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Effect of Organic Manures and Adjusted N Application on Cowpea (*Vigna unguiculata* L. Walp) Yield, Quality and Nutrient Removal in Sandy Soil

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ABSTRACT

The objective of this work is to investigate the effect of N application as adjusted level (75% of the recommended rate) when combined with compost and farmyard manure) at four levels (0, 5, 10 and 20 m^3 equal to 0, 3, 6 and 12 t fed^{-1}) in newly reclaimed sandy soil on cowpea crop. Another objective of this trial was to measure specifically the nitrogen replacement value of the organic manures (compost and farmyard manure). The results showed that the total N content on a dry solids basis, indicated that farmyard manure contained 32 % more N compared with the average content in compost. The estimated N application from compost ranged between (12.5 - 75), farmyard manure (17.4 - 69.8) kg N fed^{-1} according to the rate of application. Compost and supplied greater (40%) amounts of total P in the dry solids. the FYM applied to the field trials contained more than three times the amount of K (0.51 % ds) compared with the compost (0.17 % ds). Meanwhile the concentrations of trace elements in the cowpea plant compost are larger than for FYM. Significant effects of the treatments were observed for number of pods per plant, seed and total yield, but differences in straw yields did not quite achieve significance (P = 0.068). Straw accounted for most of the total cowpea crop (75 %). The results indicate that compost or FYM applied at 10 m^3 fed^{-1} achieve maximum yields, as well as the addition of inorganic fertilizer in addition to the manures do not provide any further yield increase. The addition of fertilizer to compost and FYM at 10 m^3 fed^{-1} increased yields further, albeit such increase was not significant. Organic manures have significant N fertilizer replacement value and N equivalency was 32 % for compost relative to inorganic N while it was 69 % for FYM. Cowpea leaf and seed samples analysis for nutrient and trace element concentrations, detected no significant effects of the treatments on tissue concentrations, although P and Mn in seed were almost significant. The greatest protein yield fed^{-1} resulted from treating cowpea with 30 kg N fed^{-1} or compost at 20 m^3 fed^{-1} as well as FYM at 10 m^3 fed^{-1} plus the adjusted N rate. P and K intake reached their maximum values by treating cowpea compost at 20 m^3 fed^{-1} as well as FYM at 10 m^3 fed^{-1} plus the adjusted N rate (45 kg N). Substantial amounts of macro and micro nutrients were removed by cowpea above ground biomass off take. N removal ranged between 115.9 and 219.9 kg N fed^{-1} for the untreated control and compost application at 20 m^3 fed^{-1}, respectively. The greatest removal of P and K due to organic fertilizer occurred when the plants were treated with compost at 20 m^3 fed^{-1} as well as FYM at 10 m^3 fed^{-1} plus the adjusted N rate. Soil chemical analysis after harvesting of cowpea, showed that there were minor but statistically significant changes in pH due to compost (increase) and FYM (reduction), compared with the control. Electrical conductivity was highly significantly greater on the FYM treatment (P<0.001).

Key words: N application, Cowpea *(Vigna unguiculata* L. Walp), compost and farmyard manure

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is a major grain legume grown in semi-arid regions of Sub-Saharan Africa. It is a major source of protein and a cheap source of quality protein for both rural and urban dwellers in Africa (Ajeigbe *et al*., 2012 and Dube and Fanadzo, 2013). Cowpea leaves and green pods are consumed as vegetable and the dried grain is used in many different food preparations.

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Protein content of cowpea leaves range from 27 to 43% and protein concentration of the dry grain range from 21 to 33% (Ahenkora *et al*., 1998 and Abudulai *et al*., 2016). It is estimated that cowpea can fix up to 200 kg N ha^{-1} (Dakora *et al*., 1987; Giller, 2001; Rusinamhodzi *et al*., 2006 and Adjei-Nsiah *et al*., 2008) and can leave a positive soil N balance of up to 92 kg ha^{-1} (Chikowo *et al*., 2004 and Rusinamhodzi *et al*., 2006). According to FAO, cowpea was grown on an estimated 12.3 million ha in Africa in 2014 with the bulk of production occurring on 10.6 million ha in West Africa, particularly in Niger, Nigeria, Burkina Faso, Mali and Senegal (Food and Agriculture Organization of the United Nations Statistics Division (FAOSTAT), 2016).

Cowpea (*Vigna unguiculata* L. Walp) has been introduced to the Egyptian agriculture as a promising double purpose forage and seed crop for its green canopy or using it in animal diets as dry seeds as well as it is a primary source of plant protein for humans and animals (Hamd Alla *et al.,* 2014). It is a high nutritive value and known in Africa for human consumption. Cowpea as a summer crop will compete with other summer dominant crops, likely, it has a wide range of compatibility with other crop species in intercropping systems. At the same time, cowpea is an important legume crop. It is a primary source of plant protein for humans and animals.

Compost products have gained impetus in organic farming to boost agricultural production to its important multi various features such as being rich in nutrients, vitamins, growth regulators, free from pathogens and containing immobilized micro flora. These composts provide all nutrients in readily available forms and also enhance uptake of nutrients by plants and play a major role in improving growth and yield of different field crops. Hassan *et al*., (2007) found that compost manure application at a rate of 15 t fed^{-1}. With a half rate of recommended NPK (25 + 60 + 50 kg ha^{-1}) significantly affected on the quality and mineral content of NPK in seeds of pea plants. Khosro *et al.* (2010) found that content of phosphorus, zinc and other mineral in the chick pea plant increased under application of compost, farmyard manure and biofertilizers. Organic manures stimulate the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH (Alabadan *et al*., 2009). Organic manures like Verm composts can be a good substitute for chemical fertilizers to overcome their adverse effects. The organic manures combination with chemical fertilizer for crop is more useful to obtain high yields (Wijewardana, 1993).

Therefore, the objective of this study was to investigate the effect of N application as adjusted level when combined with compost and farmyard in newly reclaimed sandy soil. Another objective of this trial is to measure specifically the nitrogen replacement value of the organic manures as well as determining the nutrient removal by cowpea plants in such sandy soil.

Materials and Methods

Field trial was conducted in the two summer seasons of 2015 and 2016 at a private farm, Tawfik El Hakim Village, Nubaria Province, Behaira Governorate, Egypt, in a newly reclaimed desert soil. The objective of the trial was to investigate the effect of N application as adjusted level (75% of the recommended rate) when combined with compost and farmyard manure) at four levels (0, 5, 10 and 20 m^3 equal to 0, 3, 6 and 12 t fed^{-1}) in newly reclaimed sandy soil. The area of the trial was 0.13 ha (0.31 feddan). The soil at Nubaria was sandy in texture (46.84% coarse sand, 49.66% fine sand and 3.50% clay + silt) with (pH 7.87; EC 0.22 dsm^{-1}; OM 0.73%; 5.2% $CaCO_3$; N 1256 ppm; P 26 ppm; K 864 ppm; Fe 3684 ppm; Mn 95.4 ppm; Zn 18.7 ppm and Cu 9.8 ppm). The experiment included 16 treatments which were 4 nitrogen fertilizer levels *i.e.* 0, 30, 45 and 60 kg N fed^{-1} and 4 levels of compost and farmyard manure (0, 3, 6 and 12 t fed^{-1} equal to 0, 5, 10 and 20 m^3 fed^{-1} with and without adjusted N fertilizer rate 45 kg N fed^{-1}. The experimental design in the trial was complete randomized block design. Cowpea Karim-7 cultivar was sown in hills 15 cm apart on June 28*th* and 4*th* July in 2015 and 2016, respectively at rate of 15 kg fed^{-1} by hand in ridges before sowing cowpea seeds were inoculated with the specific *Rhizobium* strain. Harvest was done at mid-October. During harvest 10 plants were taken at random and no of pods $plant^{-1}$ were counted. The yield of plants in the four inner ridges of each plot were collected and cleaned, threshed and seed, straw and biological yields per plot and per feddan were determined. To define the optimum dressings of compost and FYM for crop production a more dynamic modelling approach to describe yield effects and quantitative numerical descriptions of the relationships between crop yield and the amount of a particular input applied to the soil. Visual inspection of the data is necessary to decide.

- The model used to describe the crop yield take the numerical form (Cooke, 1982) as follows:

(1) linear model: $y = a + b_1 x$

where: y is the measured yield variable (units: t fed^{-1} or kg fed^{-1}); b_1 is the regression coefficient representing the linear gradient (or slope) of the incremental yield response to increasing application rate; x (units: kg fed^{-1}, t fed^{-1} or m^3 fed^{-1}) of the fertilizer or manure; and a is a constant value (intercept) representing the yield obtained without fertilizer or manure. The N fertilizer equivalency is calculated by dividing the regression coefficient for the manure, on the basis of its rate of total N application, with the coefficient obtained for the yield response to applied mineral N. The units quantifying the rate of N supplied to the soil are the same, kg N/fed, in both cases for both manures and inorganic fertilizer.

- The N equivalency value was estimated by the following equation according to Colwell (1994):

$$\text{N equivalency (\%)} = \frac{1/b(y-a)}{N} \text{x}100$$

Where: a is the regression intercept value), b is the regression coefficient, y is the mean root yield recorded for the plots supplied with compost or FYM at a rate of 10 m^3 fed^{-1} and N is the rate of N application at 10 m^3 fed^{-1} of farmyard manure or compost.

Chemical analysis of the organic manures was carried out on dried and ground samples. Nitrogen was determined by micro-Kjeldahl according to the A.O.A.C. (1995). After wet digestion of the samples according to Chapman and Pratt (1961), P was determined by spectrophotometry, K by flame photometer (Jackson, 1967), and Fe, Mn, Cu and Zn were determined by atomic absorption spectrophotometry according to Chapman and Pratt (1961).

Determination Protein, P and K yields per feddan.

Protein yield per feddan was calculated by multiplying total N concentration in seeds in 6.25 to obtain protein percentage in seeds. Protein, P and K yields fed^{-1} were calculated by multiplying seed yield per feddan in Protein%, P% and K%. After harvest five plants of each treatment were taken and the whole plant was analysed to determine macro and micronutrient concentrations in the above ground biomass. Then the nutrient removal were calculated by multiplying nutrient concentrations in the above ground biomass to obtain nutrient removal/fed..

Soil analysis after the experiment.

Soil samples were taken for chemical analysis after cowpea harvest from selected plots (control and the highest rates of fertilizer, compost and FYM), and were analysed according to Jackson (1967).

Statistical analysis.

The analysis of variance of complete randomized block designwas carried out using MSTAT-C Computer Software (MSTAT-C, 1988), after testing the homogeneity of the error according to Bartlett's test, combined analysis for both seasons were done. Means of the different treatments were compared using the least significant difference (LSD) test at $P < 0.05$.

Results and Discussion

Organic manures characteristics.

The chemical analysis of organic manures applied to the field trials is reported in Table (1). Typical inputs of compost and farmyard manure components and nutrients based on the average composition data were calculated and are listed in Tables (2 and 3) on a volumetric and converted to mass addition basis. Actual N loadings in organic manure to specific field trials are listed in Table (4).

The organic manures samples were collected in the field prior to application and were analysed. The FYM contained more than 10.7 % dry solids with a typical content. The volatile and organic matter contents were representative of the tested manures (Table, 1). The organic matter contents of FYM was greater than the compost by > 50% (Table, 1). Therefore, FYM would be expected to have comparable soil conditioning properties as the conventional bulky organic manure at equivalent rates of application to soil.

Table 1: Chemical analyses of organic manures.
(Units: ds, VS, N, P, K and Fe as %; other elements as mg kg^{-1}).

Manure	ds (%)	VS %ds	OM %ds	pH	EC (ds m^{-1})	Total content (% ds)				Total content (mg kg^{-1} ds)							
						N	P	K	Fe	Mn	Zn	Cu	Ni	Cd	Pb	Cr	Co
Compost	83.4	31.0	22.3	7.5	0.78	1.50	0.14	0.17	1.69	164	473	242	55	0.35	51	39	17
FYM	92.3	34.4	33.8	8.5	2.07	1.89	0.10	0.52	0.18	57	193	5	nd	nd	2	5	5
% Increase	10.7	11	51.5		265	32	40	305	938								

Table 2: Dry solids addition in organic manurest fed^{-1}.

Rate m^3 fed^{-1*}	Rate t fed^{-1}	Compost	FYM
5	3	2.50	2.77
10	6	5.0	5.54
20	12	7.5	11.1
ds (%)		58.8	71.9
Density (w/v)		0.64	0.60

Fed = 4200 m^2

Table 3: Nitrogen content of bio-solids applied.

Manure	N content (% ds)	Dry solids (%)	Density* (t m^{-3})	kg N t^{-1}	kg N m^{-3}
Compost	1.50	83.4	0.60 (0.54 - 0.63)	12.5	7.5
FYM	1.89	92.3	0.64 (0.62 - 0.67)	17.44	11.16

* *Mean (n = 5) and range*

Table 4: Nitrogen additions in manures applied.

Mass addition (t fed^{-1})	Compost (kg N fed^{-1})	FYM (kg N fed^{-1})
3	12.5	17.44
6	37.5	34.9
12	75	69.8
ds (%)	83.4	92.3
Density (w/v)	0.64	0.60

The total N content on a dry solids basis, indicated that farmyard manure contained 32% more N compared with the average content in compost. Compost and supplied greater (40%) amounts of total P in the dry solids. K excreted in the wastes of domestic livestock is largely retained in the bedding material that forms the main bulk matrix of FYM. Consequently, FYM is a relatively rich source of K compared with compost including organic manures products. Indeed, the FYM applied to the field trials contained more than three times the amount of K (0.51 % ds) compared with the compost (0.17 % ds). Supplementation with this major plant nutrient is recommended where the other organic manures are frequently applied to soil to maintain crop productivity by also supplying FYM or inorganic K fertilizer in the crop rotation. As expected, the concentrations of trace elements in the plant compost are larger than for FYM. The estimated N application from compost ranged between (12.5 - 75), farmyard manure (17.4 - 69.8) kg N fed^{-1} according to the rate of application (Table, 4). Ahn (1993) reported that organic manures supplies most of the nitrogen, sulphur and half phosphorus needed by unfertilized crops. The regular addition of organic amendments to soil is very important in the developing world of the tropics, where most traditional farming systems are not sustainable (Sangakkara, 1993). Organic manure improves soil tilth, infiltration rate and soil water holding capacity, contributes nutrient to the crop and it is an important source of raw or partially decomposed organic matter (Bill, 2001). The value of organic amendments in crop production is centred on the ability of animals and plants to provide nutrients and to improve the chemical, physical and biological properties of soils (IFIA, 1992).

Cowpea yield characters.

Significant effects of the treatments were observed for number of pods per plant, seed and total yield, but differences in straw yields did not quite achieve significance (P = 0.068). Straw accounted for most of the total crop (75 %). Addition of fertilizer increased yields over the untreated control, although there were no significant differences between the rates of application (Table, 5). The differences in yields from the compost and FYM applied at the lowest rate (5 m^3 fed^{-1}) were insignificant compared to the untreated control, but with 10 and 20 m^3 fed^{-1} yields were significantly increased, although 20 m^3 fed^{-1} did not provide additional yield benefit. The addition of fertilizer to compost and FYM at 10 m^3 fed^{-1} increased yields further, albeit such increase was not significant, but at the highest rate of manure application, there were decreases in yield with the fertilizer addition. There was no clear tendency which appear a strong correlation between pod number and seed yield. Results indicate that compost or FYM applied at 10 m^3 fed^{-1} achieve maximum yields, as well as the addition of inorganic fertilizer with the manures do not provide any further yield increase.

Table 5: Yield characteristics of cowpea at Nubaria.

Treatment	No. of pods/plant	Seed yield (kg fed^{-1})	Straw yield (t fed^{-1})	Biological yield (t fed^{-1})
Control	5.1	186	1.219	1.405
30 kg N fed^{-1}	18.0	456	1.127	1.583
45 kg N fed^{-1} (F)	19.7	459	1.534	1.993
60 kg N fed^{-1}	16.0	435	1.429	1.864
Compost 5 m^3 fed^{-1}	5.2	285	1.759	2.044
Compost 5 m^3 fed^{-1} + F	18.7	497	1.464	1.961
Compost 10 m^3 fed^{-1}	17.7	548	1.274	1.822
Compost 10 m^3 fed^{-1} + F	28.3	661	1.770	2.431
Compost 20 m^3 fed^{-1}	23.0	665	1.873	2.538
Compost 20 m^3 fed^{-1} + F	16.0	542	1.972	2.514
FYM 5 m^3 fed^{-1}	5.6	251	1.491	1.742
FYM 5 m^3 fed^{-1} + F	14.6	335	1.553	1.888
FYM 10 m^3 fed^{-1}	27.0	525	2.242	2.767
FYM 10 m^3 fed^{-1} + F	18.0	632	2.051	2.683
FYM 20 m^3 fed^{-1}	19.0	594	1.692	2.286
FYM 20 m^3 fed^{-1} + F	25.7	492	1.731	2.223
CV %	14.8	15	24.24	21.0
Probability	<0.001***	<0.001***	0.068	0.014*
LSD at 0.05	4.29	117.7	ns	0.75

The fact that the yields from the manure treatments were generally much greater than from fertilizer on its own, indicates that the manures are satisfying other growth factors, presumably related to organic matter and trace elements. Integrated use of organic manures and fertilizers has been found to be promising not only in maintaining higher productivity but also for providing stability in crop production. Long term manorial experiments conducted in India showed a declining trend in productivity with application of N, P and K fertilizers alone (Nambiar and Abrol, 1989). An application of manure usually shows a favourable influence on crop yields for several years. Greater efficiency of manure is obtained when applied in small amounts and more often (Gibberd, 1995 and Yoganathan *et al*., 2013). The animal manure combine with chemical fertilizer gave a higher yield when compared to the sole application of animal manure. The soil analysis showed that the nitrogen content and phosphorus content of poultry manure treated plots were higher than other treatments tested. But potassium content was higher in goat manure treated plots. The results further revealed that the poultry manure has a beneficial effect on crop growth and yield compared with other treatments. Therefore, the combined use of poultry manure with inorganic fertilizer application has been recognized as the most suitable way of ensuring high crop yield.

Fertilizer equivalency ratio (N fertilizer replacement value in manures).

The yield of cowpea seed increased significantly with N fertilizer application at the lowest rate (30 kg N fed^{-1}) compared with the untreated control, but there was no yield advantage from the higher rates of fertilizer (Table, 6) Therefore, the yield response pattern to inorganic fertilizer was determined using data for this treatment and the control plot on the assumption that the yield pattern followed a linear trend between the control and an application of 30 kg N fed^{-1}. The comparison of regression coefficients (Table, 6) suggested a N equivalency of 32 % for compost relative to inorganic N. However, the data suggest that yield may be increased further by N supplied in compost compared with conventional inorganic fertilizer. This may be explained because, in addition to N, other physico-chemical attributes of the compost may beneficially ameliorate desert soils for crop production, thus maximising the potential utilization of resources applied to the soil in the composted product. Organic manures have significant N fertilizer replacement value for cowpea on reclaimed desert soils. Farmyard manure is more effective as a soil amendment at increasing crop yield compared with plant compost product. On the basis of equivalent rates of N application in plant compost, the crop yield response to the farmyard manure material was 37 % higher compared to the compost product. These results are agreement with those obtained by Abd El Lateef (2002) who reported that fertilizer equivalency suggested that the compost has N fertilizer equivalency value of 50% in potato.

Table 6: Nitrogen equivalency ratios of compost and FYM for cowpea production on reclaimed desert soil.

Manure	Compost	FYM
Regression coefficientfor manure N (a)	2.86	6.14
Regression coefficientfor inorganic N (b)	8.87	8.90
% N efficiency (a/b*100)	32	69

Chemical composition of cowpea straw and seeds.

Cowpea straw and seed samples were analysed for nutrient and trace element concentrations, and the results are given in Tables (7 and 8), respectively. ANOVA of the data detected no significant effects of the treatments on tissue concentrations, although P and Mn in seed were almost significant (P = 0.054 and 0.053, respectively). The foliar content of N, K, Fe and Cu were below the normal range, particularly for copper which was at deficiency levels. Mn and Zn supply were satisfactory, despite the high pH of this soil, although the farmer normally applies foliar trace elements to ensure satisfactory yields. This was also reflected in the seed concentrations for these elements. It was found that organic manures like these composts provide all nutrients in readily available forms and also enhance uptake of nutrients by plants and play a major role in improving growth and yield of different field crops. Hassan *et al*., (2007) found that compost manure application at a rate of 15 t fed^{-1}, with a half rate of recommended NPK (25 + 60 + 50 kg ha^{-1}) significantly affected on the quality and mineral content of NPK in seeds of pea plants. Khosro *et al*., (2010) found that content of phosphorus, zinc and other mineral in chick pea plant increased under application of compost, farmyard manure and biofertilizers. In this respect Abebe *et al*., (2005) mentioned that nitrogen concentration in cowpea tissues were significantly greater for manure treated pots (3.8%) over the control (2.15%), which was 76.7% higher for manure treatment. Cattle manure treated pots resulted in higher tissue N concentration (4.23%) than poultry litter treated pots (3.36%) indicating that cattle manure treatment supplied cowpea plants more amount of N than did poultry litter treatment. Similarly, the concentration of tissue P was also superior for manure treated pots (0.16%) over control (0.10%). Lower tissue P concentration could be due to P fixing ability of calcareous soils resulting in non-availability of P. Cattle manure treated pots showed higher tissue P (0.16%) than poultry litter treated pots (0.15%). An increase in the rate of cattle manure also resulted in increasing tissue P concentration Similarly, the concentration of tissue K^+ for manure treated pots (3.97%) was superior over the control (2.47%), which was 60 % higher for manure treatment than the control. This tissue K^+ value was sufficient for control and manure treatments. Suwwan and Hattar (1987) observed an increase in plant uptake of macro- and micro-nutrient above 25 tonnes ha-1 poultry litter application. Tissue trace elements (Cu, Mn and Zn) were significantly higher in the plant grown on manure treated pots than those of the control treatment, whereas, tissue Fe concentration was not significant. Concentration of tissue Cu, Mn and Zn were significantly greater for plants grown using poultry litter than cattle manure treated. However, tissue Fe was higher in cattle manure treated pots than poultry litter treated pots. As the rate of poultry litter increased, the concentration of tissue Fe, Mn and Cu increased.

Table 7: Chemical composition of cowpea straw (Units: macronutrients as %; other elements as mg kg^{-1}).

Treatment	N	P	K	Fe	Mn	Zn	Cu
Control	4.03	0.44	1.37	87.7	28.3	10.5	3.83
30 kg N fed^{-1}	5.62	0.50	1.37	58.7	32.0	22.3	4.17
45 kg N fed^{-1} (F)	3.58	0.35	1.34	84.0	23.5	19.3	3.51
60 kg N fed^{-1}	3.57	0.25	1.28	89.3	34.8	10.7	1.40
Compost 5 m^3 fed^{-1}	3.79	0.31	1.56	105.8	49.0	12.8	1.70
Compost 5 m^3 fed^{-1} + F	3.83	0.39	1.34	62.3	34.5	14.2	2.67
Compost 10 m^3 fed^{-1}	3.45	0.34	1.28	65.7	32.7	14.3	1.91
Compost 10 m^3 fed^{-1} + F	3.35	0.29	1.29	78.8	29.8	15.8	2.68
Compost 20 m^3 fed^{-1}	3.96	0.37	1.83	81.8	23.7	15.0	2.67
Compost 20 m^3 fed^{-1} + F	4.17	0.29	1.49	67.0	57.3	14.5	1.12
FYM 5 m^3 fed^{-1}	3.57	0.29	1.19	106.2	39.8	16.8	2.87
FYM 5 m^3 fed^{-1} + F	3.42	0.45	1.38	109.0	33.2	14.7	1.42
FYM 10 m^3 fed^{-1}	3.34	0.44	1.38	68.2	39.7	12.3	1.88
FYM 10 m^3 fed^{-1} + F	3.84	0.31	1.51	76.2	31.2	15.8	1.18
FYM 20 m^3 fed^{-1}	3.52	0.37	1.09	81.8	35.2	15.2	3.02
FYM 20 m^3 fed^{-1} + F	3.77	0.49	1.50	98.5	54.7	19.2	2.18
Mean	3.80	0.37	1.39	82.6	36.1	15.2	2.39
Probability	0.406	0.192	0.832	0.210	0.157	0.727	0.670
Significance	ns	ns	Ns	ns	ns	ns	Ns

Table 8: Chemical composition of cowpea seed, (Units: macronutrients as %; other elements as mg kg^{-1}).

Treatment	N	P	K	Fe	Mn	Zn	Cu	Ni	Cd	Pb	Cr	Co
Control	4.25	0.41	0.62	72.2	3.83	20.0	3.35	0.70	0.18	1.87	0.90	1.21
30 kg N fed^{-1}	4.29	0.44	0.64	115.3	4.50	24.0	4.35	0.05	0.27	1.52	0.18	2.14
45 kg N fed^{-1} (F)	3.70	0.28	0.69	62.5	4.50	15.0	3.35	0.05	0.16	0.05	0.05	2.52
60 kg N fed^{-1}	3.74	0.38	0.64	26.8	5.50	15.0	4.08	0.52	0.20	1.44	0.04	0.04
Compost5 m^3 fed^{-1}	4.58	0.43	0.74	65.5	4.50	22.8	3.60	1.46	0.12	1.50	0.12	1.50
Compost 5 m^3 fed^{-1} + F	4.07	0.41	0.64	48.7	4.17	15.8	4.18	0.05	0.15	0.73	0.05	2.67
Compost 10 m^3 fed^{-1}	4.19	0.46	0.74	46.7	3.00	18.3	4.35	0.20	0.15	1.02	0.50	0.51
Compost 10 m^3 fed^{-1} + F	4.14	0.42	0.57	57.8	3.33	28.3	4.85	0.20	0.43	1.50	0.53	2.02
Compost 20 m^3 fed^{-1}	4.73	0.51	0.69	62.2	2.83	21.7	3.02	0.05	0.17	1.35	0.57	1.67
Compost 20 m^3 fed^{-1} + F	4.21	0.44	0.65	50.2	5.17	23.0	4.78	0.05	0.33	2.12	0.07	1.65
FYM 5 m^3 fed^{-1}	4.35	0.40	0.73	52.2	4.00	30.0	4.52	0.70	0.08	1.33	0.48	0.19
FYM 5 m^3 fed^{-1}+ F	4.78	0.31	0.59	67.0	3.17	11.3	3.18	0.05	0.28	1.18	0.22	0.68
FYM 10 m^3 fed^{-1}	3.90	0.37	0.53	34.7	4.33	21.5	4.18	0.05	0.38	1.52	0.05	2.55
FYM 10 m^3 fed^{-1} + F	3.76	0.50	0.54	51.8	4.50	27.5	4.60	0.05	0.50	0.78	0.05	3.50
FYM 20 m^3 fed^{-1}	3.70	0.42	0.64	48.5	4.00	15.0	2.85	0.05	0.02	1.00	0.10	0.04
FYM 20 m^3 fed^{-1} + F	4.25	0.39	0.56	51.3	2.83	24.8	4.68	1.70	0.38	0.20	0.05	0.62
Mean	4.20	0.41	0.64	57.8	3.94	21.1	4.03	0.36	0.24	1.22	0.27	1.46
Probability	0.55	0.05	0.29	0.77	0.05	0.57	0.54	0.71	0.17	0.75	0.51	0.68
Significance	ns	ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns

Protein, P and K yields for cowpea seeds (kg/fed).

Data presented in Table (9) show protein, p and k yields in cowpea seeds fed^{-1}. In other words, it expresses about the intake by cowpea seeds. The lowest protein, P and K yields fed^{-1} was recorded by the untreated control. Concerning the organic manures, the lowest protein yield and P and K intakes in cowpea seeds was found when cowpea plants treated with the lowest level of FYM or Compost (5 m^3 or 3 t fed^{-1}). The greatest protein yield fed^{-1} resulted from treating cowpea with 30 kg N fed^{-1} or compost at 20 m^3 fed^{-1} as well as FYM at 10 m^3 fed^{-1} plus the adjusted N rate. P and K intake reached their maximum values by treating cowpea compost at 20 m^3 fed^{-1} as well as FYM at 10 m^3 fed^{-1} plus the adjusted N rate (45 kg N). Kyei-Boahen *et al*. (2017) reported that grain protein concentration followed a similar trend as grain yield and ranged from 223 to 252 g/kg but a negative correlation between grain yield and protein concentration was observed. Inoculation increased net returns by $ 104 -163 ha^{-1} over that for the control. Sarker *et al.* (2011) noticed that cowpea removed the highest quantity of nutrient elements from the soils in the treated plots compared to mungbean and blackgram.

Table 9: Protein, P and K yields for cowpea seeds (kg/fed).

Treatment	Protein yield (kg fed^{-1})	P yield (kg fed^{-1})	K yield (kg fed^{-1})
Control	49.33	76.14	115.13
30 kg N fed^{-1}	122.18	200.51	291.65
45 kg N fed^{-1} (F)	106.07	128.44	316.50
60 kg N fed^{-1}	101.68	165.30	278.40
Compost 5 m^3 fed^{-1}	81.50	122.42	210.68
Compost 5 m^3 fed^{-1} + F	126.50	203.89	318.27
Compost 10 m^3 fed^{-1}	143.51	252.08	405.52
Compost 10 m^3 fed^{-1} + F	171.11	277.75	376.94
Compost 20 m^3 fed^{-1}	196.50	339.00	458.64
Compost 20 m^3 fed^{-1} + F	142.61	238.48	352.30
FYM 5 m^3 fed^{-1}	68.16	100.28	183.01
FYM 5 m^3 fed^{-1} + F	100.17	103.94	197.83
FYM 10 m^3 fed^{-1}	127.97	194.25	278.25
FYM 10 m^3 fed^{-1} + F	148.52	316.00	341.28
FYM 20 m^3 fed^{-1}	137.36	249.48	380.16
FYM 20 m^3 fed^{-1} + F	130.69	191.88	275.52
Probability	14.9	13.4	20.1
Significance	<0.001***	<0.05*	<0.05*
LSD at 0.05	17.7	33.6	56.9

Nutrient removal by cowpea treated plants.

Data presented in Table (10) and Figs. (1 and 2), clear that there are substantial amounts of macro and micro nutrients removed by the above ground biomass off take. N removal ranged between 115.9 and 219.9 kg N fed^{-1} for the untreated control and compost application at 20 m^3 fed^{-1}. P and K off takes were greater when the plants were fertilized with 20 m^3 fed^{-1} and 45 kg N, respectively. The greatest removal of P and K due to organic fertilizer occurred when the plants were treated with compost at 20 m^3 fed^{-1} as well as FYM at 10 m^3 fed^{-1} plus the adjusted N rate. Regarding the micro nutrients removal by cowpea plants the data show that Fe removal ranged between 92.7 and 219.7 g fed^{-1} for N application at 45 Kg N and FYM application at 20 m^3 fed^{-1} plus the adjusted N rate, respectively. Mn removal by cowpea plants reached their maximum values when the plants were either fertilized with compost or FYM at 20 m^3 plus the adjusted N rate. The greatest removal of Zn due to organic fertilizer occurred when the plants were treated with compost at or FYM at 10 m^3 fed^{-1} plus the adjusted N rate. Whereas the greatest removal of Cu due to organic fertilizer occurred when the plants were treated with compost at 10 m^3 fed^{-1} plus the adjusted N rate (45 kg N). Randall *et al.* (2006) estimated the cowpea nutrient removal cowpea (kg ha^{-1}) by 50 N, 6 P, 39 K, 9 S, 9 Ca, 6 Mg, 0.26 Mn, 0.08 Zn and 0.02 Cu. Choudhary and Kumar (2014) demonstrated that uptake of nutrients such as nitrogen (N), P, and K followed the trend of greater to lower, 100% > 75% > 50%, in order for K and P. Similarly, nutrient-use efficiencies and production efficiency followed the trend of nutrient uptake.

Table 10: Above ground biomass macro and micronutrients removal fed^{-1}.

Treatment	Above ground biomass macronutrient removal (kg fed^{-1})			Above ground biomass micronutrient removal (g fed^{-1})			
	N	P	K	Fe	Mn	Zn	Cu
Control	115.9	119.0	148.4	122.8	39.6	14.7	5.4
30 kg N fed^{-1}	156.6	148.5	180.1	92.7	50.6	35.2	6.6
45 kg N fed^{-1} (F)	144.9	125.4	207.0	167.2	46.8	38.4	7.0
60 kg N fed^{-1}	136.0	117.2	165.5	166.1	64.7	19.9	2.6
Compost 5 m^3 fed^{-1}	170.7	151.0	214.2	215.8	100.0	26.1	3.5
Compost 5 m^3 fed^{-1} + F	154.8	156.8	201.9	122.1	67.6	27.8	5.2
Compost 10 m^3 fed^{-1}	139.0	145.6	196.6	119.6	59.5	26.0	3.5
Compost 10 m^3 fed^{-1} + F	207.5	196.7	238.2	218.3	82.5	43.8	7.4
Compost 20 m^3 fed^{-1}	219.9	222.6	268.2	207.0	60.0	38.0	6.8
Compost 20 m^3 fed^{-1} + F	207.8	181.0	233.1	166.2	142.1	36.0	2.8
FYM 5 m^3 fed^{-1}	158.4	138.0	204.0	212.4	79.6	33.6	5.7
FYM 5 m^3 fed^{-1} + F	155.0	143.6	196.6	206.0	62.7	27.8	2.7
FYM 10 m^3 fed^{-1}	199.8	223.6	267.7	188.2	109.6	33.9	5.2
FYM 10 m^3 fed^{-1} + F	203.7	217.1	227.8	204.2	83.6	42.3	3.2
FYM 20 m^3 fed^{-1}	165.3	180.9	231.3	187.3	80.6	34.8	6.9
FYM 20 m^3 fed^{-1} + F	178.8	196.2	234.2	219.7	122.0	42.8	4.9
Probability	0.06	0.092	0.08	0.10	0.15	0.07	0.07
Significance	ns	ns	ns	ns	ns	ns	ns

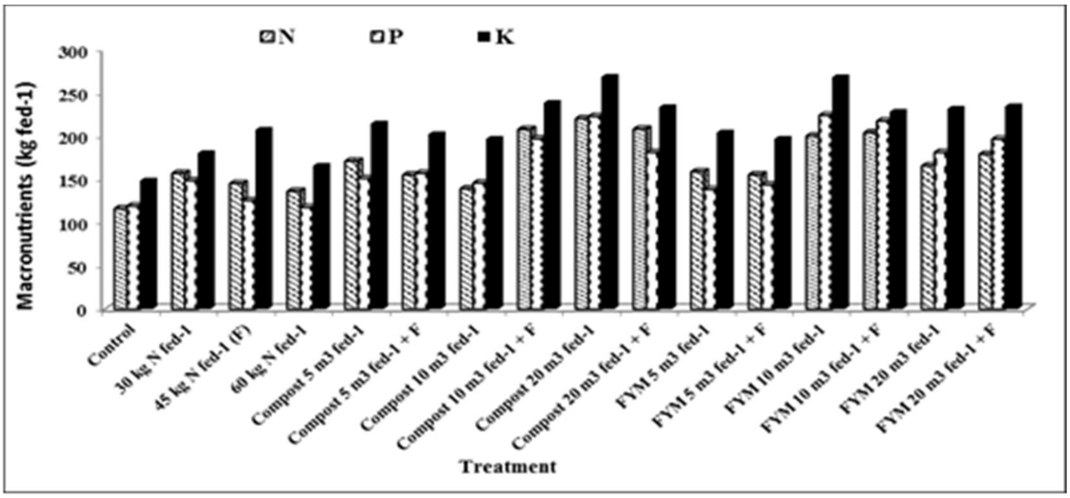

Fig. 1: Above ground biomass macronutrient removal (kg fed^{-1}).

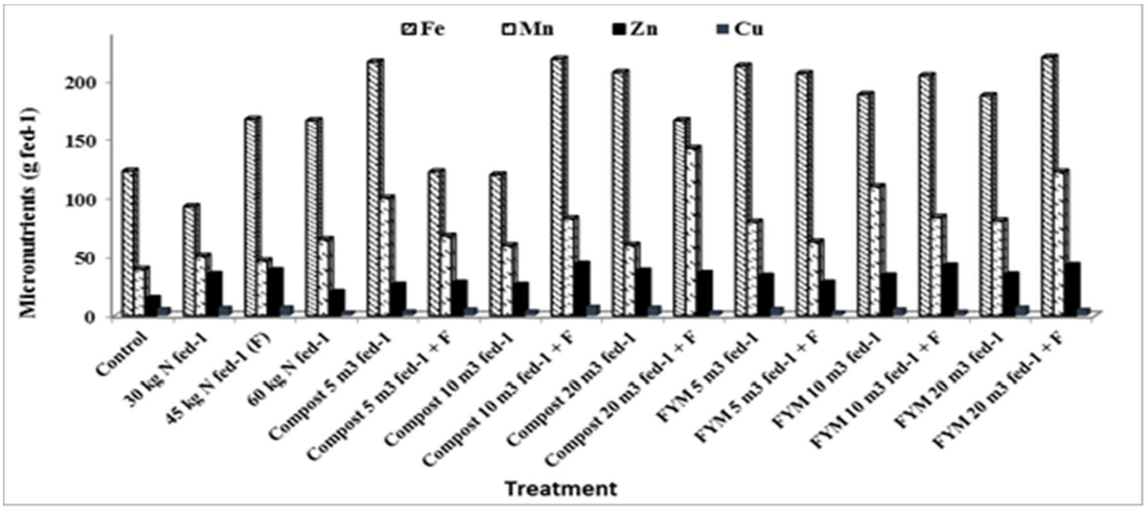

Fig. 2: Above ground biomass micronutrient removal (g fed^{-1}).

Soil analysis.

Data presented in Table (11) shows soil samples analysis which were taken for chemical analysis after cowpea harvest from selected plots (control and the highest rates of fertilizer, compost and FYM).

Table 11: Chemical analysis of soil after cowpea harvest, (Units: EC as dS m^{-1}; OM and $CaCO_3$ as %; other elements as mg kg^{-1}).

Treatment	pH	EC	OM	$CaCO_3$	N	P	K	Fe	Mn	Zn	Cu	Cr	Co	Cd	Pb	Ni
Control (before sowing)	8.50b	0.24b	0.73a	5.2	1400a	132a	826a	3694a	56.8a	17.08a	3.78a	4.98a	3.82a	0.02b	1.36a	12.9a
60 kg N fed^{-1}	8.54ab	0.24b	0.54a	6.0	1190a	129a	772a	3594a	31.7a	8.45a	2.68ab	3.55a	2.95a	0.07ab	1.62a	15.7a
Compost 20 m^3 fed^{-1}	8.59a	0.28b	0.43a	4.8	1085a	72b	848a	3406a	33.4a	8.88a	2.24b	4.05a	4.60a	0.22a	0.89a	15.4a
FYM 20 m^3 fed^{-1}	8.44c	0.41a	1.00a	5.7	1365a	109a	1033a	3575a	33.2a	12.28a	3.79a	5.02a	3.02a	0.07ab	1.68a	15.0a
Probability	0.002	<0.001	0.314	-	0.144	0.011	0.063	0.948	0.055	0.169	0.036	0.753	0.452	0.033	0.148	0.540
Significance	**	***	ns	-	ns	*	ns	ns	ns	ns	*	ns	ns	*	ns	ns
LSD at 0.05	0.06	0.05	-	-	-	33.9	-	-	-	-	1.20	-	-	0.13	-	-

Values for each mean within a column, followed by the same letter, are not significantly different at P = 0.05.

The mean pH of the soil was high at 8.5 due to the large $CaCO_3$ content (mean 5.4 %). There were minor but statistically significant changes in pH due to compost (increase) and FYM (reduction), compared with the control. Electrical conductivity was highly significantly greater on the FYM treatment ($P<0.001$). Minor significant effects were detected for Cu and Cd due to compost addition where Cu was smaller and Cd greater than in the control soil. Potassium almost achieved significance ($P = 0.063$) due to much larger K soil concentration due to FYM addition. Also, Mn was almost significant at $P = 0.055$ where the control had the largest concentration. Ahn (1993) reported that organic manures supplies most of the nitrogen, sulphur and half phosphorus needed by unfertilized crops The regular addition of organic amendments to soil is very important in the developing world of the tropics, where most traditional farming systems are not sustainable (Sangakkara, 1993). Organic manure improves soil tilth, infiltration rate and soil water holding capacity; contributes nutrient to the crop and it is an important source of raw or partially decomposed organic matter (Bill, 2001). The value of organic amendments in crop production is centred on the ability of animals and plants to provide nutrients and to improve the chemical, physical and biological properties of soils (IFIA, 1992).

Conclusion

It could be concluded from this study that organic manures have significant N fertilizer replacement value for cowpea on reclaimed desert soils. Farmyard manure is more effective as a soil amendment at increasing crop yield compared with plant compost product. On the basis of equivalent rates of N application in plant compost, the crop yield response to the farmyard manure material was 37 % higher compared to the compost product. The optimum agronomic rate of addition of farmyard manure was 10 m^3 fed^{-1} (6 t ds fed^{-1} or 14.2 t ds ha^{-1}). In addition to supplying plant available N, organic manures (and FYM) provide other growth factors (trace elements and K) which increase the yield response of cowpea over that which can be achieved with N fertilizer alone. Organic matter supplied to reclaimed desert soils in organic manures and FYM may improve the soil environment for root growth and development and increase soil water holding capacity. The patterns of N release for crop uptake from organic manures and FYM may be better synchronised with crop requirements for N compared with soluble inorganic fertilizer application reducing the potential leaching losses of N in drainage. The chemical composition of cowpea seeds produced on compost-treated reclaimed desert soil was comparable to with that with inorganic fertilizers and FYM.

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