

Effect of Organic and Nitrogen Fertilizers on Soil Fertility and Wheat Productivity in a Newly Reclaimed Sandy Soil

Enga M. Niel¹

ABSTRACT

Two field experiments were carried out in a newly reclaimed sandy soil under sprinkler irrigation system at El Ismailia Agricultural Research Station, El Ismailia Governorate, Egypt during the winter seasons of 2017/2018 and 2018/2019, to study the effect of organic amendment (compost and FYM) under different rates of nitrogen fertilizer (control, 75 and 100 % of recommended dose) on the fertility of study soil and wheat productivity. The treatments were arranged in a split-plot design with three replicates. Results indicated that 100% of recommended dose followed by 75% significantly increased all determined traits relative to control under the study conditions. Soil application of compost and FYM was superior for all growth characteristics, grain quality, and yield of wheat plants compared to control (without applications). The effect of compost or FYM combined with different rates of nitrogen mineral fertilizer increased plant height (cm), weight of 1000 grains (g), Straw yield (Mg acre⁻¹), and weight of grains yield (Mg acre⁻¹). The application of soil amendments increased N, P, and K concentrations in straw and grains. Application of organic amendments had a positive significant effect on available N, P, and K in soil. The interaction between soil amendments and different rates of nitrogen mineral fertilizer showed a significant effect on yield and its attributes, grain protein content, and total carbohydrate. Finally, it could be concluded that the application of farmyard manure with 75 % nitrogen of recommended dose improved the soil properties of sandy soil and increased the productivity of wheat plants.

Key world: Organic Amendments, Soil fertility, wheat productivity.

INTRODUCTION

Increasing wheat yield (*Triticum aestivum* L.) is a national goal to meet the ever-increasing food needs of the Egyptian population, whereas wheat is one of the three main cereal crops. Egyptian government and scientists paid great attention and efforts to narrow the wheat security gap (Youssef *et al.*, 2013). Wheat provides 37% of the total calories and 40% of the

protein in the Egyptian people's diet. Recently Egyptian investigators directed great attention to increase the productivity of wheat to minimize the gap between production and consumption through increasing unit land area productivity and increasing cultivated area.

Sandy soils represent about 90% of the Egyptian soils. Such soils represent a great hope for agricultural 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 (Coquet, 1995). Feller (1995) reported that the addition of organic matter plays a major role in soil fertility through different functions: i.e. storage of nutrients like P, Ca, K, Mg, which released during organic matter decomposition and their dynamics are thus dependent on that of organic matter. Increasing the 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, the improvement of soil structural stability, and the stimulation of faunal, microbial, and enzymatic activities that determines carbon, nitrogen and phosphorus and sulfur cycles.

Nitrogen is the most important essential nutrient in plant nutrition; it is a constituent of a large number of necessary organic compounds such as amino acids, proteins, nucleic acids, ribosomes, chlorophyll, cytochrom and some vitamins (Marschner, 1986). The positive effects of applying nitrogen fertilizer on growth, yield attributes, grain yields and quality of

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¹ Soils, Water and Environment Research Institute, ARC, Egypt
Email: enga.niel@arc.sci.eg

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wheat were reported by Hossain *et al.*, (2005), Niel (2021).

The objective of this study, therefore, was to study the effect of applying some organic soil amendments (compost and FYM) under different rate of nitrogen mineral fertilizer to obtain high crop yield with good quality of wheat and soil fertility. In addition, the possibility of reducing the inputs of chemical fertilizers was studied to produce crop of wheat under sandy soil conditions.

MATERIALS AND METHODS

Two field experiments were carried out in a newly reclaimed sandy soil under sprinkler irrigation system at El Ismailia Agricultural Research Station, El Ismailia Governorate, Egypt (Latitude 30° 35' 30" N, Longitude 32° 14' 50" E) during the winter seasons of 2017/2018 and 2018/2019 to study the effect of organic amendments (compost and FYM, both at 5 Mg acre⁻¹)

under different rates of nitrogen (control, 75 and 100 % of the recommended dose) on the fertility of soil and wheat productivity. The main physical and chemical properties of the used soil before planting (Table 1) were determined according to the methods described by Kulte (1986) and Cottenie *et al.*, (1982). In both seasons, each experiment was carried out in split plot design with three replicates. The used soil amendments were randomly arranged in the main plot, where the rates of mineral N fertilizer were arranged in the random in sub plots. The area of each experimental unit (plot) was 3 X 3.5m (10.5 m²). Soil amendments (compost and FYM, both at 5 Mg acre⁻¹) were applied to the soil 15 days before wheat grain sowing. The compost and FYM (Table2) were analyzed according to the standard methods described by Brunner and Wasmer (1978). Wheat cultivar (Giza 168) was obtained from Wheat Dept. Field Crop Res. Institute, Agric. Res. Center, Giza, Egypt. Ammonium sulphate (20.6 % N)

Table 1. Some physical and chemical properties of the used field experimental soil

Soil characters	value	
Practical size distribution (%)	Coarse sand	15.7
	Fine sand	64.3
	Silt	9.2
	Clay	10.8
	Texture class	Sandy
*EC (dSm ⁻¹)	1.39	
*pH	7.94	
O.M. (%)	0.21	
Total CO ₃ (%)	1.25	
*Cations (meq l ⁻¹)		
Ca ⁺⁺	4.58	
Mg ⁺⁺	2.93	
Na ⁺	5.54	
K ⁺	0.85	
*Anions (meq l ⁻¹)		
CO ₃ ⁻	n.d.	
HCO ₃ ⁻	2.18	
Cl ⁻	5.89	
SO ₄ ⁻	5.83	
Available macro and micro-nutrients (mg kg ⁻¹)	N	19.00
	P	5.17
	K	88.00
	Fe	2.85
	Zn	0.42
	Mn	1.22

* Soil Paste

n.d. = not detected

Table 2. Some properties of Compost and Farmyard manure

Properties		Compost	Farm Yard Manure
Moisture content	%	21	25
EC (1:10)	dSm ⁻¹	3.2	3.88
pH (1:10)		7.5	7.6
O.C	%	19.5	14.8
C/N ratio		8.4:1	16.1:1
Total macronutrients	%		
N		2.33	0.92
P		0.85	0.09
K		4.17	2.15
Total micronutrients	mgkg ⁻¹		
Fe		322	86.9
Mn		115	39.65
Zn		95	32.72
Cu		11.06	8.96

was added in three equal doses after 30, 45 and 65 days from planting date. Three nitrogen fertilizer levels; (control, 75, and 100% of recommended dose 120 Kg N acre⁻¹) were applied. Phosphorus fertilizer was applied to all experimental plots in one dose pre-planting wheat in the form of superphosphate (15% P₂O₅) at the rate of 200 kg acre⁻¹. Potassium sulphate (48 % K₂O) was applied at a rate of 50 kg acre⁻¹ at two equal doses after 30 and 45 days from planting.

At harvesting time, the following characteristics were estimated:

• Yield and its components:

The wheat plants were harvested at full maturity; ten plants were randomly taken from each plot to record the average of the following traits: plant height (cm); weight of 1000 grains (g); straw weight (Mg acre⁻¹) and grains yield weight (Mg acre⁻¹).

• Chemical analysis

Nitrogen content in the grains and straw was determined by Keldahl method (Bremner and Mulvaney, 1982). Protein content in the grains was calculated by multiplying N% by 5.75. Phosphorus was determined colorimetrically using Vanado-Molybdate

yellow color method (Jackson, 1973). Potassium was determined by flame photometer according to Jackson (1973). Micronutrients were extracted and determined according to (Soltanpour and Schwab, 1977) using an Atomic Absorption Spectrophotometer.

Total carbohydrate was determined according to Smith *et al.*, (1956).

Soil analysis after harvesting wheat:

Soil samples were collected after harvesting the wheat plant, air-dried, ground, and passed through a 2 mm sieve for the determination of available N, P, and K according to Black *et al.*, (1982).

Statistical analysis:

The obtained data was subjected to statistical analysis and the difference between the means of treatments were tested using least significant difference test (L.S.D) at 5%. The combined analysis was carried out for the two growing seasons and their average data (L.S.D) at 5% according to Snedecor and Cochran, (1967).

RESULTS AND DISCUSSIONS

Yield and its components

A-Effect of Organic Amendments on Yield and Yield Components

Table (3) showed the effect of soil amendments on yield and yield components (plant height, 1000-grain weight, grain, and straw yields). All the studied characters were significantly affected by the application of organic amendments. The application of organic amendments (FYM and/or compost) revealed significant effect than control for all growth parameters under study. The positive impacts of organic soil amendments on yield and its components are mainly due to improving soil's physical and chemical properties, preparing the suitable bed for germination, and developing plant growth that reflects on the resultant yield. Moreover, FYM is considered as an important source of humus; macro, and microelements carrier, and at the same time increase the activity of the useful microorganisms. Similar results were reported by Abedi, *et al.*, (2010).

B-Effect of nitrogen fertilization on Yield and Yield Components

Table (3) showed that the application of different nitrogen rates (0, 75, and 100 % of recommended dose) have a positive effect on yield and yield components. Increasing nitrogen fertilizer up to the lightest level (100% of recommended dose) significantly increased plant height, 1000-grain weight, grain, and straw yield acre^{-1} . This increase might be attributed to the fact that nitrogen fertilization promotes tillering in cereals and encourages the formation of more spikes/plants (El-Sebasy and Abd El-Maaboud 2003). Nitrogen is one of the most necessary components of cytoplasm, nucleic acid, and chlorophyll, which has an essential role in encouraging cell elongation and cell division. Consequently, nitrogen increases vegetative growth and activation of the photosynthesis process that enhances the number of metabolites necessary for building plant organs, hence the increment in grain and straw yields. These results follow those obtained by Amjed *et al.*, (2011) and Leghari *et al.*, (2016).

C-Effect of interactions

Results of the interaction between nitrogen rate and organic amendments (Table, 3) showed that application of FYM at 75% of the recommended nitrogen rate was more effective treatment according to (Ng'etich *et al.*, 2012) who mentioned that organic fertilizers can serve as an alternative practice to minimize the use of mineral

Table 3. Effects of different organic soil amendments and nitrogen rates on yield and yield components of wheat

Treatments		Plant height	1000 grain weight	Grain yield	Straw yield
Soil amendments	Nitrogen Rate (%)	(cm)	(g)	(Mg acre^{-1})	
Control	0	59.50	40.70	1.69	0.53
	75	69.48	50.40	2.55	1.70
	100	71.15	53.00	2.77	2.01
Mean		66.71	48.03	2.34	1.41
Compost	0	68.73	41.70	2.2	1.78
	75	85.85	56.30	2.65	2.68
	100	95.08	52.65	2.92	2.64
Mean		83.22	50.22	2.59	2.37
FYM	0	72.19	43.65	2.4	1.98
	75	89.38	59.40	2.85	4.02
	100	102.91	53.90	3.1	3.12
Mean		88.16	52.32	2.78	3.04
LSD. 0.05 Amendments		4.00	1.50	0.43	0.70
LSD. 0.05 Rates of N		2.30	2.20	0.92	0.25
LSD. 0.05 Interaction		2.75	2.00	0.22	1.00

fertilizers as they aid in improving soil structure, increase soil organic carbon and microbial biomass. Also, the application of compost or FYM improved the physical and chemical properties of sandy soil that was reflected in wheat growth parameters under study compared to control. **Effect of Organic Amendments and Nitrogen Rates on some chemical components in the grains and straw of the wheat plant**

A-Effect of Organic Amendments

Table (4) showed that application of organic amendments (compost and FYM) significantly increased N, P, and K concentrations in the grains and straw of the wheat plant. This may be due to the decomposition of organic manure supplying more available nutrients as well as the formation of organic and inorganic acids during decomposition, which slightly reduce the soil pH, which in turn enhanced the solubility, and availability of N, P, and K. These beneficial effects are in agreement with those reported by El-Kouny *et al.*, (2004). Moreover, Hassan and Mohey El-Din (2002) reported that the increasing of NPK concentration in wheat plants with FYM application, may be attributed to the mineralization of organic matter and slow releasing of minerals in an available form from organic manure or may be due to the effect of several organic acids, produced during manure decomposition, which solubilize the native P of the soil, and thus P availability increased and consequently the content in plant is increased.

B-Effect of nitrogen fertilization

The results illustrated in Table (4) showed that increasing the applied rate of nitrogen fertilizer gradually increased the concentration of N, P, and K in both grains and straw of wheat plant at maturity stage. The highest values of concentration for NPK uptake were recorded by the application of 100 % of the recommended dose. Such results might be attributed to the role of nitrogen in increasing the root surface area per unit of soil volume and also the capacity of the plant supplied with N in building metabolites, which increases the dry matter content and subsequently increases nutrients content by wheat plants. These findings are in harmony with those obtained by El-Desouky (2004) and Abd El-Hady *et al.*, (2006).

C-Effect of interactions

Concerning the impact of the interaction between organic amendments and nitrogen fertilizer on N, P, and K concentrations in grains and straw (Table, 4), it was noticed that the maximum significant values of N, P, and K concentration were obtained by the application of FYM and 75 % of the recommended dose. These results indicate that using organic amendments had a beneficial influence on reducing the amount of mineral nitrogen. Increasing mineral N to 100 % of recommended dose with compost and FYM reduced N content in straw and grains of wheat this may be due to inhibition in

Table 4. Macronutrients concentration in straw and grains of wheat plants

Treatments		Macronutrients concentration (%)					
		N		P		K	
Soil amendments	Nitrogen Rate (%)	Straw	Grains	Straw	Grains	Straw	Grains
Control	0	0.46	1.68	0.23	0.37	1.62	0.37
	75	0.65	1.89	0.26	0.44	1.70	0.42
	100	0.73	2.17	0.27	0.49	1.83	0.46
Mean		0.61	1.91	0.25	0.43	1.72	0.42
Compost	0	1.06	2.20	0.25	0.44	1.74	0.45
	75	1.32	2.75	0.29	0.49	1.86	0.48
	100	1.25	2.59	0.31	0.55	2.04	0.55
Mean		1.21	2.51	0.28	0.49	1.88	0.49
FYM	0	1.31	2.55	0.27	0.48	1.76	0.48
	75	1.50	2.92	0.33	0.54	1.96	0.54
	100	1.43	2.80	0.35	0.57	2.15	0.67
Mean		1.41	2.76	0.32	0.53	1.96	0.56
LSD. 0.05 Amendments		0.50	0.22	0.10	0.01	0.03	0.01
LSD. 0.05 Rates of N		0.11	0.11	0.01	0.01	0.028	0.02
LSD. 0.05 Interaction		0.05	0.41	0.10	ns	n.s	0.02

Table 5. Effects of different organic soil amendments and nitrogen rates on quality of wheat grain

Treatments		Protein	Total carbohydrates	Starch content
Soil amendments	Nitrogen Rate (%)	(%)	(g/ 100g DW)	
Control	0	9.66	60.10	40.70
	75	10.87	63.50	42.80
	100	12.48	64.80	44.50
Mean		11.00	62.80	42.67
Compost	0	12.65	63.90	43.90
	75	15.81	67.60	46.40
	100	14.89	65.80	45.70
Mean		14.45	65.77	45.33
FYM	0	14.66	65.50	45.90
	75	16.79	69.80	48.7
	100	16.10	67.30	47.1
Mean		15.85	67.53	47.23
LSD. 0.05 Amendments		1.1	0.65	0.21
LSD. 0.05 Rates of N		1.00	1.43	1.05
LSD. 0.05 Interaction		0.05	0.12	0.11

microorganisms activity that decompose organic matter as a result on mineral N. This may be due to the addition of organic manure encouraged the microorganisms living in the soil to convert the organic N to mineral form available for plants and hence can reduce inorganic N application.

Protein and carbohydrate contents in grains

A-Effect of Organic Amendments

Table (5) showed significant increases in protein, total carbohydrates, and starch content in wheat grains by application of two sources of organic amendments (FYM and compost). FYM recorded the highest protein (14.66%) and the highest total carbohydrates (65.50). The favorable effect of organic manure on the enhancement of grain quality could be interpreted as that organic manure contains considerable amounts of macro and micronutrients which contribute to improving chemical constituents of grains. the positive effect of organic fertilizer on soil structure that led to better root development that results in more nutrient uptake, compost not only slowly releases nutrients but also prevents the losses of chemical fertilizers through denitrification, volatilization and leaching by binding to nutrients and releasing with the passage of time (Arshad et al. 2004).

B- Effect of nitrogen fertilization

Table (5) showed that the protein concentration was significantly increased by increasing N fertilization levels up to 100% of the recommended dose. Simulating the effect of nitrogen may be due to its

function in plant metabolism as it is considered the main constituent of amino acids, protein, nucleic acids, and phospholipids. In this concern, Ali *et al.*, (2002) showed that N-fertilization of wheat plants increased the protein content and that subsequently improve the grain quality. This is due to the influence of N availability at critical stages of spike initiation and the development on plant metabolism in a way leading to increase the synthesis of amino acids and their incorporation into grain protein.

Regarding carbohydrates contents, data in Table (5) demonstrate that a significant increase took place in total carbohydrates with increasing chemical N levels up to the highest level. This increase in total carbohydrates may be due to the increase in vegetative growth, since nitrogen is an important constituent of chlorophyll which increases photosynthesis, resulting in the assimilation of more carbohydrates. These results came in agreement with those of Morvan-Bertrand *et al.*, (1999) who reported that water-soluble carbohydrates were markedly increased at higher concentrations of the N treatments suggesting that carbohydrates were reserved in leaf sheaths. Also, Weber *et al.*, (1998) stated that there is a good correlation between N-treatments and the accumulation of reducing sugars and sucrose. In addition, Manh *et al.*, (1993) suggested that a possible mechanism in the levels of amino nitrogen can regulate the carbon flux in wheat leaves from amino acids to carbohydrates through activation of phosphoenol pyruvate carboxylase pathway.

C- Effect of interactions

The interaction between soil amendments and different rates of nitrogen mineral fertilizer was significant on protein concentration and total carbohydrates compared with control. This result could be attributed to the users of compost and FYM combined with N mineral fertilizer including improvement in soil structure, soil health, microbial activity, and nutrient availability through a variety of mechanisms.

Effect of Nitrogen Rates and Organic Amendments on Soil Nutritional Status after Harvest of Wheat Plants

A-Effects of Organic Amendment Application on Soil Nutritional Status

In the current study, the available soil nitrogen (N), phosphorus (P), and potassium (K), were significantly improved by the organic amendment application (Table 6 and fig 1). The application of organic amendments increased N availability significantly as compared to the control. The application of organic amendments increased P availability significantly as compared to the control. The application of organic amendments increased K availability significantly as compared to

control. ElGhamry, Elsrafy, and El-Dissoky (2005) found that the application of compost to soil significantly increased the available N, P and K compared to the control. Ahmed and Ali (2005) found that the application of organic fertilizers to the soil significantly increased available P in soil in each cropping season compared to the control. Organic matter plays a critical role in the soil ecosystem because it provides substrates for decomposing microbes, improves soil structure and water holding capacity (Abiven, Menasseri, and Chenu 2009).

B- Effect of nitrogen fertilization

In concern with soil nutritional status data in (Table 8) indicated that application of nitrogen at different rate (0, 75 and 100 %) of recommended dose improved the nitrogen, phosphorus and potassium availability by increasing the applied nitrogen rate as mentioned by Nascente *et al.*, (2017) the early application of N further increased available N in the soil above what the plant would be able to absorb in the initial stages. Also, the positive interactive of nitrogen with other nutrients like phosphorous, potassium and sulphur was mentioned by Socolow, (1999).

Table 6. Effects of different organic soil amendments and nitrogen fertilizer rates on soil nutritional status after harvest of wheat plants

Treatments		Soil Available Nutrient (mg kg ⁻¹)		
Soil amendments	Nitrogen Rate (%)	Nitrogen	phosphorus	Potassium
Control	0	27.76	10.38	95.6
	75	37.66	11.65	107.25
	100	42.48	12.7	110.79
Mean		35.96	11.58	104.55
Compost	0	32.5	13.6	114.49
	75	49	16.45	128.55
	100	45.1	14.8	120.75
Mean		42.2	14.95	121.26
FYM	0	35.9	14.98	127.9
	75	57.85	18.74	153.85
	100	52.7	15.62	146.55
Mean		48.82	16.45	142.77
LSD. 0.05 Amendments		0.91	1.11	143
LSD. 0.05 Rates of N		2.22	3.12	2.54
LSD. 0.05 Interaction		1.72	2.33	1.32

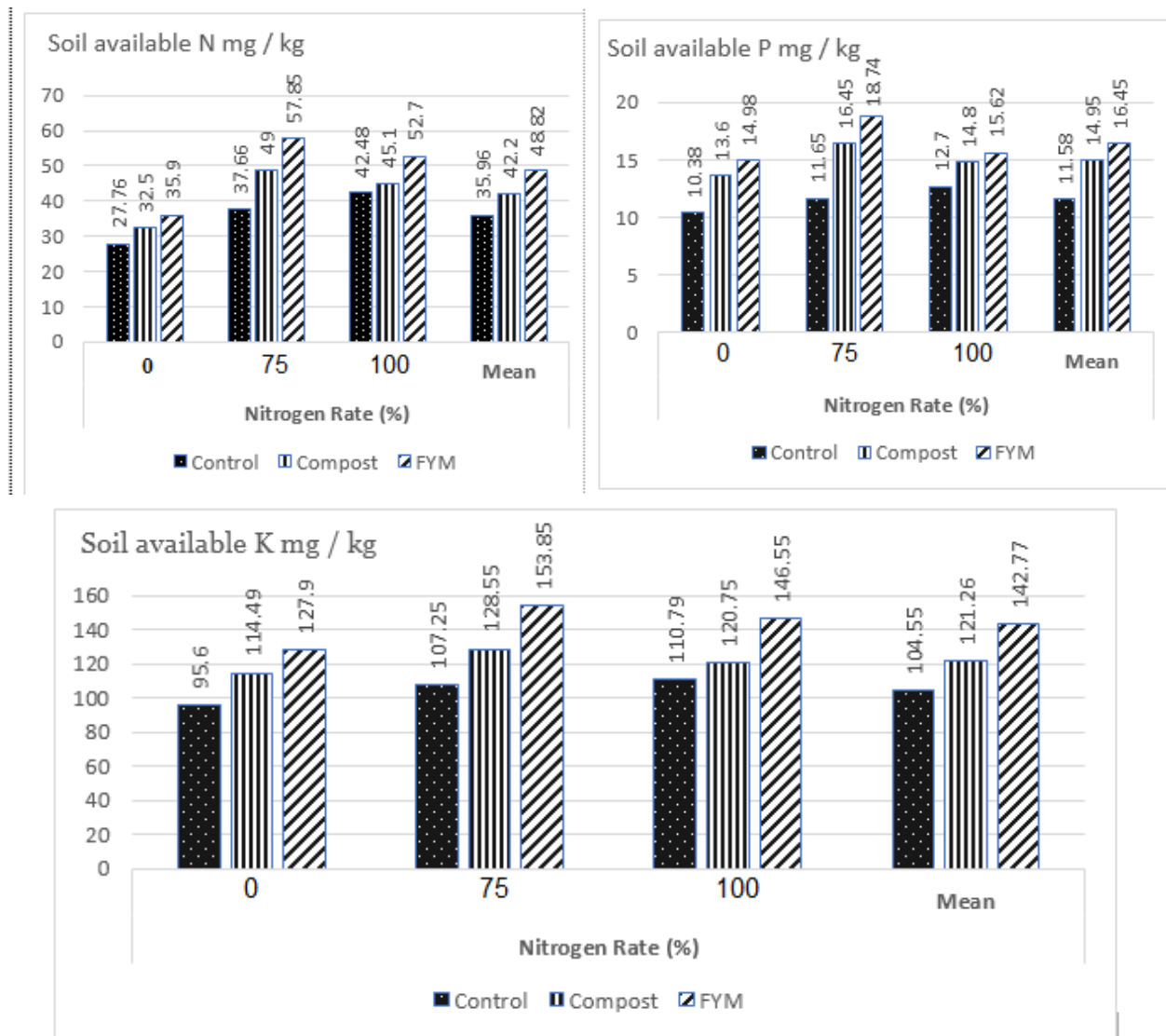


Fig. 1. Effect of organic amendment application and nitrogen rates on soil available N, P and K

C- Effect of interactions

The soils that had received both inorganic and organic amendments showed significantly higher amounts of available N, P, and K. This is primarily due to the mineralization and release of these elements contained in the organics (FYM, compost) on their decomposition. Concerning the applied organic amendments and N-mineral fertilizer, results revealed a trend of the control < N-mineral fertilizer < N- mineral fertilizer + Compost < N- mineral fertilizer + FYM treatment as an ascending order for the available N content in the studied soil. The FYM was the most effective in improving soil nutrients as compared with the compost. Combination with organic amendments

and different rates of nitrogen mineral fertilizer showed a significant effect on the availability of N, P, and K in soil. Therefore, either type of organic amendments can be applied by farmers to minimize the risks of soil degradation and fertility depletion to gain higher crop productivity and agricultural sustainability.

CONCLUSIONS

The obtained results showed that improved soil, growth, and yield of wheat were influenced by different organic amendments combined with nitrogen mineral fertilizer rates. The application of organic amendments increased growth characters and grain yield of wheat and improved chemical and physical properties of soil.

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الملخص العربي

تأثير التسميد العضوي والنتروجيني علي خصوبة الارض وانتاجية القمح المنزرع في ارض رملية حديثة الاستصلاح

انجه مصطفى نايل

واوضحت النتائج ان إضافة النتروجين بالمعدل ١٠٠% من الموصي به يليه ٧٥% اعطي اعلي استجابة مقارنة بالكنترول. كما ان اضافة المادة العضوية بنوعها اعطي اعلي استجابة مقارنة بالكنترول لجميع الصفات المقاسة. كما اظهرت النتائج ان للإضافات العضوية لها تأثير علي محتوى الارض من العناصر الغذائية ، كما ان التداخل بين الاضافات العضوية والمعدنية اعطي اعلي انتاجية للمحصول ومكوناته. ومن النتائج يمكن استنتاج ان إضافة السماد البلدي مع ٧٥% من المعدل الموصي به من السماد النتروجيني له تأثير ايجابي علي خواص الارض وانتاجية القمح.

إجريت تجربتان في ارض حديثة الاستصلاح تحت نظام الري بالتنقيط في محطة بحوث الاسماعيلية - محافظة الاسماعيلية - مصر، خلال الموسم الشتوي لعامي ٢٠١٧/ ٢٠١٨ و ٢٠١٨/ ٢٠١٩ لدراسة أثر الاضافات العضوية "الكمبوست والسماد البلدي" تحت معدلات التسميد النتروجيني (صفر، ٧٥ و ١٠٠% من المعدل الموصي به ١٢٠ كجم N للفدان) علي خصوبة الارض وانتاجية القمح، النظام الاحصائي المستخدم هو القطع المنشقة لمرة واحدة في ثلاث مكررات.