41	91.90
LSD (5%) treatment	5.28	4.74	10.66	8.58
LSD (5%) means	0.88	0.79	1.78	1.43

Table 6: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on plant height of sorghum (cm/plant) in season 2015

Treatment	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	34.33^{a}	47.72^{a}	69.61^{abc}	78.61^{a}
20 Kg N/ha	49.50^{c}	59.36^{c}	86.25^{e}	96.25^{d}
50 Kg P/ha	44.97^{bc}	60.39^{c}	86.73^{e}	91.73^{bcd}
TAL 169	34.11^{a}	47.89^{a}	69.45^{abc}	79.23^{ab}
TAL 169+20Kg N/ha	49.13^{c}	59.70^{c}	89.03^{e}	99.03^{d}
TAL 169+50Kg P/ha	44.59^{bc}	59.56^{c}	88.06^{e}	95.89^{d}
Mean	42.70	55.70	81.50	90.10
	Intercropping system			
Control	36.69^{ab}	49.03^{ab}	68.78^{a}	77.94^{a}
20 Kg N/ha	48.67^{c}	57.50^{abc}	85.00^{cde}	93.00^{cd}
50 Kg P/ha	45.47^{bc}	55.67^{abc}	85.56^{de}	94.72^{d}
TAL 169	36.94^{ab}	48.22^{ab}	69.11^{ab}	79.95^{ab}
TAL 169+20Kg N/ha	45.67^{bc}	59.61^{c}	82.89^{cde}	88.06^{bcd}
TAL 169+50Kg P/ha	45.50^{bc}	62.61^{c}	86.61^{e}	91.61^{bcd}
Mean	43.10	55.40	79.60	87.50
LSD (5%) treatment	9.42	7.82	11.02	9.82
LSD (5%) means	1.57	1.30	1.84	1.64

Table 7: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on shoot dry weight of sorghum (g/plant) in season 2014

Treatment	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	0.32^{a}	5.03^{a}	10.61^{a}	13.99^{a}
20 Kg N/ha	0.84^{de}	6.36^{abc}	18.68^{cde}	22.44^{bc}
50 Kg P/ha	0.89^{ef}	7.30^{c}	21.60^{def}	25.10^{c}
TAL 169	0.36^{ab}	5.32^{ab}	11.78^{ab}	13.79^{a}
TAL 169+20Kg N/ha	0.87^{def}	6.00^{abc}	19.35^{cdef}	20.92^{b}
TAL 169+50Kg P/ha	0.90^{f}	6.78^{bc}	21.93^{ef}	24.92^{c}
Mean	0.60	6.10	17.30	20.10
	Intercropping system			
Control	0.40^{b}	5.14^{ab}	13.39^{b}	13.76^{a}
20 Kg N/ha	0.82^{d}	6.36^{abc}	17.88^{cd}	22.00^{bc}
50 Kg P/ha	0.85^{def}	6.88^{bc}	20.48^{cdef}	23.94^{bc}
TAL 169	0.47^{c}	5.31^{ab}	17.57^{c}	14.12^{a}
TAL 169+20Kg N/ha	0.90^{f}	6.54^{abc}	20.86^{def}	22.63^{bc}
TAL 169+50Kg P/ha	0.89^{ef}	7.08^{bc}	22.80^{f}	24.91^{c}
Mean	0.70	6.20	18.80	20.20
LSD(5%) treatment	0.06	1.62	2.70	3.42
LSD(5%) means	0.01	0.27	0.45	0.57

Table 8: Effect of inoculation, N, P and intercropping (sorghum/cowpea) on shoot dry weight of sorghum (g/plant) in season 2015

Treatment	Time (Weeks after sowing)			
	4	6	8	10
	Monocropping system			
Control	0.96[a]	2.61[a]	14.11[ab]	19.03[ab]
20 Kg N/ha	1.85[b]	4.33[b]	22.18[cd]	26.70[cd]
50 Kg P/ha	1.88[b]	4.16[b]	24.93[d]	27.52[cd]
TAL 169	0.94[a]	2.12[a]	13.91[a]	16.84[a]
TAL 169+20Kg N/ha	1.85[b]	4.70[b]	21.34[bcd]	25.12[bc]
TAL 169+50Kg P/ha	1.80[b]	4.70[b]	23.10[cd]	27.38[cd]
Mean	1.50	3.70	19.90	23.70
	Intercropping system			
Control	0.95[a]	1.88[a]	13.39[a]	17.43[ab]
20 Kg N/ha	1.89[b]	4.28[b]	16.55[ab]	26.32[cd]
50 Kg P/ha	2.08[b]	4.68[b]	18.15[b]	27.75[cd]
TAL 169	0.94[a]	1.95[a]	19.07[b]	21.32[b]
TAL 169+20Kg N/ha	1.97[b]	4.26[b]	20.86[bc]	27.32[cd]
TAL 169+50Kg P/ha	2.05[b]	4.85[b]	22.80[cd]	28.25[d]
Mean	1.60	3.60	18.47	24.73
LSD (5%) treatment	0.38	0.92	3.14	2.42
LSD (5%) means	0.06	0.15	0.52	0.40

Discussion

A general assumption in intercropping cereals with legume crops is that the legumes when associated with specific *Rhizobium*, may have most of its nitrogen need supplied through fixation of atmospheric nitrogen, leaving the soil available nitrogen for the companion cereals. The leguminous plant can benefit the intercropped cereals in the same season through nitrogen execration (*Eaglesham et al*., 1981) and nodule decomposition (Saito, 1982). In this study, sorghum plant benefited from the cropping system, because the nitrogen supplied by cowpea through fixation or nodules decomposition used by it and this reflected in enhancing the growth, which increasing most of parameters studied.

Nitrogen and phosphorus fertilizers significantly increased height of sorghum. The plant height of sorghum was found to increase with nitrogen (Kharbade and Sabale, 2002; Mayub *et al*., 2002) and phosphorus (Khalid *et al*., 2003).

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