Effect of organic manures and mineral N fertilizer on production of groundnuts (*Arachis hypogaea* L.) in Malakal area

Hatim A. Sulfab[1], Nuri O. Mukhtar[2], Adam I. Adam[3] and Muawia E. Hamad[4]

[1]Faculty of Agriculture, University of Upper Nile, P.O. Box 1660, Khartoum, Sudan.
[2]Agricultural Research Corporation, Wad Madani, Sudan.
[3] Faculty of Agriculture, University of Sinnar, Sudan.
[4]Faculty of Agricultural Sciences, University of Gezira, Wad Madani, Sudan.

ABSTRACT

Field experiments were conducted for two rain-fed seasons (2006 and 2007) at the University of Upper Nile, Faculty of Agriculture farm (Malakal), to study the effect of farmyard manure, water hyacinth compost and inorganic N fertilizer on the growth and yield of groundnuts. These manures were added at 15 t ha^{-1} alone or in combination with 86 kg N ha^{-1}, compared to 86 kg N ha^{-1} alone. Application of 86 kg N ha^{-1}alone increased groundnuts vegetative growth and resulted in significantly more hay yield at harvest. However, it had no adverse effects on number of nodules per plant. It also did not significantly increase pod yield over that of the control. The treatments with either organic manure produced significantly more nodulation. They resulted in significantly high pod and hay yields over that of the control for both seasons. The treatments with either organic manure augmented with 86 kg N ha^{-1} significantly increased plant shoot and root dry weights, nodule number $plant^{-1}$, and plant N and P uptake. They resulted in significantly the highest pod and hay yields over all other treatments for both seasons.

INTRODUCTION

Groundnuts (*Arachis hypogaea* L.) was introduced as a rotational legume in the Gezira Scheme for increasing soil fertility in the late 1950s. By 1970 it proved to be a very important food (cooking oil), feed, as well as an export crop. By 1977, the Sudan attained self-sufficiency in cooking oil and the country was fourth in the list of groundnuts exporting countries. At that time, the total countries area grown to groundnuts in the Sudan was about 2.5 million feddans; no fertilizers or manures were used for groundnuts production. Today, 3 to 5 million feddans are grown to groundnuts in the Sudan. Eighty percent of the groundnuts area is under rain-fed, on the goz sands of the semi-arid zone in Kordofan and Darfur where rainfall is relatively low, and the soils have low fertility. The remaining 20% of the area is grown under irrigation in the heavy clay Vertisols of the central clay plain mainly in the Gezira and Managil Schemes (Mukhtar and Ali, 1998).

The beneficial effect of organic manures on groundnuts growth and yield has been documented. Mukhtar (1993) found that addition of organic fertilizers (manures or compost) significantly increased the growth and yield of groundnuts. Muller and Pereira (1995) reported that farmyard manure treatment increased nodule numbers and nodule mass by 34% and 36% over that of the control. Abrue Junior *et al*. (2002) found that the addition of compost improved soil organic carbon and total nitrogen. Organic manure treatments and biofertilizer exhibited high values of the soil nutrients N, P, Ca and S (Stephen and Nybe, 2003).

Mugwira *et al*. (2002) found that the addition of 15 t of farmyard manure ha^{-1} increased the grain yield of maize by 16% compared to 8.9 % by mineral fertilizer over those of the control. Shanjida Khar and Sarwar (2002) reported that application of water hyacinth compost (WH) alone or with mineral fertilizer increased the yield of rice over that of the control. The combination of organic and inorganic fertilizers recorded significantly more soybean yield than that of the inorganic fertilizer alone (Ghosh *et al*., 2004). Manisha *et al*. (2007) reported that the integrated application of farmyard manure or water hyacinth compost in combination with chemical fertilizer significantly improved the yield and quality of peanuts kernel over that of the sole chemical fertilizer.

Leidi and Rodriguez (2000) showed that the higher level of nitrogen was found to be deleterious to nodulation and N_2-fixation. Gentili *et al*. (2006) reported that when legumes are supplied with adequate mineral nitrogen, the plant resist infection by rhizobia and nodulation is drastically reduced. Nitrogen application significantly increased shoot fresh weight of guar (Babiker *et al*., 2009). Forawi (1994) found that nitrogen fertilization of 86 kg N ha^{-1} significantly increased shoot and root dry weights and shoot nitrogen content of fenugreek plant.

The objective of this study was to compare the effect of manures and mineral nitrogen on groundnuts growth, nodulation, yield and N and P uptake.

MATERIALS AND METHODS

Groundnut seeds

Seeds of groundnuts (*Arachis hypogea*e L.) cultivar Sodari were obtained from Elobeid Agricultural Research Station. Sodari cultivar was selected because it is early maturing (90 to100 days). It is an upright Spanish type cultivar. It is tolerant to water stress conditions and expected to suit southern Sudan conditions.

Site characterization

Field experiments were conducted for two rain-fed seasons (2006 and 2007) at the experimental farm of the Faculty of Agriculture, University of Upper Nile, Malakal. The soil has a high clay content (>50%) and low water permeability. It is non - saline and non - sodic. The soil has 0.07% nitrogen, 0.44% organic carbon, and fair available phosphorus (12 ppm). The soil is classified as Entic Pellusterts. The field site has never had any previous history of *Rhizobium* inoculation. Total rainfall was 781mm and 869 mm for the first and second seasons, respectively.

Land preparation

The land was ploughed, harrowed and leveled. It was then divided into 5 x 3.6 m subplots. Five ridges per plot were prepared in a north– south direction with 60 cm between ridges. The design used was the randomized complete block design with four replicates.

Fertilizers application

Nitrogen was added in the form of urea at the rate of 86 kg N ha^{-1}, and phosphorus in form of TSP at the rate of 43 kg P_2O_5 ha^{-1}. Water hyacinth (WH) compost and farmyard manure were added at the rate of 15 t ha^{-1}. Inorganic fertilizers were broadcast and incorporated into the soil before sowing. The manures were broadcast and incorporated into the soil two weeks before sowing. Some chemical properties of the manures used were determined using micro-Kjeldahl method for nitrogen, Nelson and Sommers (1982) for organic carbon and Olsen and Sommers (1982) for phosphorus (Table 1).

Table 1. Some chemical components of the organic manures.

Organic manures	N (%)	O.C (%)	C/N	P (%)
Farmyard manure (FYM)	1.79	14.3	8	0.45
Water hyacinth compost (WH)	1.26	22.6	18	0.32

Sowing

Seeds were planted by hand on the top of the ridge at the depth of 4 to 5 cm in holes with 15cm between holes and two seeds per hole as recommended by Agricultural Research Corporation (ARC). Sowing started in the first week of July in both the first season (Fs) and second season (Ss) when rainfall reached 25 mm or more. Hand-weeding was carried out starting at 2 weeks after sowing (WAS) and then each two weeks until 8WAS.

Treatments

1- Control (Con).
2- Farmyard manure (M) 15 t ha^{-1}.
3- Water hyacinth compost (WH) 15 t ha^{-1}.
4- 86 kg N ha^{-1} (N).
5- 86 kg N ha^{-1} + farmyard manure (NM).
6- 86 kg N ha^{-1} + water hyacinth compost (NWH).

Sampling procedure

Five plant samples were taken from each plot at 4 weeks after sowing (4WAS) and then three plant samples were taken at 6 and 8WAS. A tunnel was made around the plant to be sampled to avoid lateral roots destruction. A spade was used to lift up the soil clump inside the circle. Each sample was put in a labeled paper bag and taken to the laboratory.

Harvesting

Harvest was done at 100 days after sowing for both seasons. Each plot was harvested separately. Pods were detached, air-dried and weighed to determine pod and kernel yields of each plot.

Parameters measured

1-Shoot and root dry weights (g $plant^{-1}$) were determined at 4, 6 and 8WAS.
2- Number of nodules $plant^{-1}$ was determined at 4, 6 and 8WAS.
3- Early pod setting (g $plant^{-1}$) was determined at 4, 6 and 8WAS.
4-Shoot nitrogen percentage was determined using Kjeldahl method.
5- Plant phosphorus percentage was determined according to Jackson (1958).
6- Pod, kernel and hay yields (t ha^{-1}): Pod, kernel and hay yields were determined in kg per plot. Yield samples were taken from ridge numbers 2, 3 and 4 considering 1 and 5 as guard rows. Only three metres of each of the 3 rows were taken and one metre from each side was left as guard area. The sample area for the mentioned parameters was, therefore, only 5.4 m^2 from which pod, kernel and hay yields were calculated in tons ha^{-1}.

The data were subjected to the analysis of variance procedure, and the means were separated using Duncan`s Multiple Range Test.

RESULTS

Shoot dry weight

The data in Table 2 of the first season showed that at 4WAS, no treatments had any influence on plant shoot dry weight. At 6WAS, farmyard manure alone significantly ($P \leq 0.05$) increased groundnuts shoot dry weight only over that of the control. At 8WAS, treatments with either organic manure coupled with 86 kg N ha^{-1} significantly ($P \leq 0.05$) increased groundnuts shoot dry weight over those of 86 kg N ha^{-1} and the control. As for the second season, all the treatments significantly ($P \leq 0.05$) increased groundnuts shoot dry weight over that of the control. The best treatments were NM and NWH.

Table 2. Effects of organic manures and mineral N fertilization on groundnuts shoot dry weight (g plant^{-1}).

Treatment	4 WAS		6 WAS		8 WAS	
	Fs	Ss	Fs	Ss	Fs	Ss
Control	3.3 c	2.8 c	7.8 d	4.0 e	16.3 c	9.0 e
M	3.4 c	4.9 b	15.5 a	7.0 d	22.0 c	15.8 d
WH	2.7 c	5.3 b	9.0 bcd	9.5 b	20.7 c	17.2 d
N	3.5 bc	4.9 b	10.0 c	5.9 de	24.8 c	15.0 d
NM	3.3 c	5.9 a	10.6 c	12.6 a	31.4 ab	27.7 a
NWH	3.8 abc	5.6 a	14.3 b	8.3 c	34.0 a	16.8 c
SE (±)	0.5	0.6	0.7	0.8	3.2	1.6
CV (%)	23.5	20.1	21.3	23.7	21.5	23.7

Means followed by the same letters in a column are not significantly different at 5% level according to Duncan's Multiple Range Test.

Fs= first season, 2006. Ss = second season, 2007.

Root dry weight

The data in Table 3 of the first season showed that at 4WAS, no treatment had any influence on plant root dry weight. At 6WAS, farmyard manure alone significantly (P≤0.05) increased root dry weight only over the control. At 8WAS, treatments with either organic manure augmented with 86 kg N ha^{-1} significantly (P≤0.05) produced more plant root dry weight over those of 86 kg N ha^{-1} sole and the control. As for the second season, at 4WAS, either organic manure coupled with the 86 kgNha^{-1} significantly (P≤0.05) increased root dry weight only over the control. At 6WAS, WH alone and farmyard manure coupled with 86 kg N ha^{-1} significantly (P≤0.05) produced more plant root dry weight only over the control. At 8WAS, either organic manure coupled with 86 kg N ha^{-1} and WH alone significantly (P≤0.05) increased root dry weight only over the control.

Pod setting

The data in Table 4 showed that at 4WAS there was no pod formation. At 6WAS, water hyacinth compost alone significantly (P ≤ 0.05) increased pod weight over the control, but at 8WAS, all the treatments except 86 kg N ha^{-1} significantly (P≤0.05) produced more pod weight over the control in both seasons

Table 3. Effects of organic manures and mineral N fertilization on groundnuts root dry weight (g plant^{-1})

Treatment	4 WAS		6 WAS		8 WAS	
	Fs	Ss	Fs	Ss	Fs	Ss
Control	0.5 ns	0.4 b	0.71 bcd	0.7 c	0.62 c	0.8 b
M	0.7 ns	0.7 ab	1.16 a	1.2 c	0.90 abc	2.0 ab
WH	0.5 ns	0.7 ab	0.58 cd	1.7 a	1.14 abc	2.9 a
N	0.5 ns	0.7 ab	0.67 bcd	1.1 bc	0.62 c	1.7 ab
NM	0.5 ns	0.8 a	1.06 ab	1.5 b	1.24 ab	2.7 a
NWH	0.5 ns	0.8 a	0.73 bcd	1.2 c	1.32 a	2.7 a
SE (±)	0.2	0.1	0.1	0.3	0.2	0.4
CV (%)	28.5	27.3	32.1	33.5	36.6	37.1

Means followed by the same letters in a column are not significantly different at 5% level according to Duncan's Multiple Range Test.
ns= not significantly different at P≤ 0.05.
Fs= first season, 2006.
Ss = second season, 2007.

Table 4. Effect of organic manures and mineral N fertilization on pod setting (g plant^{-1})

Treatment	6 WAS		8 WAS	
	Fs	Ss	Fs	Ss
Control	1.9 c	0.8d	5.9 d	8.3 e
M	4.8 c	4.8 b	15.3 c	20.0 d
WH	10.1 a	10.8 a	14.8 c	27.2 c
N	3.2 c	2.4 cd	12.4 cd	8.3 e
NM	5.0 ab	2.8 cd	20.7 b	37.0 a
NWH	4.3 c	4.3 b	22.8 a	30.9 ab
SE (±)	2.9	1.3	2.9	3.9
CV (%)	27.5	23.8	27.8	22.2

Means followed by the same letters in a column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Fs= first season, 2006. Ss = second season, 2007.

Plant nodulation

The data in Table 5 showed that 86 kg N ha^{-1} significantly (P≤0.05) increased plant nodulation over the control at 4WAS in the first season. At 6WAS, farmyard manure alone and water hyacinth compost coupled with 86 kg N ha^{-1} significantly (P≤0.05) increased nodulation over that of the control. At 8WAS, all the treatments gave significantly (P≤0.05) more plant nodulation over that of the control. As for the second the season, at 4WAS, all the treatments except the 86 kg N ha^{-1} significantly (P≤0.05)
increased nodulation over that of the control. At 6WAS, all the treatments significantly (P≤0.05) increased nodulation over the control. At 8WAS, each of the organic manure alone and farmyard manure coupled with 86 kg N ha^{-1} gave significantly (P≤0.05) more plant nodulation over that of the control.

Table 5. Effect of organic manures and mineral N fertilization on number of nodules $plant^{-1}$.

Treatment	4 WAS		6 WAS		8 WAS	
	Fs	Ss	Fs	Ss	Fs	Ss
Control	41 c	31e	61 b	42 d	159 e	130 c
M	47 c	68 b	134 a	79 ab	261 b	248 ab
WH	44 cd	74 a	100 ab	88 a	290 a	250 ab
N	63 a	39 e	75 b	57 c	223 c	165 bc
NM	46 c	65 cd	101 ab	74 bc	217 d	303 a
NWH	53 b	57 d	148 a	74 bc	264 b	202 abc
SE (±)	6.4	5.9	16.6	6.9	30.8	39.1
CV (%)	22.6	16.2	32.2	14.9	24.8	18.0

Means followed by the same letters in a column are not significantly different at 5% level according to Duncan's Multiple Range Test.

Fs= first season, 2006.

Ss = second season, 2007.

Plant shoot N%

The data in Table 6 showed that farmyard manure significantly (P≤0.05) increased shoot N content followed by NM and NWH and the least shoot N content was recorded by the control at 4WAS in the first season. At 6WAS, all the treatments significantly (P≤0.05) produced more shoot N content over that of the control. At 8WAS, either organic manure coupled with 86 kg Nha^{-1} significantly (P≤0.05) increased shoot N content only over that of the control. As for the second season, at 4WAS, all treatments significantly (P≤0.05) increased shoot N content over that of the control. At 6WAS, water hyacinth compost alone significantly (P≤0.05) produced more shoot N content over all the treatments including the control. At 8WAS, all the treatments except 86 kg N ha^{-1}, significantly (P≤0.05) increased shoot N content over that of the control.

Plant shoot P%

The data in Table 7 showed that treatments had no significant effects on shoot P content at 4WAS in both seasons. At 6WAS and 8WAS, all treatments significantly (P≤0.05) increased shoot P content

over that of the control in the first season. As for the second season, at 6WAS, all treatments significantly (P≤0.05) increased plant P content over that of the

control. At 8WAS, NWH significantly increased shoot P content as compared to the other treatments.

Table 6. Effect of organic manures and mineral N fertilization on plant shoot (N%).

Treatment	4 WAS		6 WAS		8WAS	
	Fs	Ss	Fs	Ss	Fs	Ss
Control	1.65 e	1.80 d	1.48 b	1.81 b	1.33 c	1.20 d
M	2.24 a	1.98 c	1.91 a	1.91 b	1.60 abc	1.61 bc
WH	2.05 c	2.13 b	1.77 a	2.63 a	1.61 abc	1.65 bc
N	1.93 d	2.49 a	1.88 a	1.95 b	1.56 abc	1.40 cd
NM	2.13 b	2.10 b	1.87 a	1.96 b	1.71 a	1.78 ab
NWH	2.13 b	2.10 b	1.80 a	1.86 b	1.63 ab	1.89 a
SE (±)	0.11	0.12	0.08	0.16	0.10	0.08
CV(%)	16.60	11.10	9.60	14.20	10.80	4.90

Means followed by the same letters in a column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Fs= first season, 2006.
Ss = second season, 2007.

Table 7. Effect of organic manures and mineral N fertilization on plant shoot P (%)

Treatment	4 WAS		6 WAS		8WAS	
	Fs	Ss	Fs	Ss	Fs	Ss
Control	0.21 ns	0.19 ns	0.17 d	0.15 b	0.16 c	0.12 c
M	0.24 ns	0.22 ns	0.20 a	0.18 a	0.18 a	0.16 ab
WH	0.22 ns	0.24 ns	0.18 c	0.18 a	0.17 b	0.16 ab
N	0.22 ns	0.24 ns	0.18 c	0.18 a	0.17 b	0.14 bc
NM	0.21 ns	0.21 ns	0.19 b	0.18 a	0.17 b	0.15 ab
NWH	0.21 ns	0.23 ns	0.19 b	0.18 a	0.17 b	0.17 a
SE (±)	0.003	0.02	0.002	0.01	0.002	0.01
CV (%)	9.80	16.30	6.80	10.20	5.40	8.03

Means followed by the same letters in a column are not significantly different at 5% level according to Duncan's Multiple Range Test. ns= not significantly different at P≤ 0.05.
Fs= first season, 2006. Ss = second season, 2007.

Pod and hay yield (t ha^{-1})

The data in Table 8 showed that all treatments, significantly (P≤0.05) produced more groundnuts pod yield than that of N and the control. The best treatments were NM and NWH. The results of the second season were similar to those of the first season. For both seasons, the data showed that 86 kg

N ha^{-1} alone or coupled with either organic manure significantly (P≤0.05) increased groundnuts hay yield over all other treatments.

Table 8. Effect of organic manures and mineral N fertilization on pod and hay yields (t/ha^{-1})

Treatment	FS		Ss	
	Pod yield	Hay yield	Pod yield	Hay yield
Control	2.0 c	2.60 c	2.58 c	4.15 c
M	2.8 a	6.21 b	3.55 a	6.70 b
WH	2.9 a	6.10 b	3.30 a	6.98 b
N	2.4 bc	8.80 a	2.73 bc	9.10 a
NM	3.0 a	8.70 a	3.10 a	9.70 a
NWH	3.1 a	8.90 a	3.10 a	9.25 a
SE (±)	0.25	0.4	0.15	0.34
CV (%)	12.3	9.3	10.8	7.3

Means followed by the same letters in a column are not significantly different at 5% level according to Duncan's Multiple Range Test.
Fs= first season, 2006.
Ss = second season, 2007.

DISCUSSION

Manuring is a practice that helps to increase the organic carbon content of soils, which may induce better water infiltration, increased capacity to retain nutrients especially N against leaching and volatilization and denitrification losses. It also enhances soil fertility through increased microbial activity. Addition of either manure alone or augmented with 86 kg N ha^{-1} resulted in significantly high shoot and root dry weights. These results are in agreement with those reported by Mukhtar (1993), Forawi (1994) and Babiker *et al*. (2009).

Organic manure treatments significantly increased number of nodules $plant^{-1}$ (Table 5), a fact that confirms the findings of Muller and Pereira (1995).

Application of nitrogen at 86 kg ha^{-1} alone did not adversely affect nodulation. On the other hand, nitrogen used in combination with either manure gave much higher nodules $plant^{-1}$ compared to the control. In contrast to the above findings, Leidi and Rodriguez (2000) showed that high levels of nitrogen were found to be deleterious to nodulation and N_2-fixation. Gentili *et al*. (2006) reported that when legumes are supplied with adequate mineral nitrogen, the plant resist infection by rhizobia and nodulation is drastically reduced.

Either organic manure treatments alone or in combination with N significantly increased both shoot N and P percentages. This is in conformity with Abrue Junior *et al*. (2002) who showed that the addition

of compost increased soil organic carbon and total nitrogen. The treatments containing organic manure and biofertilizer exhibited high values of soil N, K, P, and Ca (Stephen and Nybe, 2003).

Farmyard manure, in this work, increased pod yield of groundnuts by 40% compared to 20% by N fertilizer over that of the control for the first season, and by 38% compared to 6% for the second season. Mugwira *et al*. (2002) found that the addition of 15 t manure ha^{-1} increased the grain yield of maize by 16% compared to 8.9% by mineral N fertilizer over those of the control. Combination of both organic manures with N significantly increased groundnuts pod yield over those of nitrogen alone and the control. This result is in agreement with Manisha *et al*. (2007) who reported that the integrated application of farmyard manure or water hyacinth compost in combination with N significantly increased the yield and improved the quality of peanut kernels over that of N alone. Similar results were obtained by Ghosh *et al*. (2004) and Shanjida Khar and Sarwar (2002). Forawi (1994) found that nitrogen fertilization at 86 kg N ha^{-1} significantly increased shoot and root dry weights of fenugreek plant. In this study, the application of 86 kgN alone or with either manure significantly increased groundnuts plant shoot dry weight and resulted in significantly high hay yield.

CONCLUSION

Application of organic manure in combination with N fertilizer significantly increased growth and yield of groundnuts. The use of water hyacinth as a compost could be promising for sustainable soil fertility and crop production, particularly in the adjacent areas that lie along the course of the White Nile. Composting of water hyacinth could also serve a dual purpose as a fertilizer and a means of getting rid of this water weed that has polluted the White Nile.

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تأثير الأسمدة العضوية وسماد النتروجين المعدني على إنتاجية الفول السوداني بمنطقة ملكال

حاتم عبدالله سلفاب[1]، نوري عثمان مختار[2]، أدم إبراهيم أدم[3] و معاويه البدوي حمد[4]

[1]كلية الزراعة، جامعة أعالي النيل، ص ب 1660، الخرطوم، السودان.
[2]هيئة البحوث الزراعية، واد مدني، السودان.
[3]كلية الزراعة، جامعة سنار، السودان.
[4]كلية العلوم الزراعية، جامعة الجزيرة، واد مدني، السودان.

الخلاصة

بمزرعة كلية الزراعه جامعة أعالي النيل (ملكال) وذلك 2007) و (2006 أجريت التجارب الحقلية في موسمين مطريين لدراسة تأثير السماد البلدي والسماد العضوي الصناعي المكون من أعشاب النيل وسماد النتروجين على نمو وانتاجية الفول مقارنةً هكتار،/ كجم86 اضيفت الأسمدة العضوية منفردةً بواقع 15 طن/هكتار اومتحدةً مع سماد النتروجين بواقع .السوداني كجم نتروجين/هكتار منفرداً 86هكتار منفرداً. أثبتت النتائج أن إضافة سماد النتروجين بواقع / كجم86بسماد النتروجين بواقع ادى إلى زيادة معنوية فى النمو الخضري للنبات مما أدى إلى زيادة إنتاجية العرش عند الحصاد. كما أنه لم يؤثر سلباً على عدد أدت اضافة أي من العقد الجذرية في النبات الواحد كما هو متوقع. ولم يحدث زيادة معنوية في إنتاج قرون الفول مقارنة بالشاهد. الاسمدة العضوية منفردةً الى زيادة معنوية في عدد العقد الجذرية للنبات.كما انها ادت الى زيادة معنوية في انتاج قرون الفول (NM/NWH)والعرش مقارنةً بالشاهد في الموسميين.أثبتت النتائج أن إضافة النتروجين في وجود أي من الأسمدة العضوية نتج عنها زيادة معنوية في الوزن الجاف للنبات، زيادة في عدد العقد الجذرية للنبات وزيادة في امتصاص النتروجين والفسفور، كما أدت إلى زيادة معنوية كبيرة جدا في إنتاج قرون الفول والتبن.