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Effect of the Municipal Garbage on the Growth of Lettuce

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Abstract: Municipal Garbage (MG) as a plant nutrient supply was evaluated. Some of the garbage was collected from Hail city, Kingdom of Saudi Arabia. The garbage was fermented partially after removing its contents of stones and metals. Lettuce plants were transplanted in five greenhouse pot experiments. In the first, a portion of the MG was mixed with a sandy soil at either 1, 2 or 3% before the transplanting. In the second, a portion of the MG was mixed with hydrochloric acid 0.1 Nat ratio of 1:2 for 15 days then extracted. The solid extracted portion was mixed with the sandy soil at 1, 2 , or 3%. A week after lettuce transplanting, a foliar spray technique was used to spray the HCl extract. In third and fourth experiments, the Coca Cola and the distilled water as extractants were used similarly to the second experiment. The fifth experiment was fertilized using the conventional rate of NPK fertilization (control)). The lettuce plants were harvested after two months from the experiment initiation then soil pH and total soluble salts were determined in 1:2.5 soil water extract. The pH and total soluble salt values among the treatments were not significant. Growth parameters such as the total fresh weight, shoot fresh weight, shoot dry weight and the dry matter percentage were determined. The results of the former three parameters increased as the rate of MG increased under the condition of the first four experiments. In addition, these parameters were great under the MG experiments in comparison to the control experiment. The dry matter percentages using 2% rate of MG were the greatest under all experiments except the Coca Cola experiment. This percentages increased as the rate of MG increased under the Coca Cola experiment condition. All of the growth parameters were the greatest under the condition of distilled water experiment among all of the experiments. The results of the study encourage using the water extract of MG as a source for plant nutrients and the extracted portion as a soil conditioner.

Key words: Municipal garbage, plant nutrients, HCl extractant, coca cola extractant, water extractant. lettuce, growth parameters

Introduction

In recent years, mineral fertilizers have been used increasingly to attain greater productivity. About 50% of the applied nitrogen fertilizer is not removed by crops or stored in soil. Leaching in the form of nitrate is expected to be a major reason for losses that leads to water contamination. To minimize the water and food contamination, we should use organic fertilizers that are produced from solid organic residue such as the municipal garbage (MG). These materials are usually rich in plant nutrients. Hassan (1984) reported that animal, duck, chicken and horse manure contained 5, 10, 10 and 6 kg ton^{-1} of nitrogen, respectively. The corresponding phosphorus concentrations in this manure were 1.5, 13, 8 and 2 kg ton^{-1}, respectively. Nassar (1998) and Al-Salamah and Nassar (2002) reported that the concentrations of plant nutrients (N, P, K, Fe, Mn, Cu and Zn) increased in a sandy soil when incubated with a municipal garbage compared to their native concentrations. Maynard (1991) used two organic amendments as the sole source of nutrients: spent mushroom compost (horse manure and bedding, amended with chicken manure, gypsum, cottonseed meal and cocoa bean shells), with N content of 0.5% DW, or poultry manure compost (43% chicken manure compost, 14% horse manure, 29% spent mushroom compost and 14% sawdust), with N content of 2% DW. Both composts were applied at 25 or 50 tons $acre^{-1}$ (DW) and incorporated into soil plots. Yields of 9 crops on these amended plots were compared with those from plots fertilized with conventional (controls) or organic fertilizers. With poultry manure at 50 tons $acre^{-1}$, the yields of all crops except lettuce were equal to or greater than those obtained with inorganic fertilizer. The yields of aubergine, capsicum and tomatoes were also improved by poultry manure at 25 tons $acre^{-1}$. Only peppers showed a greater yield with spent mushroom compost (50 tons $acre^{-1}$) than with control treatment. In similar studies by Rubeiz *et al.* (1992), the application of 27.5 t broiler manure or 18 t manure from laying flocks ha^{-1} (on a wet basis) gave similar lettuce yields as an application of 100 kg N ha^{-1} from NH_4NO_3 in 2 split applications. Manure or fertilizer

application had no effect on soil EC, pH or available Mazzini *et al.* (1988) studied the effect of organic fertilizers Amizina and Orgamin [residues of biological fermentation] + lime with or without NPK and micronutrients in container trials with the lettuce cv. Great Lakes. Amizina and Orgamin increased plant FW by 247.5 and 313.0%, respectively, in relation to an unfertilized control. The highest FW production was obtained when Orgamin was combined with NPK. Anid *et al.* (1983) performed Pot trials with increasing rates of town refuse compost on lettuce (*Lactuca sativa*), spinach (*Spinacia oleracea*) and rye grass (*Lolium perenne*). Pots containing more than 20% compost, decreased yields of spinach and lettuce while those with highest compost rate gave maximum dry matter for rye grass. Trace metal contents in mixtures with 20% compost or less, did not exceed normal soil concentrations. Blanc *et al.* (1983) compared the effects of farmyard manure (FYM) and equivalent quantities of mineral fertilizers in a trial on container-grown lettuces (cv. Ravel) and tomatoes (cv. H63-4 INRA) in a greenhouse. FYM reduced tomato fruit numbers and the nitrate and K contents of fruit calyces. Lettuces receiving FYM developed larger heads and an increased dry matter content, while nitrate was reduced and Ca, Mg and B contents increased. Svec *et al.* (1976) studied garden vegetables production that grown with "organic" or "commercial" fertilizer amendments added to the soil. Tomatoes, potatoes, peppers, lettuce, onions and peas were planted and leaf tissue and edible produce were harvested. Generally, the conventional plots produced more yield of vegetables, although seasonal variation was greater than variation due to soil amendments. From these data, it was concluded that the two methods of vegetable production were equal for quality and nearly equal for yield over the two years.

The municipals garbage are commonly mixed before its decomposition with a soil. This manner of application can delay the readiness of nutrients to plants and expose some nutrients, i.e. iron and phosphorous, for fixation by clay particles and calcium carbonates in some soils, i.e., calcareous soil. When triple phosphate is used as a P fertilizer, fixation problems by clay particles or calcium carbonate may occur (Tisdale *et al.,* 1985). Composting and extracting the plant nutrients partially can result better management of the garbage. During composting of this material, fermentation process takes place in it resulting the readiness of plant nutrients. These nutrients can be extracted using Coca Cola or 0.1 M hydrochloric acid. The extract can be sprayed on plants as a source for the nutrients. Schnug *et al.* (1996) found that Coca Cola is an excellent extractant for micronutrients in soils, particular for manganese (Mn). The overall extraction force of Coca Cola was similar to that of commonly used phosphoric acid methods. Compared to DTPA, Coca Cola extracted only 27% of iron (Fe), 38% of copper (Cu) and 86% of zinc (Zn), but 165% of Mn. Besides the better results in extracting available micronutrient fractions from soils, further advantages of Coca Cola as an extractant are its ubiquitous availability and readiness for use but also its easy and safe handling and the fact that the procedure has no harmful impacts on environment. Sistani *et al.* (1995) evaluated four chemical extractants (Mehlich 1, Mehlich 3, 0.1 M HCl and DTPA) for soil fertility. The extractants followed this trend for extracting the heavy metals: Mehlich 3 > 0.1 N HCl > Mehlich 1 > DTPA. Therefore, using the Coca cola or the hydrochloric acid are recommended for extracting the nutrients from the municipal garbage.

According to literature reviewed the municipal garbage could be a useful source of the organic matter and plant nutrients, but data of the plant nutrients for the municipal garbage are limited. Therefore, we conducted this study to evaluate the municipal garbage (MG) of Hail City (Saudi Arabia) as a source of nutrient supply. The municipal garbage (MG) was collected, decomposed and extracted using either Coca Cola, HCl or water extractant. The extract of MG was sprayed on lettuce plants using the foliar spray technique and the solid residual portion of the wastes was mixed with the upper portion of a sandy soil. The results of this new technique of organic fertilization was compared to conventional techniques of organic fertilization (mixing the fresh solid organic wastes with the upper portion of soil) and mineral fertilization. These fertilizer application techniques were applied to lettuce in a pot experiment.

Materials and Methods

Preparing the municipal garbage: Municipal garbage (MG) was collected from Hail Province, Kingdom of Saudi Arabia. The stones and metals were removed then; the rest portion of the collected garbage was fermented partially by spraying water to the raw garbage (City Council of Hail, Personal communications). Three portions of the MG were mixed with either a distilled water, Coca Cola (Schnug *et al.*, 1996) or 0.1 N hydrochloric acid (Sistani *et al.*, 1995) extractant at 1:2 ratio. The mixtures were incubated at the room temperature under un-aerated conditions for 15 days then extracted. The extract of the mixtures were analyzed for knowledge the nutrient concentrations. Available P was determined by the chlorostannous phosphomolybdic acid method (Jackson, 1967). K was determined by flame photometer (Jackson, 1967). Fe, Mn, Cu, Zn, Ni and Pb were determined using the Atomic Absorption. Nitrogen were determined in the same samples by distillation (Page *et al.*, 1982). The results of the extracts analysis are shown in Table 1.

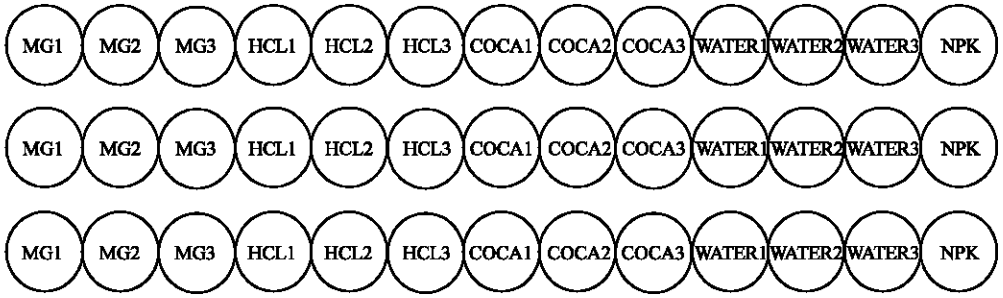

Fig. 1: Layout of the experiment of lettuce showing the treatments and three replicates

Table 1: Characterization of the MG Extract used in the fertilization of lettuce

Properties	HCl extract	Coca Cola extract	Water extract
EC, dS m^{-1}	14.7	12.43	12.46
PH	7.09	7.14	4.64
NO_3-N, ppm	4.2	6.3	23.8
Total N, ppm	49.7	14.0	94.5
P, ppm	125.0	722.0	155.0
K, ppm	1010.0	1000.0	1020.0
Zn, ppm	74.4	251.8	55.1
Fe, ppm	247.9	399.1	209.8
Mn, ppm	34.8	80.4	25.3
Cu, ppm	8.04	6.27	9.4
Pb, ppm	2.28	5.88	1.89
Ni, ppm	3.48	3.24	3.53

Table 2: A description for the treatments of fertilization used in the study.

Treat. No.	Name	Description
1	MG1	Unextracted Solid MG at 1%
2	MG2	Unextracted Solid MG at 2%
3	MG3	Unextracted Solid MG at 3%
4	HCl1	Extracted MG using HCl at 1%+ extract spraying
5	HCl2	Extracted MG using HCl at 2%+ extract spraying
6	HCl3	Extracted MG using HCl at 3%+ extract spraying
7	COCA1	Extracted MG using Coca cola at 1% + extract spraying
8	COCA2	Extracted MG using Coca cola at 2% + extract spraying
9	COCA3	Extracted MG using Coca cola at 3% + extract spraying
10	WATER1	Extracted MG using water at 1%+ extract spraying
11	WATER2	Extracted MG using water at 2%+ extract spraying
12	WATER3	Extracted MG using water at 3%+ extract spraying
13	NPK	Mineral fertilization

Greenhouse experiment: Greenhouse experiment was conducted to evaluate using the municipal garbage (MG) as an organic fertilizer. Sandy soil used in this study was sampled from a surface layer (0.0-0.3 m depth) from the Agriculture and Veterinary Collage, King Saud University, Al-Qassim. The soil sample was prepared by air-drying, crushing and sieving to pass through a 2-mm screen. The soil and garbage were primarily characterized (Al-Salamh and Nassar, 2002). Five pot experiments were conducted to study effect of the MG fertilization methods on the growth of lettuce plant. In the first experiment, the fermented municipal garbage was mixed with five kg of the sandy soil at three rates 1.0, 2.0 and 3.0%, then packed in a plastic pot. A lettuce plant was transplanted in each pot. The age of the transplanted lettuce plant was 35 days. MG was used to refer to this experiment. In the second, the solid extracted portion of hydrochloric acid was mixed with five kg of the sandy soil at rates of 1.0, 2.0, 3.0% then packed in a plastic pot. After one week of lettuce transplanting the extract of HCl was sprayed on the leaves of the lettuce in ratio 1: 2: 3. HCl was used to refer to this experiment. Similarly, the extract and the solid extracted portion of Coca Cola was used in the third experiment. COCA was used to refer to this experiment. The extract and solid extracted portion of distilled water was used in the fourth experiment. WATER was used to refer to this experiment. For evaluation the significant of the organic fertilization as a source of plant nutrients, a solution of NPK fertilizer was prepared at concentration of 0.0137, 0.0535 and 0.0196 g kg^{-1}, respectively then applied with the irrigation water a week of the lettuce transplanting. A complete summary for description the experiment is shown in Table 2 and Fig. 1. Irrigation was achieved when the metric water potential reach 10 KPa using tap water. The metric water potential was adjusted using a tensiometer. During the growing period, there were no symptomatic deficiencies of nutrients. The lettuce plants were harvested two months after the transplanting. Total fresh weight, vegetative fresh weigh, dry weight of the shoots and its dry matter percentages were recorded. Soil samples were collected for measuring the Total Soluble Salt (T.S.S) and pH. Total soluble salts (T.S.S) were determined in the extract (1:2.5) of soil using electrical conductivity (Jackson, 1967). Soil pH was measured in 1:2.5 soil water suspension using a glass electrode (Jackson, 1967).

Data analysis: The differences among the treatments were tested using the least significant differences (LSD) at 5% level according to Bisher and El-Robby (1970).

Results and Discussion

The characterization of extracts: Table 1 shows the characterization of the extracts of water, HCl and coca cola. The pH of water extract is 4.64 while the pH of the

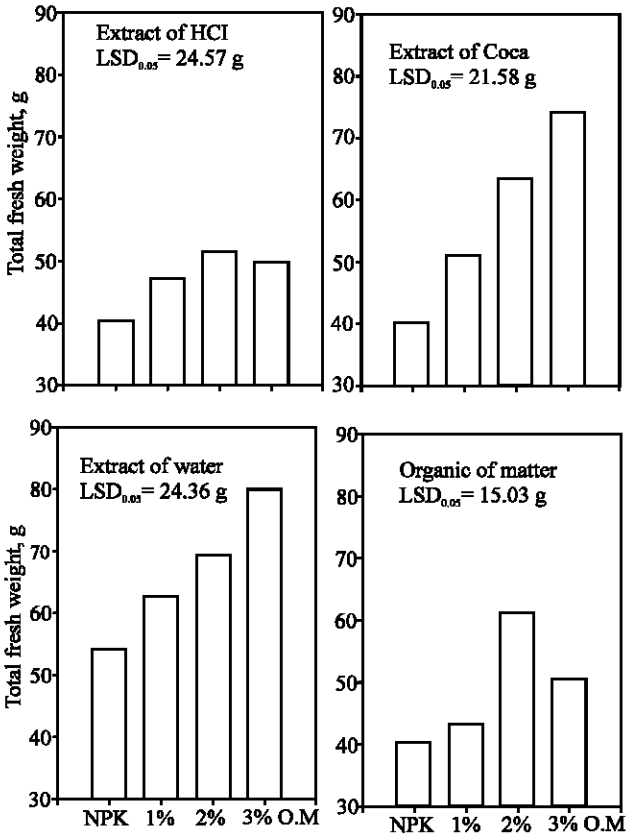

Fig. 2: Effect of NPK and organic fertilization on the total fresh weight of lettuce

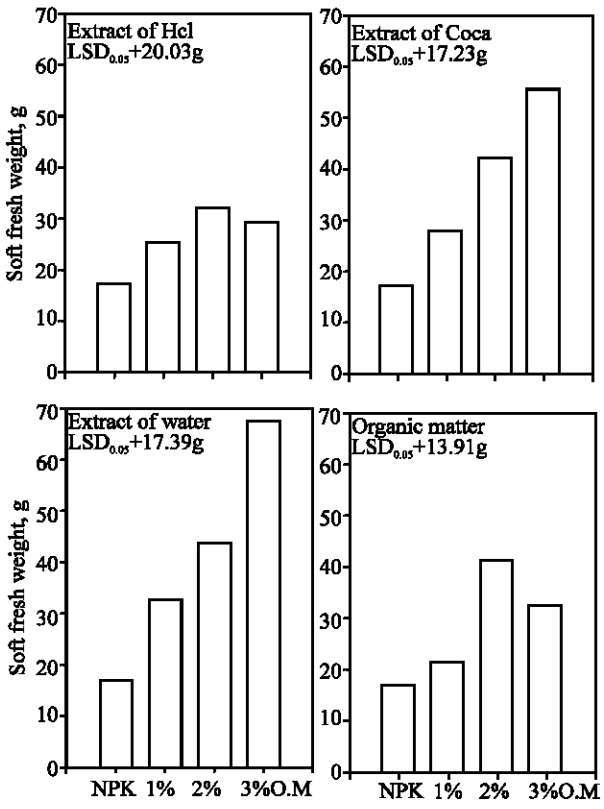

Fig. 3: Effect of NPK and organic fertilization on the shoot fresh weight of lettuce

Table 3: The values of pH and EC of the soil after growing the lettuce in extract 1:2.5 under all methods of fertilization

Treatment	PH	EC, dS m^{-1}
NPK	8.72	1.21
MG1	8.77	1.07
MG2	8.69	0.94
MG3	8.66	1.16
$LSD_{0.05}$	0.142	0.139
NPK	8.72	1.21
HCl1	8.55	1.15
HCl2	8.27	1.36
HCl3	8.25	1.41
$LSD_{0.05}$	0.143	0.227
NPK	8.72	1.21
COCA1	8.72	0.98
COCA2	8.68	0.95
COCA3	8.58	1.027
$LSD_{0.05}$	0.123	0.161
NPK	8.72	1.21
WATER1	8.58	1.09
WATER2	8.56	1.05
WATER3	8.26	1.12
$LSD_{0.05}$	0.301	0.135

Each value a mean of 3 replications.

others extracts are slightly greater than 7.0. This trend in the pH might be due to the solubility of some basic compounds in HCl and Coca Cola extractant. The extract of water possessed the greatest in the nitrogen content while the Coca cola possessed the lowest. The phosphorous concentration in the extract of Coca cola was high and this is due to the phosphoric acid presents in the Coca cola solvent. The Fe, Mn and Zn concentrations in the extracts of either HCl or Coca cola were higher than their value in the extract of water. It is worth noting that the Mn concentration extracted by the Coca cola is more than three times the Mn extracted by the water. This result are similar to that reported by Schnug *et al.* (1996). Lead and nickel are not nutrients element for plants and are considered pollutants. Fortunately, their concentrations in the extracts usually are well below concentration standards set by USEPA for biosolids (USEPA, 1993).

Effect of municipal garbage (MG) on the pH and total soluble salts in soil: The results of pH and total soluble salts are shown in Table 3. Generally, as the level of MG increased using any method of fertilization the pH of the soil decreased. The production of some organic acid of the MG could led to lowering the soil pH. The fulvic and carbonic acids increase the availability of plant nutrients. For example, the fulvic acid forms stable complexes with

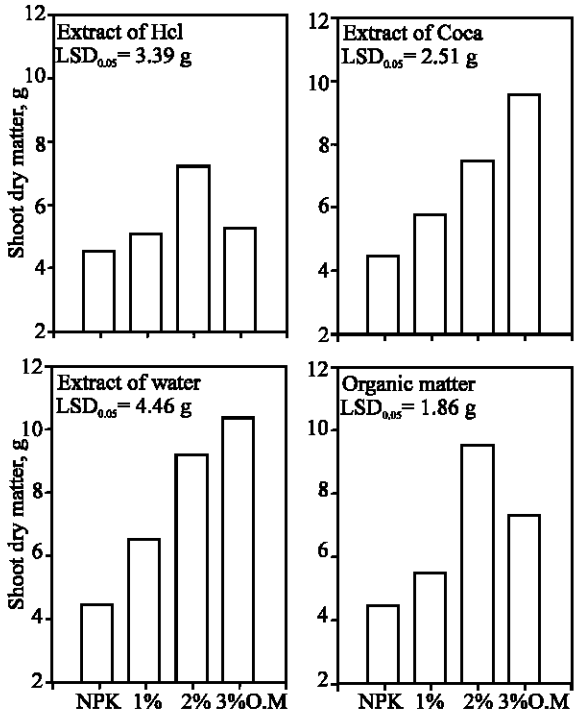

Fig. 4: Effect of NPK and organic fertilization on the dry matter of lettuce

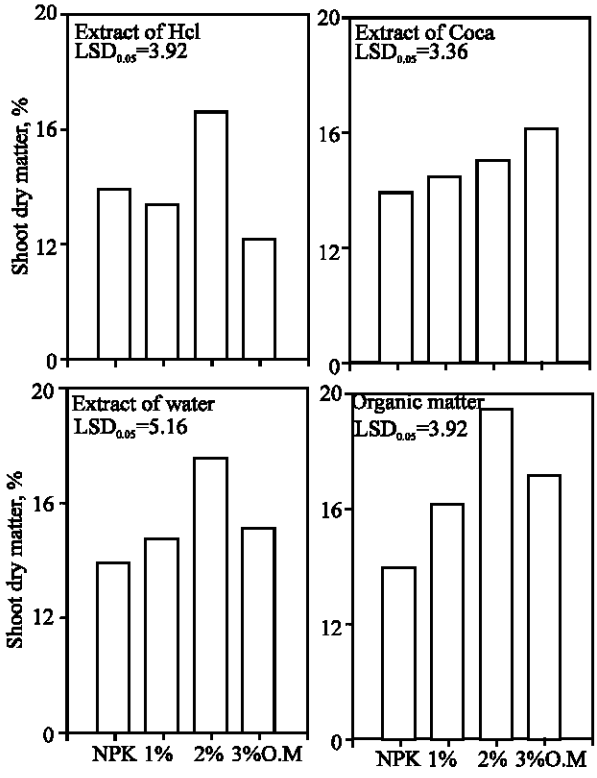

Fig. 5: Effect of NPK and organic fertilization on the shoot dry matter of lettuce

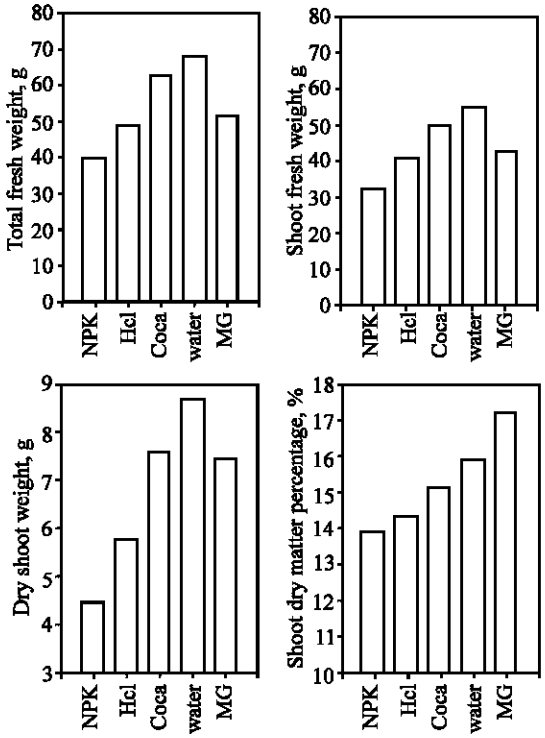

Fig. 6: Effect of NPK and organic fertilization on the growth parameters of lettuce

Fe^{3+}, Cu^{2+}, Zn^{2+} and other polyvalent (Bohn *et al.*, 1985). The pH varied between 8.26 to 8.77 for all treatments. The differences in the pH values for NPK and either 1 or 2% MG levels were not significant. But the differences in the pH values of NPK and the 3% Mg were significant under any method of fertilization. The differences between the MG levels were not consistent for total soluble salts. The difference in the total soluble salt between NPK treatment and any MG level was small. Therefore, we can conclude that the MG of Hail does not add much salt after using it as an organic fertilizer.

Effect of municipal garbage on the growth of lettuce: Sandy soils have some problems for plant growth. They suffer from the lack of organic matter and plant nutrients. Incorporation of municipal garbage as a source of organic matter and nutrients could alleviate some of these problems (Follett *et al.*, 1981). To minimize the effect of calcium carbonate of the soil on the availability of micronutrients, a foliar spray technique for the fertilizers application is recommended (Abo-Zeid, 1980). Therefore, incorporation of the MG and spraying its extract are used in the presents study. Fig. 2 shows the effect of MG rates and application techniques on the total fresh weight of lettuce. It is obvious that the weight of lettuce increased by further increasing in the rate of MG using both the

extract of WATER and COCA. Similar results were obtained for the extract of HCl and incorporation of the MG to 2%. However, the rate of 3% for the late application techniques gave low fresh weight in comparison to the 2% rate. According to the LSD values, the differences in the total fresh weight between the NPK and the application rate of 3% were significant with the extract of WATER and COCA treatments. These differences between the NPK and the other treatments (HCL and MG) were not significant.

Fig. 3 shows the effect of NPK and application method of organic fertilizer on the shoot fresh weight of lettuce. The shoot weight increased using the organic fertilizer in comparison to the NPK fertilization. In addition, the shoot weight increased as the MG rate increased using the extracts of WATER and COCA. On the other hand, the shoot fresh weight at 2% of the mixed MG is higher than those at 1 or 3% MG. Similar results were obtained for using the HCl treatments. Therefore, it can be concluded that using the MG as an organic fertilizers enhanced the lettuce growth in the sandy soil. The LSD values revealed that there are significant differences among the NPK and 2 or 3% for the experiments of WATER and COCA. The differences among the shoot weights were not significant for the MG and HCl experiments.

The shoot dry weight data are shown in Fig. 4. The shoot dry weight behaved similarly to the total fresh and shoot fresh weights. The dry weight increased as the percentage of MG increased for the experiment of WATER and COCA. In the case of MG and HCl experiment, the 2% rate gave the greatest shoot dry weight among the NPK and other rates. There were significant differences among the NPK treatments and the 3% rate for the WATER and COCA experiments. The 2% rate gave the highest dry weight among the treatments of NPK, HCl and MG experiments.

Fig. 5 shows the shoot dry matter percentage. The effect of organic fertilizers treatments was not consistent. But it can be concluded that the dry matter percentage using 2% rate for HCl and WATER extracts and MG experiments gave the highest percentage. The dry matter percentage increased as the MG increased for the COCA experiment. The differences among the dry matter percentages were not significant using different rate of MG under HCl, WATER and COCA experiments in comparison to the NPK experiment.

Fig. 6 shows the effect of fertilization methods on the mean growth parameters of lettuce (total fresh weight, shoot fresh weight, shoot dry weight and dry shoot percentage). The total fresh weights were 40.4, 49.5, 62.8, 67.9 and 51.6 g pot^{-1} for the NPK, HCl, COCA, WATER and MG treatments, respectively. The WATER treatment possessed the greatest total fresh weight mean while the NPK possessed the lowest among the treatments. The increase in the growth of lettuce plants might be partially attributed to the increase in the amounts of available nutrients in the soil due to the MG application rates (Table 1). Ahmed *et al.* (1992) reported similar results for wheat plants when water-hyacinth was mixed with a calcareous soil. In addition, it is obvious that extraction the MG then spraying the extract enhanced the nutrient availability for the lettuce plants. Also, the WATER experiment gave the highest value for shoot fresh and shoot dry weight (Fig. 6). The NPK experiment gave the lowest values for the preceding values. The dry matter percentage of shoot increased as following: NPK, HCl, COCA, WATER and MG treatments.

Municipal garbage of Hail City, Kingdom of Saudi Arabia, was evaluated as a source for plant nutrients. The results obtained from the present study support using the Municipal garbage of Hail as an organic fertilizer. It is observed that the WATER extract of MG is rich in nitrate and some micronutrients (Fe, Cu, Zn and Mn) and low in some pollutants (Ni and Pb). The WATER extract contains some organic molecules works as a chelating agent. The function of the organic molecules is a maximization for the availability of micronutrients. A high lettuce yield was obtained when the WATER extract of MG was sprayed on the lettuce plants and the solid extracted portion of MG was mixed with the sandy soil. The previous condition of using the MG gave the highest yield for the lettuce in comparison to the mineral fertilization or mixing the MG with soil. For future study, the WATER extract of MG can be sprayed at different stage of growth such a plant.

Acknowledgments

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