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THE EFFECT OF ORGANIC, MINERAL AND BIO-FERTILIZATION ON GROWTH, YIELD AND CHEMICAL COMPOSITION OF PIGEON PEA (*Cajanus cajan*) UNDER ISMAILIA REGION CONDITIONS

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ABSTRACT

Fertilization of pigeon pea plants with organic, bio and mineral N fertilizers at different rates increased growth and yield compared with control. However mineral N at 80 kg/fed or/with cattle manure at 25 m^3/fed or with compost at 8 ton/fed were the best treatments for average pod number/plant, fresh yield and seed yield/fed. Fertilization of pigeon pea plants grown in sandy loam soil during summer plantations with cattle manure at 25 m^3/fed increased vine yield as fresh green forage for animals (21.55 ton/fed) followed by fertilization with mineral N at 80 kg/fed (18.75 ton/fed).
Keywords: Fertilization, pigeon pea and yield.

INTRODUCTION

Pigeon peas (*Cajanus cajan*, L. Mill sp.) belong family Fabaceae, also known as arhar deil (in India), guandula (in Puerto Rico), pois d'angola (in French), arvega de angola (in Spanish), pisello d'angola (in Italian) and taubenerbse (in German). Pigeon peas are used as a food crop (dried, peas, flour or green vegetables peas) and forage/cover crop. They contain high levels of protein and important amino acids methionine lysine and tryptophan. The woody stems of pigeon peas can also be used as firewood, fencing and hatch. Growing pigeon pea as a pure crop is not economically viable due to its low productivity and longer duration (maturity in 180-280 days), therefore, intercropping with short duration pulses (green gram and black gram) and seed oil (gingelly) or with cereals (sorghum, pearl millet, maize) in pigeon pea enhance total productivity (Sarma *et al*., 1995).

In a cropping season, pigeon pea plants fix about at 40 kg/ha atmospheric nitrogen and add valuable organic matter to the soil through fallen leaves. Also, legumes can fix as much as 200 kg N/ha/year under optimal field conditions (Giller, 2001). Such fixation of N can only be activated in the presence of efficient rhizobial strains which can be added to the soil introduced in form of commercial inoculants. Organic manure can improve soil content from organic matter and this in turn led to improve soil conditions. For maximum exploitation of organic matter, mineralization of manure by its flora led to utilize the organic manure. Therefore, application of organic and mineral nitrogen fertilizers together may increase the exchangeable water soluble of N P K and the uptake of these elements (Cook, 1972). FYM contains many species of living organisms which release phytohormones as GA3, IAA and CYT which stimulates plant growth, absorption of nutrients and photosynthesis processes (Reyndres and Vlassake, 1982). Nitrogen is an essential element for building protoplasm, amino acids and proteins which induced cell division and initiate meristematic activity. Also, N is a constituent of chlorophyll molecule (Marschner, 1995). Mineral nutrient deficiencies limit nitrogen fixation by the legume-rhizobuim symbiosis, resulting in low legume yields.

Arisha and Bardisi (1999) on common bean plants and Sawon *et al*. (2001) showed that increasing organic fertilizer levels from 0 to 16 tons/fed significantly increased growth characters of sugar pea . Yield and its components (pod length, number of pods/plant, pod weight, yield/plant, yield/fed, number of seeds/pod and seeds weight/ pod, nitrogen, phosphorus, potassium, total carbohydrates total protein and TSS in seeds were significantly increased with application of 15 and 30 m^3/fed organic manure (El-Shafie and El-Shikha 2003, Nour ,2004 and Khairy 2007). In addition, Elsoni and Osman (2011) reported that inoculation with Rhizobium increased pigeon pea seeds and 100-seed weight compared with uninoculated (control). Mohamed and Babiker (2012) found that rhizobium inoculation significantly increased the yield. Application of nitrogen fertilizer up to the highest rate (120 kg/ha) significantly increased, seed yield, seed weight per plant, 100 seed weight and seed number per pod (Rabbi *et al.*, 2011, Vankosky *et al*., 2011). Bahrani *et al.*, 2012 and Salehin and Rahman 2012). Therefore, the aim of this work was to maximize productivity of pigeon pea plants grown in sandy loam soil with high pod and seed quality by using some minerals, organic and bio-fertilizers, i.e. rhizobuim, compost, cattle manure and mineral nitrogen.

MATERIALS AND METHODS

This work was carried out during summer seasons of 2009 and 2010 at Private Farm, Fayed Region, Ismailia Governorate, Egypt, to study the effect of some mineral, organic and bio-fertilizers on growth, plant chemical composition , yield and its components and seed quality of pigeon pea growth in sandy loam soil. The physical and chemical properties of the experimental soil are presented in Table (1)

This experiment included nine treatments as follows:

1. Control (without fertilization),
2. Inoculation with Rhizobium (5g/kg seeds),
3. Cattle manure at 25 m^3/fed.,
4. Cattle manure at 25 m^3/fed. + Rhizobium (5g/kg seeds),
5. Compost at 8 ton/fed.,
6. Compost at 8 ton/fed.+ Rhizobium (5g/kg seeds),
7. Nitrogen at 60 kg/fed.,
8. Nitrogen at 80 kg/fed. and
9. Nitrogen at 120 kg/fed.

These treatments were arranged in randomized complete block design, with three replications. Total N % in different organic fertilizers sources are presented in Cattle manure and compost were obtained from the

Armed Forces Animal Farm at Geneva and Egy-land Company at Al-Salheya, respectively, and added at the time of soil preparation, trenched in the bottom of the row and covered by 20 cm height of sand. Source of mineral N fertilizers was ammonium sulphate $(NH_4)_2SO_4$ (20.5 % N), which was divided into three equal portions and were added as soil application at 45, 60, 90, and 120 days from sowing.

Table (1): Physical and chemical properties of the experimental soil.

Properties	Values
A-Physical analysis	
Sand	78.75 %
Silt	4.75 %
Clay	16.50 %
Soil type	Sandy loam
B-Chemical analysis	
Available Phosphorus(mg/l)	550
$CaCO_3$%	13.6
E.C.(m.mohs/Cm, 25^oC	2.13
pH	8.2
C- Soluble anions (meq/L)	
Cl^-	5.50
HCO_3^-	6.50
$SO_4^=$	9.30
D-Soluble Cations (meq/L)	
Ca	11.5
Mg	4.00
Na	4.84
K	0.96
E-Available micronutrients (mg/L)	
Fe	13.9
Zn	5.13
Cu	2.40
Mn	8.64

The pigeon pea seeds "Maruti" were inoculated with root nodule bacteria *Rhizobium leguminosarum* strain ARC 201 + 202 at dose of 5gm/kg seeds. Gum Arabic 16% was used as an adhesive agent to insure good contact with inoculation. Sown immediately and covered with the soil in order to minimized rhizobia exposure to the sun. Care was taken to avoid cross contamination of inoculated and uninoculated seeds by planting the uninoculated seeds prior to inoculated seeds. The pigeon pea seeds were sown on April 25th, in both seasons (2009 and 2010) on one side of the row (three seeds/hill) at 75 cm apart, then thinned to leave one plant /hill. Plot area was five square meters. It contained one row with five meter long and one meter wide.

Data recorded: Two plants from each plot were randomly taken at 180 days after sowing and the following data were recorded:

1) **Growth parameters**. Stem diameter (mm), leaf area/plant (cm^2) and total fresh weight/plant (kg).
2) **N, P and K contents.** The dry weight of shoots (leaves + branches) after 180 days from sowing were finely ground and wet digested with sulphoric acid and percloric acid (3:1), Nitrogen, phosphorus and potassium were

determined according to the methods described by Bremner and Mulvany (1982), Olsen and Sommers (1982) and Jackson (1970), respectively.

3) **3. Yield and its components.** It was determined as average number of pods/plant, fresh yield (kg/fed.), and seed yield (kg/fed.).
4) **4. Seed quality.** Total carbohydrate was determined by microkjeldhl method as described by A.O.A.C. (1985), crude protein content A.O.A.C. (1985) and ascorbic acid (vitamin C) were determined according to the method of A.O.A.C. (1985).

All obtained data were subjected to analysis of variance according to Snedecor and Cochran (1980) and the Least Significant Difference was calculated as mentioned by Gomez and Gomes (1948).

RESULTS AND DISCUSSION

1. Plant growth

1.1. Stem diameter: The obtained results in (Table 2) show that fertilization of pigeon pea plants with organic, bio and mineral nitrogen fertilizers had significant effect on stem diameter in both seasons. In the 1st season, mineral N at 80 kg/fed recorded the maximum stem diameter (43.6 mm) followed by organic N as cattle manure at 25 m^3/fed (36.8 mm) and compost at 8 ton/fed (36.5 mm), whereas, in the 2nd season, cattle manure at 25 m3 /fed recorded the maximum stem diameter (38.5 mm), followed by N at 60 kg/fed (37.4 mm) and N at 80 kg/fed (36.9 mm). In general, fertilization of pigeon pea plants with compost at 8 ton/fed or with mineral N at 80 kg/fed or with cattle manure at 25 m^3/fed were the treatments had the maximum for enhancing stem diameter at 180 days after sowing.

1.2. Leaf area: The effect of bio, organic and mineral fertilizers on leaf area are presented in (Table 2). Fertilization of pigeon pea with 60 kg mineral N/fed and without fertilization (control) recorded the maximum values of leaf area/plant at 180 days after sowing in the 1st season only (16.8 and 16.7, respectively).

1.3 Total fresh weight /plant: The effect of bio, organic and mineral N fertilizers on total plant fresh weight in both seasons is presented in (Table 2). In the 1st season, fertilization of pigeon pea plants with organic N as cattle manure at 25 m^3/fed recorded the maximum values of total plant fresh weight (3.03 kg/plant) at 180 days after sowing, whereas in the 2nd season, fertilization of pigeon pea plants with low mineral N (60 kg/fed) recorded the maximum values of total fresh weight (2.26 kg/plant). In general, organic N as cattle manure at 25 m^3/fed and low mineral N (60 kg/fed) were the best treatments for increasing total fresh weight/plant, in both season. The stimulative effect of organic N as cattle manure at 25 m^3 /fed on total fresh weight/plant, may be due to that cattle manure increased number of leaves /plant and stem diameter. Organic manure can improve soil content from organic matter and this in turn led to improve soil conditions. For maximum exploitation of organic matter, mineralization of manure by its flora led to utilize the organic manure. Therefore, application of organic and mineral nitrogen fertilizers together may increase the exchangeable water soluble of

N P K and the uptake of these elements (Cook, 1972). FYM contains many species of living organisms which release phytohormones as GA3, IAA and CYT which stimulates plant growth, absorption of nutrients and photosynthesis processes (Reyndres and Vlassake, 1982). Nitrogen is an essential element for building protoplasm, amino acids and proteins which induced cell division and initiate meristematic activity. Also, N is a constituent of chlorophyll molecule (Marschner, 1995). These results agree with those obtained by Arisha and Bardisi (1999) on common bean plants and Sawon *et al*. (2001) who showed that increasing organic fertilizer levels from 0 to 16 tons/fed significantly increased growth characters of sugar pea.

2. N, P and K contents in shoots

2.1. N content: The obtained results in (Table 3) show that fertilization with organic, bio and mineral nitrogen fertilizers reflected a significant effect on N content in shoots of pigeon pea at 180 days after sowing. Inoculation with Rhizobium and fertilization with compost at 8 ton/fed, cattle manure at 25 m^3/fed and mineral N at 60, 80 and 120 kg/fed increased N content in shoots compared with control, also mineral N at 120 kg/fed increased N content in shoots (3.86 and 3.73 % in the 1^{st} and 2^{nd} seasons, respectively) followed by N at 60 and 80 kg/fed.

2.2. P content: Data in (Table 3) showed that fertilization of pigeon pea plants with organic, bio and mineral nitrogen fertilizers at different rates had significant effect on P content in shoots in the 1^{st} season only. Inoculation of seeds with Rhizobium at 5 g/kg seeds + fertilization with cattle manure at 25 m^3/fed recorded the maximum values of P content in shoots (2.83 %) followed by inoculation with Rhizobium + cattle manure at 25 m^3/feddan.

2.3. K content: The obtained results in (Table 3) indicated that fertilization of pigeon pea plants with Rhizobium (biofertilizer), cattle manure and compost single or in combination (Rhizobium + cattle manure and Rhizobium + compost) increased K content in shoots. The results of organic, bio and mineral nitrogen fertilizers on NPK content of seeds of pigeon pea plants confirm the results of **Osman (1998)** on pea plants and Mohamed and Babiker (2012) on faba bean, they illustrated that organic, bio and mineral nitrogen fertilizers had a significant effect on NPK content in shoots.

3. Yield and Its Components

3.1. Average pod fresh weight: Data in (Table 4) show that fertilization of pigeon pea plants with compost at 8 ton/fed, or with cattle manure + Rhizobium or with N at 80 kg/fed gave the highest average pod weight in the 1^{st} season only (1.02, 0.84 and 0.78 g /pod for compost, N at 80 kg and cattle manure + Rhizobium, respectively).

3.2. Average pod number/plant: The effect of organic, bio and mineral N on average pod number/plant in both seasons are presented in (Table 4). Fertilization of pigeon pea with organic, bio and mineral N fertilizers increased average pod number / plant compared with control (unfertilized).

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In the 1st season, N at 80 and 120 kg/ fed, and cattle manure at 25 m^3 /fed recorded the highest average pod number /plant (807, 701 and 676 pod/plant, respectively), in the 2nd season, N at 60, 80 and 120 kg /fed, compost at 8 ton/fed and cattle manure at 25 m^3/fed recorded the maximum values of average pod number /plant (681, 547, 625, 499 and 483 pod /plant, respectively). In general, mineral N at 60, 80 and 120 kg /fed, cattle manure at 25 m^3/fed and compost at 8 ton/fed increased average pod number/plant.

3.3. Total fresh yield/fed.: Fertilization of pigeon pea plants with organic, bio and mineral nitrogen at different rates increased fresh yield compared with control (Table 4). In the 1st season, mineral N at 80 kg /fed recorded the highest fresh yield /fed (2723 kg) followed by compost at 8 ton /fed (2004 kg) and cattle manure (1870 kg), but in the 2nd season, N at 60 kg recorded the highest values of fresh yield/fed (1970 kg) followed by N at 120 kg /fed (1937 kg). In general, N at 60 and 80 kg /fed increased total fresh yield/fed followed by cattle manure at 25 m^3 /fed and compost at 8 ton/feddan.

3.4. Total seed yield/fed.: Fertilization of pigeon pea plants with different rates of organic, bio and mineral nitrogen increased the seed total yield/fed compared with control in both seasons (Table 4). In the 1st season N at 80 and 120 kg/fed increased the total seed yield/fed (1206 and 1004 kg, respectively) followed by cattle manure at 25 m^3/fed (747 kg), whereas in the 2nd season N at 60 kg/fed gave the highest total seed yield /fed (1030 kg) followed by N at 120 kg (853 kg), N at 80 kg (709 kg), compost at 8 ton/fed (686 kg) and cattle manure at 25 ton/fed (647 kg). In general N at 60, 80 and 120 kg /fed increased total seed yield followed by cattle manure at 25 m^3 /fed and compost at 8 ton/feddan. The simulative effect of mineral N at 60, 80, and 120 kg /fed and cattle manure at 25 m^3 /fed and compost at 8 ton /fed on total fresh weight and total seed yield may be due that these treatments increased average pod number /plant (Table 6). These results are in harmony with those reported by Bahrani *et al.*, (2012) on red bean, Salehin and Rahman (2012) on *Phaseolus vulgaris*, and Vankosky *et al*., (2011) who showed that, nitrogen fertilizers had a significant effect on seed yield and its components.

4. Seed quality.

4.1. Protein (%): Fertilization of pigeon pea plants with organic, bio and mineral N at different rates had significant effect on protein (%) in seeds (Table 5). N mineral at 120 and 80 kg /fed increased protein (23.01 and 23.33 % for N at 120 kg, 20 and 21.5 % for N at 80 kg /fed in the 1st and 2nd seasons, respectively) followed by N at 60 kg, compost and cattle manure.

4.2. Total carbohydrate (%): Data presented in (Table 5) show that in the 1st season fertilization of pigeon pea with organic N as cattle manure at 25 m^3 /fed increased total carbohydrate (17.08 %), whereas N at 80 and 120 kg/h gave the lowest values of total carbohydrate in seeds (10.62 % for 80 kg N and 10.64 % for 120 kg N). Similar results were obtained by Merghany (1999) on snap bean, and Arisha and Bardisi (1999) on common pea who reported that nitrogen fertilizers had a significant effect on seed quality. From the foregoing results in the 1st experiment it could be concluded that fertilization of pigeon pea plants grown in sandy soil during summer season under Ismailia Governorate conditions with organic, bio and mineral N fertilizers at different rates increased growth and yield compared with control, in general mineral N at 80 kg/fed or with cattle manure at 25 m3 /fed or with compost at 8 ton/fed were the best treatments for average pod number/plant, total fresh yield and total seed yield/fed.

Table (5): Effect of organic, bio and mineral nitrogen fertilizers on protein and total carbohydrates content in seeds of pigeon pea grown in sandy loam soil at 180 days after sowing during summer seasons 2009 and 2010.

Treatments	Protein %		Carbohydrate %	
	2009	2010	2009	2010
Control (unfertilized)	17.26	16.45	11.87	13.73
Rhizobium at 5g/1gk seeds	19.25	19.25	13.45	10.55
Cattle manure at 25 m3/ fed.	19.40	20.50	17.08	12.90
Cattle manure + Rhizobium	18.76	18.43	14.07	13.76
Compost at 8 ton/fed.	19.48	21.00	11.70	15.01
Compost + Rhizobium	16.21	19.25	10.72	11.92
N at 60/fed	19.95	21.53	13.50	16.17
N at 80/fed.	20.00	21.50	10.62	16.04
N at120/fed.	23.01	23.33	10.64	11.29
LSD 0.05	**3.96**	**4.08**	**2.25**	**N.S.**

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تـأثير التسميد العضوى و المعدنى و الحيوى على النمو و المحصول و المكونـات الكيميائية لبسلة الحمام تحت ظروف منطقة الإسماعيلية

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تسميد بسلة الحمام بأسمدة نيتروجينية عضوية أو حيوية أو معدنية أدت إلى زيادة النمو والمحصول بالمقارنة بالكنترول (بدون تسميد) وأن التسميد بسماد نيتروجيني معدني بمعدل ٨٠كجم/فدان أو سماد الماشية بمعدل ٢٥ متر مكعب / فدان أو سماد الكمبوست بمعدل ٨ طن/فدان كانت أفضل المعاملات لزيادة متوسط عدد القرون على النبات، المحصول الأخضر ومحصول البذور الكلي للفدان. أدى تسميد نباتات بسلة الحمام المنزرعة في أرض رملية صفراء خلال الزراعات الصيفية بسماد الماشية بمعدل ٢٥ متر مكعب للفدان إلى زيادة محصول العرش كعلف أخضر طازج للحيوانات حيث بلغت إنتاجية الفدان من العرش ٢١.٥٥ طن يلية التسميد بالنيترجين المعدني بمعدل ٨٠ كجم للفدان حيث أعطى الفدان ١٨.٧٥ طن عرش كعلف أخضر طازج.

قام بتحكيم البحث

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Table (2): Effect of organic, bio and mineral nitrogen fertilizers on stem diameter, leaf area and plant fresh weight of pigeon pea grown in sandy loam soil at 180 days after sowing during summer seasons 2009 and 2010.

Treatments	Stem diameter (mm)		Leaf area(cm^2)		Plant fresh weight(kg)	
	2009	2010	2009	2010	2009	2010
Control (unfertilized)	26.5	29.0	16.7	16.4	1.12	0.69
Rhizobium at 5g/1gk seeds	32.5	31.6	13.0	13.9	1.59	1.79
Cattle manure at 25 m^3/fed.	36.8	38.5	12.4	14.3	3.03	1.28
Cattle manure + Rhizobium	27.5	24.7	14.2	12.8	1.26	0.9
Compost at 8 ton/fed.	36.5	32.9	12.4	11.9	1.9	1.22
Compost + Rhizobium	35.3	35.3	10.2	11.6	0.81	0.55
N at 60/fed.	27.1	37.4	16.9	13.0	1.41	2.26
N at 80/fed.	43.6	27.6	14.3	15.9	1.87	1.88
N at120/fed.	33.4	36.9	14.7	11.2	1.43	1.41
LSD 0.05	**11.25**	**10.2**	**4.27**	**N.S.**	**1.05**	**0.74**

Table (3): Effect of organic, bio and mineral nitrogen fertilizers on N, P and K contents in the shoots of pigeon pea grown in sandy loam soil at 180 days after sowing during summer seasons 2009 and 2010

Treatments	N		P		K	
	2009	2010	2009	2010	2009	2010
Control (unfertilized)	2.76	2.63	1.69	1.94	0.74	1.03
Rhizobium at 5g/1gk seeds	3.08	3.08	2.02	1.92	1.48	1.47
Cattle manure at 25 m3/ fed.	3.10	3.28	2.12	1.91	1.58	1.44
Cattle manure + Rhizobium	3.00	2.94	2.83	1.81	1.34	1.33
Compost at 8 ton/fed.	3.11	3.36	1.96	1.78	1.65	1.60
Compost + Rhizobium	2.59	3.08	2.01	1.66	1.33	1.43
N at 60/fed	3.19	3.44	1.84	1.57	1.20	1.08
N at 80/fed.	3.20	3.44	1.66	1.52	1.24	0.96
N at120/fed.	3.68	3.73	1.63	1.48	1.08	1.17
LSD 0.05	**0.63**	**0.65**	**0.88**	**N.S.**	**0.5**	**0.32**

Table (4): Effect of organic, bio and mineral nitrogen fertilizers on days to first flowering, average number of seeds/pod and average pod fresh weight of pigeon pea grown in sandy loam soil at 180 days after sowing during summer seasons 2009 and 2010.

Treatments	Average pod fresh weight (g)		Pod number/ plant		Fresh yield (kg/fed)		Seed yield (kg/fed	
	2009	2010	2009	2010	2009	2010	2009	2010
Control (unfertilized)	0.68	0.68	211	325	582	891	279	439
Rhizobium at 5g/1kg seeds	0.65	0.70	503	440	1335	1239	664	546
Cattle manure at 25 m3/ fed.	0.69	0.73	676	483	1870	1351	747	647
Cattle manure + Rhizobium	0.78	0.69	517	345	1622	979	724	437

Compost at 8 ton/fed.	1.02	0.66	441	499	2004	1270	555	686
Compost +Rhizobium	0.66	0.673	414	360	1089	977	448	409
N at 60/fed	0.710	0.72	522	681	1498	1970	678	1030
N at 80/fed.	0.84	0.69	807	547	2723	1559	1206	709
N at120/fed.	0.72	0.78	701	625	1995	1937	1004	853
LSD 0.05	**0.24**	**N.S.**	**267**	**284**	**1216.8**	**846.9**	**407.92**	**431.65**