American Journal of

Plant Nutrition and Fertilization Technology

ISSN 1793-9445

Academic
Journals Inc.

www.academicjournals.com

American Journal of Plant Nutrition and Fertilization Technology 5 (2): 50-60, 2015
ISSN 1793-9445 / DOI: 10.3923/ajpnft.2015.50.60

Effect of Different Sources of Nitrogen Fertilizers Combined with Vermiculite on Productivity of Wheat and Availability of Nitrogen in Sandy Soil in Egypt

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ABSTRACT

A field experiment was conducted on a sandy soil conditions at El-khtara, Al Sharqia government, Egypt, during the growth season of 2014-2015 to study the effect of nitrogen fertilization from different sources i.e., mineral, organic and bio-fertilizers combined with vermiculite on yield and NPK-uptake by wheat plants (*Triticum aestivum* cv., Sakha 93). Data 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. Could be arranged the treatment as following order Compost+238 kg N ha^{-1}> Compost+119 kg N ha^{-1}>Compost>biofertilizer+238 kg N ha^{-1}>biofertilizer+119 kg N ha^{-1}> biofertilizer>238 kg N ha^{-1}>119 kg N ha^{-1}>control. Application of vermiculite was enhanced the effects of former treatments.

Key words: Wheat, mineral fertilizers, bio-fertilizers, compost, sandy soil, vermiculite, Egypt

INTRODUCTION

Wheat (*Triticum* sp.) is considered the most strategic crop for Egypt and some other developing countries. Increasing wheat production is a national target in Egypt to fill the gap between wheat consumption and production. Great attention and efforts have been paid by the Egyptian government and scientists to narrow wheat security gap (Youssef *et al*., 2013).

Sandy soils represent about 90% of the Egyptian soils. Such soils represent a great hope for the agriculture expansion. 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. Organic and mineral soil amendments are soil improving agents .The application of such amendments could improve the retentive capacity of sandy soil for water and fertilization nutrients and also may help in improving the unfavorable structure and in increasing nutrients. Most of the newly reclaimed soils are sandy which are poor in their content of organic matter and available nitrogen (Sharpley, 1985; Coquet, 1995). Feller (1995) reported that addition of organic matter plays a major role in soil fertility through different functions: (1) The storage of nutrients like P, Ca, K, Mg. They are released during organic matter decomposition and their dynamics is thus dependent on that of organic matter, (2) The increase in CEC. This function is linked to the surface properties of soil organic and organic mineral components: Cation and anion exchange capacity, physical and chemical adsorption and desorption properties. These properties define the availability of some nutrients, cation equilibrium and the efficiency of fertilizers and xenobiotic molecules, (3) The improvement of soil structural stability and (4) The stimulation of faunal, microbial and enzymatic activities that determines carbon, nitrogen and phosphorus and sulfur cycles. Composting is a biological process in which organic biodegradable wastes are converted into hygienic, hums rich product (compost) for use as a soil conditioner and an organic fertilizer (Popkin, 1995; Hoitink and Grebus, 1994). The addition of municipal solid waste compost to agricultural soils has beneficial effects on crop development and yields by improving soil physical and biological properties (Zheljazkov and Warman, 2004; Tanu *et al*., 2004).

Biofertilizer is a broad term used for products containing living or dormant micro-organisms such as bacteria, fungi, actinomycetes and algae alone or in combination which help in fixing atmospheric N or solubilize/mobilize soil nutrients in addition to secrete growth-promoting substances (Rai, 2006; Salem *et al*., 2010) who showed that compost manure at high rate of nitrogen was associated with low nitrate concentration in potato plants. Alian (2005) found that artichoke plant treating with *Azotobacter* and *Azospirillum* as a biofertilizer resulted in significant increases in shoot height, number of leaves and fresh weight. A significant decrease in nitrate accumulation was noticed when the plants treated with all studied biofertilizers (Tilak and Reddy, 2006). The plant growth promoting rhizobacteria can influence plant growth directly through the production of phythormones and indirectly through nitrogen fixation and production of bio-control agents against soil-borne phytopathogens (Glick, 2003). The *Zospirillum* species are nitrogen-fixing organisms (diazotrophs), capable of forming an associative relationship with the roots of several economically important cereals (Broek and Vanderleyden, 1995). Studies indicated that *Azospirillum* promotes plant growth (Cohen *et al*., 2007; Van Dommelen *et al*., 1998). Farmyard manure application with the recommended doses of N and bio-fertilizers increased the growth, yield and water use efficiency of wheat under the limited water supply (Sushila and Gajendra, 2000; Youssef, 2011). Sarwar (2005) found that grain yield and yield components of wheat significantly increased with the application of different organic materials resulting in the compost to be the most superior one. Matter *et al*. (2007) indicated that wheat yield increased with using the organic fertilization. Moreover, Youssef (2011) concluded that using the bio-fertilizer in the presence of organic and mineral nitrogen resulted in increase in the wheat grain yield of wheat.

Vermiculite is the geological name given to a group of hydrated laminar minerals which are aluminum-iron magnesium silicates which have the appearance of mica and is found in various parts of the world. When processed for horticultural use, the mineral is subjected to intense heat, expanding it into accordion-shaped granules with countless layers of thin plates. Horticultural vermiculite has the excellent property of improving soil aeration while retaining moisture and nutrients to feed roots, cuttings and seeds for faster, maximum growth. The high water content in the structure determines its main feature, the short-term heating to 950°C greatly increased volume and reduced weight (expansion). Vermiculite is a natural bio stimulant for plant growth. Vermiculite is an excellent regulator of the soil moisture and positively influences the development of roots with its favorable properties of aeration and air capacity. When added to soil, it supports optimal conditions of soil moisture, air capacity and heat balance, creating favorable conditions for plant nutrition (Marinova *et al*., 2012). Martinez-Medina *et al*. (2009) reported that plants treated with the benmgite-vermiculite formulation showed a higher shoot weight and higher resistance to fusarium wilt disease.

The present study aims to investigate the effect of mineral, organic and bio-fertilization combined with vermiculite on yield and NPK-uptake by wheat plants under sandy soil conditions in Egypt.

MATERIALS AND METHODS

A field experiment was conducted on a sandy soil conditions at El-khtara, Al Sharqia government, Egypt during the growth season of 2014-2015 to study the effect of nitrogen fertilization from different sources i.e., mineral, organic and bio-fertilizers combined with vermiculite on yield and NPK-uptake by wheat plants (*Triticum aestivum* cv. Sakha 93). Physical and chemical properties of the investigated soil was analyzed according to the methods described by Richards (1954) and are shown in Table 1.

Mineral nitrogen was added as ammonium sulfate (200 g N kg^{-1}) at the rate of 0, 119 and 238 kg N ha^{-1}, respectively in three equal splits. The first dose was after complete germination, while the second and third doses were added after 45 and 60 days, respectively from the first dose. During the preparation of soil for cultivation, the recommended doses of phosphorus and potassium were added for all experimental plots as ordinary super phosphate (65 g P kg^{-1}) at the rate of 31 kg P ha^{-1} and potassium fertilizers were added to the soil as potassium sulphate (410 g K kg^{-1}) at a rate of 100 kg K ha^{-1} before planting. Compost and vermiculite were added and thoroughly incorporated in the soil before planting at the rate of 30 and 4 Mg ha^{-1}, respectively. Chemical analyses of the compost are shown in Table 1. Seeds were inoculated with *Azospirillum brasilense* inoculum which has activity in N_2 fixation in the soil and is produced commercially by the Soil Microbiology Unit of the Soil, Water and Environments Research Institute of the Agriculture Research Center, Giza, Egypt. The former factors study i.e., mineral, organic and bio-fertilizers combined with or without vermiculite. Analyses of the vermiculite is shown in Table 1. After

Table 1: Some properties of studied soil, compost and vermiculite

Properties	Soil	Compost	Vermiculite
Texture class	Sand	-	-
Organic matter (g kg^{-1})	6.10	612	-
Organic carbon (g kg^{-1})	-	355	-
$CaCO_3$ (g kg^{-1})	4.30	-	-
WHC (%)	18.30	390	101
Bulk density (Mg m^{-3})	1.65	-	1.12
EC (mS cm^{-1})*	0.31	2.98	2.50
pH (suspension 1:2.5)	8.14	7.41	7.23
Soluble ions ($mmol_c$ L^{-1})*			
Na^+	1.25	-	-
K^+	0.30	-	-
Ca^{2+}	1.30	-	-
Mg^{2+}	0.60	-	-
Cl^-	0.99	-	-
HCO_3^-	1.12	-	-
SO_4^{-2}	1.34	-	-
Cation exchange capacity ($cmol_c$ kg^{-1})	16.0	-	160
Available nutrients (mg kg^{-1})			
Nitrogen	44	360	-
Phosphors	5.5	63	-
Potassium	92	880	-
Total nitrogen (g kg^{-1})	-	17.0	-
C/N ratio	-	20.88	-

*Soil water extracts 1:1, WHC: Water holding capacity preparation of soil for cultivation, the filed was divided into plots each one was 5×10 m. The design was a factorial randomized complete block, involving two factors; factor A: Nitrogen fertilization sources i.e., mineral, organic and bio-fertilizers and factor B: Vermiculite. Therefore, the study contains treatments as follows: Compost+ 238 kg N ha^{-1}, Compost+119 kg N ha^{-1}, Compost, biofertilizer +238 kg N ha^{-1}, biofertilizer+ 119 kg N ha^{-1}, biofertilizer, 238 kg N ha^{-1}, 119 kg N ha^{-1} and untreated. Previous combinations were applied to plots mixed with or without vermiculite.

At the end of growing season, plant samples were collected and dried at 70°C until constant weight and wet digested using a mixture of $HClO_4$ and H_2SO_4 for determining some nutrients (Piper, 1950). Dry matter content, nutrient uptake "NPK", protein content and grains yield of wheat plant were conducted. Particle size analysis was determined by the pipette method, bulk density (Klute, 1986), pH and EC were measured in saturated paste extracts (Page *et al*., 1982), Determination of Ca and Mg was done by atomic absorption spectrophotometry and K and Na by flame emission spectrophotometry, Cation Exchange Capacity (CEC) by the method of Chapman and Pratt (1961) and soil organic matter by wet oxidation (Page *et al*., 1982).

Statistical analysis: Data was analyzed with analysis of variance (ANOVA) procedures using the MSTAT-C Statistical Software package (Michigan State University, 1983). Differences between means were compared by LSD at 5% level of significant (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield parameters: Treatments had significant effect on yield and other attributes i.e., straw weight, grain weight, biological yield, harvest index and 1000 grain weight of wheat (Table 2). Yield was significantly higher in the compost+N2 plots combined with or without vermiculite as compared to the other plots. The highest values of yield was 5.32 Mg ha^{-1} obtained by compost+N2 combined with vermiculite, while the lowest one was obtained in plants not receiving N-Source i.e., nitrogen mineral fertilization, organic fertilization or bio-fertilizers. Generally, plots receiving compost or bio-fertilizers was more emergence than sole N or control plots. Response to other attributes of wheat i.e., straw weight, grain weight, biological yield, harvest index and the 1000 grain weight followed a similar pattern as that of yield. Superiority of compost+N2 combined with vermiculite over other all treatments occurred with all parameters.

Application of vermiculite under different treatments of N-sources increased straw weight, grain weight, biological yield, harvest index and the1000 grain weight by averages 3, 6, 4.5, 1.4 and 4%, respectively. The favorable effect of vermiculite material on dry matter yield of wheat plants may be due to the positive effect of this material on increasing the available moisture content and hence increasing the availability of nutrients in the soil solution. Obtained results are in agreement with those obtained by Marinova *et al*. (2012) and Merwad *et al*. (2013). Martinez-Medina *et al*. (2009) reported that plants treated with the benmgite-vermiculite formulation showed a higher shoot weight and higher resistance to fusarium wilt disease.

Previous studies justified the positive effects of nitrogen application (Abedi *et al*., 2010; Ghaderi-Daneshmand *et al*., 2012) and biofertilizer inoculation (Diaz-Zorita and Fernandez-Canigia, 2009; Kandil *et al*., 2011). Piccinin *et al*. (2013) showed that the grain yield of wheat improved when wheat plants were grown with a combination of chemical N and biofertilizer inoculation. Kandil *et al*. (2011), Wortman *et al*. (2011), Ghaderi-Daneshmand *et al*. (2012), Estrada-Campuzano *et al*. (2012), Liu and Shi (2013) and Namvar *et al*. (2012) noted that the decrease in biomass production with decreasing supply of N was associated with decreases in both

Table 2: Effect of nitrogen fertilization from different sources combined with vermiculite on yield parameters of wheat plants

N-source (factor A) and vermiculite (factor B)	Straw weight (Mg ha^{-1})	Grain weight (Mg ha^{-1})	Biological yield (Mg ha^{-1})	Harvest index (%)	1000 grain weight (g)
Control					
With	4.13	4.10	8.23	49.79	46.37
Without	3.95	4.00	7.95	50.30	45.30
Mean	4.04	4.05	8.09	50.04	45.83
119 kg N ha^{-1} (N1)					
With	3.49	4.17	7.66	54.38	49.00
Without	3.92	4.17	8.09	51.52	48.13
Mean	3.71	4.17	7.87	52.95	48.57
238 kg N ha^{-1} (N2)					
With	4.13	4.87	9.00	54.06	51.63
Without	4.16	4.73	8.89	53.20	50.50
Mean	4.15	4.80	8.95	53.63	51.07
Bio-fertilizer (Bio)					
With	4.45	5.37	9.82	54.66	49.17
Without	4.32	5.10	9.42	54.17	48.27
Mean	4.39	5.23	9.62	54.42	48.72
Bio+N1					
With	4.69	5.27	9.96	52.86	56.10
Without	4.00	5.07	9.07	55.87	56.07
Mean	4.35	5.17	9.51	54.37	56.08
Bio+N2					
With	5.07	6.67	11.73	56.83	61.30
Without	4.45	5.47	9.92	55.13	59.87
Mean	4.76	6.07	10.83	55.98	60.58
Compost					
With	4.80	6.13	10.93	56.09	57.70
Without	4.72	6.03	10.75	56.10	54.17
Mean	4.76	6.08	10.84	56.10	55.93
Compost+N1					
With	4.88	6.40	11.28	56.74	65.37
Without	5.25	5.63	10.89	51.74	62.27
Mean	5.07	6.02	11.08	54.24	63.82
Compost+N2					
With	5.41	6.90	12.31	56.04	73.93
Without	5.23	6.83	12.06	56.66	67.10
Mean	5.32	6.87	12.19	56.35	70.52
Vermiculite					
With	4.56	5.54	10.10	54.60	56.73
Without	4.44	5.23	9.67	53.86	54.63
Grand mean	4.50	5.38	9.89	54.23	55.68
$LSD_{0.05}$					
A	0.191	0.222	0.320	1.404	0.995
B	0.090	0.104	0.151	0.662	0.469
AB	0.269	0.313	0.452	1.986	1.407

radiation interception and Radiation Use Efficiency (RUE). Nitrogen is known to be an essential nutrient for plant growth and development involved in vital plant functions such as photosynthesis, DNA synthesis, protein formation and respiration (Blackshaw *et al*., 2005; Rana *et al*., 2012; Diacono *et al*., 2013). The growth parameters such as LAI, biomass and leaf photosynthesis significantly decreased due to unsatisfactory N availability (Khan *et al*., 2007; Azeez, 2009).

Nutrient uptake: The effect of N-fertilization, biofertilizer inoculation and compost on N, P, K and protein of wheat were presented in Table 3. All treatments receiving any or more combinations of the added material showed higher uptake of N, P and K in straw as well as grain compared with control. The highest values of NPK obtained by compost+N2 combined with vermiculite, while untreated plots was the lowest one. Could be arranged the treatment as following order

Table 3: Effect of nitrogen fertilization from different sources combined with vermiculite on N, P and K uptake by wheat plants and protein content

N-source (factor A) and vermiculite (factor B)	Straw ($kg\ ha^{-1}$)			Grain ($kg\ ha^{-1}$)			
	N	P	K	N	P	K	Protein ($g\ kg^{-1}$)
Control							
With	74.32	6.88	70.21	80.57	7.37	57.40	112.1
Without	56.56	4.74	56.59	69.30	5.87	41.30	98.8
Mean	65.44	5.81	63.40	74.93	6.62	49.35	105.5
119 kg N ha^{-1} (N1)							
With	81.49	7.45	74.51	97.40	9.20	66.77	133.0
Without	81.01	7.58	78.40	83.34	8.33	58.33	114.0
Mean	81.25	7.51	76.45	90.37	8.77	62.55	123.5
238 kg N ha^{-1} (N2)							
With	114.40	10.76	104.75	126.44	13.80	97.27	148.2
Without	105.39	9.57	92.86	110.54	11.35	86.77	133.0
Mean	109.90	10.16	98.80	118.49	12.58	92.02	140.6
Bio-fertilizer (Bio)							
With	97.90	9.79	93.39	125.27	11.45	84.10	133.0
Without	84.99	8.06	79.17	102.00	10.04	71.43	114.0
Mean	91.44	8.92	86.28	113.64	10.75	77.77	123.5
Bio+N1							
With	125.04	12.34	118.94	143.77	13.33	105.17	155.8
Without	94.67	9.60	86.67	121.54	11.82	89.54	136.8
Mean	109.86	10.97	102.80	132.65	12.58	97.35	146.3
Bio+N2							
With	162.19	17.36	150.40	204.70	20.44	151.20	174.8
Without	135.20	13.22	117.20	162.14	16.22	109.34	169.1
Mean	148.70	15.29	133.80	183.42	18.33	130.27	172.0
Compost							
With	115.15	12.81	131.18	173.74	17.37	144.94	161.5
Without	95.95	11.17	111.66	150.84	15.28	122.64	142.5
Mean	105.55	11.99	121.42	162.29	16.33	133.79	152.0
Compost+N1							
With	148.06	15.63	169.18	204.84	22.41	170.70	182.4
Without	150.54	15.94	166.40	165.17	17.09	137.00	167.2
Mean	149.30	15.79	167.79	185.00	19.75	153.85	174.8
Compost+N2							
With	194.91	22.78	207.55	264.51	35.65	225.30	218.5
Without	175.87	20.73	181.20	234.60	29.15	207.27	195.7
Mean	185.39	21.75	194.38	249.55	32.40	216.29	207.1
Vermiculite							
With	123.72	12.87	124.46	157.91	16.78	122.54	157.7
Without	108.91	11.18	107.79	133.27	13.91	102.62	141.2
Grand mean	116.31	12.02	116.13	145.59	15.34	112.58	149.5
$LSD_{0.05}$							
A	7.801	1.321	6.906	7.739	1.096	6.075	5.76
B	3.678	0.623	3.255	3.648	0.516	2.864	2.72
AB	11.033	1.868	9.767	10.944	1.549	8.591	ns

Compost+238 kg N ha^{-1}>Compost+119 kg N ha^{-1}>Compost>biofertilizer+238 kg N ha^{-1}> biofertilizer+119 kg N ha^{-1}>biofertilizer>238 kg N ha^{-1}>119 kg N ha^{-1}>control.

As shown in Table 3, N application, biofertilizer inoculation and compost had significant effects on protein content of wheat grains. The highest protein content was observed in the application of compost+N2 combined with vermiculite. The highest rate of nitrogen application increased protein content compared to control. Moreover, plants treated with biofertilizer showed more protein content than control. These results are in accordance with the reports of Khan *et al*. (2007), Sary *et al*. (2009) and Abedi *et al*. (2010). Rana *et al*. (2012) reported an enhancement of 18.6% in protein content with biofertilizer inoculation in wheat. It has been found that in case of an adequate supply of N in the soil, leaf senescence is slower and the plant is able to supply its seeds with N and photoassimilate for a longer period which results in higher protein and grain yield (Azeez, 2009; Abedi *et al*., 2010).

Application of vermiculite under different treatments of N-sources gave increases of N, P and K uptake in straw of up to 13.6, 15 and 15.5%, respectively and comparable increases in NPK-uptake in grain of up to 18.5, 21.3 and 19.4%, respectively. These results are agreement with those obtained by Merwad *et al*. (2013) who reported that the application of vermiculite under organic amendments gave the highest values of NPK-uptake by straw and grain of barley plants in sandy soil.

Relationship between nitrogen uptake and grain yield, straw yield and protein: The relationship between nitrogen uptake and grain yield, straw yield and protein under the influence of different treatments were illustrated in Fig. 1 and 2. Overall, there was a positive relationship between nitrogen uptake, grain yield and straw yield of the plant wheat. The correlation coefficient (r) values between nitrogen uptake, grain yield and straw yield of wheat were 0.96 and 0.87, respectively.

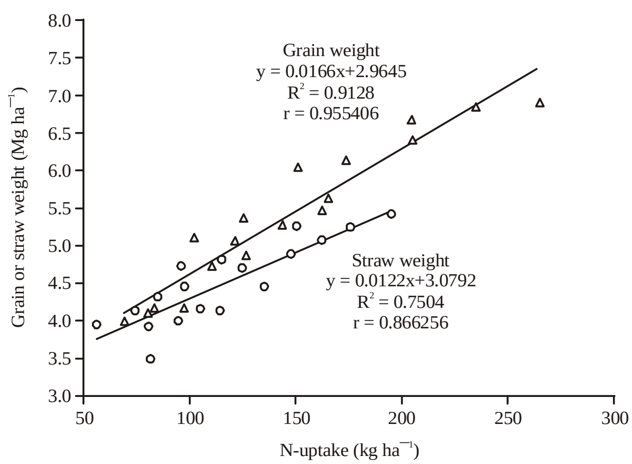

Fig. 1: Relationship between nitrogen uptake, grain and straw yield of wheat plant

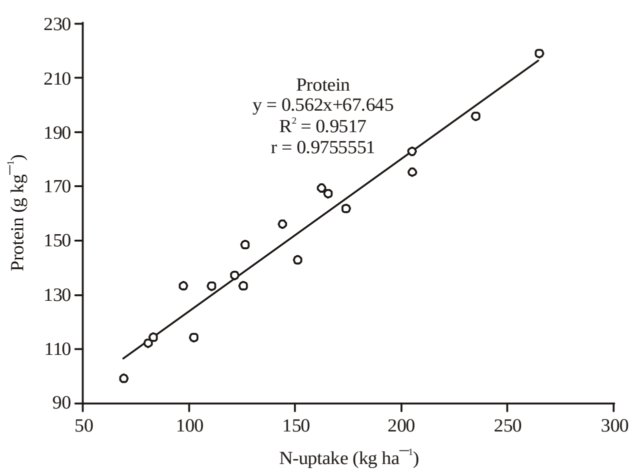

Fig. 2: Relationship between nitrogen uptake and protein

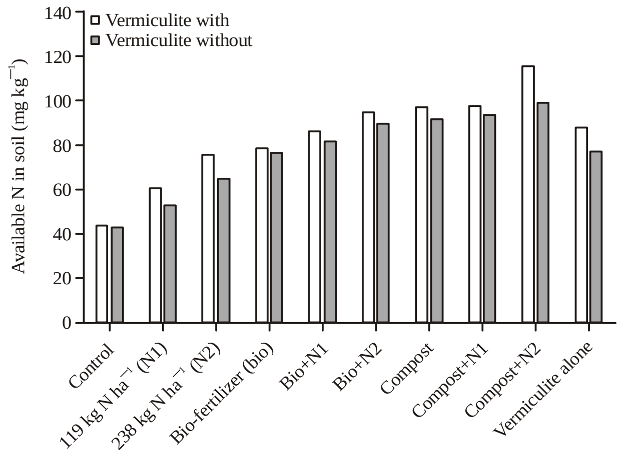

Fig. 3: Effect of nitrogen fertilization from different sources combined with vermiculite on available nitrogen in soil after harvest

The relationship between nitrogen uptake and protein of wheat plant takes the same positive relationship former trend where more increase nitrogen uptake by wheat plant caused more increase in protein (Fig. 2). The correlation coefficient (r) values between nitrogen uptake and protein was 0.98.

Available nitrogen in soil: Data illustrated in Fig. 3 reveal that values of available nitrogen (mg kg^{-1}) in the treated soil with nitrogen fertilization from different sources combined with vermiculite after harvest. The treatment of compost+238 kg N ha^{-1} combined with vermiculite gave the highest available potassium, while the lowest ones were found with untreated soil. These results are agreement with those obtained by Mohamed *et al*. (2008) who reported that the addition of compost and taffla to sandy calcareous soil increased N availability in the soil after cultivation. The pattern of comparison among treatments was rather similar to those regarding yields of straw and grains. Use of FYM, wheat straw and green manure in conjunction with fertilizers increased the soil organic carbon, available N, P, K status (Kumar *et al*., 2012). Significant increases in soil nutrient availability with the application of farmyard manure, paddy straw and green manure along with inorganic fertilizer (Ghosh *et al*., 2012). Application of vermiculite under different treatments of N-sources gave increases of available nitrogen of up to 14%. These results are agreement with those obtained by Marinova *et al*. (2012).

CONCLUSION

The results obtained from this study clearly indicated that wheat (*Triticum aestivum* L.) yield, yield components and protein content of grains had a strong association with the N fertilization, biofertilizer inoculation and compost. Data indicated that application of compost+238 kg N ha^{-1} combined with vermiculite giving increases of growth parameters and NPK-uptake of wheat by over that of the other treatments and control. In addition, vermiculite were enhanced effects the former treatments.

REFERENCES

Abedi, T., A. Alemzadeh and S.A. Kazemeini, 2010. Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. Aust. J. Crop Sci., 4: 384-389.

Alian, F.S., 2005. Response of globe artichoke to some organic manure, mineral nitrogen levels and biostimulant treatments under sandy soil conditions. Ph.D. Thesis, Faculty of Agriculture Cairo University Egypt.

Azeez, J.O., 2009. Effects of nitrogen application and weed interference on performance of some tropical maize genotypes in Nigeria. Pedosphere, 19: 654-662.

Blackshaw, R.E., L.J. Molnar and F.J. Larney, 2005. Fertilizer, manure and compost effects on weed growth and competition with winter wheat in western Canada. Crop Prot., 24: 971-980.

Broek, A.V. and J. Vanderleyden, 1995. Review: Genetics of the *Azospirillum*-plant root association. Crit. Rev. Plant Sci., 14: 445-466.

Chapman, H.D. and P.F. Pratt, 1961.. Methods of Analysis for Soils, Plants and Water. University of California, Berkely, California, USA.

Cohen, A.T., P. Mariela, B. Ruben and P. Patricia, 2007. Azospirillum brasihense and ABA improve growth in Arabidopsis. Proceedings of the 19th Annual International Plant Growth Substances Association Meeting, July 21-25, 2007, Puerto Vallarta, Mexico.

Coquet, Y., 1995. [*In situ* study of shrink-swell phenomena in soils. Application to two weakly swelling tropical soils]. Master's Thesis, Universite d'Orleans, Orleans, France

Diacono, M., P. Rubino and F. Montemurro, 2013. Precision nitrogen management of wheat: A review. Agron. Sustainable Dev., 33: 219-241.

Diaz-Zorita, M. and M.V. Fernandez-Canigia, 2009. Field performance of a liquid formulation of *Azospirillum brasilense* on dryland wheat productivity. Eur. J. Soil Biol., 45: 3-11.

Estrada-Campuzano, G., G.A. Slafer and D.J. Miralles, 2012. Differences in yield, biomass and their components between triticale and wheat grown under contrasting water and nitrogen environments. Field Crops Res., 128: 167-179.

Feller, C., 1995. [Organic matter in tropical soils with 1:1-type clay. Research of functional organic compartments. A particle-size approach]. Ph.D. Thesis, Travaux Universitaire, France.

Ghaderi-Daneshmand, N., A. Bakhshandeh and M.R. Rostami, 2012. Biofertilizer affects yield and yield components of wheat. Int. J. Agric., 2: 699-704.

Ghosh, S., B. Wilson, S. Ghoshal, N. Senapati and B. Mandal, 2012. Organic amendments influence soil quality and carbon sequestration in the Indo-Gangetic plains of India. Agric. Ecosyst. Environ., 156: 134-141.

Glick, B.R., 2003. Plant Growth Promoting Bacteria. In: Molecular Biology-Principles and Applications of Recombinant DNA, Pasternak, J.J. (Ed.). ASM Press, Washington DC., USA., pp: 436-454.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. 2nd Edn., John Wiley and Sons Inc., New York, USA., ISBN: 13-9780471879312, pp: 13-175.

Hoitink, H.A.J. and M.E. Grebus, 1994. Status of biological control of plant diseases with composts. Compost Sci. Utilizat., 2: 6-12.

Kandil, A.A., M.H. El-Hindi, M.A. Badawi, S.A. El-Morarsy and F.A.H. Kalboush, 2011. Response of wheat to rates of nitrogen, biofertilizers and land leveling. Crop Environ., 2: 46-51.

Khan, I., G. Hassan, M.I. Khan and M. Gul, 2007. Effect of wild oat (*Avena fatua* L.) population and nitrogen levels on some agronomic traits of spring wheat (*Triticum aestivum* L.). Turk. J. Agric. For., 31: 91-101.

Klute, A., 1986. Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. 2nd Edn., American Society of Agronomy-Soil Science Society of America, Madison, WI., USA., ISBN-13: 978-0891188117, Pages: 1358.

Kumar, S., R. Dahiya, P. Kumar, B.S. Jhorar and V.K. Phogat, 2012. Long-term effect of organic materials and fertilizers on soil properties in pearl millet-wheat cropping system. Indian J. Agric. Res., 46: 161-166.

Liu, D. and Y. Shi, 2013. Effects of different nitrogen fertilizer on quality and yield in winter wheat. Adv. J. Food Sci. Technol., 5: 646-649.

Marinova, S.V., R. Toncheva, E. Zlatareva and H. Pchelarova, 2012. Characteristics of vermiculite and its influence on the yield of lettuce in greenhouse experiments. Institute of Soil Science, Sofia, Bulgaria, Ohrid.

Martinez-Medina, A., A. Roldan and J.A. Pascual, 2009. Performance of a *Trichoderma harzianum* bentonite-vermiculite formulation against fusarium wilt in seedling nursery melon plants. HortScience, 44: 2025-2027.

Matter, K.M., K.F. Moussa, S.A.H. El-Naka and M.A. Ali, 2007. Effect of some soil organic amendments on the productivity of sandy soil. Zagazig. J. Agric. Res., 34: 225-247.

Merwad, A.M.A., E.A.M. Awad, I.R. Mohamed and S.M.M. Dahdouh, 2013. Effect of some phosphatic fertilizers and soil amendments on the availability of phosphorus in soil. Zagazig J. Agric. Res., 40: 483-494.

Michigan State University, 1983. MSTAT-C: Micro-computer statistical program, Version 2. Michiga State University, East Lansing, USA.

Mohamed, W.S., M.A. Sherif and I.A. Youssef, 2008. Effects of some natural organic and inorganic materials on some soil properties and growth in sandy and calcareous soil. Minia J. Agric. Res., 28: 331-394.

Namvar, A., T. Khandan and M. Shojaei, 2012. Effects of bio and chemical nitrogen fertilizer on grain and oil yield of sunflower (*Helianthus annuus* L.) under different rates of plant density. Ann. Biol. Res., 3: 1125-1131.

Page, A.L., R.H. Miller and D.R. Keeny, 1982. Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties, Volume 2. 2nd Edn., America Society of Agronomy, Madison, WI., USA., ISBN-13: 9780891180722, Pages: 1159.

Piccinin, G.G., A.L. Braccini, L.G.M. Dan, C.A. Scapim, T.T. Ricci and G.L. Bazo, 2013. Efficiency of seed inoculation with *Azospirillum brasilense* on agronomic characteristics and yield of wheat. Ind. Crops Prod., 43: 393-397.

Piper, C.S., 1950. Soil and Plant Analysis. Inter Science Publishers, New York, USA.

Popkin, R., 1995. Good news for waste watchers: Recycling, composting show results for the future. Environ. Prot. Agency J., 21: 188-190.

Rai, M.K., 2006. Microbial Biofertilizers. Haworth Press, Pinghamton, NY.

Rana, A., M. Joshi, R. Prasanna, Y.S. Shivay and L. Nain, 2012. Biofortification of wheat through inoculation of plant growth promoting rhizobacteria and cyanobacteria. Eur. J. Soil Biol., 50: 118-126.

Richards, L.A., 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook No. 60, United State Government Printing Office, Washington, DC., USA., Pages: 160.

Salem, M.A., W. Al-Zayadneh and C. Abdul Jaleel, 2010. Effects of compost interactions on the alterations in mineral biochemistry, growth, tuber quality and production of *Solanum tuberosum*. Front. Agric. China, 4:: 170-174.

Sarwar, G., 2005. Use of compost for crop production in Pakistan. Okologie und Umweltsicherung. 26/2005. Universitat Kassel, Fachgebiet Landschaftsokologie und Naturschutz, Witzenhausen, Germany.

Sary, G.A., H.M. El-Naggar, M.O. Kabesh, M.F. El-Kramany and G.S.H. Bakhoum, 2009. Effect of Bio-organic fertilization and some weed control treatments on yield and yield components of wheat. World J. Agric. Sci., 5: 55-62.

Sharpley, A.N., 1985. Phosphorus cycling in unfertilized and fertilized agricultural soils. Soil Sci. Soc. Am. J., 49: 905-911.

Sushila, R. and G.R. Gajendra, 2000. Influence of farmyard manure, nitrogen and biofertilizers on growth, yield attributes and yield of wheat (*Triticum aestivum*) under limited water supply. Indian J. Agron., 45: 590-595.

Tanu, A. Prakash and and A. Adholeya, 2004. Effect of different organic manures/composts on the herbage and essential oil yield of *Cymbopogon winterianus* and their influence on the native AM population in a marginal alfisol. Biosour. Technol., 92: 311-319.

Tilak, K.V.B.R. and B.S. Reddy, 2006. *Bacillus cereus* and *B. circulans*-novel inoculants for crops. Curr. Sci., 90: 642-644.

Van Dommelen, A., V. Keijers, J. Vanderleyden and M. de Zamaroczy, 1998. Methyl ammonium transport in the nitrogen-fixing bacterium *Azospirillum brasilense*. J. Bacteriol., 10: 2652-2659.

Wortman, S.E., A.S. Davis, B.J. Schutte and J.L. Lindquist, 2011. Integrating management of soil nitrogen and weeds. Weed Sci., 59: 162-170.

Youssef, M.A., 2011. Synergistic impact of effective microorganisms and organic manures on growth and yield of wheat and marjoram plants. Ph.D. Thesis, Faculty of Agriculture Cairo University Egypt.

Youssef, M.A., M.M. El-Sayed and I.I. Sadek, 2013. Impact of organic manure, bio-fertilizer and irrigation intervals on wheat growth and grain yield. Am. Eur. J. Agric. Environ. Sci., 13: 1488-1496.

Zheljazkov, V.D. and P.R. Warman, 2004. Source-separated municipal solid waste compost application to Swiss chard and basil. J. Environ. Qual., 33: 542-552.