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Response of Wheat and Barley Grown on Sandy Calcareous Soils to Organic and Inorganic Application

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Abstract

Wheat and barley are the most important cereal crops of Egypt and well adapted to its soil and climatic conditions. Two field experiments in spit plot design were carried out in the growing season of 2014-2015 at Mansoura University Farm, Egypt, to investigate the growth and yield of wheat and barley as affected by organic amendments with different rates of mineral fertilization. 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 obtained results showed that interaction among chicken manure and 125% minerals fertilizers gave highest values of fresh yield of wheat and barley which was 1837.5 and 1263 g m-2 respectively. The highest levels on total dry weight of wheat were found between chicken manure and 125% minerals treatments which recorded 7143kg.fed-1. While the highest values on total dry weight of barley crop was found between biochar and 125% minerals treatments which recorded 5113 kg fed-1. Also, organic-mineral fertilization interaction significantly affects both wheat and barley plant height where chicken manure+125% of mineral fertilizer treatment recorded the highest values 94.50cm and 72.25cm respectively. In both crops the highest spike length was found due to apply chicken manure at rate of 5-ton fed-1 +125% of mineral recommended dose where the spike length of wheat and barley were 11.50 and 8.00 cm. Whereas, addition of biochar +50.0 % of minerals recommended dose slightly reduced spike length of wheat compared with the control. It can conclude chicken manure treatment was the superior and gave the highest values of most tested parameters compared with other amendments.

Key words: *wheat; barley; sandy soil; biochar; compost; chicken manure; mineral fertilization*

1. Introduction

Wheat (*Triticum aestivum L*.) is considered one of the most widely cultivated crops with 650 million tons per year of the world production. It ranks the 3rd most-produced cereal behind maize and rice [1]. Also, barley (*Hordeum distichon L*) is the staple food for a large part of the world population. In Egypt, it is grown in 75,479 thousand hectares with total production of 149,238 thousand tons [2]. Increasing productivity of wheat and barley is a main task in Egypt to fill the gap between production and the local consumption. Most of the newly reclaimed areas of Egypt are poor in their content of organic matter and nutrients. One of the potential ways for increasing the productivity of cereal crops is application of soil amendments which has received great attention from agriculturists and environmentalists due to their directly and indirectly effects on crop growth and yield as well as soil properties [3].

Many researchers have conducted the effects of different levels of organic amendments on plant growth, yield and soil fertility. [4] Reported that compost application could improve the physical, chemical and biological characteristics, soil organic matter, and nutrient status of the soils. [3] Carried out an experiment to study the interaction between chemical nitrogen and compost rates application. The data showed significant effect on plant dry weight m^{-2}, leaf area index, plant height, number of tillers and spikes number m^{-2}, number of grains/spikes, Also Application of 90 kg N fed^{-1} +4.5- or 3-ton compost fed^{-1} gave the highest significant values of plant height (103.5cm). [5] Indicated that plots receiving compost+238 kg N ha^{-1} combined with vermiculite giving increases of growth parameters and NPK-uptake by wheat by over that of the other treatments and control.

In many countries animal manures like farm-yard manure (FYM), Cowdung and chicken manure (CM) are excellent fertilizers for crops. Manures are a rich source of nitrogen, phosphate, potash and micronutrients which are important for increasing growth and yield of many field crops and vegetables as well as soil properties [6]. [7] Stated that chicken manure or farmyard manure application, at a rate equivalent to 100 kg N/fed significantly enhanced dry weight of wheat plants grown on soils of different textures, but high response was recorded with sandy and calcareous

soils than in the clayey ones. Significant increase of plant height and chlorophyll content of leaves over the control plants was found due to organic manures application. It has the potential of increasing spring barley yield by 1.5 to 4-fold [8].

Several studies have focused on the impact of biochar addition on growth and yield of crops, which is the critical factor to assess biochar as a valuable resource for agriculture. Positive effects of biochar on plant growth and crop yield is well documented, for example, positive effects of biochar addition up to 30 % on wheat and maize yield was reported[9,10]. A significant increase in wheat yield by 20–30% was observed in the treatment supplemented with biochar applied at 144 mL pot^{-1} Hoagland nutrient solution [11]. Application of poultry litter biochar in doses of 2.25 t and 5 t DM ha^{-1} contributed to an increase in plant biomass production by 32% and 30%, respectively compared to the control (C) [12]. Also, [13] studied the effect of biochar on growth spring wheat - spring barley. Results found that results found that Pyro-char had particularly positive effects on root development and shoot growth

During the 20th century around 50% of the increase in crop yields worldwide was because of application of inorganic fertilizers. Nowadays in the USA and England approximately 40 to 60% of yield attributable to chemical fertilizer use and tended to be much higher in the tropics [14]. Recycling of organic wastes mixed with inorganic fertilizers could be possible options to reduce chemical fertilizer use [15]. The aim of this study was to evaluate the effect of biochar, compost and chicken manure on the growth and yield of wheat(Sakha 68) and barley(Gemeza123) under sandy soil conditions.

2. Materials and Methods

Two field experiments in spit plot design were conducted in winter season of 2014-2015 at Mansoura University Farm, Qalabshu region, Dakhlia Governorate, Egypt, to investigate the growth and yield of wheat and barley growing on sandy soil under different application rates of organic and mineral fertilizers. The studied parameters were fresh yield, total dry weight, plant height and spike length.

2. 1 Soil samples and analyses

Sandy soil, 70 % sand, 11% silt and 19% clay. Clay comes from artificial addition of clayey soil to the surface layer, 30 cm, and mixed well, 15 years usage before its used as soil experimental in this study. Qalabshu region mainly depends on drainage water in irrigation process, where its dissolved salts content is less than 2000 ppm in winter season. According to [16] the initial soil sample before planting representing the experimental sites has been done as well as irrigation water as shown in table (1).

Table 1. Some 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 replicates to be 64 experimental unites. Each plot has a 2.5m width and 10m length.

2. 2 Organic and inorganic amendments

The used biochar represent the finest byproduct of charcoal manufacture was brought from Komombo, Abo-Elmatameer District, Elbehara province, Egypt. The used compost was manufacture by organic farming project, Faculty of Agriculture, Mansoura University, Egypt. Chicken manure was collected from poultry farm of Qalabshu research center, Faculty of Agriculture, Mansoura University, Egypt Chemical analyses of the biochar, compost and chicken manure were determined according to the standard methods described by the Association of Official Analytic Chemists [17] and illustrated in table 2.

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}.

Table 2. Some properties of used Biochar, Compost and Chicken manure.

Analysis	Biochar	compost	Chicken manure
Moisture content (%)	2.87	13.16	15.23
EC (dS/m)	6.48	2.15	5.16
pH	12.5	6.8	7.5
Available N, P and K			
N (%)	1.21	1.67	0.95
P (ppm)	13.9	19.6	24.21
K (ppm)	268	100.6	225.2
Total C (%)	29.05	35.1	13.82
C/N ratio	24.01	21.02	14.55

2. 3 plant samples and harvest of crops

Plants of one square meter ($1m^2$) from each plot were collected, weighed immediately in the field and representative samples were transferred to the lab. Where they were air dried, plant height, spike length were measured and oven dried at 70 C^o till constant weight were done. Straw dry weight was calculated.

Each crop was harvested at its fully mature stage where all plant become yellowish in color and the spikes were bent down. Barley was harvested by the end of march and wheat by the end of April.

2. 4 Experimental design and data analysis

The analysis of variance was done according to [18] for all collected data. The comparison of means was investigated using the least significant difference at (0.05) probability.

3. Results and Discussion

3. 1 Effect of organic, mineral fertilization and their interaction on fresh weight, total dry Plant length and Spike length.

Data presented in table .3 showed the individual influence of organic and mineral fertilization on fresh weight per square meter (m^2) of wheat and barley crop. It is noticed that all tested organic treatments significantly increased fresh weight per square meter of wheat and barley crops compared to control, (without organic addition). The fresh weigh of wheat and barley varied between 1393.75 to 1737.50 g m^{-2} of wheat and between 931.25 to 1193.75 g m^{-2} of barley. Chicken manure treatment was the superior one in this respect for both crops.

Concerning the impact of mineral fertilizers treatments, results of table .3 showed that mineral fertilizers significantly increased fresh weight with adding 50%, 75%, 100% and 125% of the recommended dose of mineral fertilizers as follow 1371.88, 1528.13, 1621.88 and 1668.75 $g.m^{-2}$, respectively for wheat. Whereas with barley they were 950.00, 1043.75, 1181.25 and 1237.50, respectively. It could be concluded that the dose of 125% mineral fertilizers was superior one in this respect. The increasing percentage of fresh weight of wheat and barley due to 125% treatment were 21.64 % and 30.26% compared with that of 50% mineral fertilizers.

Table 3. Effect of organic and mineral fertilization on fresh weight , total dry weight ,plant height, and spike length.

Characteristics / Treatments	Fresh weight g m^{-2}		Total dry weight kg fed^{-1}.		Plant height, cm.		Spike length, cm.	
	Wheat	Barley	Wheat	Barley	Wheat	Barley	Wheat	Barley
Organic fertilizer treatments								
Control	1393.75	931.25	5501.46	3765.46	75.31	53.75	7.56	5.25
Boichar	1437.50	1096.88	5685.26	4476.72	76.44	60.56	7.75	5.88
Compost	1621.88	1190.63	6384.26	4839.99	87.44	64.50	7.94	7.44
Chicken manure	1737.50	1193.75	6757.88	4807.85	89.57	70.34	9.50	7.59
LSD at 5%	51.653	50.758	259.52	235.46	1.43	0.89	0.442	0.679
F.test	**	**	**	**	**	**	**	**
Mineral fertilizer treatments								
50%	1371.88	950.00	5351.69	3872.30	78.44	58.81	7.438	6.063
75%	1528.13	1043.75	6048.87	4243.20	81.81	60.63	8.000	6.188
100%	1621.88	1181.25	6388.50	4775.40	83.88	63.59	8.375	6.531
125%	1668.75	1237.50	6539.81	4999.11	84.63	66.13	8.938	7.375
LSD at 5%	51.653	53.819	164.98	229.64	1.31	1.01	0.424	0.601
F.test	**	**	**	**	**	**	**	**

Figs. 1 and 2 showed the effect of interaction among organic treatments and mineral treatments on fresh yield of wheat and barley crops. The results revealed interaction among chicken manure and 125% minerals fertilizers gave highest values which was 1837.5 and 1263 g m^{-2} respectively. Also, other interactions enhanced fresh yield and the interaction between 125% mineral fertilizers with compost and biochar was recorded 1775 and 1537.5 g m^{-2} for wheat, whereas with barley presented 1250, and 1138 g m^{-2}. The interaction between controls + 50% treatment gave the lowest values which were 1275 and 713 g m^{-2} of wheat and barley compared with other interactions.

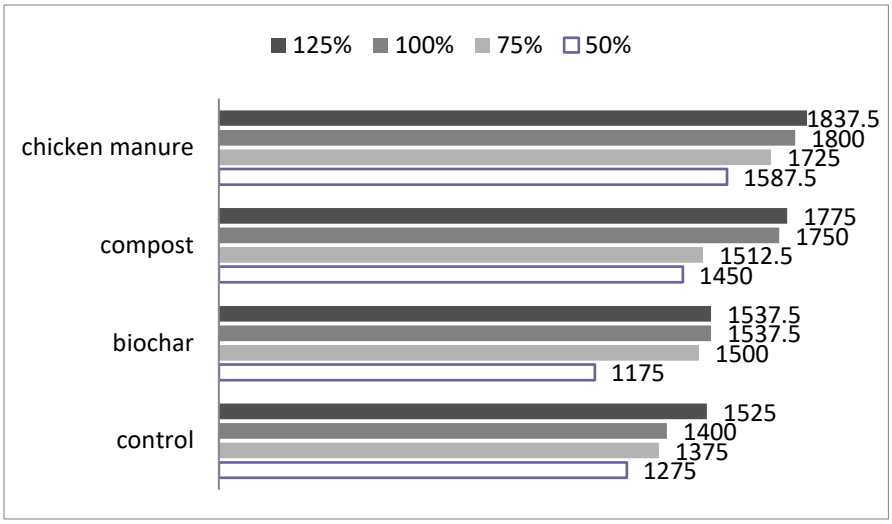

Fig.1 Organic-minerals fertilization interaction effect on wheat fresh yield.

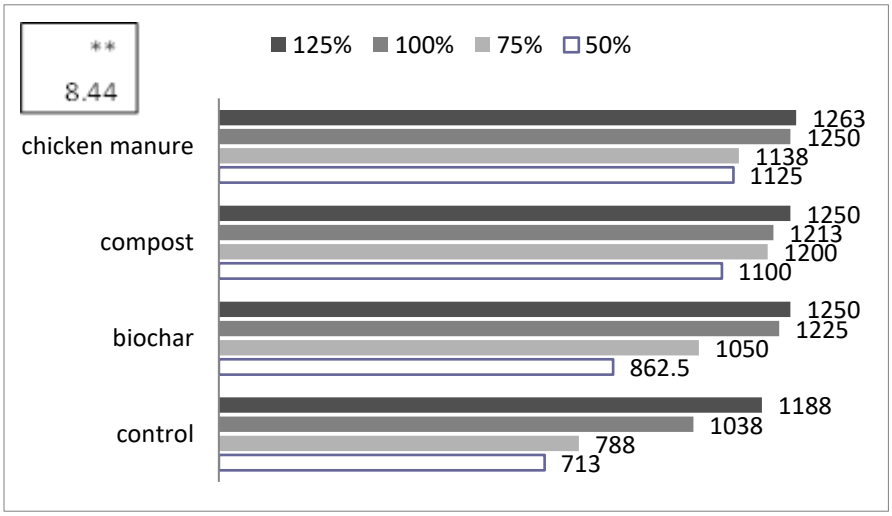

Fig. 2 Organic-minerals fertilization interaction effect on barley fresh yield.

These results are in a harmony trend with that of [6]. They stated that the vegetative growth of wheat and plant uptake of N and P were significantly or highly significantly improved by the applied organic matter farm yard manure (FYM), chicken manure (CM) and town wastes (TW) as well as increasing N–fertilization level from 120 to 150 kg N/fed caused significant improvement in plant growth parameters and plant uptake of N and P. [19] Reported that chicken manure and

sulphur, irrespective of phosphorus fertilizer, had a significant effect on plant height, fresh total yield and blub yield of garlic plants in the two growing seasons. application of poultry manure with 5 ton fed^{-1} of poultry manure and 100 kg fed^{-1} of sulphur contained the higher values of plant height (cm),fresh total yield (ton fed^{-1}). Higher leaf number and fresh yield were obtained from organic fertilizers treated plants. Possible reasons behind this result are organic composts that added higher phosphorus and potassium content in soil than farming with no-compost [20].

Data of table.3 revealed that biochar, compost and chicken manure gave total dry weight kg fed^{-1} values were 5685.26, 6757.88 and 6757.88, respectively which increased straw dry weight kg fed^{-1} compared to control for wheat. Also, with barley the values of total dry weight kg fed^{-1} 4476.72, 4839.99 and 4807.85 kg fed^{-1} were obtained with biochar, compost and chicken manure, respectively.

Chicken manure treatment was the superior and gave the highest values of total dry weight $kg.fed^{-1}$ in wheat and increased by 22% compared with that of control ,while compost treatment was the superior and gave the highest values of total dry weight kg fed^{-1} in barley and increased by 1.27% compared with that of control .Concerning the influence of mineral fertilizers, data in table.3 showed that mineral fertilizers significantly increased total dry weight kg fed^{-1} as 5351.68, 6048.87, 6388.50 and 6539.81 kg fed^{-1} with adding 50%, 75%, 100% and 125 kg fed^{-1} of the recommended dose of mineral fertilizers, respectively for wheat. While with barley crop they were 3872.30, 4243.20, 4775.40 and 4999.11, respectively. It could be concluded that the dose of 125% mineral fertilizers of wheat was superior one in this respect and the increasing percentage of total dry weight $kg.fed^{-1}$ of wheat due to 125% treatment were 1.22 whereas the increasing percentage of total dry weight $kg.fed^{-1}$ of barley due to 100% treatment were 1.29 % compared with that of 50% mineral fertilizers.

Fig .3 showed that the best interaction which gave the highest levels on total dry weight wheat kg fed^{-1} was found between chicken manure treatment and 125% minerals treatments where was 7143, followed the interaction between compost and with 125% minerals. On the other hand the highest values on total dry weight of barley crop kg fed^{-1} was found between biochar treatment and

125% minerals treatments which recorded 5113 kg fed^{-1}, followed the interaction between compost treatment with 125% minerals treatments which reported 5090 kg fed^{-1} (Fig. 4). In both cases the lowest influence on total dry weight was found in the interaction between control and 50 % minerals treatments where was 5035and 2899 kg fed^{-1} for wheat and barley.

These results a crossed with [21]. They reported that using compost and farmyard manure "FYM" with rates of 0.0, 5.0 and 10 t/fed increased plant height and dry weight of wheat plants with a slightly higher effect of compost. [3] Stated that increasing chemical nitrogen rates from 0 to 90 kg N/fed. with compost rates application (0,1.5, 3, 4.5 ton /fed.) significantly increased plant dry weight/m^2 plant height, number of tillers and spikes/m^2 number of grains /spike, weight of 1000-grain, grain and straw yield/ fed. and grain protein content.

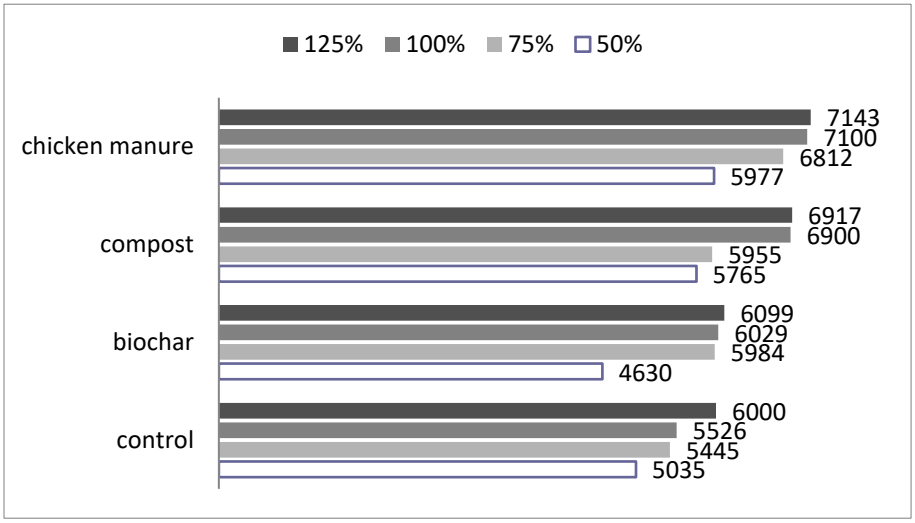

Fig. 3 Organic-minerals fertilization interaction effect on wheat total dry weight.

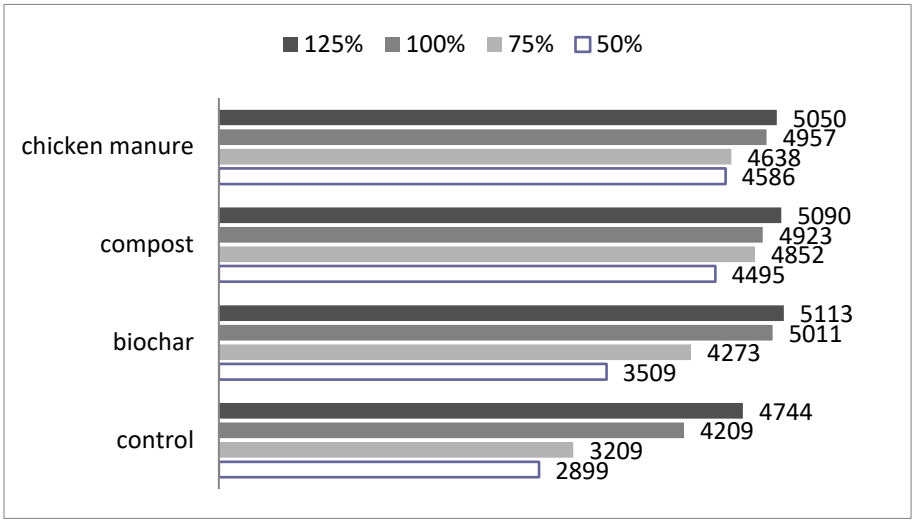

Fig. 4 Organic-minerals fertilization interaction effect on barley total dry weight.

Data presented in table .3 reported the individual effect of organic and mineral fertilization on height of wheat and barley plant. Data revealed that all tested organic treatments significantly increased plant height of wheat and barley plants compared to control. Data of table.3 declared that organic matter treatments (biochar, compost and chicken manure) and mineral fertilizer rates (50.0, 75.0, 100.0, and 125.0% of recommended dose) effect on stem height of wheat and barley plants.

The plant height of wheat plant at mature stage varied from 75.31 to 89.75 cm where barley plant height at the some physiological stage varied from 53.75to70.34 cm. The obtained data reveal also that organic type used significantly increase the plant height of wheat and barley plant. So from table.3 data clearly show the chicken manure superiority in this respect for both crops.

Data of table.3 revealed that plant height of each wheat and barley were significantly increased with increasing mineral fertilization dose. The lower values of wheat and barley plant height were achieved with treatment of 50% of recommended dose , 78.44 and 58.81 cm, respectively.

Lower increases but significant were noticed due to mineral fertilization increasing from 50% to 125% of recommended dose for both wheat (6%) and barley (11%). Organic-mineral fertilization interaction significantly affect both wheat and barley plant height where chicken manure,125% of mineral fertilizer treatment recorded the highest values 94.50 cm for wheat and 72.25 cm for

barley plant height. Treatment 0.0 organic 50% mineral fertilizer recorded the lowest values of wheat and barley height 73.25 cm and 49.00 cm respectively, as plotted in Figs. (5 and 6).

These results are in agreement with that of [22]. They mentioned that application of chicken manure was superior to farm yard manure and had significant differences among plant height, number of heads, grain yield, 1000 grain weight and straw yield.[8] Found that organic manures (chicken manure, cowdung, chicken manure pellet, sheep manure and horse manure) significantly increased plant height and chlorophyll content of leaves over the control plants of spring barley (*Hordeum vulgare* L.). Also [23] adding organic fertilizers (poultry manure and biochar) through mixed and lined method improved plant height and head diameter (cm) of sunflower. [24] Reported that applied amino acids, sulphur or FYM significantly increased several growth parameters like increased plant height (cm), dry weight/plant, number of spikes/m^2 as well as some soil properties.

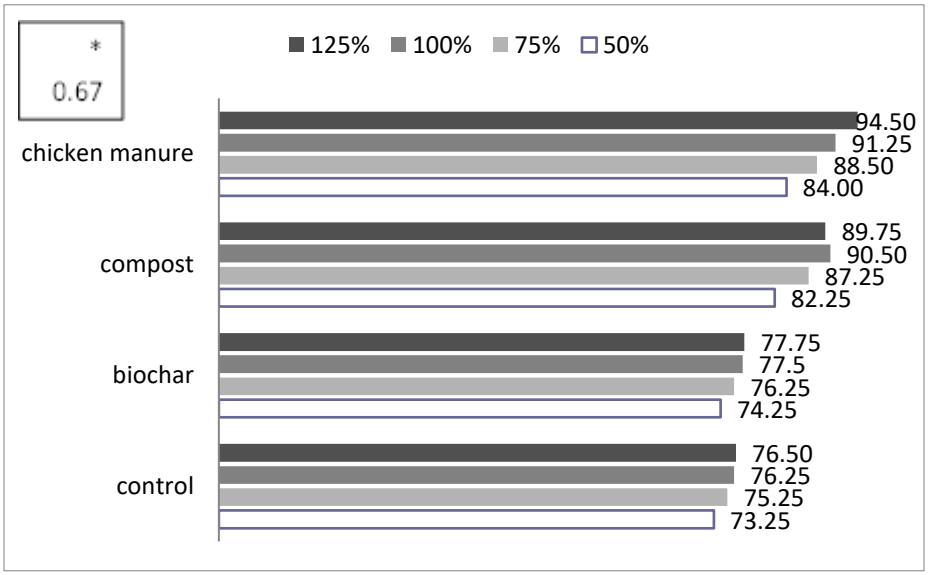

Fig. 5 Organic-minerals fertilization interaction effect on wheat plant height.

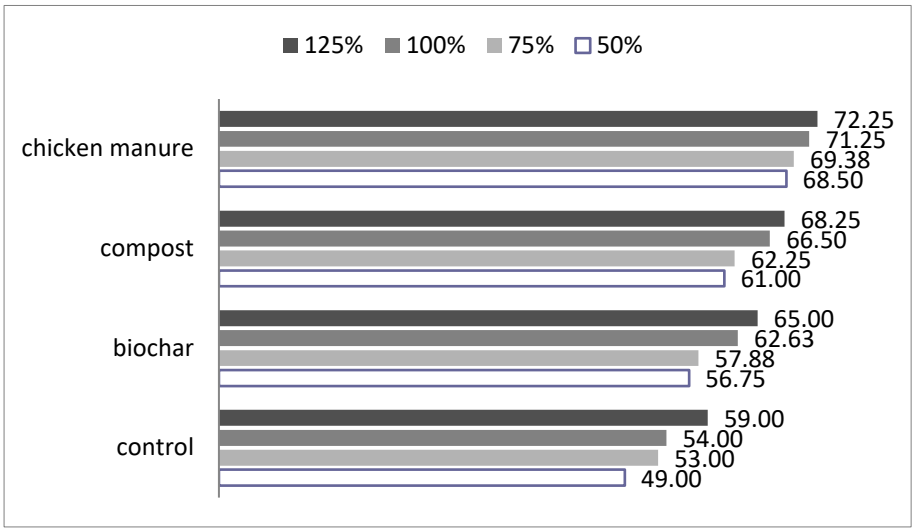

Fig. 6 Organic-minerals fertilization interaction effect on barley plant height.

Data of table.3 presented organic matter treatments (biochar, compost and chicken manure) and mineral fertilizer rates (50.0, 75.0, 100 and 125% of recommended dos) effects on spike length of wheat and barley plant.

Biochar, compost and chicken manure treatments recorded wheat spike length 7.75, 7.94 and 9.50 cm respectively compared with 7.56 cm which recorded with 0.0 organic addition. Chicken manure addition exhibited significant and appreciable increase in wheat spike length compared to 0.0 organic matter addition, spike length of wheat was increased from 7.56 cm to 9.5 cm with, 25.6 % increase. Barley spike length as it is shown in table.3 is lesser than that of wheat. Biochar treatment recorded a slightly increase in barley spike length (from 5.25 to5.88 cm,12% increase) compared with the other organic fertilizer types (compost and chicken manure). Compost and chicken manure addition caused a pronounced increase in barley spike length (from 5.25 to 7.44 cm, 41.71 % increase and from 5.25 to 7.59 cm, 44.57 % increase due to compost and chicken manure treatments, respectively).

Regarding to mineral fertilization treatment effect on spike length of wheat and barley data of table.3 revealed that wheat spike length was significantly increased with increased mineral fertilization dose, where spike length 50.0, 75.0, 100.0 and 125.0 % mineral fertilizer

recommended dose were 7.44, 8.0, 8.33 and 8.94 cm, respectively. The highest mineral fertilization dose caused 20.16% increase compared with 50% of mineral fertilization recommended dose.

Concerning to mineral fertilization effect on spike length of barley plant, data of table.3 showed that 75.0 % of mineral fertilizer recommended dose slightly increase spike length of barley from 6.06 cm to 6.19 cm (2.14% increase) spike. The first noticeable increase this treat was found due to 100% mineral fertilization recommended dose treatment from 6.06 to 6.38 cm (1.76 % increase). 125.0% of mineral fertilizer recommended dose treatment recorded the highest increase in barley spike length compared with the lowest mineral fertilizer of recommended dose this increase was amounted by 21.78 %.

Effect of organic- mineral fertilization treatments on spike length of wheat and barley plant was plotted in Figs 7 and 8. Spike length of wheat and barley significantly affected by organic-mineral fertilizers interaction treatment , where the least significant difference between spike length of wheat and barley were 0.693 and 0.743. Data plotted in Fig.7 revealed that spike length was increased from 7.0 cm to 11.5 cm due to fertilizer increment from 0.0 organic + 50 % of recommended mineral fertilizer dose treatment to chicken manure 5 tons fed^{-1} +125 % of recommended mineral fertilizer dose treatment.

Data plotted in Fig. 7 also reveal that addition of biochar to the lowest mineral fertilization dose slightly reduced spike length of wheat. This is due to the higher adsorbed capacity of biochar which chalet nutrients and its alkaline action. this negative effect was omitted with increasing the mineral fertilization dose as it is obviously clear in Fig.7.

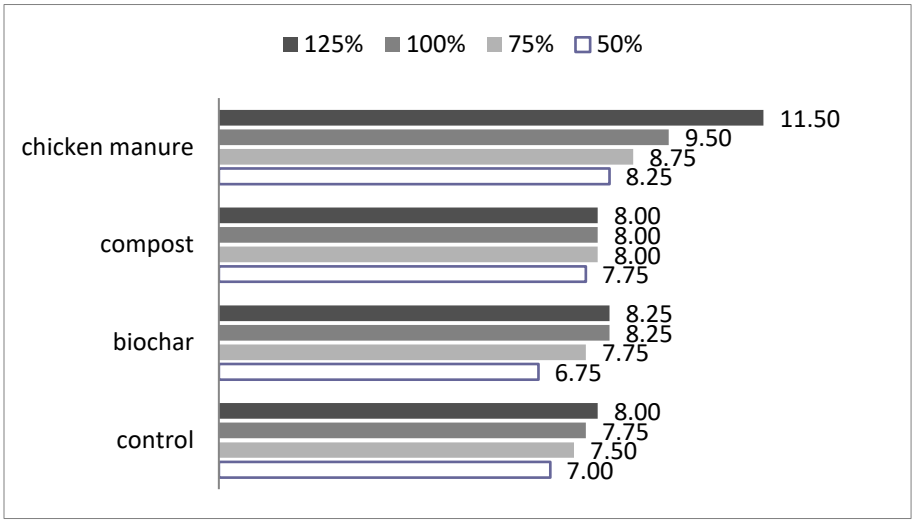

Fig. 7 Organic-minerals fertilization interaction effect on wheat spike length.

In barley addition of biochar to the lowest level of mineral fertilizer dose (50.0 % of recommended) did not reduce spike length as it is found in wheat due to the higher growth rate of barley roots than that of wheat roots and may be to the higher absorption capacity of barley root too. In both crops the highest spike length was found due to apply chicken manure at rate of 5 ton fed^{-1} +125% of mineral recommended dose where the spike length of wheat and barley were 11.50 and 8.00 cm respectively.

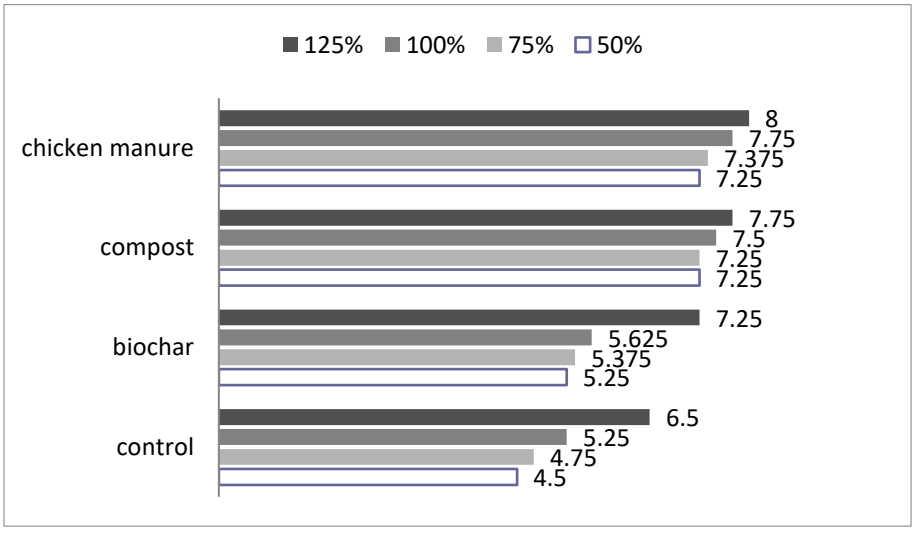

Fig. 8 Organic-minerals fertilization interaction effect on barley spike length..

[25] Pointed out that a positive effect of organic fertilizer + chemical fertilizer treatments on growth of wheat plant which increased plant high and improved spike length and plant weights of wheat plant. Also, [26] reported that rice straw compost and chicken manure application significantly increased the mean values of grains per spike and spike length (cm) of wheat (*Triticum aestivum L*.) plants as compared with the control treatment.

It is worthy to noticed that plant growth and yield increases with organic additions have, in most cases, been attributed to enhance nutrient supply to the plants, increase microbial biomass and activity in soil and improve soil biophysical and chemical properties [27,28 and 4], slower nutrient release from added organic matter, and better retention of cations due to higher CEC [29]. In addition, increases in growth and yield of crops following organic application can be partially attributed to the increases in soil anions retention [30].

4. Conclusion

It is worthy to conclude that chicken manure + 125% mineral treatments was the superior in all amendments and gave the highest values of on fresh yield, total dry weight, plant height and spike length. Also, for sustainable agricultural systems in developing countries like Egypt, Integrated combination of organic and mineral fertilizers can be a good option for developing effective plant-growth management strategies in many situations.

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