مجلة العلوم البحتة والتطبيقية
Journal of Pure & Applied Sciences
www.Suj.sebhau.edu.ly ISSN 2521-9200
Received 13/05/2019 Revised 06/09/2019 Published online 17/11/2019

Effect of Organic (Biochar, Compost and Chicken Manure) and Mineral Fertilization on Available NPK on Sandy Soil

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Abstract Sandy soils characterize about 90% of the Egyptian soils. Such soils represent a great hope for the agriculture expansion. Soil amendments has been used widely in agriculture lands of Egypt. Thus, two field experiments with design of spit plot were carried out in winter season of 2014-2015 at the Faculty of Agriculture Research Farm, Mansoura University, Egypt to examine available NPK on sandy soil cultivated by wheat and barley under different application rates of organic and mineral fertilizers. Treatments of organic were chicken manure, compost and biochar, while the studied mineral fertilizer treatments took with rates of 50,75,100 and 125 % .The results showed that available NPK by wheat and barley's soil increased with the application of organic- mineral treatments. The available rate of NPK by wheat's soil were 49.5, 14.5, and 382.3ppm, respectively; while with barley's soil amounted by 57.6, 19.2, and 359.8ppm, were assigned with the treatment of chicken manure + 125% of recommended NPK treatments. The results also revealed that the ability of tested organic-mineral treatments increased the remained available N (85.21%) and P (54.84 %) in barley's soil and 46.88 and 45% respectively, of wheat's soil compared with 0-0 organic, while available k was higher in wheat's soil than barley. In summary, chicken manure + 125% mineral treatments was the superior in all amendments and gave the highest values of available NPK. Also, Integrated use of organic materials ,and chemical fertilizers is beneficial in improving available N, P and K in soil as well as soil pH and crop yield.

Keywords: Available NPK ; biochar; chicken manure; compost; mineral fertilization.

تأثير الأسمدة العضوية (الفحم الحيوي والكمبوست و سماد الدواجن) والمعدنية علي النيتروجين والبوتاسيوم والفوسفور المتاح في التربة الرملية

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الملخص تمثل الترب الرملية حوالي 90٪ من الأراضي المصرية. مثل هذه التربة تمثل أملاً كبيراً نحو التوسع الزراعي. تستخدم المحسنات الزراعية على نطاق واسع في الأراضي الزراعية في مصر. لذلك نفذت تجربتان حقليتان باستخدام تصميم القطع المنشقة في الموسم الشتوي 2014–2015 بمزرعة ابحاث كلية الزراعة بجامعة المنصورة، مصر لتقدير النيتروجين والفوسفور والبوتاسيوم المتاح في تربة رملية مزروعة بمحصولي القمح والشعير تحت ظروف تسميديه مختلفة من الأسمدة المعدنية والعضوية . المعاملات العضوية كانت سماد الدواجن والكمبوست والفحم الحيوي، في حين كانت المعاملات المعدنية المدروسة بمعدل 50، 75، 100 و 125%. أظهرت النتائج بأن النيتروجين والفوسفور والبوتاسيوم المتاح في التربة ازداد معدله بعد استخدام الأسمدة العضوية والمعدنية معاً. معدل النيتروجين والفوسفور والبوتاسيوم المتاح في التربة المزروعة بالقمح سجل 49.5 ppm و 14.5 و 382.3 علي التوالي، فيما سجل 57.6 ppm و 19.2, و 359.8 علي التوالي في التربة المزروعة بمحصول الشعير وسجلت جميعها مع معاملة سماد الدواجن +125% معدني . أظهرت النتائج ايضاً بان المحسنات العضوية والمعدنية زادت معدل النتروجين (85.21%) والفسفور(54.84%) المتاح في التربة المزروعة بالشعير أعلي من تلك المزروعة بالقمح 46.88% و45 علي التوالي، في حين كان معدل البوتاسيوم المتاح أعلي في تربة القمح منه في تربة الشعير . يمكن القول بان بأن النيتروجين والفوسفور والبوتاسيوم لمعاملة سماد الدواجن +125% معدني كان هو الأفضل في جميع الحالات. خلصت هذه الدراسة الي أن استعمال الأسمدة العضوية والمعدنية في التربة يؤدي الي تحسين معدل النيتروجين والفوسفور والبوتاسيوم المتاح في التربة مما يؤدي الي تحسين درجة حموضة التربة وانتاجية المحاصيل.

الكلمات المفتاحية: NPK المتاح– سماد الدواجن، الكمبوست، الفحم الحيوي، الأسمدة المعدنية.

1. Introduction

Soil is an essential part of the natural environment. It effects the distribution of many species of plants and offers a habitat for a wide range of organisms. However, Wheat (Sakha 68) and barley (Gemeza123) are the most widely cultivated crops on newly reclaimed areas of Egypt, where organic fertilizers and amendments are needed [1]. Soil amendments defined as elements added to the soil to improve its properties which can be physical, chemical or biological to allow healthy crop growth [2]. Farmyard –manure (FYM), compost and chicken manure known as organic amendment. Nowadays, biochar is classified as a new soil organic matter amendment [3].

In agricultural lands, soil organic matter increases production by improving soil physical, chemical and biological properties. Application of organic matter provides nutrients such as N, P, K and Ca to the soil, improve aggregate stability and enhance water holding capacity as well as helps the soil to maintain good tilth and thereby better aeration for germinating seeds and plant root development [4-5].

chicken manure is preferred amongst other animal wastes because of its high concentration of macro-nutrients .In addition, application of chicken manure to soil enhances concentration of water soluble salts in soil. Plants absorb nutrients in the form of soluble salts, but excessive accumulation of soluble salts defeats plant growth [6]. The use of FYM alone as a substitute to inorganic fertilizer is not be enough to maintain the present levels of crop productivity of high yielding varieties. Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously as the most effective method to maintain a healthy and sustainably productive soil[7].

Applied biochar as a source of available P, led to beneficial effects on crop production, However, at the highest mineral fertilizer rate, addition of biochar led to about 20–30 % increase in grain yield of wheat compared with the use of the mineral fertilizer alone[8]. Compost is rich source of nutrients with high organic matter content. Physical and chemical properties of soil can be improved by using compost, which may ultimately increase crop yields [5]. Continuous use of chemical fertilizers, FYM, compost and green manure enhanced the potassium status in the soil and increased potassium uptake by wheat [9]. The main aim of this study was to assess the effect of organic (biochar, compost and Chicken manure) and mineral fertilization on available N,P and K of sandy soil.

2. Materials and Methods

2.1 Study Area and Data Collection

Two field experiments were carried out in winter season of 2014-2015 at Mansoura University Farm, Qalabshu region, Dakhlia Governorate, Egypt, to evaluate the available N,P and K on sandy soil under different application rates of organic and mineral fertilizers.

Sandy soil, 70 % sand, 11% silt and 19% clay. Clay was artificially added within a clayey soil which incorporated with the surface layer, 30 cm, 15 years ago. The mixed surface layer have electrical conductivity of 1.86 dSm^{-1}, a 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 HCO^{3} , CL^{-1} and SO^{4} 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.

Soil was vertically harrowed twice, land levelling 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, 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 2.5m width *10m length.

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 done . One week later soil was plowed with a small rotary plow. Sown of barley and wheat was done by soaked seeds and planted 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 2.36, 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 extracted with 0.5 M (NaHCO3) adjusted at pH 8.5 and was determined at a wavelength 660 nm by spectrophotometer as described by[10]. Available K was extracted by ammonium acetate 1 N , pH 7.00 and determined by using Flam photometer according to[11]. Chemical analyses of biochar, compost and chicken manure were determined according to the standard methods described by the Association of Official Analytic Chemists (A.O.A.C.,1990).

2.2 Soil analysis:

The electrical conductivities of the soil paste extracts were measured by EC meter according to the method of US [11]. Soil reaction (pH) was determined in soil paste by using Beckman pH meter [11]. Mechanical analysis and calcium carbonate were determined as described [12]. Available N was extracted by potassium chloride 1 N and measured using the conventional method of Kjeldahl as described by [13]. Available P extracted

with 0.5 M (NaHCO3) adjusted at pH 8.5 and was determined at a wavelength 660 nm by spectrophotometer as described by [10]. Available K was extracted by ammonium acetate 1 N , pH 7.00 and determined by using Flam photometer according to [11]. Chemical analyses of biochar, compost and chicken manure were determined according to the standard methods described by A.O.A.C.,1990.

2.3 Statistical Analysis:

The data were analysed using CO-STAT-C computer software package [14].

3. Results and Discussion

Data of Table (1) showed organic (biochar, compost and Chicken manure) and mineral fertilization effect on soil available N,P and K. Data reveal that biochar, compost and chicken manure in wheat's soil at harvesting stage increased available N from 38.72 ppm to 42.8, 44.7 and 46.3 ppm respectively, similar increases were also found in barley soil due to the same amendment, where available N was increased from 35.2 to 44.4, 46.4 and 49.3 ppm respectively. Previous data show a higher available N of untreated treatments of wheat and barley's soil 38.7 and 35.2 ppm which attributed to rapid decomposition of wheat and barley root hair. So lower effect of biochar , compost and chicken manure for increasing available N came from plant absorption of the readily available form and low decomposition rate of those amendment especially in winter season.

Concerning to mineral fertilization levels effect, the soil available N after harvesting outlined in Table (1) ,increasing the mineral fertilization dose from 50.0 to 75.0% of mineral recommended dose increased available N from 40.0 to 41.5 ppm for wheat's soil and from 39.2 to 41.1 ppm for barley's soil. Increasing mineral fertilization dose from 100.0 to 125.0 % of mineral recommended dose gave an increase in available N from 44.8 to 46.3 ppm for wheat's soil and from 45.8 to 49.2 ppm for barley's soil. This unexpected trend comes from higher solubility of N source added and higher utility of its available from which was retained by soil.

Table 1: Effect of Organic and Mineral Fertilization on Available N, P and K of Soil.

Characteristics / Treatments	Available N ppm		Available P ppm		Available K ppm		pH	
	Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Organic fertilizer treatments								
Control	38.7	35.2	10.8	13.5	316.2	289.8	8.40	8.40
Boichar	42.8	44.4	12.0	14.7	334.4	305.5	8.73	8.65
Compost	44.7	46.4	12.1	15.1	362.3	317.7	8.30	8.30
Chicken manure	46.3	49.3	12.8	16.9	364.1	340.0	8.19	8.18
Mineral fertilizer treatments								
50%	40.0	39.2	11.0	13.1	321.4	292.5	8.31	8.25
75%	41.5	41.1	11.5	14.4	336.8	309.3	8.36	8.33
100%	44.8	45.8	12.2	16.0	353.9	321.3	8.37	8.36
125%	46.3	49.2	13.0	16.7	365.0	329.8	8.29	8.30

Organic mineral fertilization coupled effects were shown in Figs 1-2, in wheat's soil after harvesting chicken manure + 125% has given the highest available of N **(**57.6 ppm). The second interaction with the level of + 125% mineral fertilizer treatments was found with biochar **(**46.7 ppm). On the other hand, the highest one was found due to chicken manure + 125% of recommended treatments, followed by compost with + 125% mineral fertilizer. Similar trend with a lesser treatments recorded the lowest values of available N, 31,1 and 33.7 ppm of wheat and barley's soil. These results were similar to the findings of [15]. They reported that "increase in nitrogen levels from 40 - 60% and 17 - 38% with respect to control for Norfolk sandy soils and Cecil sandy loam soils, respectively following application of manure". The results are in agreement also with [16] and [17] who mentioned that in non-cultivated soils, it is likely that more than 95% of the Nitrogen is found in the soil organic matter. Furthermore, organic-mineral additions led to increased available N in wheat's soil by 46.88% and 85.21%ppm in barley's soil compared with 0.0 organic addition as a result of high up take of N by wheat than barley. [18] noted that "in any one year and for any one rate of N, the percentage crude protein in wheat was consistently higher than that of barley".

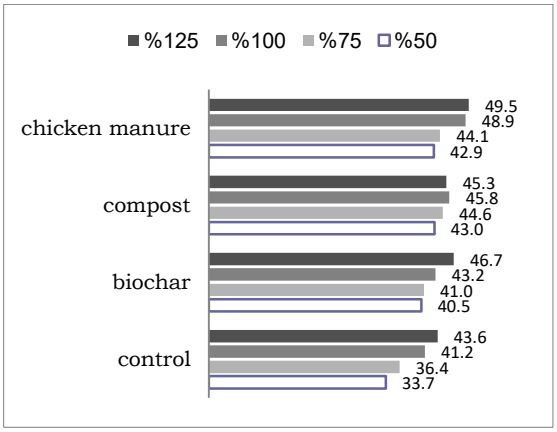

Fig. 1: Effect of organic –minerals fertilization interaction on available N of wheat's soil.

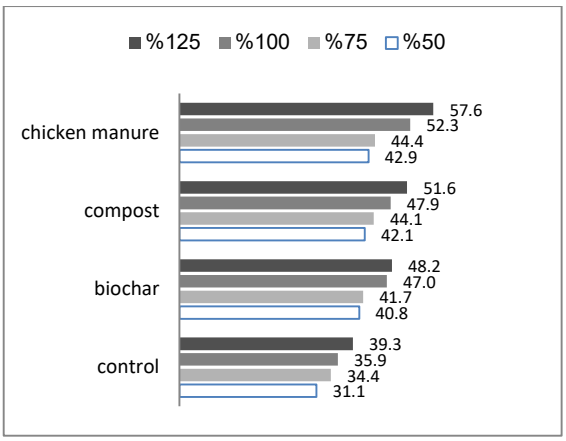

Fig. 2: Effect of organic –minerals fertilization interaction on available N of barley's soil.

Data oriented in Table (1) showed each of organic and mineral fertilization effects on available phosphorus remained after wheat and barley harvesting. In wheat's soil data revealed that the remained available phosphorus due to applying biochar and compost is approximately equal (12.0 and 12.1 ppm) while chicken manure exhibited a higher value 12.8 ppm. Whereas, in barley's soil 0.0 organic, biochar, compost and chicken manure treatments recorded 13.5, 14.7, 15.1, and 16.9 ppm as remained available phosphorus respectively. Data also revealed that the remained available phosphorus was higher in barley's soil than that of wheat's soil with the same treatment of organic addition.

Furthermore, data presented in Table (1) revealed that increasing mineral fertilization from 50.0 up to 125.0% of recommended dose in wheat led to a slight increase in residual available phosphorus. Mineral fertilization rate of 125.0% of recommended dose caused an increase amounted by 15.39% than that of 50% of the recommended dose. The remained available phosphorus in barley soil was also increased with increasing mineral fertilization rate, where 125.0% of recommended dose treatment caused an increase in that trait amounted by 25.19 % increase compared with that of 50.0 % of recommended dose treatments.

Data plotted in Figs 3 and 4 explain the participate effect of organic types and mineral fertilization levels on available phosphorus of wheat and barley's soil after harvesting. The highest value in both wheat and barley's soil were achieved with chicken manure+125.0 % of commended mineral fertilizer treatments, 14.5 and 19.2 ppm, respectively. The lowest values were obtained with 0.0 organic + 50.0% of recommended mineral fertilizer treatments, 10.0 and 12.4 ppm for wheat and barley's soil, respectively. With addition of chicken manure, the results indicated increased available P with application rate for the soil. This because concentration of P in soils is influenced by, besides the mineralogical composition of the parent material, anthropogenic sources like addition of fertilizers and organic manure to improve soil fertility[19]. In addition, the results of available P are in line with the work done by[7] and [20] who mentioned that about 25% of in the Phosphorus, is found in the soil organic matter .Moreover, organic-mineral additions led to increase the remained available P in barley's soil by 54.84% and 45%ppm in wheat's soil compared with 0.0 organic addition.

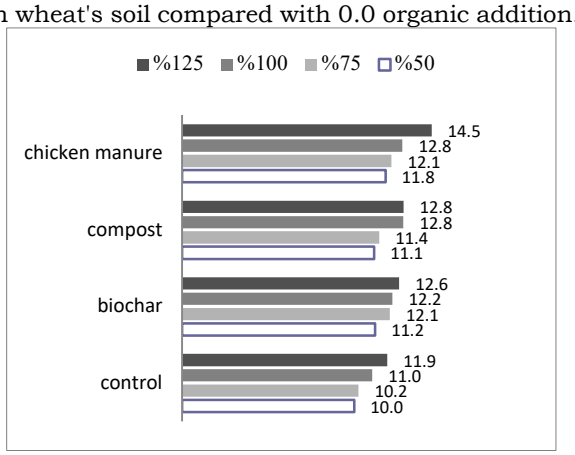

Fig. 3: Effect of organic –minerals fertilization interaction on available P of wheat's soil.

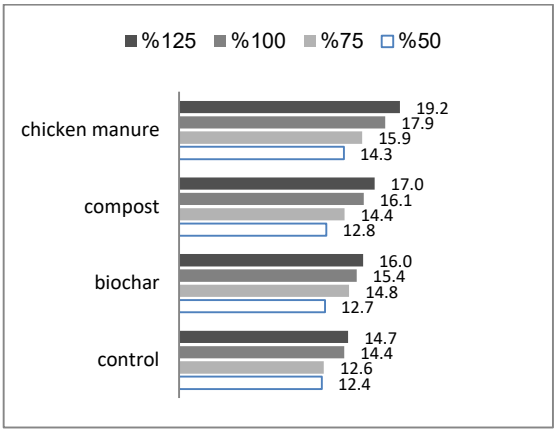

Fig. 4: Effect of organic –minerals fertilization interaction on available P of barley's soil.

Data presented in Table (1) show the individual effect of organic and mineral fertilization on available K of wheat and barley's soil after harvesting. Data revealed that all tested organic treatments increased available K compared to control (without organic addition). The available K varied between 316.2 to 364.1 ppm in wheat's soil and between 289.8 to 340.0 ppm in barley's soil. Mineral fertilization dose of 50.0, 75.0, 100.0 and 125.0% of recommended fertilization dose treatments recorded 321.4, 336.8, 353.9 and 365.0 ppm as available potassium after wheat harvesting, while the same treatments recorded 292.5, 309.3 321.3 and 329.8 ppm as available potassium after barley harvesting.

Data of Figs 5 and 6 reveal the interactions among organic and mineral treatments on available potassium of wheat and barley's soil after harvesting. Figs presented the lowest records (274.4, and 269.4 ppm) of available potassium with 0.0 organic + 50.0% recommended mineral fertilization treatments in both wheat and barley's soil. The highest values in both wheat and barley's soil 382.3 and 359.8 ppm, were recorded with chicken manure+125.0% of recommended mineral fertilizer treatments. These results agree with results of [21], who outline that because of high

amount of K in organic amendments that increases CEC, the K amount rises in soil, as well as with[22]. They stated that use of FYM, wheat straw and green manure in conjunction with fertilizers increased the soil organic carbon, available N, P, K status. In addition, the remained available potassium was higher in barley's soil than that of wheat's soil with the same treatment of organic addition.

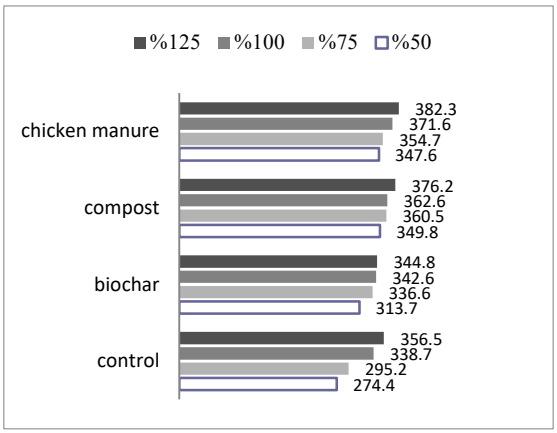

Fig. 5: Effect of organic –minerals fertilization interaction on available K of wheat's soil.

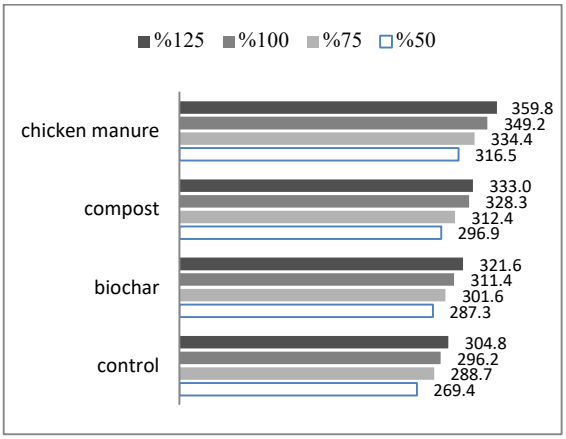

Fig. 6: Effect of organic –minerals fertilization interaction on available K of barley's soil.

4. Conclusion

Soil is an important factor influencing the productivity of agricultural crops. Sandy soils are characterized by their poor physical and chemical properties as well as their low capacity to retain water and their low supplying power for nutrients. Therefore, using combination of organic and mineral fertilizers for soil quality and productivity improvement has been receiving much attention in Egypt. In this study, integrated use of organic-mineral fertilizers was done to improve the available NPK on sandy soil. Generally, the use of organic-mineral treatments increased the available amount of NPK of wheat and barley's soil than the use of inorganic fertilizers alone. From the results of the current experiment, it could be concluded that combined applications of chicken manure addition plus 125% NPK of mineral fertilizers treatment has recorded the highest value of available NPK of both crops' soil. The results also revealed that biochar, compost and chicken manure additions led to increase available rate of N, P and K of wheat's soil by 46.88 , 45 and 39.32 % compared with 0.0 organic addition, where the same amendments with the same order increased available N, P and K of barley's soil by 85.21 , 54.84 and 33.55 %. Hence, the ability of tested organic-mineral materials increased available N and P in barley's soil higher than that of wheat's soil ,while available k was higher in wheat's soil that that of barley's soil. Beside, chicken manure and compost, biochar can be used as soil organic matter amendment without suffering from the negative effects. In a word, the effect of combination of organic materials and chemical fertilizers improve the overall soil fertility, because of more nutrients availability.

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