Qatar Univ. Sci. J. (2001), 21: 47-54

COMPARATIVE STUDY OF ORGANIC AND INORGANIC FERTILIZERS ON FORAGE CORN (Zea mays L.) GROWN ON TWO SOIL TYPES

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دراسة مقارنة بين الأسمدة العضوية والمعدنية على نمو علف الذرة الشامية في نوعين من التربة

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تم تنفيذ تجربتين في أصص موسمي ١٩٩٦/١٩٩٥ و ١٩٩٧/١٩٩٦ لدراسة أثر الأسمدة العضوية والمعدنية على أداء علف الذرة الشامية في نوعين من التربة هما الأراضي المتشققة(Vertisols) في مشروع الجزيرة والأراضي الجافة(Aridisols) في غرب أم درمان. شملت الأسمدة العضوية السماد الأخضر ومخلفات الدواجن بينما شملت الأسمدة المعدنية اليوريا (N) والسوبرفوسفات (P) وكبريتات البوتاسيوم (K) وخليط منهم (NPK) . تم تكرار المعاملات ثلاث مرات في تصميم تجاربي كامل العشوائية (CRD) كما استخدم إختبار دنكان لفصل المتوسطات، أوضحت تجارب الموسمين فرقاً معنوياً بين النباتات المعاملة مقارنة بمثيلاتها غير المعاملة بالأسمدة (الشاهد). زاد وزن العلف الأخضر معنوياً نتيجة لإضافة الأسمدة العضوية خاصة مخلفات الدواجن مقارنة مع الأسمدة المعدنية في كلا التربتين. محتويات أوراق الذرة الشامية من النيتروجين والفوسفور زادت زيادة معنوية بإضافة مخلفات الدواجن مقارنة مع المعاملات الأخرى. في التربتين. محتوى البوتاسيوم في أوراق النباتات المعاملة بمخلفات الدواجن أعلى منه في المعاملات الأخرى. عموماً نمو النبات متميز جداً في الأراضي المتشققة مقارنة مع نموه في الأراضي الجافة نتيجة لإضافة الأسمدة العضوية. لابد من تأكيد هذه النتائج بالإختبار تحت ظروف الحقل والذي قد تنتج عنه معدلات إضافة مختلفة من هذه الأسمدة.

Key Words : Vertisols, Aridisols, Gezira scheme, organic fertilizer

ABSTRACT

Two pot experiments were conducted in 1995/96 and 1996/97 to investigate the interactive effects of organic and inorganic fertilizers applied to two soil types on the performance of corn (Zea mays L.). The soil types were Vertisols from Gezira scheme and Aridisols from West of Omdurman. The organic fertilizers were green manure and chicken manure; the inorganic fertilizers were: urea (N), superphosphate (P), potassium sulphate (K) and combination of NPK. The treatments were replicated thrice in a completely randomized design and the means were separated by Duncan's multiple range test (DMRT). The results of the two experiments showed that the treated plants were significantly different from the non-treated plants in both soils. The fresh weight was significantly higher due to the application of organic fertilizer especially chicken manure compared to inorganic fertilizers in the examined soils. The leaf nitrogen and phosphorous contents were significantly increased by chicken manure fertilizer compared to other fertilizer treatments in both soils. The leaf potssium content of chicken manure treatment was higher compared to the other treatments in both soils. Plant growth in Vertisols was generally superior to that in the Aridisols due to the application of organic fertilizers. Confirmation of these results under filed conditions may suggest using different ratios of organic and inorganic fertilizers for the two mentioned soil types.

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INTRODUCTION

Nutrient availability is becoming a limiting yield factor in all countries. It is most certain that efficient use of fertilizers and the amount applied poses a pronounced effect on food production. Interest is increasing in alternative, low input cropping systems. Potential interactive effects of input additions or eliminations on crop yield must be delineated to develop the most resource-efficient cropping systems (1, 2). Organic fertilizers contain nutrients that can be released slowly and utilized by the present and the following crop. They are now favored because they provide balanced nutrients to the plant and therefore, prevent the harmful effects resulting from the excess of a particular nutrient (3, 4). In most countries inorganic fertilizers have been used to supply much more plant nutrients than organic manure. However, inorganic fertilizers are expensive, especially in developing countries. In the Sudan, soils are low in organic matter and also low in some major and minor nutrients to the extent that addition of nitrogen fertilizers is essential for the economic production of cash crops. This situation calls for adoption of rational policies for fertilizer use with a view to reduce cost of inputs with maximizing the use of organic fertilizer (5).

In general, soil modification may be aimed at some specific item of fertility such as supplementing one or more plant nutrients or it may be aimed at a more general change in the chemical and physical properties of the soil (6). Most unfarmed soils have little quantities of phosphorus for high quality and quantity of cultivated crop, and superphosphate was the first fertilizer used to improve the fertility of agricultural land (3). The activity of the soil phosphorus is indirectly related to soil pH, the conservative limits of which are 6 to 7. The overall phosphorus problem in the Sudanese soils is: (a) the unavailability of native phosphorus, and (b) a marked "fixation" of added soluble phosphates (7). The role of potassium received full recognition recently in comparison with nitrogen and phosphorus. Unavailability; leaching losses and high removal of potassium by plants, are the most general problem of potassium economy (8 ; 9).

Maize (*Zea mays*) an American Indian word for corn, means literally "that which sustain life" comes after wheat and rice in providing nutrients for human and animals worldwide (10). Because of its worldwide distribution; the relatively lower price of the grain, relatively tolerant to pests and easily stored, maize has a wide range of uses than other cereals (11). Maize is an important crop grown by rains in the Central West of the Sudan (Nuba Mountains Region) as well as in the Southern region. It was estimated that some 300,000 hectares are grown under rain and some relatively modest acreage under irrigation in Northern and Central Sudan, mainly used as fodder with generous fertilizer input. Therefore, fertilization of an irrigated corn by organic fertilizers is essential for maximizing productivity, while minimizing the environmental hazards by using inorganic fertilizers. Hence, the objectives of this work are:

1. To measure the response of the growth of corn to organic and inorganic fertilizers grown on two soil types namely: Vertisols and Aridisols of Sudan.
2. To study the effects of the type of fertilizer on some elemental composition of corn shoot.

MATERIALS AND METHODS

A complete randomized design, with factorial arrangement was chosen for two pot experiments to investigate the effects of two soil types, organic and inorganic fertilizers on yield and chemical composition of corn. The soil types were Vertisols from Wad El-Hadad, Gezira scheme classified as: very fine montmorillonitic isohyperthermic Typic Chromusterts, deep, dark brown, cracking soil, over deep grey, calcareous, non sodic layer occurs on a flat plain, moderately suitable (12). The other soil type was Aridisols of semi-arid zone of Sudan, classified as: fine, mixed, isohyperthermic Typic Camborthids, from Rawakeeb, west of Umdurman (13). Some characteristics of the two soils and the organic manures are shown in Table 1. Surface soil samples (0-30 cm) were treated with the following:

1- Green manure	= 11.9 tones/ ha
2- Chicken manure	= 11.9 tones/ha
3- Urea	= 190.4 kg/ha
4- Superphosphate	= 119 kgP2O5/ha
5- Potassium sulphate	= 190.4 kg K2SO4/ha
6- NPK	= 190 kg/ha (1:1:1)

Treatments were replicated thrice. The soils were ground in a wooden mortar, passed through a 2-mm diameter sieve and 2.5 kg soil were added to each 5 cm diameter plastic pot. The fertilizers were mixed with the top soil in each pot and the pots were tapped on the working bench to attain a bulk density of = 1.3 Mg/m^3. Five certified seeds of maize variety Giza 2 were sown in each pot (0.0254 m^2) placed in an open field at the Faculty of Agriculture, Shambat, University of Khartoum (long. 32° 32'E; lat. 15 14'N).

The quantity of irrigation water applied per one irrigation, Q (mm), was approximated by the following relationship:

$Q = K \times Ep \times F$ where:

K is an empirical constant equal to 0.5, 0.85 and 1.05 for the three successive growing months of the crop. Ep is US class A pan evaporation (mm/day) estimated from a previous data collected during the period 1989 - 1994, and F is the frequency of irrigation which was four days. Plant leaves and soil samples were taken at the end of the experiment for analysis.

Chemical analysis :

Plant leaves were washed, dried at 65°C, ground and sieved through 0.2 mm diameter sieve and analyzed for calcium, magnesium, sodium and potassium according to (14) using atomic absorption spectrophotometer, model 2380, Perkin Elmer, using air acetylene flame. Nitrogen and phosphorus were determined as described (15). The pH of the soil paste was measured using Corning pH meter model 7. The electrical conductivity of the saturation extract was measured by conductivity TDS meter, model 44600 (Hach).

RESULTS AND DISCUSSION

Fresh yield :

Seedlings emerged from the Vertisols after three days while in Aridisols seedlings emergence was after five days from sowing. The data revealed that treatments had the same trend in the two seasons. The shoot fresh weight was significantly increased by all treatments compared to the control, with the exception of potassium treatment. This may be explained by the high fixing capacity of both soils for potassium. The organic fertilizers had the highest fresh yield compared to inorganic fertilizers. Chicken manure was superior relative to the other treatments in both seasons (Table 2). This is because the organic manures may have special advantage in giving maximum yields due to their characteristics of improving soil physical properties, supplying nitrogen and all other macro and micronutrients slowly upon decomposition. The combination of inorganic fertilizers (NPK) had a significant effect compared to single application of these fertilizers. Vertisols out-yielded Aridisols in all treatments i.e. fertilizers are more effective on Vertisols compared to Aridisols. This may be due to the improvement of the physical conditions which are more limiting in Vertisols compared to Aridisols.

Leaf nitrogen content :

Organic and inorganic fertilizers had significantly (P0.01) affected the leaf nitrogen content in both experiments. Chicken manure had the highest nitrogen level. This positive response to nitrogen was expected in these semi-arid soils, because they were deficient in nitrogen (5). The high nitrogen value obtained by organic fertilizer application increased the level of plant nitrogen consistently. The average nitrogen content in Vertisols is greater than that in Aridisols, but nitrogen level is below the adequate level for corn plants as established by (11) (Table 3). As the level of nitrogen supply increases (over a considerable range) compared with other nutrients, the extra protein produced allows plant to grow larger and to have larger surface available for photosynthesis (16). It is worthmentioning that the best response to nitrogen will be when phosphorous and potassium are non-limiting as documented by von Liebig's model commonly known as the law of the minimum.

Leaf phosphorous content :

The initial phosphorous concentration in the two soils was 17 and 13 ug/g for Vertisols and Aridisols, respectively, which was about the critical concentrations of soil-test phosphorous (STP) used to identify soils where response to phosphorous fertilization should be expected (17). The data (Table 4) revealed significant differences (P(0.05) due to fertilizers application in both soil types. There was no significant difference in leaf phosphorous content between chicken manure, P2O5 and NPK in Vertisols and urea, P2O5 and NPK in Aridisols. This is natural because i) all these fertilizers added phosphorous to the soil. ii) the nitrogen contained in the treatments (NPK and urea) result in a root growth stimulation that increased the volume of the soil occupied and hence more phosphorous will be taken by the plants. This result agreed with the results of (18) and (19). The leaf phosphorous content in Vertisols exceeded the leaf phosphorous content in Aridisols by 29.6% and 45.3% in the first and the second experiment, respectively. This is because the fine-textured soils generally hold more water than do medium-textured soils and are therefore likely to contain more phosphorous in solution (20).

Leaf potassium content :

There was a significant effect (P(0.05) of organic and inorganic fertilizers on leaf-potassium content relative to the control in both soils (Table 5). The leaf phosphorous content was not significantly different among fertilizer treatments. This may be due to the fact that the quantity of potassium present in the soil is adequate for plant growth and/or these soils had a high fixing capacity for potassium. This result is in agreement with (21). The leaf potassium content in Vertisols exceeded that in Aridisols by 3.6% and 3.8% in the first and the second season, respectively.

Leaf calcium and magnesium contents :

The results indicated that fertilizer treatments affected the calcium content of the plant significantly (P(0.05) compared to the control except the green manure treatment in Vertisols. Generally, the differences among fertilizer treatment were not significant, despite the slight increase of calcium content of those treated with chicken manure because chicken manure contains appreciable amount of calcium when used as an amending agent. Significant differences (P0.05) in leaf magnesium content were detected between the fertilizer treatments and the control, but there was no significant differences between the fertilized plants (Table 6). The slight increase in magnesium content of plants treated with organic manure could be due to the release of Mg from the slowly decomposed organic manure. However, it was concluded that nutrient concentrations in plant tissue were mostly dependent on their amounts supplied (22). The levels of both calcium and magnesium were in the adequate range for corn as suggested by (11).

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Table 1

Some selected physical and chemical properties of Vertisols (Wad El Haddad) and Aridisols (El Rawakeeb).

Properties	Vertisols (Wad El Haddad)	Aridisols (El Rawakeeb)	Green manure	Chicken manure
Sand %	12	51.6	-	-
Clay %	68	35.5	-	-
Silt %	20	13.4	-	-
pH	7.4	8.2	6.8	7.2
ECe (dS/m)	4.5	2.40	2.99	7.5
SAR	5.50	3.38	0.53	1.7
Na (mmol/l)	19.21	9.4	0.89	1.61
K ,,	0.90	0.76	0.58	0.38
Ca ,,	15.71	11.0	3.73	5.98
Mg ,,	8.93	4.46	1.96	3.54
HCO_3	nil	0.82	-	-
O.C %	1.2	0.99	33.28	51.32
N %	0.024	0.007	0.044	0.77
CEC (mmol/100g soil)	71.5	53	13.13	15.45
Pg/g	17	13	-	-
Ca: Mg ratio	-	-	1.90	1.69

Table 2

Fertilizers effects on corn fresh weight (g/plant) grown in two soil types.

Treatments	1st experiment		2nd experiment	
	Vertisols	Aridisols	Vertisols	Aridisols
Control	51.14 i	48.23 j	59.67 g	50.90 i
Green manure	88.81 b	80.83 d	96.76 b	77.63 e
Ckicken manure	100.60 a	89.00 b	107.2 a	94.93 bc
Urea (N)	65.76 e	59.47 f	75.68 e	68.10 f
Superphosphate	57.70 g	54.77 h	59.24 g	55.63 h
Potassium sulphate	51.90 i	47.07 j	61.41 g	50.27 i
NPK	87.02 c	89.67 b	90.72 d	92.60 cd
Mean	71.85	67.01	78.67	70.05

Means followed by the same letter(s) are not significantly different at P = 0.05 using Duncan Multiple Range Test (DMRT).

Table 3

Corn leaf nitrogen content (%) as affected by organic, inorganic fertilizers and two soil types.

Treatments	1st experiment		2nd experiment	
	Vertisol	Aridisol	Vertisol	Aridisol
Control	1.54ef	1.40 fg	1.43 f	1.50ef
Green manure	1.6 e	1.69 e	1.67 e	1.66e
Ckicken manure	2.63a	2.55a	2.55 a	2.37ab
Urea (N)	2.30bc	2.17c	2.20 bc	2.10cd
Superphosphate	1.87d	1.60 e	1.97 d	1.58ef
Potassium sulphate	1.27gh	1.20 h	1.20 g	1.06g
NPK	2.40b	2.33 b	2.43 a	2.20bc
Mean	1.96	1.85	1.92	1.78

Means followed by the same letter(s) are not significantly different at P = 0.05 using Duncan Multiple Range Test (DMRT).

Table 4

Effects of organic, inorganic fertilizers and two soil types on leaf phosphorous (ug/g) content of corn.

Treatments	1st experiment		2nd experiment	
	Vertisol	Aridisol	Vertisol	Aridisol
Control	1.23 i	0.96 j	1.47 f	0.80 h
Green manure	1.70 fg	1.23 i	1.83 df	1.23 g
Ckicken manure	2.80 a	2.10 d	3.07 a	2.23 c
Urea (N)	2.33 c	1.77 ef	2.70 b	1.80 de
Superphosphate	2.35 be	1.93 de	2.80 b	2.00 d
Potassium sulphate	1.50 gh	1.40 hi	1.73 e	1.30 fg
NPK	2.60 ab	1.97 de	2.77 b	1.90 de
Mean	2.10	1.62	2.34	1.61

Means followed by the same letter(s) are not significantly different at P = 0.05 using Duncan Multiple Range Test (DMRT).

Table 5

Effects of organic, inorganic fertilizers and two soil types on the potassium content (%) of corn leaf.

Treatments	1st experiment		2nd experiment	
	Vertisol	Aridisol	Vertisol	Aridisol
Control	1.07 i	1.03 d	0.97 e	1.00 e
Green manure	1.50 ab	1.50 ab	1.47 abc	1.40 abcd
Ckicken manure	1.62 a	1.57 ab	1.55 a	1.50 ab
Urea (N)	1.47 ab	1.50 ab	1.53 a	1.30 cd
Superphosphate	1.40 ab	1.30 c	1.45 abcd	1.27 d
Potassium sulphate	1.50 ab	1.40 bc	1.30 cd	1.33 bcd
NPK	1.53 ab	1.43 bc	1.40 abcd	1.50 ab
Mean	1.44	1.39	1.38	1.33

Means followed by the same letter(s) are not significantly different at P = 0.05 using Duncan Multiple Range Test (DMRT).

Table 6

Mean values of organic and inorganic fertilizers effects on leaf calcium and magnesium concentrations (%) of corn plants grown in two soil types.

	First Experiment		Second Experiment	
	Vertisols	Aridisols	Vertisols	Aridisols
Treatments	Calcium	Magnesium	Calcium	Magnesium
Control	09.3 c	0.44 f	0.91 c	0.41 e
Green manur	0.95 c	0.64 de	0.97 bc	0.62 d
Ckicken manure	1.34 a	0.75 d	1.20 a	0.69 d
Urea (N)	1.19 b	0.66 de	1.21 a	0.65 d
Superphosphate	0.99 c	0.64 de	1.19 a	0.63 d
Potassium sulphate	1.15 b	0.62 e	1.09 ab	0.61 d
NPK	1.23 b	0.68 e3	1.12 ab	0.67 d
Mean	1.11	0.63	1.10	0.61

Means followed by the same letter(s) are not significantly different at P = 0.05 using Duncan Multiple Range Test (DMRT).