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APPLICATION OF FARM BY-PRODUCTS AND THEIR IMPACT ON THE CHEMICAL PROPERTIES AND PRODUCTIVITY OF CALCAREOUS SOIL.

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A field experiment was conducted at Maryut Experimental Station, of the Desert Research Center, to evaluate the uses of some different organic manures, such as, farmyard manure (F), rabbit manure(R) and turkey manure (T), for improving the chemical properties of the calcareous soils and their productivity, barley was used as a test crop.
The results indicated that the application of any of the three organic manure either individually or in combinations increased soil organic matter content and decreased soil pH and salinity, as well as, increased total nitrogen, exchangeable potassium and available phosphorus in the soil. All treatments increased the availability of Fe, Mn, Zn and Cd but they decreased Pb availability.

The data showed that the application of the studied three organic manures increased significantly the dry weight of barley yield either grains or straw as compared to the control treatment. The increment varied according to the type and the level of manure.

The results indicated that both concentration and uptake of N, K, P, Fe, Mn, Zn, Cd and Pb by grains and straw of barley plants increased by the increasing application of the three organic manures either added individually or in combination.

Keywords: farmyard manure, rabbit manure, turkey manure, calcareous soil, barley plants, soil properties, nutrients content.

The importance of organic matter for agriculture in Egypt comes next to that of water. The huge amounts of organic waste accumulation due to the increase in both population and industrials-agricultural activities should be utilized. It is well known fact, that recycling organic waste materials for increasing agricultural production, reduces environmental pollution. In this respect, Dahdoh *et al.* (1996) indicated that the extractable Pb decreases with increasing peatmoss application.

Organic matter plays an important role in the chemical behaviour of several elements in soils through its active groups (fulvic and humic acids) which have the ability to retain the metal in the complex and chelate form. According to Mickievich *et al.*(1977) much higher concentrations of Cu, Pb and Ti are associated with fulvic acid rather than with humic acid.

The addition of organic manures particularly to newly reclaimed soils is of vital importance due to their effect on improving physical, chemical and biological properties of the soil. Balogh (1970) noted that organic fertilizers protecting the soil surface against erosion by water and wind, raising the buffering capacity of soil, and leads to increase its productivity. El-Badry *et al.*(1982), Badran (1983) and Chen and Wang (1987) found that the soil organic matter content was increased in the soil due to applied organic manures from different origins Also, Sinha (1972) emphasized the importance of organic matter decomposition on the availability of nutrients in soils. Abdel-Salam and El-Sibaie (1983) , El-Sibaie *et al.*(1983), Dahdoh and El-Hassanin (1994) and Dahdoh *et al.*(2002) found that barley yield was positively affected by organic manure treatment.

The present work aims to study the effect of farm by-products such as; farmyard manure, rabbit manure and turkey manure and their effects on some chemical properties of calcareous soil and its productivity of barley as well as, its macro and micro-nutrients content and some heavy metals.

MATERIALS AND METHODS

A field experiment was carried out in Maryut Experimental Station of DRC. The soil analysis of the experimental site is calcareous sandy clay loam as shown in table(1). The experimental plots were arranged in completely randomized blocks, with 19 treatments and 4 replicates for each treatment and the least significant difference(L.S.D) was used to compare the averages. The dimensions of each plot were 3x3.5m.(1/400 feddan; one feddan =4200 m^3).The applied treatments were as follows:

1-Control (without organic manure application).
2-Farmyard manure at the rate of 10 m^3/fed (F_1).
3-Farmyard manure at the rate of 20 m^3/fed (F_2).
4-Rabbit manure at the rate of 10 m^3/fed (R_1).
5-Rabbit manure at the rate of 20 m^3/fed (R_2).
6-Turkey manure at the rate of 10 m^3/fed (T_1).
7-Turkey manure at the rate of 20 m^3/fed (T_2).

8- F_1R_1	9-F_1R_2	10-F_1T_1	11-F_1T_2
12-F_2R_1	13-F_2R_2	14-F_2T_1	15-F_2T_2
16-R_1T_1	17-R_1T_2	18-R_2T_1	19-R_2T_2

All treatments were added to the soil and mixed with the surface layer 15 days prior cultivation.

Barley was sown at the rate of 40 kg/fed. in 22/11 (1999) in the experimental plots, the water was applied intervals 10 days using surface irrigation. All treatments received the same rates of NPK fertilizer. The rates added in the form of superphosphate (30Kg P_2O_5/fed.) before cultivation, ammonium nitrate (40 Kg N/fed.) and potassium sulphate (30Kg K_2O/fed.) were added through two doses; i.e. the first application was after 15 days from planting and the second was before flowering stage.

Plants were harvested at maturity and yield of barley(grain and straw) per plots was weighted after the separation of grains from straw, thereafter plant samples were taken and prepared for analysis. At the harvest of barley yield, representative soil samples were collected from the surface layer of five sites from each replicate and were mixed for chemical analysis; EC, pH were determined by using a bench type Bekman glass electrode PH meter Model(Alpha 200).Organic matter was determined according to the Walkely-Black method (Richards ,1954), total N according to the modified Kjeldahl method after Chapman and Pratt (1961), available phosphorus (Olsen *et al.*, 1954), available potassium (Jackson, 1973) and available Fe, Mn, Zn, Cd and Pb according to Lindsay and Norvell (1978). The plant samples were wet ashed with ternary acid mixture (HNO_3-$HClO_4$-H_2SO_4) following the method reported by Van Schowenburg (1968) . Potassium was estimated using flame photometer. Phosphorus was determined according to the method of ascorbic acid described by Frie *et al.* (1964). Fe, Mn, Zn, Cd and Pb were determined using atomic absorption. N was determined using Kjeldahl method as described by FAO(1970).

Statistically analysis was carried out according to the method described by Snedecor and Cochran (1980) using the least significant difference (L.S.D) was used to compare the averages.

The main properties of the studied soil at the beginning of the experiment and the analysis of the organic manures under investigation are presented in table (1).

TABLE (1). Some chemical and physical soil properties and analysis of organic manures.

a-Main properties of the soil at Maryut (0-30 cm).

PH	CaCO3	OM	EC	Particle size distribution %				Texture
	%	%	dS/m	C. sand	F. sand	Silt	Clay	
8.04	19.2	0.65	6.43	1.5	62	12.5	24	S.C.L.

b- Organic manure analyses.

Manures	Moisture %	OM %	Total C %	Total N %	C/N ratio	Total P %	Total K	Total Fe ppm	Total Mn	Total Zn	Total Cd	Total Pb
Farmyard manure	45.00	15.46	8.97	0.59	15.2:1	0.18	1.14	5842	638	86	0.8	8
Rabbit manure	32.00	25.83	14.98	1.44	14.4:1	0.14	1.05	3658	368	98	1.7	19
Turkey manure	63.00	23.74	13.77	1.62	8.5:1	0.26	1.32	1248	457	93	3.5	12

RESULTS AND DISCUSSION

Data in table (2) reveal the effects of applied treatments on some chemical properties of the soil; pH, EC, and soil organic matter content.

Soil Reaction (pH)

The data in table (2) show that all added organic manure either added individually or in a combination decreased soil pH as compared to the control treatment. With respect to the individual application of three organic manure under investigation, data showed the application of farmyard manure was the most effective on reduction soil pH as compared to the other two sources. The reduction in soil pH increased with increasing application rate of the three amendments. On the other hand, the combined applications of every two amendments were more effective on reducing soil pH as compared to the individual application of those amendments. Generally, the combined application (F_2R_2) treatment was superior to all other treatments and was followed by (F_2R_1) and (F_1T_2) treatments respectively. This effect could be attributed to the formation of organic acid during decomposition of organic matter and also due to the formation of CO_2 gas due to high microbial activity. Dissolution of CO_2 in soil moisture leads to the formation of carbonic acid (Dahdoh and El-Hassanin,1994 and Dahdoh *et al.*, 2002). Also, it is noticed that the decrease in pH varied between 0.03 to 0.4 units depending on the source and the rate of the added organic manure.

Soil Salinity (EC)

Data presented in table (2) indicate there was a consistent trend of decreased EC values with all the organic amendment treatments as compared to the control. Regarding the individual application of the three organic manure under investigation, the application of rabbit manure was the most effective followed by turkey manure and finally farmyard manure. It is notice that the reduction of soil EC increase with increasing application rates of three amendments. The decreasing of EC reached to 27, 22 and 20% at addition of R_2, T_2 and F_2 respectively, as compared to the control treatment. In this respect tc the combined application of every two amendments were more effective than the individual application. The most effective treatments on reducing soil salinity was enhanced by (R_2T_2) treatment followed by (F_2T_2) and (R_1T_2) treatments, which caused decreases reached to 41, 38 and 30% respectively, as compared to the control treatment. These results were in agreement with those findings by Hashem *et al.*(1992) and Beheiry *et al.*(1997). The decrease of EC values could be due to improved leaching rates of salts associated with improved physical properties of the soil due to application of organic manures.

Soil Organic Matter

The effect of treatments on soil organic matter content are presented in table (2). Data show that all treatments increased soil organic matter

content as compared to the control treatment. The application of rabbit manure or turkey manure induced apparent increase in soil organic matter content as compared to farmyard manure. It is noticed that soil organic matter content increased with increasing application rate of three organic manures. The individual application of R_2 treatment was superior to other individual treatments on increasing soil organic matter content followed by (T_2) treatment, which caused increases reached to 55 and 48% over the control treatment. On the other hand, the combined application of R_2T_2 was superior to all other treatments and was followed by R_2 T_1 and R_1T_2 treatments. This was corresponded the soil organic matter content of 87, 84 and 79% respectively, relative to control treatment. The effectiveness of organic manures application in increasing soil organic matter content is attributed to the addition of organic matter or enhancement of root mass and distribution of the root system and recycling of greater crops in the soil. These results were supported by those found by Badran (1983), Beheiry (1993) and El-Aaser *et al.* (1996).

Soil Macronutrients (NPK) Content

The data presented in table (3) show the effect of the three added organic manures on soil, total nitrogen, available phosphorus and exchangeable potassium.

Concerning the total nitrogen soil, data indicate that all treatments increased soil N as compared to the control. Regarding the individual application of the three organic manure, data show that turkey manure application was higher effect as compared to rabbit and farmyard manures. It is noticed that the values of total N increased with increasing application rate of the three organic manures, where T_2 treatment show superior effect followed by R_2 and then F_2 treatments. The increases of total N over control treatment reached to 46, 33 and 16% corresponding to the application of T_2, R_2 and F_2, respectively. The combined application of every two manures increased soil total N than the individual one. It is clear that the combined application of R_1T_2 was superior to all other treatments followed by R_2T_2 and F_2T_1 treatments, which led to increase reached to 79, 67 and 58% respectively over the control treatment. Similar trends were obtained by Beheiry *et al.* (1997) and Gouda (1979) who mentioned that the addition of organic manures to sandy soils led to increase organic matter content, total N and C/N ratio.

With respect to the effect of treatments on soil available phosphorus, data in table (3) indicate that increasing application dose of organic manure either individually or in a combination increased soil available P as compared to the control treatment. The application of turkey manure was more effective than other manures. On the other hand, the combined application of F_2T_2 was superior than other treatments followed by F_1T_2 and R_2T_2 treatments which led to increase amounts of P to about 195, 176 and 157% over the control, respectively. Similar trends were reported by Soper

and El-Bagouri (1964), Singh and Dahiya (1980), Dahiya and Singh (1980) and Hilal and El-Bagouri(1986), who found that the increase in P concentration due to organic manure application could partly be due to the release of organic acids which solublize the native P of the soil.

Concerning the effect of treatments on exchangeable potassium of soil, data in table (3) reveal that all treatments increased exchangeable K as compared to the control treatment. The higher increases were noticed at the higher rate of organic manure. The application of turkey manure increased K exchangeable over was superior than other two amendments; followed by farmyard manure. With respect to the combined application, data showed that F_2T_2 and R_1T_2 treatments were superior and followed by R_2T_2 and F_2T_1 and led to 28, 24 and 22% increases over the control treatment. These results were supported by Fahim (1986) and El-Sersawy *et al.* (1992) and Beheiry (1993) who attributed that the organic manure as a materials with high potassium content and supply in addition to its positive effects on the physico-chemical properties including the CEC of the soil which in turn leads to improvement of potassium retention and decrease potassium losses from the root zone. It is important to mention that the increase of all studied macronutrients may be due to the decomposition of the studied organic manure by the microbial activities.

Soil Micronutrients (Fe, Mn, Zn) and Heavy Metals(Cd and Pb) Content

Data presented in table (3) show the effect of treatments on the availability of Fe, Mn, Zn, Cd and Pb in soil. This data show that addition of organic manures increased the available amounts of Fe, Mn, Zn and Cu while decreased the amount of Pb especially in case of farmyard manure. The application of farmyard manure show superior effect on the availability of Fe and Mn, while application of Turkey manure show superior effect on the availability of Zn and Cd. This effect is more pronounced with increasing application of organic manure.

With respect to the combined application of manures, data show that the application of F_2T_2, F_2T_2, F_2R_2 and R_2T_2 treatments were superior to all other treatments and were followed by R_1T_2, R_2T_2, R_2T_2 and R_1T_2 treatments on increase of soil available Fe, Mn, Zn and Cd respectively. However, the application of F_2T_2 treatment was superior to all other treatments and was followed by F_2T_1 treatment on decreasing availability of Pb in the soil. These results were in agreement with those finding by Dahdoh *et al.* (1996) who attributed that the extractable Pb decreased with increasing peatmoss application. They attributed that to biodegradation of peatmoss application which resulted in organic acids which have active groups that can retain metals in the form of complexes and chelates with the possible change of its chemical behaviour, and they added that Fe, Zn and Mn increased with increasing peatmoss application. These results are supported with those

found by Yousery *et al.* (1984) and El-Gala *et al.* (1990). It is important to mention that the increase of available micronutrients may be due to the decomposition of organic manures and the consequent release of these nutrients from one and also well decrease of soil pH and consequently increase the availability of trace elements in soil.

Barley Yield

Table (4) illustrates the effect of treatments on the dry matter yield of barley (grains and straw). Concerning the grain yield of barley, all treatments significantly increased the grain yield over the control treatment. The individual application of the three organic manures under investigation showed that the application of 20 m^3/fed. of each manure increased grain yield of barley as compared to the application of 10 m^3/fed. Generally, the application of F_2 treatment was superior to all other three individual application treatments. With respect to combined application treatments, it is clear that the application of F_2R_2 gave highly significant increase of barley grain yield over other combinations. While there was no significant effect among F_2T_1, F_2R_1, F_1T_2 and F_1R_2 treatments.

With respect to barley straw, increasing application of organic manures either individually or in combination increased straw yield as compared to control, but the increase was not significant incase of R_1, T_1, R_1T_1, R_1T_2 and R_2T_1 treatments. The individual application of F_2 was superior to all others. where there was no significant between F_2 and F_1, R_2 and T_2 treatments. On the other hand, the combined application of F_2T_2 treatment gave highly significant increase in barley straw over all other combined application and followed by F_2R_2 treatment.

The highest increase of barley grains and straw could be attributed to the formation of improvement soil aggregates (Fahim,1986), and increasing the soil water retention (Gouda,1984) and to the contribution of organic manures for improving the chemical properties and nutritional status of soil. The later contribution includes decreasing pH which would lead to increased availability of nutrients (Dahdoh and El-Hassanin,1994 and Dahdoh *et al.*, 2002). Also, organic manures would act as complexing agents and it minimizes the loss of nutrients by leaching (Balba,1973) and stimulates biodegradation through increasing the population and activities of micro-organisms in soil (Amara and Dahdoh,1997).

NPK Content and Uptake of Barley (Grains and Straws)

The effect of treatments on the concentration and uptake of NPK in barley grains are presented in table (5). Data indicate that increasing application of all treatments increased significantly the plant content of NPK by barley grains as compared to the control treatment. The F_2 treatment was superior to all other individual applications and followed by T_2 and R_2 treatments for increasing N and K concentration in grains. While R_2 treatment was superior to all other individual treatments and followed by F_2

and T_2 treatments for increasing P content. Concerning the combined application, data show that the application of F_2R_2, F_1T_2 and F_1T_2 treatments were superior to all others and followed by F_1T_2, F_2T_2 and F_2R_2 treatments on N, P and K concentrations

Regarding the uptake of NPK by barley grains, the results indicated that the F_2 treatment show higher effect as compared to other individual treatments on increasing NK uptake of grain. However, the applications of R_2 was superior for increasing P uptake. On the other hand, the combined applications F_2R_2, F_1T_2 and F_2R_2 treatments were superior to all other combined treatments for increasing the NPK uptake of barley grains and followed by F_2T_1, F_2R_2 and F_1T_2 treatments respectively. Dahiya *et al.* (1987), Sakr *et al.* (1992) and Jarecki (1991) observed that the application of FYM increased the concentration of NPK of maize and wheat plants.

With respect to the effect of treatments on NPK concentration and uptake of barley straw. Data show that all treatments increased significantly NPK content and uptake of barley straw as compared to the control treatment. The application of T_2 was superior to all other treatments on increasing NPK content and uptake of barley straw. It is noticed that the NPK content and uptake of barley straw increased with increasing application rates of organic manure. On the other hand, the combined application of F_1T_2 and F_2R_2 treatments show higher effects on increasing the concentration and uptake of N by barley straw. However, F_2T_2 treatment was superior to all other treatments for increasing PK content of barley straw.

These results reflect the beneficial effect of organic manures addition to soil on N, P and K nutrients uptake by plants which due to the continuous decomposition of organic manures by soil micro-organisms. Also the influence of organic matter on P availability may involve several reactions according to Stevenson (1986) as follows: 1-chelation of Ca ions by organic acids and other organic compounds produced during decomposition resulting and thus decreasing P precipitation, 2-the production of carbonic acid from CO_2 released during organic matter decay which would encourage solubilization of soluble Ca and Mg-phosphate, 3-humus may form a productive surface over colloidal sesquioxides, with reduction in phosphate absorption.

Micronutrients and Heavy Metals Concentration and Uptake of Barley (Grains and Straw)

The data are presented in table (6) indicates the effect of treatments on Fe, Mn, Zn, Cd and Pb content in barley grains. Concerning to the micronutrients and heavy metals content of barley grains, data showed that all treatments increased the concentration of micronutrients as compared to the control. Among to the individual applications of three organic manures, the results indicated that micronutrients content of barley grains increased with increasing application rates of manures. The application of R_2, F_2, T_2 F_2 and T_2 treatments were superior to all other individuals treatments on

increasing Fe, Mn, Zn, Cd and Pb concentration in grains respectively. On the other hand, the combined applications of F_1R_2, F_1T_2, F_2R_2, R_2T_2 and F_1R_2 treatments show the superior effect among others.

Regarding Fe, Mn, Zn, Cd and Pb uptake in barley grains, data reveal that all treatments increased significantly the uptake of these elements by grains as compared to the control. With respect to the individual application of three organic manures, it is clear that the application of R_2, F_2, R_2, F_2 and F_2 treatments was higher effective on increasing Fe, Mn, Zn, Cd and Pb uptake respectively .The combined application F_1R_2 treatment was superior to all other treatments on increasing uptake of Fe and Pb of grains, however, F_2R_2 treatment was on the most effective increasing Mn, Zn and Cd uptake of grains. These results were in harmony with those found by Ibrahim *et al.* (1986) who showed significant increases in Fe, Mn and Zn concentration of herb and pea plants with increasing organic substances.

With respect to the effect of treatments on micronutrients and heavy metals concentration and uptake of barley straw, data in table (6) show that all treatments increased the concentration and uptake of micronutrients and heavy metals by barley straw.

Concerning to the effect of treatments on the concentration of micronutrients and heavy metals of barley straw. The application of T_2 treatment show superior effect to all other treatments on increasing the concentration of Fe and Mn of barley straw. However, the application of F_2 treatment was superior to all other individual treatments on increase the concentration of Zn and Pb. On the other hand, R_2 treatment was superior to all other treatments on increasing Cd of barley straw Concerning the effect of the combined treatments, data show that F_1R_1, F_2R_2, F_2T_2, R_1T_2 and F_1T_2 treatments were superior to all other combined treatments on increasing Fe, Mn, Zn, Cd and Pb concentrations, respectively.

Regarding the effect of the individual treatments on Fe, Mn, Zn, Cd and Pb uptake of barley straw, the results indicate that the application of F_2 treatment was superior to all other treatments on increasing uptake of Fe, Zn and Pb, while the application of R_2 treatment show higher effect on increasing Mn and Cd uptake. On the other hand, the combined application of F_2T_2 treatment was superior to all others on increasing Fe, Zn and Cd uptake of barley straw. However, the application of F_1R_2 and F_1T_2 treatments were superior on increasing Mn and Pb uptake, respectively.

It is noticed that the concentration of the studied micronutrients lies within the sufficiency range which was given by Lockman (1996), as follows Fe (50-300 ppm), Mn (50-150 ppm) and Zn (20-50 ppm) while the non toxic level of Pb (5-10 ppm) and Cd (0.02 ppm) and the toxic levels of Pb and Cd were 30-300 ppm and 5-30 ppm, respectively.

CONCLUSION

The application of all organic manures under this investigation improved soil chemical properties as well as increased the availability of macro , micronutrients and heavy metals in calcareous soils. Also, the data show that the application of these conditioners increased the dry weight of barley grains and straw and its content of elements. Generally, the combined treatment of farmyard manure with $20m^3$/fed. + turkey manure with 20 m^3/fed. was the best treatment followed by F_2T_2 treatment.

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اضـــــافة مخلفات المزرعه وتأثيرها على الخواص الكيميائيه للأراضى الجيريه وانتاجيتها

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أجريت تجربه حقليه بمحطة بحوث مريوط التابعه لمركز بحوث الصحراء، وذلك لتقييم استخدام بعض الاسمده العضويه الموجوده فى مزرعة محطة بحوث مريوط مثل سماد المزرعـه (مكموره)، سماد الارانب وسماد الرومى للاسـتفاده منها فـى تحسـين الخـواص الكيميائيـه للاراضى الجيريه وانتاجية محصـول الشعير ومحتواهما من العناصر الغذائيه. وقـد اشـارت النتائج الى أن استعمال أى من الاسمده العضويه الثلاثه التى تحت الدراسه سواء كانت منفرده او مركبه زادت محتوى الارض من الماده العضويه وخفضت كلا من رقم حموضة التربه والتوصيل الكهربائى وكذلك زاد محتوى التربه من النتروجين الكلى، الفوسفور الميسر والبوتاسيوم المتبادل. كل المعاملات ادت الى زيادة تيسر الحديد، المنجنيز، الزنك، الكادميوم وقللت تيسر الرصاص فى التربه.

كما وضحت النتائج ان اضافة المحسنات الثلاثه التى تحت الدراسه ادى الـى زيـاده معنويه للوزن الجاف لمحصول الشعير سواء الحبوب او القش بالمقارنـة بمعاملـة الكنتـرول. وتختلف الزيادة طبقا لنوع المحسن ومستوى الاضافه حيث زاد الوزن الجاف للشعير بزيادة معدل الاضافه من تلك المحسنات. وكذلك اشارت النتائج الى ان تركيز وامتصاص عناصر النتـروجين والفوسفور والبوتاسيوم والحديد والمنجنيز والزنك والكادميوم والرصاص بحبوب وقش الشـعير زادت باضـافة المحسنات الثلاثه التى تحت الدراسه سواء كانت الاضافه منفرده او فى صـورة مخاليط.

TABLE (2). Effect of treatments on some chemcial properties of

Treatments	PH	EC (dSm^{-1})	OM %
cont.	7.96	5.52	0.85
F_1	7.82	3.90	1.12
F_2	7.80	3.20	1.16
R_1	7.93	4.81	1.22
R_2	7.85	4.02	1.32
T_1	7.94	5.51	1.18
T_2	7.87	4.31	1.26
F_1R_1	7.85	3.92	1.33
F_1R_2	7.57	3.90	1.39
F_1T_1	7.62	5.31	1.28
F_1T_2	7.60	5.18	1.36
F_2R_1	7.84	4.14	1.39
F_2R_2	7.62	3.94	1.42
F_2T_1	7.88	4.07	1.34
F_2T_2	7.77	3.41	1.41
R_1T_1	7.82	3.94	1.44
R_1T_2	7.65	3.87	1.52
R_2T_1	7.78	4.11	1.56
R_2T_2	7.71	3.25	1.59

Each value in this table is an average of 4 replecates.

TABLE (3). Effect of treatments on soil contents from some nutrients.

Treatments	N	K	P	Fe	Mn	Zn	Cd	Pb
	%	mq/100g soil	mg Kg-1	mg Kg-1				
cont.	0.048	1.720	5.250	2.020	1.960	0.660	0.144	0.987
F_1	0.053	2.000	9.250	3.890	2.310	0.840	0.156	0.690
F_2	0.055	2.050	11.500	4.040	2.640	1.090	0.172	0.610
R_1	0.060	1.900	5.750	2.880	2.110	0.770	0.192	0.880
R_2	0.064	1.910	6.750	3.300	2.410	0.970	0.221	0.810
T_1	0.066	2.100	12.000	2.950	2.210	1.150	0.177	0.793
T_2	0.070	2.120	13.250	4.000	2.620	1.240	0.272	0.677
F_1R_1	0.063	1.930	11.250	3.290	2.500	0.990	0.185	0.660
F_1R_2	0.071	1.980	11.750	4.150	2.250	1.350	0.212	0.620
F_1T_1	0.065	1.850	12.400	3.650	2.280	1.140	0.179	0.577
F_1T_2	0.068	2.060	14.500	4.300	2.440	1.380	0.208	0.563
F_2R_1	0.071	1.990	11.500	3.950	2.340	1.180	0.213	0.617
F_2R_2	0.074	2.010	13.250	4.310	2.820	1.430	0.222	0.537
F_2T_1	0.070	2.130	12.500	3.760	2.800	1.050	0.194	0.523
F_2T_2	0.076	2.210	15.500	4.750	2.900	1.160	0.231	0.490
R_1T_1	0.065	2.010	10.250	3.420	2.260	1.140	0.268	0.713
R_1T_2	0.086	2.210	11.300	4.450	2.710	1.310	0.307	0.627
R_2T_1	0.075	2.050	12.600	3.500	2.790	1.160	0.256	0.613
R_2T_2	0.080	2.140	13.500	4.160	3.070	1.380	0.342	0.557

Each value in this table is an average of 4 replicates.

Table(4). Effect of treatments on the dry weight of barley.

Treatments	Grain	Straw
	ton/fed.	
cont.	0.953	2.328
F_1	1.502 **	2.663 *
F_2	1.678 **	2.977 **
R_1	1.213 **	2.240
R_2	1.560 **	2.880 **
T_1	1.275 **	2.450
T_2	1.411 **	2.711 *
F_1R_1	1.699 **	2.669 *
F_1R_2	1.829 **	2.875 **
F_1T_1	1.778 **	2.910 **
F_1T_2	1.843 **	3.015 **
F_2R_1	1.923 **	3.021 **
F_2R_2	2.109 **	3.315 **
F_2T_1	2.017 **	2.867 **
F_2T_2	1.384 **	3.398 **
R_1T_1	1.359 **	2.315
R_1T_2	1.386 **	2.361
R_2T_1	1.449 **	2.469
R_2T_2	1.566 **	2.668 *
L.S.D 0.05	0.183	0.325
L.S.D 0.01	0.246	0.436

Each value in this table is an average of 4 replicates.

* significant at L.S.D 0.05 ** highly significant at L.S.D 0.01

TABLE (5). Effect of treatments on NPK content of barley.

	Grains			Straw		
	a)-concentration (%)					
Treatments	N	P	K	N	P	K
cont.	1.920	0.451	0.655	0.685	0.082	2.400
F_1	2.246 *	0.539	0.783 **	0.704	0.088	2.600
F_2	2.709 **	0.805 **	0.895 **	0.719	0.093	3.500 **
R_1	2.307 *	0.652 **	0.706	0.827 **	0.093	3.667 **
R_2	2.428 **	0.874 **	0.777 **	0.865 **	0.133 **	4.067 **
T_1	2.385 **	0.588	0.730	0.909 **	0.186 **	4.000 **
T_2	2.686 **	0.692 **	0.844 **	1.103 **	0.205 **	4.800 **
F_1R_1	2.459 **	0.627 *	0.828 **	0.820 **	0.106 **	3.500 **
F_1R_2	2.228 *	0.725 **	0.899 **	1.026 **	0.120 **	3.767 **
F_1T_1	2.302 *	0.771 **	0.856 **	0.955 **	0.115 **	3.800 **
F_1T_2	2.533 **	0.854 **	0.955 **	1.236 **	0.163 **	4.800 **
F_2R_1	2.382 **	0.601 *	0.831 **	1.080 **	0.136 **	3.567 **
F_2R_2	2.793 **	0.704 **	0.911 **	1.150 **	0.138 **	3.800 **
F_2T_1	2.389 **	0.645 **	0.845 **	1.016 **	0.143 **	4.000 **
F_2T_2	2.537 **	0.831 **	0.875 **	1.071 **	0.226 **	5.200 **
R_1T_1	2.282 *	0.653 **	0.853 **	0.823 **	0.140 **	2.867
R_1T_2	2.416 **	0.770 **	0.902 **	0.918 **	0.144 **	3.867 **
R_2T_1	2.307 *	0.657 **	0.848 **	0.929 **	0.095	3.600 **
R_2T_2	2.385 **	0.829 **	0.888 **	0.953 **	0.120 **	3.867 **
L.S.D 0.05	0.297	0.142	0.082	0.098	0.017	0.724
L.S.D 0.01	0.398	0.191	0.110	0.131	0.023	0.971
	b)-Uptake (kg/fed.)					
Treatments	N	P	K	N	P	K
cont.	18.32	4.27	6.26	15.97	1.89	55.97
F_1	33.72 **	8.08 **	11.75 **	18.75	2.33	69.15
F_2	45.51 **	13.59 **	15.01 **	21.41 *	2.78 **	104.37 **
R_1	27.98 **	7.82 **	8.56 *	18.50	2.10	82.51 *
R_2	37.93 **	13.66 **	12.11 **	24.93 **	3.82 **	117.28 **
T_1	30.39 **	7.49 *	9.32 **	22.32 **	4.56 **	97.35 **
T_2	37.85 **	9.77 **	11.88 **	29.87 **	5.55 **	129.82 **
F_1R_1	42.07 **	10.64 **	14.08 **	21.85 **	2.83 **	93.69 **
F_1R_2	40.79 **	13.21 **	16.47 **	29.43 **	3.47 **	109.02 **
F_1T_1	40.95 **	13.68 **	15.22 **	27.81 **	3.34 **	110.49 **
F_1T_2	46.57 **	15.75 **	17.60 **	37.22 **	4.90 **	144.72 **
F_2R_1	45.89 **	11.63 **	16.01 **	32.65 **	4.10 **	107.24 **
F_2R_2	58.86 **	14.82 **	19.27 **	38.06 **	4.55 **	125.96 **
F_2T_1	48.14 **	13.01 **	17.05 **	29.25 **	4.11 **	115.56 **
F_2T_2	35.11 **	11.55 **	12.07 **	36.38 **	7.66 **	176.84 **
R_1T_1	30.92 **	8.88 **	11.62 **	19.02	3.23 **	66.52
R_1T_2	33.47 **	10.66 **	12.49 **	21.70 **	3.42 **	90.70 **
R_2T_1	33.44 **	9.53 **	12.29 **	22.94 **	2.35	88.81 **
R_2T_2	37.37 **	12.97 **	13.91 **	25.42 **	3.20 **	103.22 **
L.S.D 0.05	6.960	2.59	2.23	4.22	0.61	24.47
L.S.D 0.01	9.33	3.47	2.99	5.69	0.81	32.81

Values of this table are averages of 4 replicates * significant at 0.05 ** highly significant at 0.01

TABLE (6). Effect of treatments on the micronutrients and heavy metals content of barley.

	Grains					Straw				
	a)-concentration (mg kg^{-1})									
Treatments	Fe	Mn	Zn	Cd	Pb	Fe	Mn	Zn	Cd	Pb
cont.	75.67	25.67	20.00	2.16	7.63	183.33	105.33	12.67	1.19	6.00
F_1	89.67 **	45.33 **	22.00	3.94 **	10.50 **	200.00	116.67 *	16.00	1.36	7.65 *
F_2	101.67 **	60.00 **	32.00 **	4.38 **	13.90 **	253.67 **	121.33 **	23.67 **	1.45	8.65 **
R_1	118.67 **	25.67	31.00 **	2.43	8.30	206.67	117.00 *	14.67	2.58 **	6.93
R_2	126.33 **	36.33 **	34.67 **	3.07 **	13.80 **	231.00 **	126.00 **	19.33 **	3.80 **	8.15 **
T_1	113.00 **	32.33 *	28.67 **	2.42	12.30 **	177.33	124.67 **	15.00	1.90	7.74 *
T_2	124.33 **	38.00 **	37.67 **	2.80 **	15.80 **	265.67 **	128.67 **	15.33	3.20 **	8.64 **
F_1R_1	126.67 **	58.67 **	31.33 **	2.53	12.53 **	247.67 **	139.67 **	16.67	2.35 *	9.12 **
F_1R_2	177.00 **	66.33 **	39.33 **	3.06 **	15.17 **	352.00 **	144.00 **	22.00 **	4.45 **	9.18 **
F_1T_1	122.00 **	43.67 **	26.00 **	2.37	10.47 **	256.67 **	126.67 **	19.67 **	4.60 **	11.67 **
F_1T_2	132.33 **	50.67 **	32.00 **	2.83 **	15.00 **	266.33 **	145.67 **	22.67 **	4.30 **	16.35 **
F_2R_1	108.00 **	52.00 **	25.00 *	3.20 **	7.87	213.00 *	130.00 **	26.33 **	2.10 *	11.31 **
F_2R_2	135.67 **	59.00 **	43.33 **	3.34 **	11.10 **	294.00 **	150.00 **	30.00 **	2.30 *	13.63 **
F_2T_1	127.00 **	57.67 **	29.00 **	3.44 **	8.83	230.33 **	124.67 **	25.33 **	3.35 **	14.25 **
F_2T_2	136.67 **	70.67 **	33.00 **	3.82 **	13.60 **	336.67 **	137.00 **	37.00 **	4.50 **	10.27 **
R_1T_1	121.67 **	67.33 **	31.67 **	2.90 **	13.23 **	223.67 **	118.67 *	18.67 **	3.05 **	7.57 *
R_1T_2	139.00 **	74.00 **	36.67 **	3.69 **	14.30 **	280.00 **	136.00 **	21.67 **	4.90 **	10.16 **
R_2T_1	121.33 **	53.33 **	23.00	3.52 **	13.27 **	265.00 **	124.00 *	24.33 **	3.15 **	8.38 **
R_2T_2	151.67 **	64.00 **	28.00 **	3.97 **	14.70 **	288.33 **	136.00 **	27.33 **	4.65 **	6.88
L.S.D 0.05	10.29	5.29	3.97	0.46	1.30	25.30	10.12	4.05	0.73	1.37
L.S.D 0.01	13.80	7.10	5.32	0.62	1.74	33.93	13.57	5.43	0.98	1.83
	b)-Uptake (g/fed.)									
Treatments	Fe	Mn	Zn	Cd	Pb	Fe	Mn	Zn	Cd	Pb
cont.	72.30	24.30	19.16	2.05	7.28	425.70	245.04	30.14	2.77	13.87
F_1	134.69 **	68.19 **	33.09 **	5.93 **	15.70 **	531.63	310.29 *	41.89	3.61	20.49 *
F_2	170.84 **	100.59 **	53.74 **	7.32 **	23.36 **	754.51 **	361.15 **	75.51 **	4.32	25.70 **
R_1	144.37 **	31.12	37.80 **	2.97 *	10.07	462.94	261.74	37.09	5.75 **	15.63
R_2	197.03 **	56.58 **	54.13 **	4.79 **	21.54 **	665.66 **	363.14 **	61.50 **	10.95 **	23.44 **
T_1	143.84 **	41.16 *	36.50 **	3.08 **	15.70 **	434.79	305.37 *	36.05	4.63	18.94 *
T_2	175.40 **	53.75 **	53.24 **	3.95 **	22.30 **	719.22 **	348.68 **	43.41	8.69 **	23.44 **
F_1R_1	215.11 **	99.64 **	53.18 **	4.30 **	21.27 **	660.47 **	372.53 **	47.11 *	6.28 **	24.34 **
F_1R_2	323.60 **	121.55 **	72.08 **	5.58 **	27.77 **	1013.11 **	414.51 **	64.58 **	12.74 **	26.54 **
F_1T_1	216.87 **	77.55 **	46.27 **	4.20 **	18.61 **	747.27 **	368.73 **	57.15 **	13.37 **	33.85 **
F_1T_2	243.24 **	93.39 **	59.00 **	5.22 **	27.62 **	800.42 **	438.89 **	70.17 **	12.90 **	49.38 **
F_2R_1	207.87 **	100.50 **	48.22 **	6.13 **	15.21 **	643.46 **	393.18 **	79.35 **	6.43 **	34.06 **
F_2R_2	286.79 **	124.52 **	91.40 **	7.05 **	23.50 **	976.87 **	498.95 **	90.17 **	7.64 **	45.22 **
F_2T_1	256.28 **	116.44 **	58.53 **	6.94 **	17.84 **	662.89 **	357.07 **	73.67 **	9.52 **	40.88 **
F_2T_2	189.23 **	98.13 **	45.62 **	5.28 **	18.91 **	1143.49 **	465.44 **	112.66 **	15.31 **	34.91 **
R_1T_1	165.90 **	91.79 **	42.91 **	3.92 **	17.99 **	518.85	275.46	43.90 *	7.04 **	17.54
R_1T_2	193.10 **	102.70 **	51.00 **	5.09 **	19.84 **	660.64 **	320.91 **	50.37 **	11.54 **	23.99
R_2T_1	175.82 **	77.27 **	33.32 **	5.10 **	19.22 **	654.06 **	306.04 *	58.40 **	7.78 **	20.68 **
R_2T_2	237.40 **	100.19 **	43.81 **	6.21 **	23.02 **	769.73 **	362.76 **	72.07 **	12.41 **	18.36
L.S.D 0.05	31.47	15.63	9.62	0.75	3.52	116.28	53.96	13.68	2.09	5.04
L.S.D 0.01	42.20	20.96	12.90	1.01	4.71	155.91	72.35	18.34	2.80	6.76

Each value in this table is an average of 4 replicates.

* significant at L.S.D 0.05 ** highly significant at L.S.D 0.01