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Effect of Organic Farming Practice on Nutrient Availability and Wheat Yield Grown on Torripsamments

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A FIELD experiment was conducted to measure the usefulness of supplementing of different organic materials [water hycinth compost (MC), town refuse compost (TR) and chicken manure (Ch)] to a sandy soil.

The optained results strongly confirmed that application of organic materials increased organic matter content, CEC and decreased the hydraulic conductivity of the investigated soil. The results also showed that the application of organic materials either alone or in combination with chemical fertilizers caused a substantial increase in total N, available P, K and micro nutrients (Fe, Mn, Cu, Zn), as well as wheat yield (straw and grain). The highest yield was obtained when HC was applied at rates 10 and 20 t/fed in combinations with 50% of the recommend dose of NPK chemical fertilizers. Economical examination was carried out by calculating the benefit to cost ratio B/C parameter.

It is worth to mention that the application of mixed organic-organic fertilizers using Ch at rate of 3 t/fed with MC at rate of 10 t/fed gave almost the same crop production as of using the recommended dose of NPK chemical fertilizers. This emphasis the importance of organic farming practices in desertic sandy soils to minimize consuming the chemical fertilizers and to avoid environmental pollution hazardous.

Keywords: Water hycinth compost (HC), Town refuse compost (TR), Chicken manure (Ch) , Chemical fertilizers (F).

The use of organic materials in crop production is receiving renewed attention worldwide. Vertical and horizontal extensions in agriculture are of equal importance arid both of them need good fertilization regime. Most of the newly reclaimed areas in the deserts of Egypt are sandy soils which have certain problems in their cultivation. Sandy soils are very poor in their organic matter contents as well as their primitive fertility. On the other hand, organic materials such as crop residues, farmyard manure, town refuse compost, water hyacinth compost, etc, are available in abundance and reach tremendous amounts every day. Total reliance on such materials alone, however, is unrealistic and mineral fertilizers (NPK) should be applied to obtain desirable crop yields. So organic farming practices should be followed by the application of these organic materials to minimize consuming the chemical fertilizers and conserve the environmental elements from pollution hazard.

The influence of organic matter on plant growth is not just a matter of nutrient supply (Isaeva, 1982; Holanda *et al.*,1982; Ismail *et al*, 1988; Sharma and Mittra, 1988; More, 1994; Raveendran *et al*, 1994 and Cuu *et al*, 1997), but they influence the physical characteristics of the soil (Parr *et al.*, 1982; Faltas *et al.*, 1986; Zaid and Kriem, 1992; Sabra *et al.*, 1993; Khaled, 1993 and Khalil *et al.*, 1997), the chemical properties (Ismail *et al.*, 1988, Singh and Yadav, 1989; Mizal, 1993; Abd Elmoez *et al*, 1997). Application of organic materials produced positive effect on crop yield (Sharma and Mittra, 1988; 1990 and 1991; Majid., *et al.*,1992; Rabie *et al.*, 1995 and Abdel Sabour and Abo El Seoud,1996).

The present study was undertaken to measure the usefulness of supplementing of different organic materials (ton refuse compost, water hyacinth compost and chicken manure) to minimize consuming chemical fertilizers. The economical evaluation of applying these materials either alone or in combinations with chemical fertilizers is going to be considered.

Material and Methods

A field experiment was conducted on a desertic sandy soil during the season (November, 1996- May, 1997) at Wadi El Molak Ismailia, Egypt. The physical and chemical properties of the studied soil are presented in Table 1. Three

different organic materials were used, namely: town refuse compost (TR), chicken manure (Ch), and water hyacinth compost (HC). The chemical composition of the used organic materials is presented in Table 2. Town refuse compost was added at rate of 10 t/fed (TR). Water hyacinth compost was added at rates of 10 (MC_1) and 20 (MC_2) t/fed. Chicken manure was added at rate of 3 t/fed (Ch). Chemical fertilizers (F) was used at rate of 50 % of the recommended dose (50 kg N + 15 kg P_2O_5 + 12 kg K_2O/fed.). Eight treatments were achieved as follows: control, conventional HC_1, HC_2 HC_1 F, HC_2 F, $HC1_1$ Ch, TRCh. The treatments were chosen to be applied according to the promising treatments previously choosen from the results of the greenhouse experiments (Taalab, 1999).

TABLE 1. Some physical and chemical properties of the studied soil.

pH (1:2.5)	EC (dS/m) (1:2.5)	OM %	$CaCO_3$ %	CEC Cmol/kg	Particle size distribution (%)			Textural grade	Soil Taxonomy*
					Sand	Silt	Clay		
8.0	2.94	0.11	3.4	4.4	85.5	9.5	5.0	Sandy	Typic Torripsamments

* Soil Survey staff, 1998

Total N (ppm)	AB-DTPA – extractable elements (ppm)						Soluble ions (meq/l)						
	P	K	Fe	Mn	Zn	Cu	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$(CO_3^{=} + HCO_3^{-})$	Cl^{-}	$SO_4^{=}$
170	10.5	43.0	11.3	2.0	0.61	0.32	6.5	3.1	20.7	0.58	1.8	20.3	8.78

The conventional treatment is the chemical fertilizers application carried out by the neighbor farmers around the studied area and was taken for comparison. Those farmers are following the recommended dose of applying NPK fertilizers (100 kg N + 30 kg P_2O_5 + 24 kg K_2O/fed) according to the Fertilizers Recommended Organization, Ministry of Agriculture, Gizay, Egypt. Complete randomized block design 2m x 3m plots with three replicates were achieved. Wheat (Sids 6) planted on 20th of November 1996. Organic materials and phosphate fertilizers were added to the soil before sowing, while ammonium nitrate and potassium sulphate were added in two equal doses. The first dose was at 20 days after sowing and the second one was two weeks later. Plants were harvested on the 10th of May, 1997. Plant and soil samples were subjected to physical and chemical determinations. Particle size distribution (Piper, 1950),

TABLE 2. Total elements content in the used organic materials.

Element	Water hyacinth compost (HC)	Town refuse compost (TR)	Chicken manure (Ch)
N (%)	2.6	1.5	5.1
N (ppm)	26000	15000	51000
P_2O_5 (%)	1.72	0.46	8.93
P (ppm)	7396	1978	38399
K_2O (%)	3.0	0.82	4.5
K (ppm)	24900	6806	37350
C (%)	41.2	33.6	38.3
C/N ratio	15.8	22.4	7.5
Heavy metals (ppm)			
Fe	670	1355	690
Mn	620	245	510
Zn	57	258	150
Cu	47	102	32
Pb	6	8	0.01
Ni	1.1	0.9	6.9
Cd	1.5	3.3	0.01
Cr	7.3	10	12.2
Co	18.0	21.9	16.2
EC (dS/m)*	2.6	1.9	3.0
CEC (cmol /kg)	47	28	56
Available N (ppm)			
NH_4	89.6	78.4	150.8
NO_3	56.0	12.4	72.9
Available P (ppm)	136.2	114.5	158.8
Available K (ppm)	4158	2033	16170
Water holding capcity %	201	135	235
Moisture %	45	20	30

* Extract 1 : 10

organic matter, total nitrogen, total soluble salts and soluble cations and anions (Jackson, 1967). Available P, K, Fe, Mn, Zn and Cu were measured using NH_4HCO_3 DTPA (Soltanpour, 1985). Fe, Mn, Zn and Cu were determined using atomic absorption spectrophotometer. Available water was measured and calculated as described by Klute (1986). Hydraulic conductivity was estimated on disturbed soil according to Darcys law (Richards, 1954) and water holding capacity was determined according to the standard procedure (Black, 1982). The plant shoot was dried at 70 °C for 24 hr and weighted. Dry matter were digested using a mixture of sulphuric and percloric acids (Jackson, 1967). The digested plant solutions were analyzed for: N, P, K, Fe, Mn, Zn and Cu.

Benefit-cost analysis were carried out according to Cittinger (1973).

Results and Discussion

Effect of organic manures on some soil properties

The application of the different organic materials to the examined sandy soil improved its physical as well as chemical and fertility properties. The addition of organic manures increased the organic matter content after the harvest of wheat (Table 3). The increase was 1.5-2 times that of the conventional treatment and 4 times that of the control treatment. Organic matter in the soil plays an important role through building up soil aggregates and hence enhancing proper soil physical and physicochemical properties.

The problem in sandy soils is the open texture and the relative wide sizes of the macro pores. The improvement of water holding capacity in such soil is the main goal of any reclamation process. The data presented in Table 3 indicate that the use of organic materials increased the field capacity of the soil more than its wilting point and consequently increased the available water. The efficiency of the used organic materials on increasing soil field capacity could be arranged in the following descending order:

HC_2 > HC_2F> HC_1Ch > TRCh> HC_1F> HC_1 conventionel > control.

TABLE 3. Effect of organic and chemical fertilizers on soil properties.

Treatment	Hydraulic Conductivity (cm/h)	CEC (cmol/kg)	O.M. %	Soil moisture (%)		
				Field capacity	Wilting point	Available water
Control	10.9	4.5	0.15	11.1	2.0	9.1
Conventional	10.8	4.6	0.30	11.5	2.1	9.4
TRCh	9.5	5.8	0.50	15.7	2.5	13.2
HC_1	9.0	5.7	0.52	15.0	2.2	12.8
HC_1Ch	8.5	5.9	0.50	16.9	2.5	14.4
HC_2	7.3	6.5	0.62	18.5	3.0	15.5
HC_2F	7.2	6.2	0.60	17.4	2.9	14.5
HC_1F	7.4	5.8	0.59	15.3	2.3	13.0

The increase of available water could be ascribed to the beneficial effect of these organic materials on forming soil aggregates. Along with that, the humus produces from microbial decomposition of organic manures can absorb more than six times of its own weight water, thereby increases the soil moisture retention (Tester, 1990). Accordingly, the available water increased from 9.1 % for the virgin soil to 14.4 % and 15.5 % when water hyacinth compost was added at rates of 10 and 20 t/fed, respectively.

The values of hydraulic conductivity are also used as an indicative figure for this purpose, however the use of HC manure decreased the K-values of the studied soil. The addition of 2% hycinth compost showed a noticeable figure as the K-value decreased from 10.9 cm/hr in the virgin soil to 7.3 cm/hr with the addition of 20t/fed. (Table 3). It could be concluded that the use of composted materials are more reliable and practical in improving the soil water characteristics in such soil.

Cation exchange capacity is one of the most important properties of soil which is considered as an indication of soil fertility. It gives a direct measure for total capacity of a soil to retain nutrient elements in a moderately available form

to plant uptake. The CEC of the studied soil was 4.5 cmol/kg, while the CEC values of the used organic materials were 46.9, 28.1 and 56.3 cmol/kg for HC, TR and Ch, respectively (Table 2). The addition of 10 and 20 t/fed. of HC compost increased CEC values to about 5.7 and 6.5 cmol/kg (Table 3), respectively.

Nutrients availability and wheat yield

The data presented in Fig. 1 and 2 show that the application of organic materials significantly increased the total N and the available fraction of P and K as well as micronutrients (Fe, Mn, Zn and Cu).

The obtained data evidently confirmed the greater availability of NPK by applying the organic materials HC_2 and HC_2F under field conditions. The highest values of available Fe and Mn are associated with either HC_2 treatment alone or in combinations with the chemical fertilizers, while the highest value of available Zn and Cu were yielded from TRCh treatment.

The data presented in Table 4 show a significant increase in both the straw and grain yields of wheat crop at the different organic materials applications.

Almost all organic treatments (individually or in combination with the chemical fertilizers) yielded a substantial increase in the yield of wheat (straw and grains) as compared either to control treament or the conventional one. The highest yield of wheat crop is associated with HC at rates of 10 and 20 t/fed. in combination with 50% of the recommended chemical fertilizers rate, i.e. treatments of HC_1F and HC_2F (Fig.3)

The grain yields were 2266 and 3146 kg / fed, of the above mentioned treament. While the straw yields were 3280 and 4030 kg / fed., respectively. The obtained crop yields reach about 1.63 and 2.26 times that of the conventional treatment for grains and 1.82 and 2.24 times for straw, respectively.

It seems likely that the beneficial effects of organic materials must be attributed more to an improved overall fertility of the soil than to an improved availability of NPK only. When simple salt fertilizers are added to the soil the increases in crop yields may be ascribed to the increase in the available amount

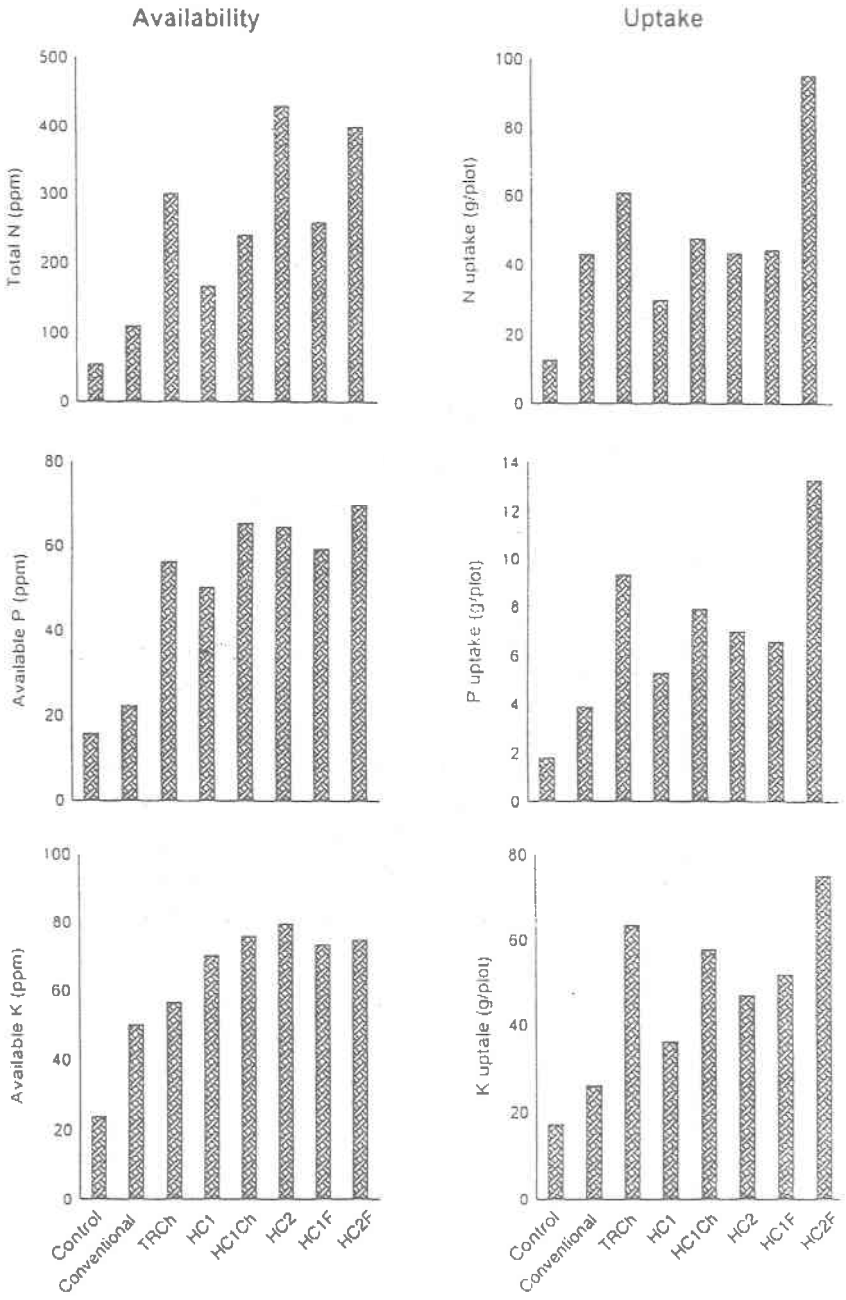

Fig. 1. Effect of applied organic and chemical fertilizers on the total N and availability of P and K in the soil and their uptake by wheat crop.

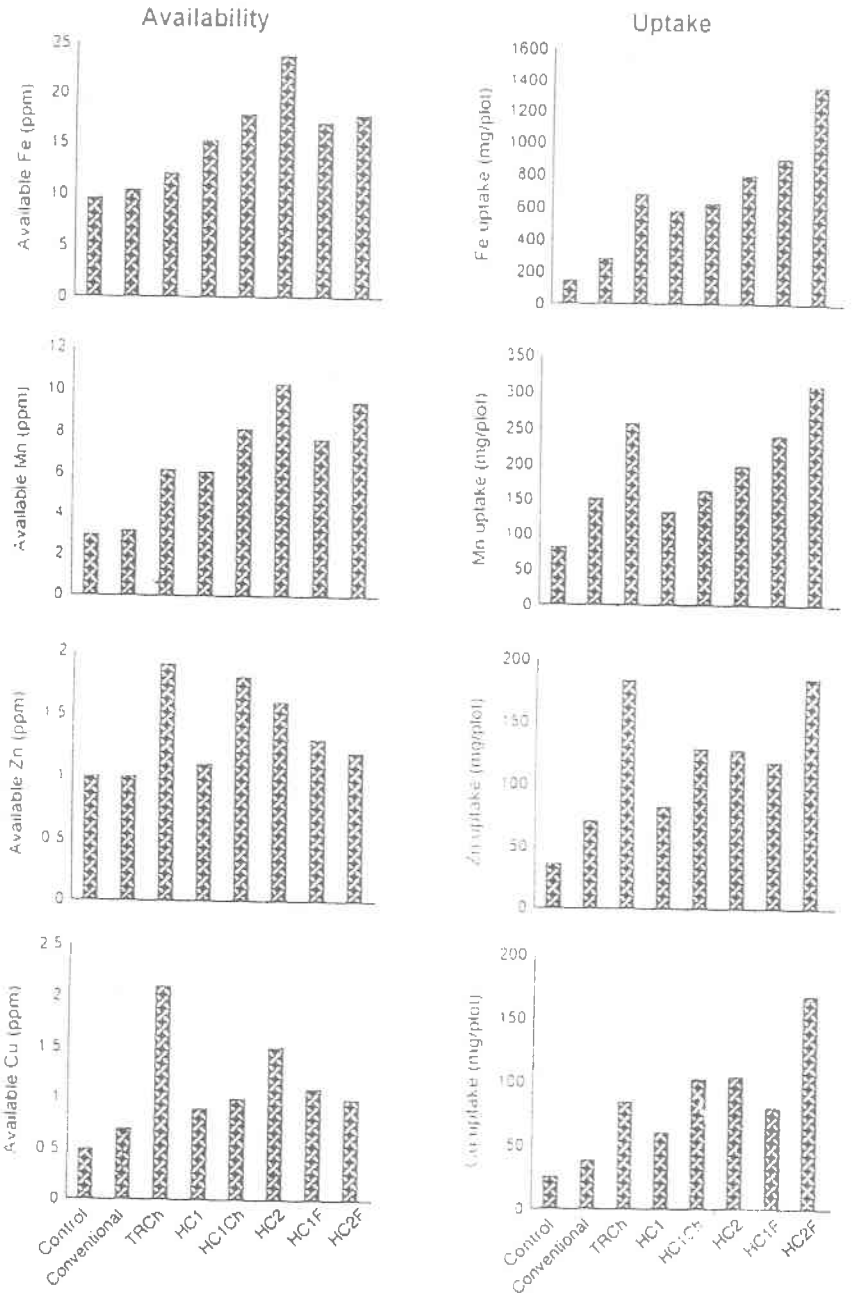

Fig. 2. Effect of applied organic and chemical fertilizers on the availability of micronutrients in the soil and their uptake by wheat crop.

TABLE 4. The straw and grain yields of wheat crop (kg / fed.) and benefit to cost ratio (B/C) for the studied field treatments.

Treatment	Cost (LE)	Grain		Straw		Total income (LE)	Profit (LE)	Benefit/ Cost Ratio	Order
		Kg	Price (LE)	Kg	Price (LE)				
Conventional	262	1390	927	1800	216	1143	881	3.36	3
TRCh	446	1932	1288	2613	314	1602	1156	2.59	5
HC_1	195	1000	666	1117	134	800	605	3.10	4
HC_1Ch	346	1817	1211	2415	290	1501	1155	3.34	3
HC_2	390	1577	1051	2693	323	1374	984	2.52	6
HC_2F	521	3146	2097	4030	484	2581	2060	3.95	2
HC_1F	326	2266	1511	3280	394	1905	1579	4.84	1

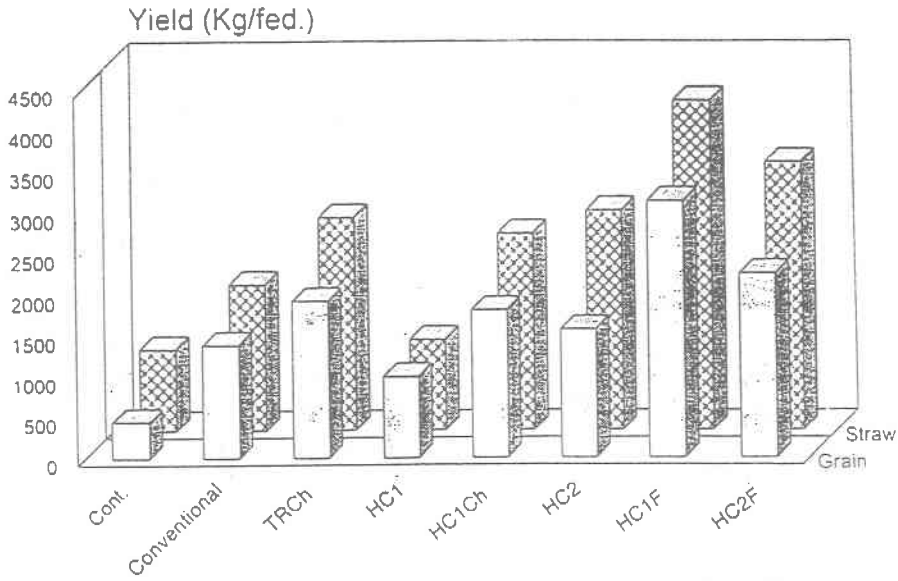

Fig. 3. Effect of the applied organic and chemical fertilizers on wheat yield.

of one limiting element that has been applied. However, the increases in the crop yields caused by the application of organic matter are not readily ascribable only to the increase in availability of the nutrient. The tremendous increase in the wheat yield following HC, TR and Ch as organic applications is probably due mainly to the improvement of the soil environment, which encourage proliferation of roots, which in turn draw more water and nutrients from large area and also greater depth. The improvement by adding organic materials is mainly rendered to improving organic matter content, cation exchange capacity as well as water properties as previously mentioned. Moreover, the decomposed organic materials release macronutrients (N, P and K) along with micronutrients which become available to the plants and thus increase the plant uptake.

Economic evaluation

As shown in Table 4 HC_2F treatment gave the highest profit followed by HC_1F. Economic evaluation is a predicating for the economic value of implementing a given treatment to the soil. This is more useful than a purely physical evaluation. The economic evaluation is carried out based on the benefit (B) to cost (C) ratio (B/C) for each material type.

The (B/C) ratio was calculated from the obtained data of the maximum yield for each treatment. The benefit to cost ratio of the maximum yield and the economic classes are shown in Table 4. The data show that the most economically treatment is HC_1F followed by HC_2F. The B/C ratio was in the order:

$HC_1F > HC_2F > HC_1Ch$ = conventional > HC_1 > TRCh > HC_2

Taking in account the residual effects of organic materials, as previously mentioned, the cost will reduce in the next crop and consequently the profit will be increased. In addition, the role of organic materials in improving soil physical, physicochemical, and biological characteristics should be considered in evaluation its effect on increasing soil productivity and the net profit.

Conclusion

Organic practices should be followed by application of different organic materials to minimize consuming the chemical fertilizers and conserve the

environment from pollution hazards. In this point, water hyacinth compost at rate of 10 t/fed in combinations with 50% of the recommended dose of chemical fertilizers (NPK) is the most usefulness treatment.

The mixed organic - organic fertilizers treatment (Chicken manure at rate of 3 t/fed with hyacinth compost at rate of 10 t/fed is also very useful. It gives the same crop production when using recommended dose of chemical fertilizers (conventional farmers application). Moreover, it improves physical, chemical and biological properties of the soil. In addition application of such materials conserve the agricultural environment from pollution hazards.

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تأثير إضافة المادة العضوية على صلاحية العناصر ومحصول القمح النامى فى الأراضى الرملية Torripsamments

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أجريت تجربة حقلية لدراسة أثر إضافة المواد العضوية (مكمورة ورد النيل HC ، مكمورة قمامة المدن TR وسمادة زرق الدواجن Ch) منفردة أو فى إضافات مع بعضها أو مع الأسمدة الكيماوية وذلك على إنتاجية محصول القمح النامى فى الأراضى الرملية الصحراوية.

أوضحت الدراسة أن الإضافات العضوية أدت إلى زيادة محتوى التربة من المادة العضوية والسعة التبادلية الكاتيونية بينما إنخفض التوصيل الهيدروليكى للتربة.

كما أوضحت النتائج أن الإضافات العضوية أدت إلى زيادة النيتروجين الكلى والفوسفور والبوتاسيوم والحديد والمنجنيز والزنك والنحاس الصالحة للنبات وأدى إلى زيادة امتصاص هذه العناصر وانعكس ذلك على إنتاجية محصول القمح من الحبوب والقش.

وبينت الدراسة أن أقصى محصول للقمح كان عند إضافة ورد النيل بمعدل ١٠ ، ٢٠ طن للفدان مخلوطاً مع الأسمدة الكيماوية بمعدل ٥٠٪ من الكمية الموصى بها، ولقد أكدت الدراسة الإقتصادية هذه النتائج.

وبينت الدراسة أيضا أن التسميد العضوى باستخدام زرق الدواجن (٣ طن / فدان) مع مكمورة ورد النيل (١٠ طن / فدان) كان لها نفس العائد الإقتصادى عند إضافة الأسمدة الكيماوية منفردة بالمعدلات الموصى بها ، مما يوضح أهمية الزراعة العضوية من أجل تحجيم استهلاك الأسمدة الكيماوية وحماية البيئة الزراعية من مخاطر التلوث .