



Integrated Effect of Fertilizers on Soil pH, EC and Organic Matter Content

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ABSTRACT

Two field experiments in split-plot design were carried out in the winter season of 2014-2015 at Mansoura University Farm, Egypt, to investigate the effect of biochar, compost, and chicken manure with different rates of mineral fertilization on soil pH, EC, and organic matter content. Treatments of organic were biochar, compost, and chicken manure, while the studied mineral fertilizer treatments (NPK) took with rates of 50,75,100, and 125 %. The obtained results can be summarized in; biochar, addition led to an increase in the pH of wheat (Sakha 68) soil by 8.73 %, compost, and chicken manure decreased the pH of wheat soil by 8.30 and 8.19% compared with 0.0 organic addition, where the same amendment with the same order increased pH of barley (Gemmiza 123) soil by 8.65, and reduce with 8.30 and 8.18% of compost and chicken manure. Biochar, compost, and chicken manure treatments increased values of EC 2, 2.43, and 2.10 dS m⁻¹ of wheat soil and 2.80, 2.23, and 2.14 dS m⁻¹ of barley, respectively. Organic matter improved and the highest result was found with chicken manure 2.798 and 2.767 % of wheat and barley soil. Mineral fertilizer decreased both pH of wheat and barley soil as well as increased EC and organic matter up to the highest level used. A significant organic fertilizer type - mineral fertilization dose interaction was found with the most of tested treatments. The highest effect on pH in soil paste was found in the interactions between biochar with mineral treatments compared to other treatments of both wheat and barley soil. The best mean value of EC was recoded with the interaction between compost and 100 % NPK treatment (2.76 dS m⁻¹) of wheat soil, a similar trend was also achieved with barley soil (3.29 dS m⁻¹). Chicken manure -125 % of recommended NPK treatment gave the heights values of wheat and barley organic matter content, 2.798 and 2.767 %. Respectively.

تداخل تأثير الاسمدة علي درجة الحموضة والايصالية الكهربائية والمادة العضوية في التربة

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الكلمات المفتاحية:

درجة الحموضة
الايصالية الكهربائية
المادة العضوية
الفحم الحيوي
الكمبوست
سبلة الدواجن
الاسمدة المعدنية
التربة الرملية

الملخص

تم إجراء تجربتين حقليتين بنظام القطع المنشق في الموسم الزراعي الشتوي لسنة 2014/2015م. بمزرعة الأبحاث بجامعة المنصورة، مصر. لدراسة تأثير إضافة البيوشار (الفحم الحيوي) والكمبوست وسماد الدواجن مع معدلات مختلفة من الاسمدة المعدنية علي قيمة الرقم الهيدروجيني pH والايصالية الكهربائية (EC) والمحتوي المادة العضوية لتربة (OM). المعاملات العضوية كانت البيوشار والكمبوست وسماد الدواجن في حين أن معاملات الاسمدة المعدنية المدروسة هي (NPK) مع معدلات (56, 75, 100, 125%). يمكن تلخيص النتائج في التالي إضافة البيوشار أدى الي ارتفاع قيمة درجة الحموضة للتربة المزروعة بمحصول القمح (Sakha 68) بنسبة 8.73 % بينما إضافة سماد الكمبوست وسماد الدواجن أدى الي خفض قيمة درجة الحموضة للتربة المزروعة بمحصول القمح بنسبة 8.30% و 8.18% مقارنة مع عينة الشاهد، في حين أن نفس الاضافات ونفس الترتيب أدت الي رفع قيمة pH التربة المزروعة بمحصول الشعير (Gemmiza 123) وبنسبة ارتفاع 8.65% للبيوشار

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وبنسبة انخفاض قدرها 8.30% و 8.18% لكل من الكمبوست وسماد الدواجن. معاملات البيوشار والكمبوست وسماد الدواجن أدت إلى ارتفاع قيمة EC بقيمة 2.43, 2.10 ds m⁻¹ وقيمة 2.80, 2.23 ds m⁻¹ و 2.14 ds m⁻¹ لترب محصول الشعير على التوالي. أظهرت النتائج تحسن في محتوى المادة العضوية للتربة حيث سجلت أعلى نتيجة مع سماد الدواجن بنسبة 2.798% و 2.767% لتربة المزرعة بالقمح والشعير. استخدام الأسمدة المعدنية أدى إلى خفض (pH) التربة المزرعة بالقمح والشعير بالإضافة إلى ارتفاع قيمة EC والمادة العضوية إلى أعلى مستوى لها. تداخل الأسمدة العضوية والمعدنية أدى إلى حدوث تغيرات معنوية مع معظم المعاملات المدروسة. أعلى قيمة لتداخل الأسمدة والخاصة بدرجة الحموضة PH سجلت في التداخل الحاصل ما بين سماد البيوشار والأسمدة المعدنية مقارنةً مع باقي المعاملات ولترب كلي المحصولين. أفضل معدل انخفاض في قيمة الايصالية الكهربائية Ec سجلت في التداخل الحاصل بين سماد الكمبوست و 100% NPK حيث انخفضت قيمتها إلى 12.76 ds m⁻¹ لتربة محصول القمح ونفس النتائج سجلت مع تربة محصول الشعير بقيمة 13.29 ds m⁻¹. سماد الدواجن مع 125% NPK أعطي أعلى قيمة في محتوى المادة العضوية لكل من ترب القمح والشعير بنسبة 2.798% و 2.767% على التوالي.

Introduction

In agricultural crop production system, soil fertility is foremost importance to get the higher yield. One of the most important soil problems for agronomic systems is organic matter loss which lead to decreasing soil fertility and productivity. In this Respect the use of soil organic amendments such as compost, chicken manure and biochar can be a key master for sustainable agriculture in long term, increasing soil fertility and productivity [1].

Organic manure application to soil has numerous benefits not only by supplying the essential nutrients to crop but also by enhancing the soil properties that has a great influence on plant growth. Soil pH affects nutrient solubility and influences the sorption of nutrients. [2] Stated that compost, as the organic waste can be a valuable and inexpensive fertilizer and source of plant nutrients. The effects of different levels of organic amendments on soil properties and fertilities have observed by several researchers. For example, increasing the rate of compost application increased soil organic matter content (O.M), total N content and soil microbial population [3]. In addition, [4] evaluate the effects of top dressing compost dairy manure on soil chemical properties of Kentucky bluegrass, found that compost applications at rated of 66 m³. ha⁻¹ or greater raised soil electrical conductivity (EC).

Chicken manure is preferred amongst other animal wastes because of its high concentration of macro-nutrients. [5] Stated that following application of manure increase in N levels from 40 – 60 % and 17 – 38 % compared to control for Norfolk sandy soils and Cecil sandy loam soils, respectively. Furthermore, application of chicken manure to soil improves concentration of water soluble salts in soil. The pH of dry chicken manure pellets was found to be 7.9, with most of the nutrients available in this environment. [6] Reported that applies biochar + chicken manure (50:50) increased organic matter of soil ranged between 19.5 and 23.2 g kg⁻¹ compared to 11.7 and 10.2g kg⁻¹ in the control and N fertilizer treatments. [7] Carried out an experiment to study poultry manure effect with two methods (broadcasting on the soil surface and the incorporated) on chemical properties of slightly acidic, sandy loam soil. Soils were low in organic matter (OM), total N, and exchangeable Ca. Their data showed that in two years, 2012 and 2013 of experiment, incorporation of poultry significantly increased soil organic matter, compared with broadcasting method.

In the recent years, application of biochar to agricultural soils is rapidly emerging as a new management strategy for its probable role in carbon sequestration, soil quality improvements, and plant growth promotion. It can produced from a varied range of biomass sources including woody materials, agricultural wastes such as olive husk, peanut shell, corn Stover, animal manures and other waste products. [8] reported that application of biochar to soil can improve numerous physicochemical and biological properties of the soil such as increased soil pH, cation exchange capacity (CEC) and reducing nitrogen (N) leaching. [9] examined the green waste biochar as a soil amendment. They reported that applied biochar (50 ton ha⁻¹)

enhanced chemical properties and increase soil pH. Also, [10] carried out an experiment to study the effect of biochar (0.24 and 72 t.h⁻¹) application on soil properties with mineral N supply 150.0 Kg N fed⁻¹. Data showed that applied biochar, with N treatment increased soil EC values by 83.3 μscm⁻¹.

The continued use of chemical fertilizers alone may be cause health and environmental risks such as pollution of surface and ground water by nitrate leaching. Thus, the chief challenge in field management is to decrease the applied amount of nitrogen fertilizers to the field without a nitrogen deficiency [11]. One of the possible options to reduce chemical fertilizer use could be adoption of integrated use of organic and inorganic fertilizers [12]. The main objective of this study was to assess the effect of biochar ,compost and chicken manure on soil properties (pH, EC and O.M) compared to inorganic fertilizers and their interaction in sandy soil.

2. Materials and Methods

Two field experiments were conducted in winter season of 2014-2015 at Mansoura University Farm, Qalabshu region, Dakhliya Governorate, Egypt, to evaluate soil properties (pH, EC and O.M) in sandy soil under different application rates of organic and inorganic fertilizers.

2.1. Soil sampling and analysis

Sandy soil, 70 % sand, 11% silt and 19% clay. Clay was artificially added within a clayey soil that incorporated with the surface layer, 30 cm, 15 years ago. The mixed surface layer have electrical conductivity of 1.86 dSm⁻¹, pH value of 8.5 and the available N, P and K were 17, 2.5 and 62 ppm , respectively . The study area mainly depends on drainage water in irrigation process, where its dissolved salts content is less than 2000 ppm in winter season. 2.45 dSm⁻¹ and a pH value of 7.5 were measured in a growing season period. Soluble cations of Ca⁺², Mg⁺², Na⁺, K⁺ in the used soil and irrigation water recorded 1.80 , 5.10 , 9.87 and 0.80 meq/l of the soil and 2.8 , 13.3, 12.87 and 0.496 meq/ of the water, respectively. Soluble anions HCO₃⁻, CL⁻¹ and SO₄ reported 4.13, 4.56 and 8.82 meq/l and 4.37, 10.2 and 14.896 meq/l of the soil and water, correspondingly, analysis of the tested soil was done according to [13]. Mechanical analysis and calcium carbonate were determined as described [14].

The electrical conductivities of the soil paste extracts were measured by EC meter according to the method of US [15]. Soil reaction (pH) was determined in soil paste by using Beckman pH meter [15]. Organic matter (O.M) was determined according to Walkley and Black method as described by [16].

2.2. Soil amendments

Appropriate organic fertilizer was added to the surface of appropriate plots 15 day before planting and mixed well by a small rotary plow, then the irrigation was applied. One-week later soil was plowed with a small rotary plow. Sown was done by soaked seeds (one hour for wheat and three hour for barely) were left for two hours after soaking to ease seed distribution as equal, at the end of March

and April respectively.

The used biochar represent the finest byproduct of charcoal manufacture with an EC value of 6.48 (dSm⁻¹ in paste extract), pH of 12.5 (in paste) and available NPK as 1.21, 13.9, 268 ppm, respectively. It was brought from kom-ombo, abo-Elmatameer district, Elbehara province, Egypt. Compost were manufacture by organic farming project, Faculty of Agriculture, Mansoura Univ. Egypt 2011-2015. This compost with available P (19.6ppm) extracted with 0.5 M (NaHCO₃) adjusted at pH 8.5 and was determined at a wavelength 660nm by spectrophotometer as described by [13]. Available K (100.6ppm) was extracted by ammonium acetate 1 N , pH 7.00 and determined by using Flam photometer according to [15]. Available N was (1.67 ppm) as mentioned by [17]. Available NPK of Chicken manure were 0.95, 24.21 and 225.2 ppm. Chemical analyses of biochar, compost and chicken manure were determined according to the standard methods described by the Association of Official Analytic Chemists [18].

2.3 .Experimental design and Statistical analysis:

Soil was vertically harrowed twice, land leveling and divided as split plot design. Four organic fertilizer treatments (0.0 organic, biochar 0.5 % of 15cm surface layer weight ,compost,10000 kg fed⁻¹, and Chicken manure, 5000 kg fed⁻¹) occupied main plot while sub plot was occupied with four levels (50 % ,75 % , 100% and 125 % of

recommended N,P,K) mineral fertilization, hence the experiment comprise from16 plots with four replicate to be 64 experimental unites. Each plot have a 2.5 m width *10m length.

All data were statistically analysis According to Gomez and Gomez using CO-STAT-C computer software package. The least significant difference at (0.05) level of probability was used for testing the means of the different variables.

3. Results and Discussion

3.1. Effect of organic, mineral fertilization and their interaction on soil pH

Data of table1 reveal biochar, compost and chicken manure as organic fertilizers and mineral fertilization doses (50, 75, 100, and 125 % recommended) effects on soil pH and electrical conductivity values as well as organic matter. Soil pH at harvesting stage of wheat and barley was varied according to organic fertilizer type addition, where soil pH values of biochar treated soil was increased from 8.40 to 8.73 and 8.65 for wheat and barley respectively. The contrary trend was found due to compost and chicken manure addition, where their addition descried soil pH values of wheat and barley soil. Compost application descried soil pH from 8.40 to 8.30 for both wheat and barley soil. Chicken manure descried soil pH from 8.40 to 8.19 for wheat soil and to 8.18 for barley soil; chicken manure addition ability to reduce soil pH was higher than that of compost

Table 1: Effect of organic and mineral fertilization on soil pH, EC and O.M

Characteristics	pH		EC dS m ⁻¹		O.M %	
	Wheat	Barley	Wheat	Barley	Wheat	Barley
Organic fertilizer treatments						
Control	8.40	8.40	1.67	1.66	1.286	1.418
Boichar	8.73	8.65	2.00	2.80	2.139	2.293
Compost	8.30	8.30	2.43	2.23	2.396	2.637
Chicken manure	8.19	8.18	2.10	2.14	2.513	2.727
Mineral fertilizer treatments						
50%	8.31	8.25	2.00	2.31	1.898	2.132
75%	8.36	8.33	1.99	2.49	2.044	2.248
100%	8.37	8.36	2.12	2.61	2.148	2.326
125%	8.29	8.30	2.10	2.43	2.244	2.369

Data tabulated in table .1 presented mineral fertilization dose effect on soil pH for both crops, wheat and barley. Data reveal that little effect of the studied treatment (50.0, 75.0, 100.0, 125.0 % of recommended dose) on soil pH of wheat and barley soil at harvesting stage. Soil pH values of wheat soil at harvesting stage were 8.31, 8.36, 8.37, and 8.29 for mineral fertilization treatment of 50.0, 75.0, 100.0 and 125.0 % mineral fertilizer recommended dose, where soil pH values of barley soil at harvesting stage were 8.25, 8.33, 8.36 and 8.30 for the same order of mineral fertilization treatments

Data of fig .1 showed that the best interaction which presented the highest effect on pH in soil paste was found in interactions between biochar with 50 % mineral treatments compared with other treatments where was 8.78, followed by the interaction between biochar with100, 75, and 125 % . Whereas, the lowest level which gave the lowest effect on pH in soil paste was found in the interaction between control treatments with 50 % mineral treatment where was 8.04, compared to other interactions.

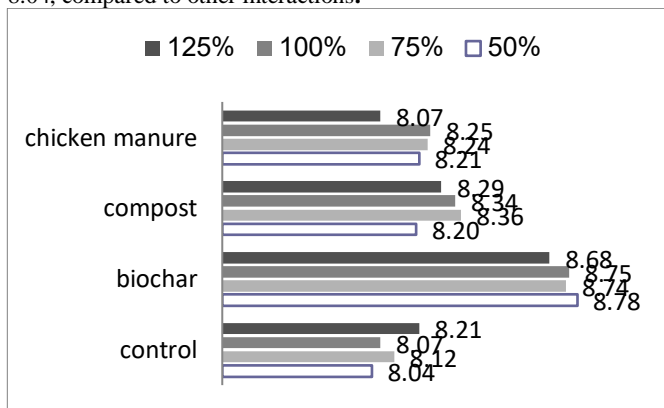


Fig 1: Organic-minerals fertilization interaction effect on wheat soil pH.

Data of fig. 2 presented organic-mineral fertilization interaction on soil pH value of barley soil at harvesting stage. Data reported that all treatments significantly increased the values of pH .Also the treatment of biochar with 125 % mineral resulted the highest values which recorded 8.72 compared other treatments. On the other hand interaction between control treatment with 50 % mineral treatment gave the lowest value with 8.05.

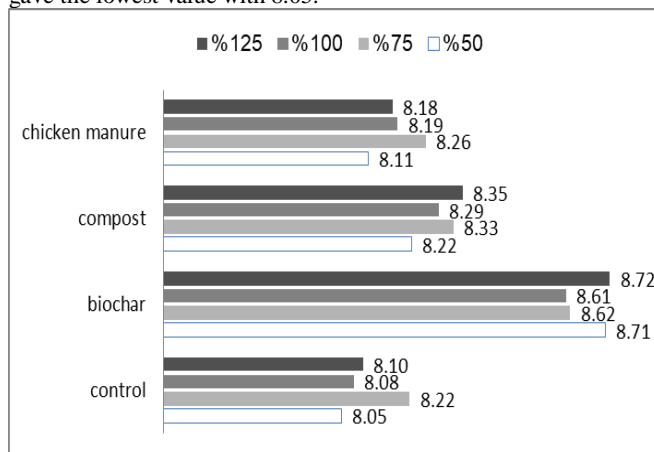


Fig 2: Organic-minerals fertilization interaction effect on barley soil pH.

Data declare that biochar addition at a rate of 5 % caused a sharp increase in soil pH under either cultivated crops, wheat or barley with any studied mineral fertilization dose. With the exception of treatment containing biochar, all treatment have a nearest values of soil pH, 0.3 unit as a maximum difference between treatment means for wheat soil, and 0.2 unit as a maximum difference between

treatment means for barley soil.

Post-harvest soil analysis indicated that soil pH was significantly increased due to single or mixed organic–mineral treatments. Biochar raised soil pH and showing the high pH tendency and liming or alkaline effect of biochar. This correlated with the results of a previous study by [19] where a significant positive linear correlation between biochar-treated soil pH and biochar pH was observed. It has been reported that biochar is a highly basic due to the presence of organic ions and inorganic carbonates, hence its application would increase soil pH. [20] Found that biochar addition increase the mean pH value in both fertilized and non-fertilized soils. [8] Reported that relatively highest mean pH value was observed in the soil treated with 15 ton ha⁻¹ biochar.

3.2.Effect of organic, mineral fertilization and their interaction on soil EC dS m⁻¹.

Data presented in table.1 showed the individual effect of organic and mineral fertilization on EC values of wheat and barley soil. Data revealed that all tested organic amendments increased EC values compared to control, (without organic addition). The mean values of EC were 1.67, 2.00, 2.43 and 2.10 dSm⁻¹ for soil wheat treated with 0.0 organic, 5.04 ton.fed⁻¹ of biochar, 10 ton.fed⁻¹ compost and 5 ton.fed⁻¹ of chicken manure, respectively whereas similar values for barley soil at harvesting stage were 2.66, 2.80 , 2.23 and 2.14 dSm⁻¹ for the same treatments.

Concerning to mineral fertilization impact on soil EC values at harvesting stage data of table.1 reveal that a very slight increase or decreases was found between treatments 50.0, 75.0 100.0 and 125.0 % of recommended mineral fertilizer recorded 2.00, 1.99, 2.12 and 2.10 dS.m⁻¹ for wheat soil. Similar trend was also found due to applied the same treatments with barley plant whereas the obtained values were higher than that obtained with wheat plant, 2.31, 2.49, 2.61 and 2.43 dSm⁻¹.

Data plotted in figs.3 and 4 show organic-mineral fertilization effects on soil electrical conductivity at harvesting stage of wheat and barley crops. Figs reveal that the electrical conductivity of soil cropped by wheat is lower than that of barley even they have the same treatment within the area of wheat crop treatments containing compost or chicken manure. Where the adverse trend was obtained with barley crop, the adverse trends could be attributed to the differences of irrigation quantity and time which are more for wheat than that of barley. Consequently more salts, were leached from biochar salts, So the herbal cover of wheat is more dense than that of barley which lower secondary salinization in wheat land compared with barley land.

These results are in agreement with [21] who reported that soil salinity (ECe) and saturation hydraulic conductivity (Ks) as well as available N, P, and K in the soil were significantly increased with increasing N rates applied generally up to 90 kg N/fed. [22] studied the effect of compost on soil planted with wheat and the results indicated that at harvest stage, the electrical conductivity of the soil was significantly changed by the compost application as compared to the control. [23] Found that among four N-fertilization rates of 0, 60, 120, 180 kg N ha⁻¹ and three organic sources two biochars and compost led to slightly increased of EC because of biochar addition. [24] Reported mixed bio-fertilizer with organic manure at a rate of 10 t/fed resulted in maximum wheat productivity and improved soil properties and fertility of soil after wheat harvest.

In general, the content of several ions in the compost is a potential nutritional value to plants, especially when the heavy metals content are low, but high concentrations of some ions can potentially increase salinity soils [25]. [26] Stated that biochar caused significant increases in soil pH and electrical conductivity EC of wheat (T. durum L. cv. Vitron).

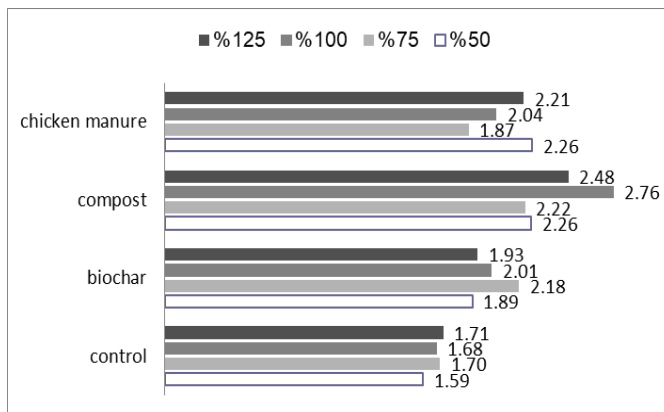


Fig 3: Organic-minerals fertilization interaction effect on wheat soil EC.

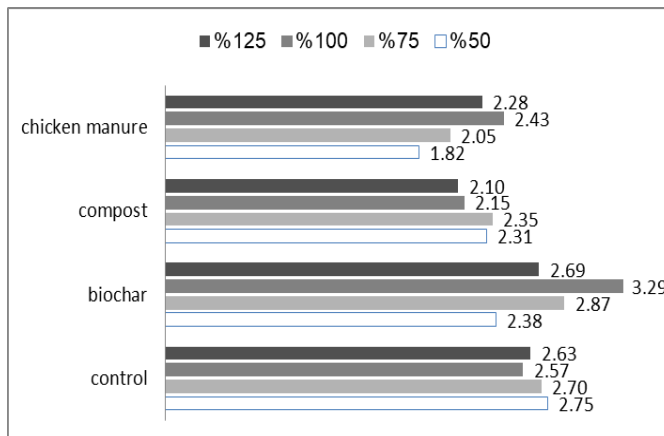


Fig 4: Organic-minerals fertilization interaction effect on barley soil EC.

3.3. Effect of organic, mineral fertilization and their interaction on soil O.M %.

Results of table.1 present that biochar, compost and Chicken manure significantly increased OM %, from 1.286 % (0.0 organic matter =control) to 2.139, 2.396 and 2.513 %, respectively for wheat, whereas with barley crop organic treatments significantly increased OM % values from 1.418 % to 2.293, 2.637 and 2.727 %, with biochar, compost and chicken manure, respectively. The increasing percentage of OM % of wheat and barley's soil due to Chicken manure treatment were 1.95 and 1.92 % compared with that of control.

Concerning mineral fertilizer treatments in table.1 significantly increased OM % in all treatments (50, 75, 100 and 125 % of recommended dose) the results were 1.898, 2.044, 2.148, and 2.244, respectively for wheat. Whereas with barley the values were 2.132, 2.248, 2.326 and 2.369 %, respectively with the obvious treatments. The increasing percentage of OM % of wheat and barley' soil due to 125% mineral fertilizer treatments were 18 and 11 % compared with that of 50 % mineral fertilizers.

Fig (5) showed that the best interaction which presented the highest values of soil organic matter (2.798 %) was found with chicken manure and 125 % minerals treatments, followed by the interaction between compost and 125 % minerals treatments which presented 2.575 %, whereas the lowest value was found in the interaction between control and 50 % minerals treatments 1.172 %, that led to the lowest influence on soil organic matter compared with other interactions.

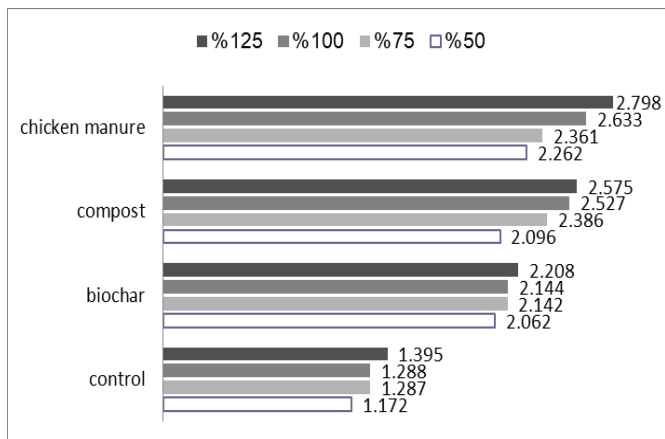


Fig 5: Organic-minerals fertilization interaction effect on wheat soil O.M

The same trend was found in soil cropped by barley. Fig.6 showed that the highest value of soil organic matter (2.767 %) was found with chicken manure and 125 % minerals treatments, the followed interaction was between compost and 125 % minerals treatments (2.72%), whereas the lowest value was found in the interaction between control and 50 % minerals treatments 1.257 %, which presented the lowest influence on soil organic matter compared other interactions.

These results are in agreement with that of [27] who stated that compost application could increase the physical, chemical and biological characteristics as well as soil organic matter (SOM). The application of compost in long-term increased SOM concentrations due to their higher level of stable carbon as well as positive effects on soil properties. [28] Reported that the effect of different proportions of manure and chemical fertilizer treatment on grain yield, feed yield of barley as well as soil chemical properties were significant.

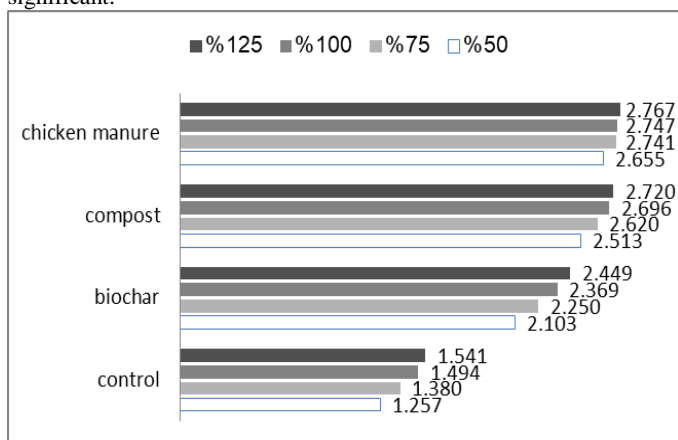


Fig 6: Organic-minerals fertilization interaction effect on barley soil O.M.

4.Conclusion

Application of soil amendments has received a great attention from agriculturists and environmentalists due to the direct and indirect effects on crop growth and yield as well as soil properties. Effect of chicken manure enriched with 125 % mineral treatment significantly greater on soil properties (pH, EC and O.M) of wheat and barley compared to enriched with other treatments. It can concluded that combined use of organic and inorganic fertilizer could be more effective and economical to increase soil fertility and the yield of crop plants on sustainable basis than the chemical fertilizer alone

5.References

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