

Effect of Adding Phosphorous With Organic Matter on Wheat Production under Sandy Soil Conditions

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Abstract

Wheat is one of the most important strategic crops in terms of food security. Phosphorus (P) is an essential macronutrient being required by plants in relatively large amounts. The availability of phosphorus in soils is affected by several factors such as the decomposition of organic matter in the soil. Higher soil organic matter concentrations have been proved to enhance the yield and yield components of cereals. The present study, therefore, aims at studying the effect of adding phosphorus and farmyard manure as a source of organic matter on the yield of wheat plants grown under sandy soils conditions. To fulfill the objective of the study a field experiment was conducted at Balouza station in North Sinai, Desert Land Research Center, in the winter season 2018-2019. The design of the experiment was a factorial randomized complete block design with two factors in three replicates. The experimental site was divided into two main plots. Each main plot was divided into three subplots. Organic manure was added to the first half of the main plots at a rate of 25 kg/plot, O₁ (25 ton/ hectare) and at a rate of 50 kg/plot O₂ (50 ton/hectare) to the other half. Superphosphate was added at three rates i.e P₁ = 840 kg/hectare superphosphate fertilizer (6.8 % P). as soil application; P₂= 630 kg/hectare superphosphate fertilizer as soil application + 210 kg/hectare superphosphate fertilizer as foliar application and P₃ = 420 kg/hectare superphosphate fertilizer as soil application + 420 kg/hectare superphosphate fertilizer as foliar application. Each treatment was replicated three times. The foliar application was done as the supernatant of soaked superphosphate fertilizer.

Wheat grains (**cv. Giza 168**) was cultivated in 23 November 2018. Irrigation was done with Al-Salam Canal water. At maturity (9/5/2019) wheat plants were harvested and separated into grains and straw. The grain yield and the straw yield was recorded. Subsamples of wheat straw and grains were ground. A 0.5 gram samples was digested using a mixture of sulphuric and perchloric acids (1:1 v/v). Digests were diluted with distilled water up to a 100 ml and analyzed for N, P and K concentration. The obtained results could be summarized as follows: There was a significant difference in grain yield due to the application of organic manure at increased rate from O₁ to O₂. Also, a significant difference in grain yield occurred due to the application of P fertilizer at increased rate from P₁ to P₃, and the rate P₂ gave the highest increase. The interaction effect between the organic manure rate and P fertilizer rate was significant, where a significant difference in grain yield occurred between P₂ application and the grain yield obtained due the application of P₁ and P₃ under the application of organic manure at the rate O₁. Under the application of organic manure at the rate O₂ significant difference in wheat grain yield occurred between P₁, P₂ and P₃, however, the highest grain yield was obtained under the application of P at the rate P₂ with the application of the organic manure at the rate O₂.

There was a significant difference in straw yield obtained under the application of organic manure at increased and the highest straw yield was obtained at the rate O₂. On the other hand, application of P fertilizer at increased rate significantly increased straw yield from P₁ application up to P₂ application. However, increasing P application from P₂ up to P₃ decreased wheat straw yield. There was a significant interaction between the organic manure and P fertilizer on the straw yield of wheat, where a significant difference occurred between the straw yield obtained due to the application of P at increased rate from P₁ up to P₃ under the application of organic manure at the rates O₁(25 ton/hectare) and O₂ (50 ton/hectare). However the highest straw yield was obtained under the application of P fertilizer at the rate P₂ and the application of organic manure at the rate O₂.

Application of P fertilizer at increased rate under the application of organic manure at increased rate, increased the concentration of N, P and K in both of the straw and grains of wheat plants and the highest increase was obtained under the application of P fertilizer at the rate P₂ and the application of organic manure at the rate O₂.

Key words: Phosphorous, Wheat, Organic, Sandy Soil Conditions

Introduction

Wheat is one of the most important strategic crops in terms of food security. Phosphorus (P) is an essential macronutrient being required by plants in relatively large amounts. Its primary role in plant is to store and transfer energy produced by photosynthesis for use in growth and reproductive processes. The

availability of phosphorus in soils is affected by several factors such as soil pH, clay and sesquioxide content, and exchangeable Al₃⁺ content (**White, 2006**) and the decomposition of organic matter in the soil and activities of microorganisms (**Brady and Weil, 1999**), soil water conditions and soil temperature (**Sanchez, 2007**). The application of farmyard manure to the soils led to improving soil chemical, physical

and biological properties (Belay *et al.*, 2001). Soil pH values fell by one degree as result of adding farmyard manure due to the decomposition and mineralization of organic matter (Singh *et al.*, 1980). Organic matter in soil improves soil structures, holding capacity and nutrient retention, aeration, soil moisture water infiltration (Deksissa *et al.*, 2008). No doubt, that the chemical fertilizers are richer in their nutrient contents, less bulky, easier to transport and apply in the field, thus show quick response on crop in term of grain yield (Hussain *et al.*, 1987). Due to larger consumption of chemical fertilizers, these are becoming expensive due to elimination of subsidy, more dependent on chemical fertilizers for higher grain yield, declining efficiency of fertilizers and mismanagement of fertilizers at farm level. The nitrogenous fertilizers are lost in the form of ammonia volatilization violation and excessive leaching in the form of nitrates and fixation of larger portion of phosphorus may affect the environment (Maynard, 1993). Higher soil organic matter concentrations have been proved to enhance the yield and yield components of cereals (Sarwar, 2005) as well as soil aeration, soil density and maximizing water holding capacity of soil for seed germination and plant root development (Zia *et al.*, 1998). Since phosphate is highly immobile in soil, diffusion is the main way that phosphate anions can reach the root surface (Lambers *et al.* 2008). Although the diffusion coefficient of phosphate in the soil is much less than that of other nutrients, the diffusion can be increased by increasing the phosphate concentration in the soil solution (Lambers *et al.* 2006).

The application of organic manure with phosphatic fertilizers is considered a possible mean of mobilizing P because of the acidic environment generated during the decomposition of the manure. The different types of organic manure increase the microorganisms, release acids in the root rhizosphere and may help to solubilize P and to increase P availability to the plants. Thus, The present study, aims at studying the effect of adding phosphorus with farmyard manure as a source of organic matter on the growth and yield of wheat plants grown under sandy soils conditions.

Material and Methods

A field experiment was conducted at Balouza station in North Sinai, Desert Land Research Center, to study the effect of adding phosphate fertilizer with organic manure on wheat production under sandy soil conditions during the winter season 2018-2019.

The experimental work:

The experiment was conducted on a total area of three kirat divided into two main plots, then each main plot was divided into three subplots. Table 1 show

some properties of the experimental soil. The area of each plot was 11m². Organic manure was added to the first half of plots at a rate of **25 kg/plot, O1 (equivalent to 25 ton/ hectare)** and at a rate of **50 kg/plot, O2 (equivalent to 50 ton/hectare)** to the other half. Table 2 show some characteristics of the organic manure used in the study. Superphosphate was added to each of the sub main plots at three rates i.e **P1 = 0.924 kg superphosphate (6.8 % P) /plot** equivalent to 100 % of the P-fertilizer requirements for wheat plants (**840 kg/hectare**) as soil application; **P2 = 0.693 kg superphosphate /plot equivalent to 75 %** of the P-fertilizer requirements for wheat plants (**630 kg/hectare**) applied as soil application + **210 kg /plot equivalent to 25 %** of P fertilizer requirements for wheat plants applied as foliar application and **P3 = 0.462 kg superphosphate /plot** equivalent to **50 %** of the P-fertilizer requirements for wheat plants (**420 kg/hectare**) applied as soil application + **0.462 kg superphosphate /plot** equivalent to 50 % of the P-fertilizer requirements for wheat plants applied as foliar application. The soil application of P- fertilizer was done during the preparation of the soil for sowing, while the foliar application was done on four doses; the first after 25 days, the second after 45 days, the third after 65 days and the fourth after 90 days from sowing. The foliar application was done as the supernatant of soaked superphosphate fertilizer.

The design of the experiment was a factorial randomized complete block design with two factors in three replicates as follows:

Factor A: Phosphate fertilizer (P) applied at three rates as follows:

P1 = 0.924 kg P-fertilizer/plot applied as soil application

P2 = 0.693 kg P-fertilizer/plot applied as soil application and 0.231 kg P-fertilizer /plot applied as foliar application

P3 = 0.462 kg P-fertilizer /plot applied as soil application P and 0.462 kg P-fertilizer /plot applied as foliar application

Factor B: Organic manure (O) applied at two rates as follows:

O1 = 25 kg organic manure / plot (25 ton/hectare)

O2 = 50 kg organic manure / plot (50 ton/hectare)

Each treatment was replicated three times, hence, the total number of the experimental treatments plots was: 2 O x 3 P x 3 replicates = 18 plots.

Table 1. Soil physical and chemical properties.

Soil Characteristics	Values
Soil particle size distribution	
Sand %	91.50
Silt %	3.30
Clay %	5.20
Textural class	Sand
pH	8.12
EC dS m ⁻¹	1.72
O.M %	0.22
CaCO ₃ %	1.93
Soluble cations and anions (mmol_c L⁻¹)	
Ca ²⁺	3.92
Mg ²⁺	2.78
Na ⁺	4.29
K ⁺	1.64
CO ₃ ²⁻	0.00
HCO ₃ ⁻	1.37
Cl ⁻	4.80
SO ₄ ²⁻	6.46
Available N (mg kg ⁻¹)	7.85
Available P (mg kg ⁻¹)	6.55
Available K (mg kg ⁻¹)	144

Table 2. Some characteristics of the organic manures used in the study.

Organic manure	EC dSm ⁻¹	pH	Organic carbon	C/N Ratio	Humidity %	N %	P %	K %
Farm yard manure	3.35	8.5	20.6	12.5	10	2.25	0.55	0.60

Wheat grains (*Triticum aestivum* L.cv. Giza 168) was cultivated in 23 November 2018. During the growth season, nitrogen fertilizer was added on 3 doses according to the recommended dose at a rate of 450 kg / hectare as ammonium sulfate (20% at sowing, 40% with the first irrigation and 40 % with the second irrigation). Also, K fertilizer was added, at three doses in the form of potassium sulphat at a rate of 300

kg/hectare. The first dose was added after 25 days, the second dose after 45 days and the third after 65 days from sown. Irrigation was done with Al-Salam Canal water, which is a mixed water of the Nile water and agricultural drainage water at a ratio of 1:1. **Table 3** show the chemical analysis of Al-Salam water which was done according to the standard method cited by **Page (1982)**.

Table 3. Chemical analysis of the water used in irrigation

pH	EC (dSm ⁻¹)	TDS (mg/L)	Cations (meq/L)				Anions (meq/L)			
			Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
7.81	2.96	1609.70	4.31	4.45	11.87	0.28	--	5.3	10.95	4.66

At maturity wheat plants were harvested on 9/5/2019 and separated into grains and straw. The grain yield and the straw yield was recorded. Subsamples of wheat straw and grains were dried and ground. A 0.5 gram samples was digested using a mixture of sulphuric and perchloric acids (1:1 v/v) as reported by **Chapman and Pratt (1961)**. Digests were diluted with distilled water up to a 100 ml according to **Page (1982)** and analyzed for N, P and K content (%).

Results and Dissection

Results in **Table 4 A and B** show the effect of adding P-fertilizer with organic manure on the grain and straw yield of wheat plants growing on studied sandy soil.

Effect on straw yield

The obtained results (**Table 4A**) show that increasing the P-fertilizer application increased wheat grain yield specially under the high rate of organic manure application (O2, 50 ton/hectare). However,

the highest increase was obtained under the application of the rate P2 = 630 kg superphosphate/hectare which equivalent to 75 % of the P-fertilizer requirements for wheat plants applied as soil application + 0.210 kg /hectare which equivalent to 25 % of P fertilizer requirements for wheat plants applied as foliar application. There was a significant difference in grain yield obtained due to the application of organic manure at increased rate from O1 to O2. Also, a significant difference in grain yield occurred due to the application of P fertilizer at increased rate from P1 to P3, and the rate P2 gave the highest yield. The interaction effect between the organic manure rate and P-fertilizer rate was significant where a significant difference occurred between the grain yield obtained due to P2 application and the grain yield obtained due the application of each of P1 and P3 under the application of organic manure at the rate O1. Under the application of organic manure at the rate O2 significant difference in wheat grain yield occurred among P1,P2 and P3 , however, the highest grain yield was obtained under the application of P at the rate P2.

Effect on straw yield

Concerning the straw yield, the obtained results in **Table 4B** show that application of the organic manure at increased rate significantly increased wheat straw yield specially under the application of the rate O2 (50 ton/hectare) where the highest straw yield was obtained. On the other hand, application of P-fertilizer at increased rate from P1 up to P2 significantly increased straw yield. However, increasing P application rate from P2 up to P3 decreased wheat straw yield.

There was a significant interaction between the organic manure application rate and the P- fertilizer application rate on the straw yield of wheat, where a significant difference occurred between the straw yield obtained due to the application of P-fertilizer at increased rate from P1 (840 kg/hectare) up to P3 (420 kg p/hectare as soil application + 420 kg p/hectare as foliar application) under the application of organic manure at the rates O1(25 ton/hectare) and O2 (50 ton/hectare). However the highest straw yield was obtained under the application of P fertilizer at the rate P2 (630 kg P-fertilizer/hectare as soil application + 210 kg P-fertilizer/hectare as foliar application) and the application of organic manure at the rate O2 (50 ton/hectar).

Table 4. Effect of application of P-fertilizer with organic manure on the yield of wheat grown on the sandy soil under study.

A: Grain yield (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus fertilizer rate			Mean
	P1	P2	P3	
O1	5016±56.58 ^{bb}	5622±71.56 ^{ba}	5046±106.40 ^{bb}	5228±106.5 ^b
O2	5209±56.00 ^{ac}	5993±57.04 ^{aa}	5623±58.08 ^{ab}	5608±116.67 ^a
Mean	5113±56.00 ^C	5807±92.50 ^A	5335±139.95 ^B	
LSD at 0.05 for		O	P	O*P
		124.56	152.55	215.74

B: Straw yield (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus fertilizer rate			Mean
	P1	P2	P3	
O1	8104±33.88 ^{bc}	8743±25.31 ^{ba}	8316±107.33 ^{bb}	8388±99.60 ^b
O2	9039±51.12 ^{ab}	9651±66.00 ^{aa}	8576±164.47 ^{ac}	9089±164.56 ^a
Mean	8572±210.79 ^B	9197±205.63 ^A	8446±105.37 ^B	
LSD at 0.05 for		O	P	O*P
		158.01	193.53	273.69

a, b & c: There is no significant difference ($P>0.05$) between any two means, within the same column have the same superscript letter.

A, B & C: There is no significant difference ($P>0.05$) between any two means for the same attribute, within the same row have the same superscript letter.

Effect on nutrient content (%)

Results in **Tables and 6** show the effect of adding P-fertilizer with organic manure on nutrients (N, P and K) content in the grains and straw of wheat plants, respectively, growing on studied sandy soil.

As for N, P and K content (%) in the wheat grains, results in **Table 5 A, B and C** show that

application of P fertilizer at increased rate with the application of organic manure at increased rate, significantly increased the concentration of N, P and K in grains of wheat plants and the highest increase was obtained under the application of P- fertilizer at the rate P2 with the application of organic manure at the rate O2. Also, application of organic manure

significantly increased N, P and K concentration specially with the application at the rate O2 where a significant difference occurred between N, P and K (%) obtained due to the application of organic manure by the rate O2 and that obtained due the application by the rate O1.

The interaction effect between P- fertilizer application rate and the organic manure application rate (Table 5A, B and C) show that there were significant differences in N, P and K contents (%) between the three rates of P-fertilizer application with the organic manure application rate. In the case of N %, significant difference occurred only between P2 and each of P1 and P3 when organic manure was applied at the rate O1 while significant difference

occurred only between P2 and P3 when organic manure was applied at the rate O2. In the case of P content (%) significant difference occurred between P2 and each of P1 and P3 under the application of organic manure at the rate O1 whereas significant difference occurred between P2 and P1 only when organic manure was added at the rate O1. However the highest P content (%) was obtained under the application of P-fertilizer by the rate P2 with the organic manure by the rate O2. With respect to K content (%) results show that the interaction effect between P-fertilizer rate and organic manure rate on K (%) tack a trend almost similar to that obtained with N.

Table 5. Effect of application of P-fertilizer with organic manure on the N, P and K contents (%) in grains of wheat plants grown on the sandy soil under study.

A: N % (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus Fertilizer rate			Mean
	P1	P2	P3	
O1	15.43±0.23 ^{bb}	16.37±0.29 ^{ba}	14.93±0.44 ^{ab}	15.58±0.27 ^b
O2	16.37±0.29 ^{aa}	17.00±0.25 ^{aa}	15.43±0.23 ^{ab}	16.27±0.26 ^a
Mean of OM	15.90±0.27 ^B	16.68±0.22 ^A	15.18±0.25 ^C	
LSD at 0.05 for		O	P	O*P
		0.53	0.65	0.92

B: P % (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus Fertilizer rate			Mean
	P1	P2	P3	
O1	9.27±0.45 ^{bb}	11.10±0.44 ^{ba}	9.87±0.57 ^{bb}	10.08±0.36 ^b
O2	11.23±0.28 ^{ab}	12.73±0.43 ^{aa}	12.33±0.67 ^{aa}	12.10±0.33 ^a
Mean	10.25±0.50 ^B	11.92±0.46 ^A	11.10±0.68 ^{AB}	
LSD at 0.05 for		O	P	O*P
		0.87	1.06	1.50

C: K % (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus Fertilizer rate			Mean
	P1	P2	P3	
O1	7.37±0.12 ^{bb}	8.40±0.17 ^{aa}	7.53±0.03 ^{bb}	7.77±0.17 ^b
O2	7.93±0.09 ^{ab}	8.53±0.09 ^{aa}	8.13±0.18 ^{ab}	8.20±0.11 ^a
Mean	7.65±0.14 ^B	8.47±0.09 ^A	7.83±0.16 ^B	
LSD at 0.05 for		O	P	O*P
		0.22	0.27	0.38

a, b & c: There is no significant difference ($P>0.05$) between any two means, within the same column have the same superscript letter.

A, B & C: There is no significant difference ($P>0.05$) between any two means for the same attribute, within the same row have the same superscript letter.

Concerning the effect on N, P and K content (%) in the straw of wheat plants, results in Table 6 A, B and C show that application of P-fertilizer with the organic manure at increased rates significantly increased N content with increasing the P-fertilizer application rate up to P3 and the highest N content (%) was obtained under the P2, while P % and K %

increased with increasing P-fertilizer application rate up to P2 then decreased with increasing P-fertilizer rate up to P3. However, the highest P and K content obtained under the P-fertilizer application rate P3. Significant difference in P % occurred only between the rate P2 and the rate P3 whereas no significant difference occurred between the three rates of P-

fertilizer application in case of K content (%). No significant differences in P % and K % in wheat straw occurred due to the application of organic manure at the rate O1 or O2

Concerning the interaction effect between P-fertilizer application rate and organic manure application rate on the N, P and K content (%) in wheat straw, the obtained results show that significant interaction occurred only on N content (%). Where,

under the application of organic manure at the rate O1 significant difference in N % occurred only between P2 and each of P1 and P3; in case of application of the organic manure by the rate of O2 significant differences occurred between the three rates of P-fertilizer application and the highest N % was obtained under the application of P-fertilizer at P3 and the organic manure at the rate O2.

Table 6. Effect of application of P-fertilizer with organic manure on the N, P and K contents (%) in the straw of wheat plants grown on the sandy soil under study.

A: N (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus Fertilizer rate			Mean
	P1	P2	P3	
O1	7.50±0.06 ^{bb}	9.87±0.22 ^{ba}	7.70±0.06 ^{bb}	8.36±0.38 ^b
O2	7.80±0.06 ^{ac}	11.57±0.20 ^{aa}	9.00±0.06 ^{ab}	9.46±0.56 ^a
Mean	7.65±0.08 ^C	10.72±0.40 ^A	8.35±0.29 ^B	
LSD at 0.05 for		O 0.23	P 0.28	O*P 0.40

B: P (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus Fertilizer rate			Mean
	P1	P2	P3	
O1	10.00±0.61 ^{aAB}	11.20±0.61 ^{aA}	8.80±0.00 ^{bb}	10.00±0.43 ^a
O2	10.40±0.83 ^{aA}	11.60±0.83 ^{aA}	10.40±0.61 ^{aA}	10.80±0.43 ^a
Mean	10.20±0.47 ^{AB}	11.40±0.47 ^A	9.60±0.45 ^B	
LSD at 0.05 for		O 1.15	P 1.41	O*P 1.99

C: K (mean±SE).

Factor (A) Organic manure rate	Factor (B) Phosphorus Fertilizer rate			Mean
	P1	P2	P3	
O1	18.83±0.52 ^{aA}	20.20±0.21 ^{aA}	19.60±1.36 ^{aA}	19.54±0.47 ^a
O2	20.00±0.15 ^{aA}	19.33±1.44 ^{aA}	18.10±0.67 ^{aA}	19.14±0.54 ^a
Mean	19.42±0.36 ^A	19.77±0.68 ^A	18.85±0.75 ^A	
LSD at 0.05 for		O 1.58	P 1.93	O*P 2.73

a, b & c: There is no significant difference ($P>0.05$) between any two means, within the same column have the same superscript letter.

A, B & C: There is no significant difference ($P>0.05$) between any two means for the same attribute, within the same row have the same superscript letter.

Conclusion

It could be application of organic manure at a rate of 50 ton/hectare and the application of P fertilizer as 630 kg P-fertilizer /hectare as soil application (which equivalent to 75 % of P-fertilizer required for wheat plant + 210 kg P-fertilizer/hectare (which equivalent to 25 % of P-fertilizer required for wheat plant) as foliar application significantly increased the productivity of wheat plant under the condition of the studied sandy soil. Also, significantly increased N content (%) and increased P and K contents (%) of wheat plants grown on the soil under study.

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