



Effect of Biochar, Compost, Chicken Manure and Mineral Fertilization on Total Uptake of NPK of Wheat and Barley in Sandy Soil

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Abstract

Wheat and barley are the most important agricultural crops in many countries around the world, just behind rice and maize in importance. Hence, 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 investigate total uptake of N, P and K by wheat (Sakha 68) and barley (Gemeza123) under different application rates of mineral and organic fertilizers, as well as grain Protein yield of Kg fed⁻¹. 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 revealed that total removed (uptake) of NPK by wheat plant were 80.88, 15.79, and 123.54, respectively; while with barley plant they amounted by 61.60, 11.21, and 56.83 were assigned with the treatment of chicken manure + 125% of recommended NPK treatments. Also, the best interaction was found between chicken manure + 125% mineral treatments which gave the highest value of protein uptake which were 310.60 and 278.76 kg fed-1 compared with other interactions of wheat and barley crops. It can conclude that Chicken manure + 125% mineral treatments were the superior in most amendments and gave the highest values of total NPK uptake and protein yield which in turn lead to improve crop productivity as well as sustain soil health and fertility.

Key words: Chicken manure-compost-biochar-mineral fertilization-wheat-barley.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crop for the public of Egypt, and considers as a strategic crop. It represents approximately 10% of the total agricultural production value and about 20% of all agricultural imports. Furthermore, barley (*Hordeum distichon* L) is the essential food for a huge part of the world population. In Egypt, the total cultivated area is 75. 479 hectares with overall production of 149. 238 thousand tons (FAO 2009).

Wheat and barley growing can be found in modern reclaimed areas of Egypt which has poor physical properties and lacks of organic materials, and nutrient deficit, thus we could

use different sources of organic fertilizers and amendments to develop soil and improve its characteristics, which lead to increase yield and help in stopping wheat importing.

Soil amendment includes any material added to soil to improve its properties which can be physical, chemical or biological to allow healthy crop growth (Ussiri and Lal.,2005). However, in agricultural areas, Usage of organic material regularly is a favorable way for improving soil physical and chemical properties, where, soil humus content increase. (Böhme and Böhme, 2006 and Sarwar *et al.*, 2008). Farmyard –manure (FYM), compost and chicken manure known as organic amendment, Currently, biochar is classified as a new soil organic matter amendment (Deenik *et al.*, 2011).

Continuous use of chemical fertilizers, FYM, compost and green manure enhanced the potassium status in the soil and increased potassium uptake by wheat (Verma *et al.*, 2002). Using compost by a rate of 20 and 80 ton ha⁻¹, especially with 80 ton ha⁻¹ to soil increased plant nutrient uptake and elements movement in soil which reflex a positive effect on plant growth (Garcia-GIL *et al.*, 2004). Erhart and Hartl, (2010) reported that the characteristics of the compost influence the mineralization process including the C/N, and found that 30 to 35% of the total N content can be available of the plant in the first year of application and most of the N release will occur in the first two years after application. Using manure compost or sewage sludge in greenhouse not only increased N, P and K concentrations in soil but also decreased DTPA-extractable Pb and Zn contents in Pb/Zn tailings and DTPA-extractable Cu contents in soil Chiu and Wong, (2006)

Lehman *et al.*, (2011). stated that the biochar physicochemical properties can cause changes in the soil nutrient and C availability and uptake of plant, also provide physical protection to microorganisms against predators and desiccation; this may alter the microbial diversity and taxonomy of the soil. 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 (Alburquerque *et al.*, 2013).

Hua Ru *et al.*, (2012) examined the effect of chicken manure on wheat crop, and observed that soil organic matter, total nitrogen, total phosphorus , total Zinc and nitrate (NO₃-N), available P and available Zn contents significantly increased with increasing rates 15, 90 and 150 ton of the chicken manure respectively. The main objectives of this study were to investigate total uptake of NPK by wheat and barley under different application rates of mineral and organic fertilizers in sandy soil, as well as grain Protein yield of Kg fed⁻¹.

Materials and Methods

1. Study Area and Data Collection

This research was done in the winter season of 2014-2015 at Mansoura University Farm, Qalabshu region, Dakhlia Governorate, Egypt, to investigate total uptake of N, P and K by wheat (Sakha 68) and barley (Gemeza 123) under different application rates of mineral and organic 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. Qalabshu region mainly depends on drainage water in irrigation process, where its dissolved salts content is less than 2000 ppm in winter season. Data of table (1) reveal some physical and chemical of the used soil and irrigation water in a growing season period.

Table (1) Some Physical and Chemical Properties of the Used Soil and Irrigation Water.

Analysis	Soil	Irrigation water
EC (dS/m) in soil paste extract	1.86	2.45
pH in soil paste	8.5	7.5
Soluble Cations		
Ca ⁺²	1.80 meq/l	2.8
Mg ⁺²	5.10 meq/l	13.3
Na ⁺	9.87 meq/l	12.87
K ⁺	0.80 meq/l	0.496
Soluble Anions		
HCO ₃ ⁻¹	4.13 meq/l	4.37
CL ⁻¹	4.56 meq/l	10.2
SO ₄ ⁻²	8.82 meq/l	14.896
Available N, P and K		
Available N ppm	17.0 ppm	Not determined
Available P ppm	2.50 ppm	Not determined
Available K ppm	62.0 ppm	Not determined

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, 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 (15/11/2014) 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 was done by soaked seeds (one hour for wheat and three hours for barely) were left for two hours after soaking to ease seed distribution as equal, at a rate 60 kg. fed.⁻¹.

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 Olsen and Sommers, (1982). Available K was extracted by ammonium acetate 1 N , pH 7.00 and determined by using Flam photometer according to Black, (1965). 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. Plant Analysis:

Total nitrogen was determined by micro Kjeldahl method as described by Hesse, (1971). Total phosphorus was determined calorimetrically at a wavelength of 660 nm using(Olsen, and Sommers,1982). Total potassium was determined using flame photometer according to Jackson (1972).

3. Statistical Analysis:

All data were Statistically analysis According to Gomez and Gomez (1984) 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.

Results and Discussion

Data presented in table 2 show the individual effect of organic and mineral fertilization on N uptake Kg.fed-1 of wheat and barley crop. Data revealed that all tested organic amendment significantly increased N uptake Kg fed-1 of wheat and barley compared to control, (without organic addition). N uptake Kg .fed-1 varied 42.73 and 64.90 Kg.fed-1 for wheat plant and between 29.37 and 51.79 Kg. fed-1 for barley plant. chicken manure treatments increased N-uptake in wheat plant by 35% compared to biochar treatments, while it increased by 12.5% compared with compost treatment. These results are in a harmony trend with that of Adeleye et al.,(2010). They stated that " the use of poultry manure in crop production is recommended as it will ensure stability of soil structure; improve soil organic matter status, nutrients availability and high crop yield"

A lower N-uptake by barley plant compared with that of wheat due to lower plant yield and N content% of barley than that of wheat. Biochar, compost and chicken manure

addition increased N-uptake of barley plant by 37%, 61% and 76% compared with that of 0.0 organic addition. Data of table 2 revealed that mineral fertilization (50, 75, 100 and 125%) significantly affect N-uptake by wheat and barley crops. N-uptake by wheat plant increased from 42.01 to 49.03, 57.31 and 64.95 Kg fed⁻¹ while N-uptake by barley crop was increased from 31.07 to 37.83, 47.25 and 52.66 Kg fed⁻¹ due to funeral fertilization dose from (50, 75, 100 and 125%), respectively.

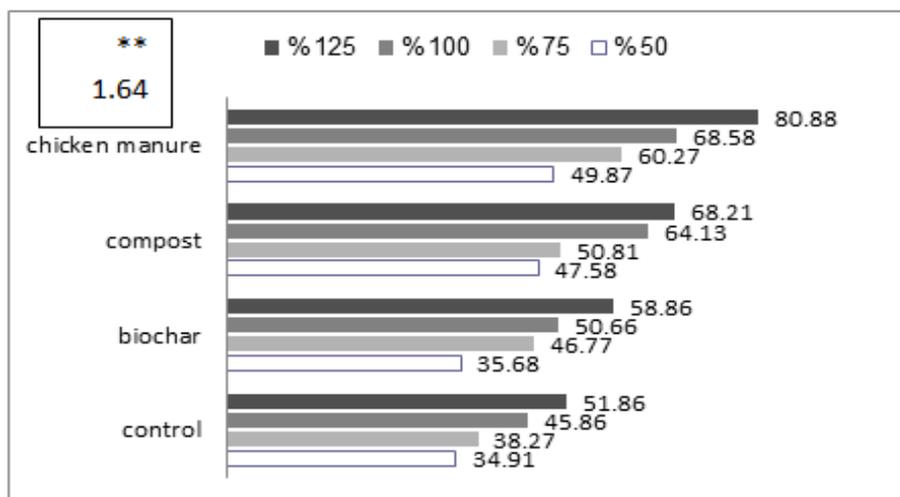


Figure (1) Organic-minerals fertilization interaction effect on wheat N uptake.

Table(2) Effect of Organic and Mineral Fertilization on Total N, P, K Uptake and Wheat and Barley Grain Protein.

Characteristics Treatments	N-uptake, Kg fed ⁻¹ .		P-Uptake Kg fed ⁻¹ .		K-uptake, Kg fed ⁻¹ .		Protein yield, Kg fed ⁻¹ .	
	Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Organic Fertilizer Treatments								
Control	42.73	29.37	7.92	5.37	62.30	27.65	178.32	129.03
Boichar	47.99	40.28	9.59	7.90	71.33	41.15	198.14	177.36
Compost	57.68	47.37	11.47	8.95	87.80	46.34	229.52	214.84
Chicken manure	64.90	51.79	12.83	10.26	103.12	53.90	256.84	224.86
LSD at 5%	2.82	3.26	0.62	0.408	6.39	5.64	13.2	15.2
F.test	**	**	**	**	**	**	**	**
Mineral Fertilizer Treatments								
50%	42.01	31.07	7.40	6.52	57.09	32.57	173.10	141.20
75%	49.03	37.83	10.08	7.55	76.86	37.78	200.53	168.41
100%	57.31	47.25	11.70	8.94	91.85	49.68	233.19	204.36
125%	64.95	52.66	12.63	9.47	98.75	49.01	256.01	232.11
LSD at 5%	2.40	3.23	0.44	0.514	5.09	5.58	15.2	13.7
F.test	**	**	**	**	**	**	**	**

Influence of organic–mineral treatments on N-uptake by wheat and barley crops were shown in Figures 1 and 2, the data statistically indicated that organic-mineral fertilization interaction increased N-uptake of wheat and barley crops. Results of Figures 1 and 2 reveal that chicken manure+125% mineral fertilizers gave the highest values of N-uptake of wheat and barley 80.88 and 61.60 Kg.fed-1 respectively, where the lowest value was given by 0.0 organic matter+50% of mineral fertilizers in both cases. This is obtained with Kanchikerimath and Singh, (2001) and Helmy et al., (2013).

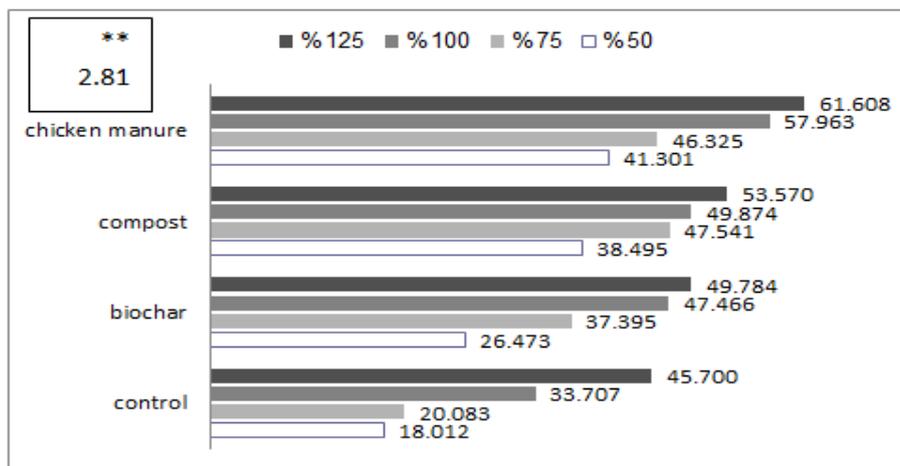


Figure (2) Organic-minerals fertilization interaction effect on barley N uptake.

Results of table 2 show that each of organic and mineral fertilization effect on wheat and barley crops. Regarding to organic effect, biochar, compost and chicken manure increased P-uptake of wheat crop from 7.92 to 9.59, 11.47 and 12.83 Kg.fed⁻¹, respectively. Similar results was also obtained with P-uptake by barley crop, which was increased from 5.37 to 7.90, 8.95 and 10.26 Kg fed⁻¹ due to application of the same organic treatments. These results are in accordance with (Alburquerque et al., 2013).

Concerning to mineral fertilization rate effect on P-uptake by wheat and barley crops, date of table 2 revealed that P-uptake were increased with increasing fertilization dose (50%, 75%, 100% and 125%) of recommended dose recorded 7.40, 10.08, 11.70 and 12.63 Kg.fed⁻¹ were taken by wheat crop. Whereas with barley the above treatments achieved 6.52, 7.55, 8.94 and 9.47 Kg fed⁻¹. It could be concluded that the dose of 125% mineral fertilizers was the superior one in this respect.

Figure 3 and Figure 4 reveal organic-minerals fertilization interaction effect on wheat and barley P uptake. The best interaction recorded between chicken manure treatment and 125% minerals treatments on total P uptake of wheat which was 15.79 Kg. fed⁻¹, followed by the interaction between compost treatment and 125 % minerals treatments was recorded 13.59 Kg.fed⁻¹, with barley crop the best interaction was found between chicken

manure and 100% mineral treatments which gave the highest influenced on total P uptake recorded 11.30 Kg.fed⁻¹, then the interaction between chicken manure and 125% mineral treatments recorded 11.21 Kg.fed⁻¹. Similar results were obtained by other scientists (Eichler-Löbermann et al., 2007; Hua Ru et al., 2012 and Joner et al., 2000).

While, the lowest value on total P uptake of wheat was found between biochar and 50% minerals treatments where was 6.13 Kg.fed⁻¹. Treatments of 0.0 organic + 50% mineral presented the lowest value of total P uptake of barley plant which was recorded 3.40Kg.fed⁻¹, compared with other interactions

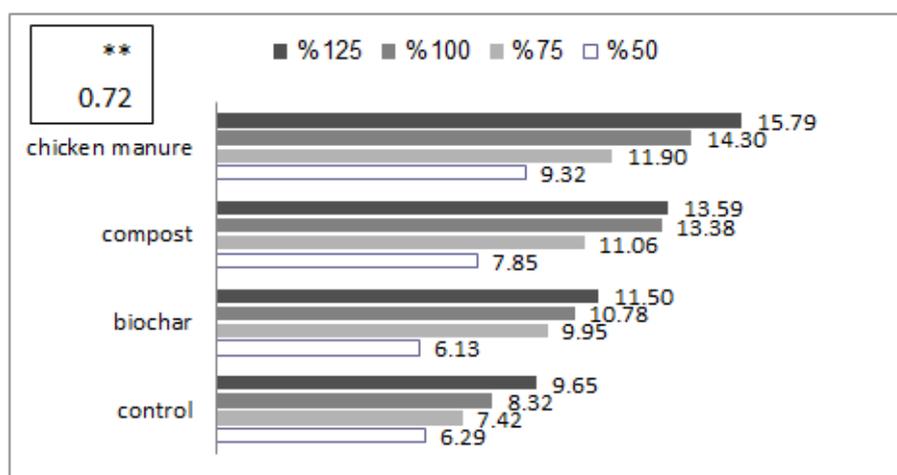


Figure (3) Organic-minerals fertilization interaction effect on wheat P uptake.

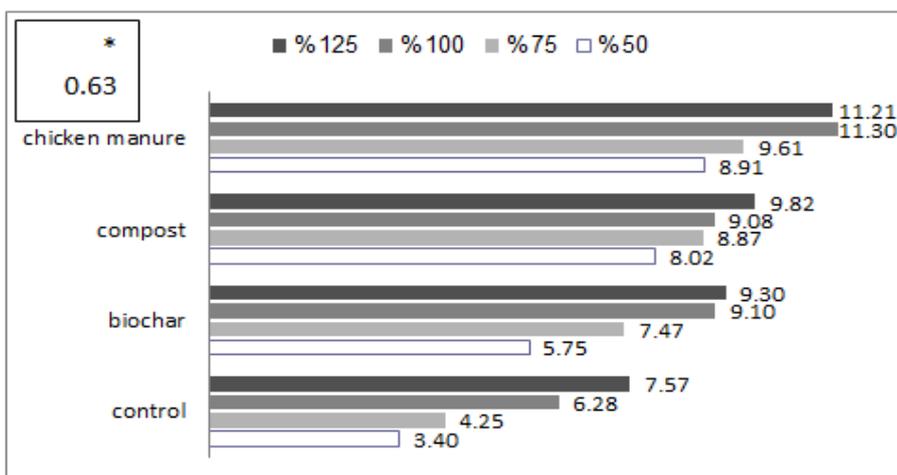


Figure (4) Organic-minerals fertilization interaction effect on barley P uptake.

Data in table 2 show the individual impact of organic and mineral fertilization on total K uptake Kg.fed⁻¹ of wheat and barley crops. Results of all tested organic treatments significantly increased K uptake of wheat and barley crops compared to control, (without organic addition).

The total K-uptake of wheat and barley varied between 62.30 to 103.12 Kg.fed⁻¹ and 27.65 to 53.90 Kg.fed⁻¹ respectively. It was noticed that biochar, compost and chicken manure addition gave the values of 71.33, 87.80 and 103.12 Kg fed⁻¹ for wheat, whereas they gave 41.15, 46.34 and 53.90Kg.fed⁻¹ for barley, respectively. The increasing percentage of total K-uptake of wheat and barley due to chicken manure treatments were 65.6% and 94.9 % compared with control treatments. these results a crossed with Abdel-Rahman,(2009). He observed an increase of total N,P and K nutrients content in all fertilized plots with compost.

It can be concluded that mineral fertilizer treatments improved total K-uptake in all treatments compared with 50% of mineral fertilizers. Results in table 2 showed that increasing fertilization dose (50, 75, 100 and 125%) of recommended dose recorded 57.09, 76.86, 91.85 and 98.75, respectively for wheat whereas, for barley the same treatments were given values of 32.57, 37.78, 49.68 and 49.01, respectively. The increasing percentage of total K-uptake Kg.fed⁻¹ of wheat and barley grains due to 125% treatment were 73.0 and 50.5 % compared with that of 50% mineral fertilizers,

Data plotted in Figure 5 and Figure 6 show interactions among organic and mineral treatments on total K-uptake of wheat and barley, the interaction between chicken manure treatments + 125% minerals treatments gave the highest values of total K-uptake of wheat which recorded 123.54 Kg.fed⁻¹. While the highest influenced on total K-uptake of barley was found between chicken manure and 100% mineral treatments which was 71.58 Kg fed⁻¹.

Whereas, the lowest values of total K-uptake of wheat and barley crops presented in the interaction between 0.0 organic addition + and 50% minerals treatments and this interaction gave 39.04 Kg.fed⁻¹ for wheat and 15.23 Kg.fed⁻¹ for barley. Chand et al., (2006) over their initial status, supply of organic and inorganic fertilizer was found most suitable combination with respect to N, P and K availability in soil, and productivity of mint and mustard crop.

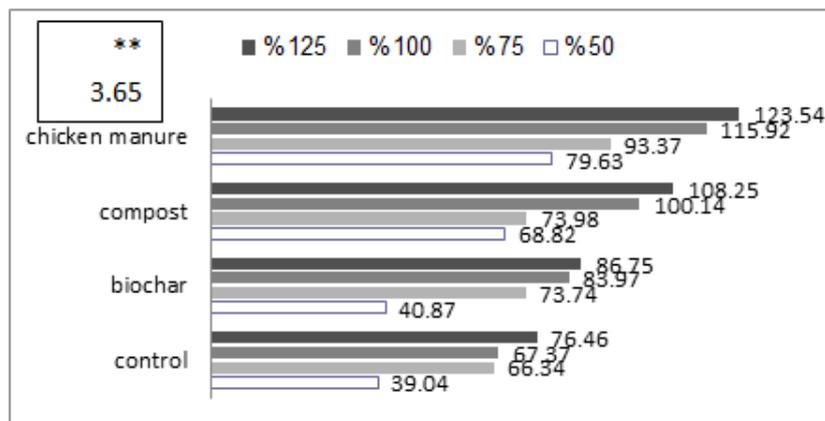


Figure (5) Organic-minerals fertilization interaction effect on wheat K uptake.

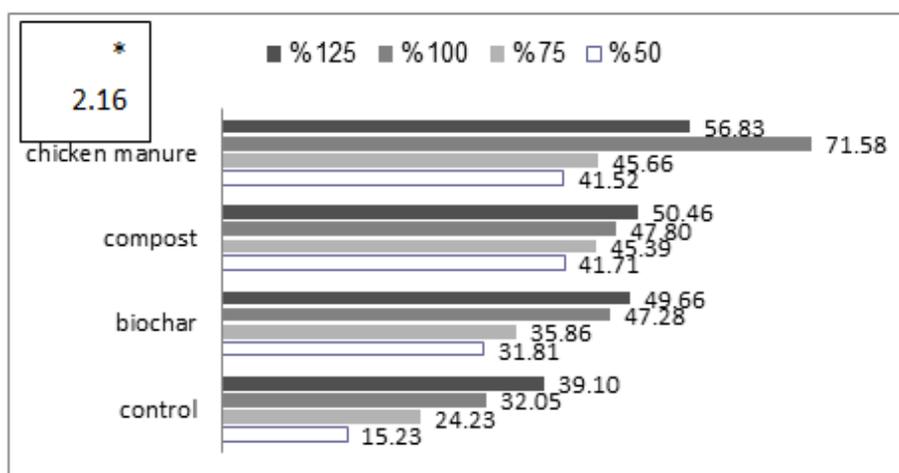


Figure (6) Organic-minerals fertilization interaction effect on barley K uptake.

Results in table 2 showed that biochar, compost and chicken manure gave grain protein yield of 198.14, 229.52 and 256.84 Kg.fed⁻¹, respectively compared to control (with 0.0 organic addition) for wheat crop. Also, with barley the values of grain protein yield were 177.36, 214.84 and 224.86 Kg.fed⁻¹ were obtained with the obvious organic treatments, respectively. Chicken manure treatments were the superior and gave the highest values of protein Kg.fed⁻¹ of wheat and barley which increased by 44.03 and 74.3% with chicken manure compared with control.

Concerning mineral fertilizer treatments, they increased grain protein yield in all treatments. The results in table 2 illustrated that the increasing percentage of protein in both wheat and barley due to 125% of mineral fertilizers were 47.9 and 64.4% compared with that of 50% mineral fertilizers. Also, increasing fertilization dose (50%, 75%, 100% and 125%) of recommended dose recorded 173.10, 200.53, 233.19, and 256.01 Kg fed⁻¹, respectively for wheat crop. Whereas, with barley they were found to be 141.20, 168.41, 204.36 and 232.11 Kg fed⁻¹, respectively compared with that 50%.

Figure 7 and Figure 8 show that chicken manure + 125% mineral treatments gave the highest value of protein uptake of wheat and barley which was 310.60 and 278.76 kg fed⁻¹ comparison with other treatments interaction of both crops. While, interaction between biochar + 50% mineral fertilizers presented the lowest values of protein yield of wheat which was 150.08 kg.fed⁻¹, on the other hand, interaction between 0.0 organic addition + 50% mineral fertilizers presented the lowest values of protein yield of barley which was 79.44 kg.fed⁻¹. These results are in agreement with that of (Abedi et al., 2010 ; Demelash et al., 2014; Ali et al. 2015 and Ahmed et al., 2016).

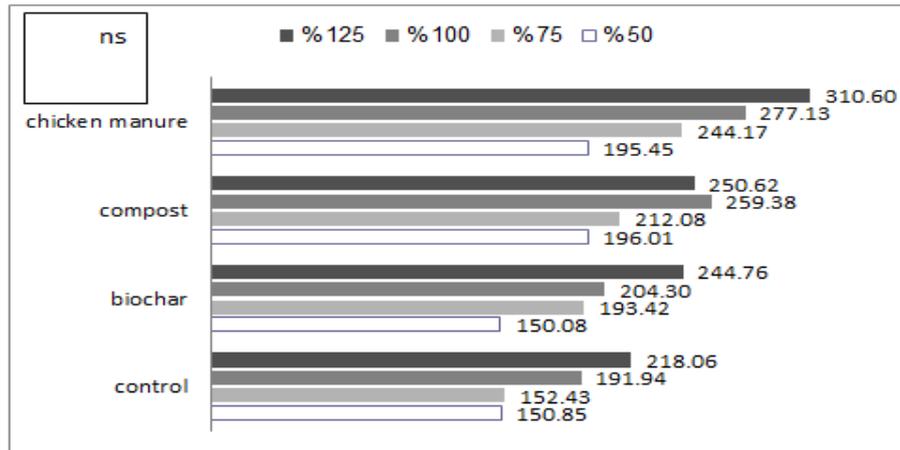


Figure (7) Organic-minerals fertilization interaction effect on wheat protein yield.

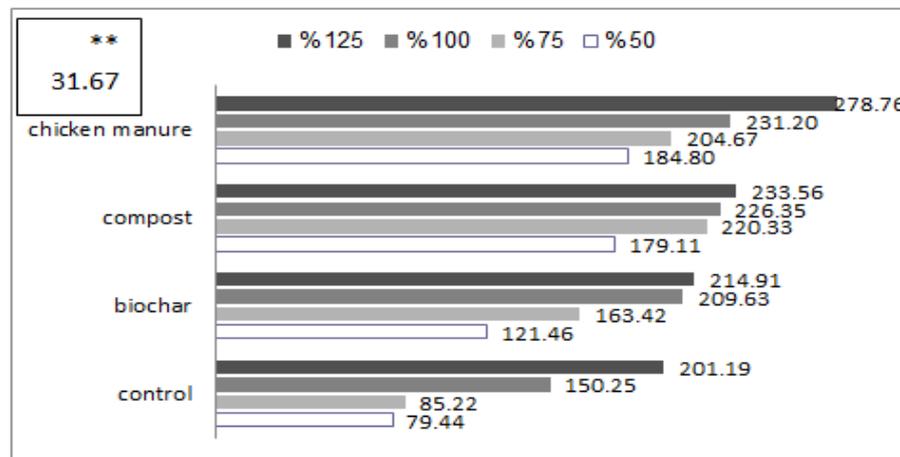


Figure (8) Organic-minerals fertilization interaction effect on barley protein yield.

Conclusion

It is worthy to conclude that under Egyptian conditions the use of chemical fertilizer, in combination with organic materials, further enhanced the crops yield. Also, organic matter can improve the physical properties of the soil and would have caused increased root development that acted positively in more uptakes of water and nutrients. In a word, the effect of combination of organic materials and chemical fertilizers on seed protein was positive, because of more nutrients availability.

We can use biochar as organic amendment to sandy soil without suffering from the negative effects. The mineral fertilizer recommendation must be changed where the highest value of wheat and barley yield quality and quantity parameters were obtained under chicken manure addition plus 125% NPK of mineral fertilizers treatment, meaning that 125% NPK of recommended alone did not sufficiency to yielded the highest yield.

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تأثير الفحم الحيوي والكمبوست وسماد الدواجن والأسمدة المعدنية على الامتصاص الكلي للنيتروجين والبوتاسيوم والفوسفور لمحصول القمح والشعير في التربة الرملية

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الملخص

يعتبر القمح والشعير من أهم المحاصيل للكثير من بلدان العالم، ولا يسبقه في الأهمية إلا محصولاً الأرز والذرة، لذلك نفذت تجربتان حقليتان باستخدام تصميم القطع المنشقة في الموسم الشتوي 2014-2015 بمزرعة أبحاث كلية الزراعة بجامعة المنصورة، مصر لتقييم الامتصاص الكلي لكل من النيتروجين والفوسفور والبوتاسيوم بواسطة محصول القمح صنف سخا 68 والشعير جميزة 123 تحت ظروف تسميد من الأسمدة المعدنية والعضوية وكذلك حساب معدل البروتين في حبة المحصول كجم.فدان⁻¹، المعاملات العضوية كانت سماد الدواجن والكمبوست والفحم الحيوي، في حين كانت المعاملات المعدنية المدروسة بمعدل 50، 75، 100 و 125%.

أظهرت النتائج بأن الامتصاص الكلي للنيتروجين والفوسفور والبوتاسيوم لمعاملة سماد الدواجن + 125% معدني لنبات القمح بلغ 80.88، 15.79، 123.54 كجم.فدان⁻¹ على التوالي بينما كان في الشعير 61.60، 11.21، 56.83 كجم.فدان⁻¹ على التوالي، بالإضافة إلى أن أفضل معاملة سجلت مع سماد الدواجن + 125% معدني والذي أعطي أعلى نسبة امتصاص بروتين للمحصول المقدرة 310.60 و 278.76 كجم.فدان⁻¹ للقمح والشعير مقارنة مع باقي المعاملات للنسب الأخرى، خلصت هذه الدراسة إلى أن معاملة سماد الدواجن + 125% معدني كانت هي الأفضل في معظم الإضافات والذي أعطي أفضل امتصاص كلي للنيتروجين والفوسفور والبوتاسيوم وكذلك أعلى معدل بروتين مما يؤدي إلى تحسين إنتاجية المحصول وخواص وخصوبة التربة.

الكلمات المفتاحية: سماد الدواجن - الكمبوست - الفحم الحيوي - الأسمدة المعدنية - القمح - الشعير.