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Full Length Article

The effect of steel converter slag application along with sewage sludge in iron nutrition and corn plant yield

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ABSTRACT
Management and application of industry, agriculture, and urban organic and inorganic wastes in agricultural lands, while reducing the environmental risks of these substances increase their efficiency. Therefore, this research was done to determine the effect of the use of urban sewage sludge, steel converter slagas well as use of them on indexes of single cross 704 corn growth and yield in a calcareous soil. Treatments include use of Isfahan city sewage sludge and steel converters lag that each of them were on two levels (2.5 and 5% w) of 2.5% w/converter slag + 2.5% w/sewage sludge of Isfahan city, control, and (FeEDDHA) fertilizer. The research was conducted in Islamic Azad University of khorasgan branch greenhouse with 3 replications using a completely randomized block design. The experimental treatments before planting corn, wastes in mentioned levels added in calcareous soil and completely mixed to soil and the pots spent a 30-day incubation period with irrigation to the amount of 70% F. C. The results of this study showed that 5% w useof urban sewage sludge caused lack of germination of the seeds. Using2.5% w/ converter slag + 2.5% w/sewage sludge caused a significant increase in fresh and dry weight of plant becomes than other treatments ($P < 0.05$). Sewage sludge caused the pH reduction and increased its converter slag. Compounds containing converter slag and sewage sludge increased the soil potassium. The sewage sludge caused a significant increase on soil phosphorus. Also, sewage sludge increased the soil absorbable iron. Generally, the results showed that using 2.5% w/converter slag along with 2.5% w/sewage sludge can obtain more yield of Single cross 704 corns.
Key words: steel converter slag, urban sewage sludge, corn, yield, calcareous soil

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INTRODUCTION

In the process of the production of iron and steel, in addition to the main product, other products are produced and from the perspective of steel producer that his/her main task isthe production of the steel types with different properties, these materials are considered as wastes. Sub products include the production of iron and steel, converter slag, dust, sludge, and oxide shell that among these products, organizing slag due to much more amount of production have needed more attention in comparison with other by-products, so that for each ton of steel product, about 150 kg of converter slag is produced [31]. Every year, 250 million kg of slag is produced in Isfahan which contains valuable materials and compounds [6]. With disability of steel industries in the recovery and use of these products, these products will create too many problems in terms of doping. So, many investigations were done in the context of the use of these wastes in agricultural production [9]. Human activities led to the production of a variety of urban and industrial waste and scrap. The existence of large amounts of sewage sludge has several problems for mankind and the environment. In the last few decades, many studies in different countries carried out in the context of the use of sewage sludge in agriculture that in addition to improving soil fertility would some deal resolve the problems of sludge disposal [19,40]. Organic substances in sewage sludge caused improving soil physical properties such as hydraulic conductivity, stability of urn, ventilation, and soil moisture; and in this way, caused improving the growth and the crops yield increase [2]. Since the formation of chlorophyll in plants is not possible without the presence of iron, so deficiency or disability of iron appear in plants with the leaves chloride [41]. The phenomenon of iron chloride can often be seen in calcareous soils. The main problems of agricultural production are iron and some micronutrients deficiency or not being absorbable in calcareous soils [26]. The soils make 25-45 percent of the world's agricultural lands. Iron chloride in the effect of iron absolute deficiency are maderarely in the soil; and in most cases,in soil chemical conditions (being sodium and calcareous), available iron are seen non-soluble and very low soluble and plant use of this element makes trouble. Because if the dissolved iron adds to soil, quickly sediment and for plants are not used, so the correction of deficiencies should be restricted to acidic soil and in this way, increases the part solubility of available iron. When the plant is in term of the iron stress, revival speed of ferric iron to ferrous iron strongly increases [14]. The best way to solve this trouble is to use iron fertilizer in plants, but due to expensive price, using them in a lot of cases is not affordable and are used only for the special products [26]. Among the important methods of iron chloride treatment, various fertilizers containing iron reformer materials can be used that include iron mineral salts, acidic reformer materials, industry sidelong wastes, and blood powder [10]. With regard to mentioned contents, the use of Mobarakeh Steel Complex's converter slag along with urban sewage sludge on agricultural lands is the best and the most suitable method for dispelling these substances from the environment. But unfortunately the low price and the convenience of fertilizers consumption prevented the use of these resources in the agricultural sector, so that today maintaining soil fertility, mainly carried out by the chemical fertilizers [13]. Overuse of chemical fertilizers along with the inappropriate methods of cultivation and work reduced the amount of soil organic matter thatwill increase the risk of losing the soil [42]. The bulk of our country has arid and semi-arid climate, and the lack of adequate vegetation caused plant residue return to soil as well as the lack of organic matter, so that some soil of the country has less than 1% organic matter [4]. On the other hand, with regard to the limitation of animal resources, this research seems to be essential on the use of other alternative sources.

MATERIALS AND METHODS

To investigate the effect of converter slag and sewage sludge on corn plant cultivation, a greenhouse experiment with a sandy loam texture was done in Azad University of khorasgan's research greenhouses. This research with 7 treatments includes 2.5 and 5% converter slag (F2/5 and F5), 2.5 and 5 percent of the sewage sludge (S2/5 وS5), 2.5% slag + 2.5% sewage sludge (SF) per unit weight of dry soil, and (FeEDDHA) fertilizer and control treatment (B) with 3 replications was carried out in pots with 5 kg/weight in a completely random design. Before applying the treatments, sampling the soil was done in order to assess the chemical properties of the soil. Converter slag treatments and sewage sludge were mixed with soil and put after passing the 30-day incubation period put in moisture of corn plant cultivation capacity (FC). Plant samples harvested after 70 days and bushes with 1 cm high of soil levelwerecut by the razor. Each bush separately was scaled and dried up for 48 hours in a ventilated oven at temperature of 65 ° c to reach to constant weight. After determining the plant dry weight in per pot, the dried samples milled and kept in plastic containers to chemical analyses. Also, the soil of under cultivation pots after harvesting bushes and drying the air mixed well with applied treatments; and was used after passing of the 2 mm sieve to do the laboratory analysis. In the laboratory, soil pH measured in the ratio of soil 1:2.5 to distilled water [17]. To measure the plant samples' phosphorus used Olsen method [33]. Soil nitrogen measured by using kajledik method [17] and soil potassium also measured by extract normal ammonium acetates and flame photometers [34].

Data statistical analysis was done using SAS programin a completely randomized design with a factorial. All average comparisons were done with Duncan at statistical level of 5 percent. The SPSS software and chart drawing with EXCEL software were used to measure the data correlation.

RESULTS AND DISCUSSION

Chemical analysis of soil showed soil pH value with distilled water is equal to 8.23. Electric conductivity of soil was about 1.3 Decimeter Siemens/M. The amount of soil available phosphorus was measured 49.1 mg/kg soil. Also, the amount of the initial soil nitrogen and potassium was high. The rest of the soil profile is also showed in the table 1. Converter slag mineralogical analysis showed that more than 100 compositions are in slag that separating them via mechanical ways are impossible (39). The results of the converter slag chemical analysis in terms of total percent of the elements are showed in table 2, as well as considerable amount of the elements absorption by using of applied extracts in soil. In addition to the alkaline properties (pH=12.44), slag contains SiO2, which has a positive role in increasing the absorbency of phosphorus (39). The results of the sewage sludge chemical analysis in terms of total percentage of elements (table 2) show that the iron element makes the most combination of the sewage sludge. Also, sewage sludge includes other elements such as micro-elements, calcium, magnesium, phosphorus, potassium and so on which are concerned as a subprime [39].

Soil potassium

Based on the results of variance analysis (table 4), the effect of experimental treatments on concentration of soil potassium was significantly in 0.01 levels. The 2.5 and 5% slag treatments as well as the 5% sewage sludge treatments as compared to the control and (FeEDDHA) fertilizer caused a significant increase of soil potassium. Also, by comparing the averages was determined that the most concentration of soil available potassium belongs to the 2.5% slag treatment (Chart 1). By comparing the soil group was determined that the most concentration of soil available potassium belongs to the 2.5% and 5% treatments of slag (chart 1). Sewage sludge had the least effect of soil absorbable potassium increase. Perhaps the reason for this is the low amount of available potassium in sewage sludge and the main reason for this phenomenon could be related to the high solubility of potassium salts. In this way, after separating sewage sludge from wastes, soluble potassium mainly could remain in wastes and potassium will be slight in part of sludge; and potassium that is added to the soil via sewage sludge does not supply plant need (23). By adding sewage sludge, these results that caused the reduction of the potassium concentration in soil have corresponded with Brofas reports (20)so that could be due to the potassium fixation by clay minerals and absorption by plants.

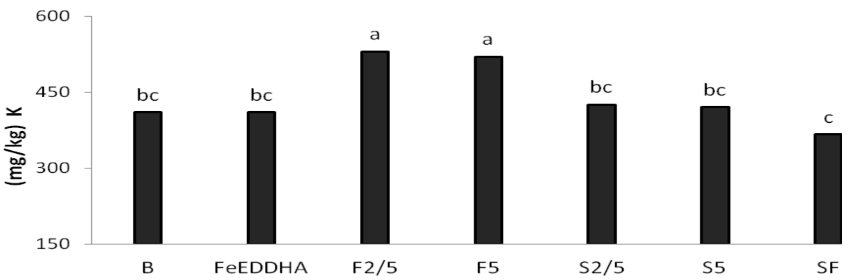

Chart 1.The effect of different treatments on soil potassium concentration. The averages with the same letters have no significant differences in the 5 % level of LSD test (LSD =8).

Soil phosphorus

Figure 2 shows the effect of different treatments on the amount of soil phosphorus. The results of variance analysis show the significant effect of experimental treatments on soil phosphorus in 0.01 levels. The comparison of averages shows that sewage sludge treatments at 2.5% and sewage sludge at 5% as well as the sewage sludge treatments along with converter slag as compared to the control have significant differences. Also, among experimental treatments, sewage sludge treatment along with converter slag has the most amount of soil phosphorur.Ber and et.al recorded [20] that adding sewage sludge to the soil increases the amount of soil phosphorus. Lobaski [30] showed the comparisons between organic and chemical fertilizers that the amount of experimental soils available phosphorus with organic fertilizers in comparison with chemical fertilizers significantly was more. The reason for this difference is the released organic acids of organic substances that prevent the phosphorus absorption in soil. In calcareous soils, phosphorus absorption is severely under the effect of sediment and absorption reactions on the surface of calcium carbonate [24, 16]. Based on the comments of some researchers, the soil phi crease caused to sediment the soil available phosphorus or to crystallization calcium phosphate (combination of apatite) and to be out of the reach of the plant [11]. So the insignificant increase of available phosphorus concentrations could be for some reason such as the high soil pH and the sediment of calcium phosphates and removal of phosphorus by plants during the growth season.

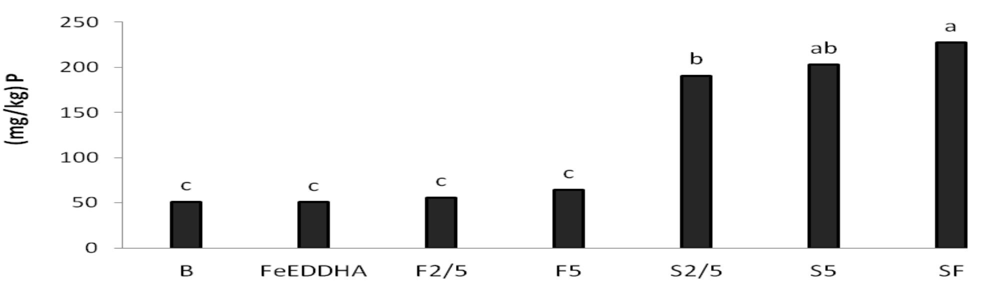

Chart 2.The effect of different treatments on soil phosphorus concentration.The averages with the same letter have no significant differences in the 5% level of LSD test (LSD=33.80).

Absorbable iron

As the results showed variance analysis (table 4), the effect of experimental treatments on absorbable iron concentration was not significant at the level of 0.01%. Figure 3 shows that the most amount of soil absorbable iron was related to 2.5% sewage sludge treatment and the least amount was related to treatment mixed with sewage sludge along with converter slag. Allslag treatments and (FeEDDHA) fertilizer except 2.5 and 5% sewage sludge treatment reduces the soil available iron(Figure 3). The use of slag increased the soil pH although some iron through this material was added to the soil. But this iron sediment with the soil pH increase as low soluble compounds in soil. Siavash Moghaddam and et al (37) recorded the application of slag in the values of 0.5 to 2%, so that all slag treatments reduced significantly soil available iron as compared to control treatment. Most of the soil available iron is related to the consumption of sewage sludge. Increasing the organic material to the soil increases the process of chelate formation and elements accessibility such as iron, copper, zinc and manganese. In (FeEDDHA) fertilizer treatment, iron available concentration to plant reduced by forming insoluble compounds for the reason of the presence of calcium due to lime and high PH as well as the absence of organic material enough for chelate [35, 28]. Also, the role of sewage sludge in soil pH reduction can increase absorbable iron in the soil. In addition, remarkable amount of iron in sewage sludge (table 2) increases absorbable iron in the effect of sewage sludge application.

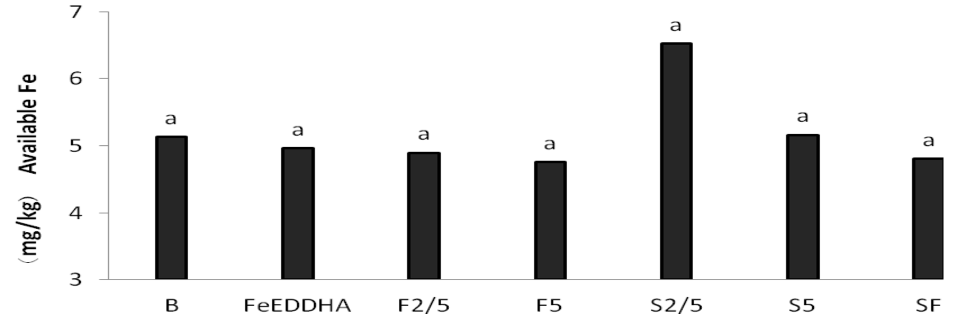

Chart 3.The effect of different treatments on absorbable iron concentrations in the soil. The averages with the same letters have no significant differences in the 5% level of LSD test (LSD=1.80).

Herbal results

Plant yield

Based on the results of the variance analysis (table 5), the effect of different levels application of sewage sludge and steel converter slag, the changes of plant yield were significant at the level of 0.001. Among applied treatments, the most performance was related to 2.5% sludge treatment along with 2.5% slag (36.72 g/pot) that had significant differences than other treatments. Despite the pH increase in2.5% slag used treatment, probably the increase of the food elements such as potassium, phosphorus, copper and zinc in comparison to the control are the reasons of the yield increase as a result of 2.5% slag application. But probably the soil pH minor increase in 5% treatment of slag application as compared to 2.5% treatment of the slag application and creating the chemical inappropriate conditions and imbalance between soil nutrients and as less concentration of nutrients such as plant zinc in this treatment compared to 2.5% treatment of slag application caused the less yield of this treatment to 2.5% slag treatment (Figure 4). So that Baghaee and et al (3) reported due to the high percentage of lime in the slag that using 4% slag treatment caused the soil pH topical increase and wiped out the effect of its fertilizer, but probably, the yield reduction in sewage sludge treatment was due to the soil salinity increase and its negative effects on plant growth. Many studies have shown that high amounts of sewage sludge decreased biomass and yield of the plant, and have expressed that was probably due to the soil salinity increase by the sewage sludge (38, 36, 25). Abbaspourand et al (15) indicated in their research that the 1 and 2% W application of converter sludge caused significant increase in plant dry weight as compared to the control while more than this amount had no significant effect on plant dry weight.Torkashvand and et al [5], on the steel converter slag application as reformer substance ofGilansoils were reported the dryweight increase of the plant with 0.5, 1 and 2% consumption of slag. Baghaeeand et al [3] in assessing the fertilizer efficiency of iron slag on tomato plant indicated the application of slag in levels 1 and 2 percent in number 2 soil caused significant increase in plant dry weight as compared to control. But the 5% slag caused the dry weight reduction of the plant. However, it had no significant difference with control.

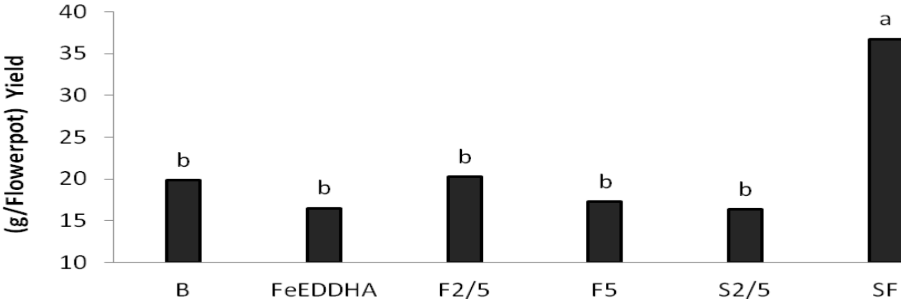

Chart 4.The effect of converter slag and waste composts on the yield of corn. The averages with the same letters had no significant differences in the 5% level of LSD test (LSD =5.92).

Plant potassium

Figure 5 indicates the effect of different treatments on potassium concentration in aerial organ of corn plant. The results of variance analysis (table 5) indicated insignificant effect of experimental treatments on potassium concentration in the aerial organ of corn plant. Also the treatments had no significant difference.Ebrahimi (1) also during his research reported that different organic fertilizers have no equality effect on soil absorbable potassium. Different levels of cow fertilizers increased concentration of these elements in soil more than any other fertilizers so that sewage sludge had the lowest and cow fertilizer the maximum effect in increasing the soil absorbable potassium. Cougar (22) also has reported that sewage sludge had no significant effect on the amount of potassium in plant tissues. Kahn and et al. (27) concluded that the 40 ton/HA application of slag increased uptake of potassium by rice. Torkashvand and et al (5) in assessing the steel converter slag as former substances of Gilan soils were reported that the soil of rice paddy has significant effect of potassium uptake by plant in slag treatments as compared to the control. Lindsay (29) in his investigation observed organic matter along with slag caused the potassium uptake increase by plant in calcareous soils.

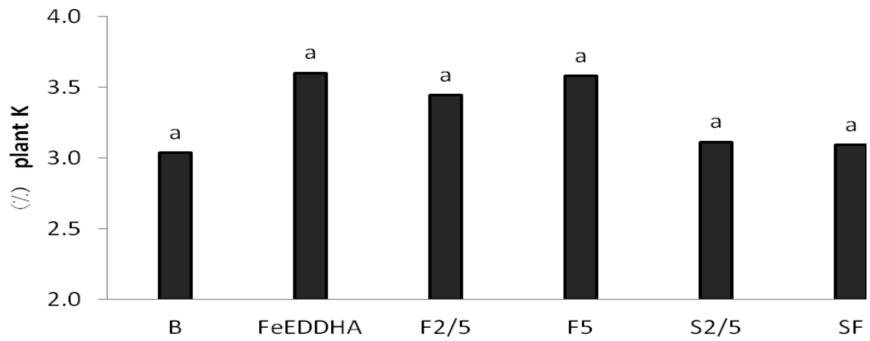

Chart 5.The effect of different treatments on potassium concentration in aerial organ of corn plant.The averages with the same letters had no significant differences in the 5% level of LSD test (LSD =0.73).

Plant phosphorus

Based on the results of variance analysis (table 5), the effect of experimental treatments on the phosphorus concentration was not significant in the aerial organ of corn plant. By comparing the average determined that the maximum concentrations of phosphorus in aerial organ of corn plant belonged to 2.5% sludge treatment (chart 6) that probably this is because of the existence of organic phosphorus in sewage sludge that is mineral and absorbable in plant. The researchers during their investigation have reported that the amount of phosphorus in aerial organ of treated corn plant with sewage sludge is more than control samples (32). According to the reports,the organic material increases the plants available phosphorus as well as the organic material analysis caused the organic acid production that with organic phosphorus increasesthe available phosphorus amount and directly prevents phosphate deposits in pH of 6 to 9 in the form of non-absorbable to plant [18]. Dastori [7] showed that the majority of converter slag and sludge treatments caused the reduction of the plant concentrations however this difference is not significant to the control. It seems that the yield increase and the effect of the dilution caused this phenomenon. Torkashvand and et al [5] in their investigation expressed that phosphorus uptake by corn plant in 4% slag application treatment had no-significant differences with the control.

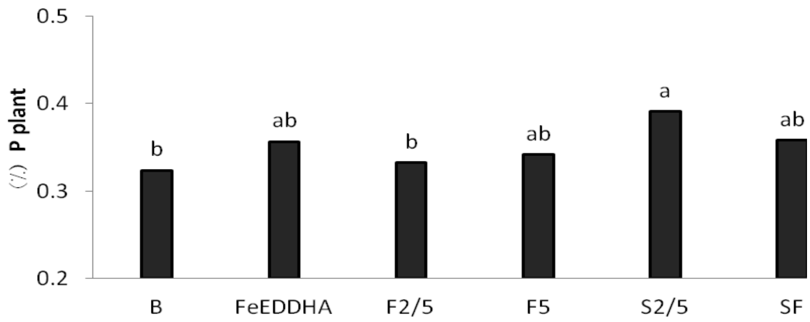

Chart 6.The effect of different treatments on phosphorus concentration in the aerial organ of corn plant. The averages with the same letters have no significant differences in the 5% level of LSD test (LSD=0.05)

Plant iron

As the results of the variance analysis (table 5) showed, the effect of the experimental treatments on Fe concentration in aerial organ of corn plant was significant at the level of 0.01. According to the figure (7), 2.5% sewage sludge treatments and converter slag as well as sewage sludge treatment along with converter slag have significant difference with the control and (FeEDDHA) fertilizer. Also, among the experimental treatments, the 2.5% sewage sludge treatment has the most amount of iron in corn plant. Slag treatment caused a significant increase of plant iron and had the most effect to the 5% slag. Treatment mixed with slag and sewage sludge showed a significant increase as compared to control, sewage sludge treatment had no the significant effect on plant Fe concentration. Probably one of the reasons for reducing the available iron amount in sewage sludge treatments according to the high amount of available iron in sewage sludge is more absorption of iron element by the plant in the treated soilswith sewage sludge, and the other reason is that the concentrations of other metals in sewage sludge was high and more complex with iron and oxide manganese are made and absorbable iron was less; generally soluble forms and metals interchangeable can be easily absorbable for the plant (8). Generally, adding the fresh organic fertilizers to soils containing high calcium carbonate and magnesium increases the activity of the microorganisms and therefore, the bicarbonate ion increases. In addition, the compounds of microbial analysis may act as the iron chelate and competed with plant root for iron element and its absorption by the plant will be reduced (12). Also, the reason of this decrease can be due to the existence of more phosphorus compounds in sewage sludge, which sediment with soil iron.The phosphorus increase in soil caused the iron deficiency due to the formation of insoluble compoundsof iron phosphate (4). Lindsay (29) in his investigation observed that the integration of organic material with inorganic compounds of iron increases the efficiency of these materials in feeding plants. Organic matter along with slag increases the yield and absorption of iron, manganese, zinc and potassium in calcareous soils by plant. Also, Chen and et al (21) indicated that the integration of iron sulfate with animal fertilizer (manure) hasa significant effect on the deficiency removal of sorghum plant iron.

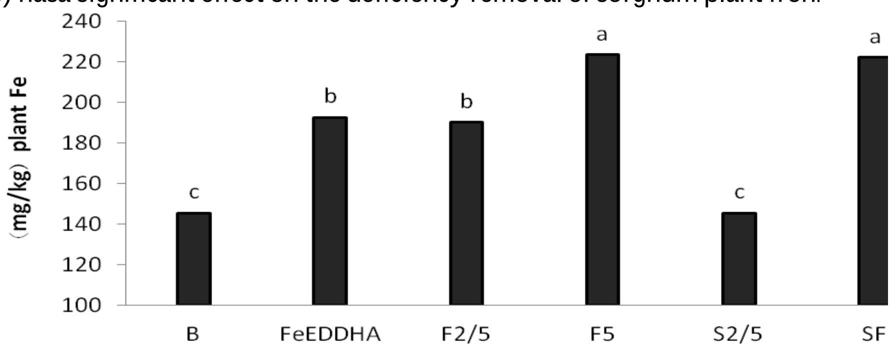

Figure 7.the effect of different treatments on the aerial organ of corn plant. The averages with the same letters have no significant differences on the 5% level of LSD test (LSD=34.60).

Table 1_% Of all the elements in the composition of the slag

elements	K_2O	Na_2O	ZnO	S	Al_2O_3	P_2O_5	MgO	CaO	SiO_2	MnO	FeO
slag	0/032	0/075	0/057	0/18	0/78	4/76	2/22	52/85	8/92	4/46	7/87

Table 2. Chemical analysis of sewage sludge

Amount	unit	Parameter
48	%	OM
13/97	-	C/N
6/4	-	pH
8/5	ds/m	EC
2/4	%	N
0/345	ppm	P
0/315	ppm	K
0/76	%	Mg
8/23	%	Ca
0/4	%	Na
427/5	mg/kg	Mn
11375	Mg/kg	Fe
650	mg/kg	Cu
660	Mg/kg	Zn
133	mg/kg	Pb
4	mg/kg	Cd
58	mg/kg	Ni

Table 3_ some physicochemical properties of the studied soils

Amount	unit	Parameter
Calcigypsids	-	Classification
Sandyloam	-	Tissue
0/69	%	OC
420	mg/kg	K
49/105	mg/kg	P
9506	mg/kg	Fe
177/2	mg/kg	Mn
8/34	mg/kg	Cu
35/48	mg/kg	Zn
23/72	mg/kg	Pb
2/05	mg/kg	Cd
0/6	gr/kg	N
4000	%	Calcium carbonate
8/23	-	PH
1/33	ds/m	EC

Table 4 - Analysis of variance treatment effect on the amount of slag and sludge from sewage potassium, phosphorus and iron in the soil

Mean-square			Degrees of freedom	Sources changes
P	K	Fe		
(mg/kg)	(mg/kg)	(mg/kg)		
ns343/12	ns819/05	ns 0/24	2	Block
19945/1***	11615/8**	1/13ns	6	Treatment
377/43	2380/2	1/02	12	Error
16/02	10/2	19/52	Coefficient of Variation(%)	

ns :No Significant.

*** و ** : The Mnydarshdn statistics 01/0 and 001/0 of the show.

Table 5 - Analysis of variance treatment effect on the amount of slag and sludge from sewage potassium, phosphorus, iron and corn

Mean-square				Degrees of freedom	Sources changes
K	P	Fe	Yield		
(%)		(mg/kg)	g/flowerpot		
ns0/25	ns0/0002	ns 331	ns2/35		
0/20**	ns0/002	***6090/4	183/30***	6	Treatment
0/16	0/001	301/7	10/61	12	Error
0/73	0/05	9/30	5/92	Coefficient of Variation(%)	

ns :No Significant.

***و** ،*: The statistical level Mnydarshdn 05/0, 01/0 and 001/0 of the show.

CONCLUSIONS

The use of sewage sludge and its combine with the slag in dry areas have the positive effect on improving the quality of soil fertility. For example, increasing the organic material as well as the values of various elements such as K, P, and Fe had the positive effect on improving the quality and fertility increase of soil. Among treatments, effect of slag application along with sewage sludge has been inconsiderable in the corn plant yield increase, so that by adding sewage sludge and slag to the soil, the yield of the plant increased several times as compared to the control.

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