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Article

Impact of integrated use of filter mud with NPK fertilizer on wheat productivity and chemical soil properties of desert land

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Abstract

A 2-year field experiment was conducted at Research Farm of Faculty of Agriculture, Sohag University, Egypt to study the effect of filter mud rates (0, 3, and 6 ton /feddan, fed = 0.42 ha) and NPK fertilizer levels (0. 50, 75 and 100 % of recommended rate) on wheat productivity, NPK uptake, and chemical soil properties. The results showed that levels of NPK had a significant effect on grain number/spike, 1000-grain weight, biological yield, grain yield, grain protein %, NPK uptake, residual NPK**,** and organic matter in the soil after harvest. Application of 100 % NPK fertilizer level produced the highest quantity and quality of wheat grain and straw yields, in addition to its good effects on soil properties. The used filter mud as organic fertilizer improved the quality of wheat grains and soil properties with no effective increases in wheat yields. The integrated use of filter mud and NPK fertilizer was better than using each fertilizer separately.

Keywords
Wheat, NPK fertilizer, Filter mud, Chemical soil properties

1. Introduction

Wheat is the most important staple food crop in Egypt. It contributes to 19.6 % of total daily food requirements, 35.2 % of calories, 36 % of proteins, and 10.4 % of fats (FAO, 2018). It is also a good source of B vitamins and dietary fiber besides its uses for animal feeding. So, increasing wheat production is becoming a national target to save food security for the annually increased population. The gap (6.1 million tons; FAO, 2019) between the quantity used for food and domestic production is too big. Expanding wheat harvested area, moving up the productivity of the unit area, and/or minimizing the yield losses (21.5 % of the domestic production, FAO, 2019) present a 3-dimensions solution to reduce the gap of wheat production in Egypt. Producing wheat in new desert lands can contribute much to improving the wheat production situation in Egypt. However, expanding the wheat cultivated area in the desert lands is mostly faced by a lack of plant nutrients and water insufficiency. The newly reclaimed soils are very poor in their organic matter contents, plant nutrient levels, and water conservation. Adding organic fertilizers to sandy soils (the dominant type of desert land in Egypt) would improve the biotic, chemical, and physical properties of such soils including water-holding capacity. Filter mud (FM, press mud, or filter cake) is one of the by-products of the cane sugar industry and is produced in huge amounts near to 4 % of annually millable cane yield. FM is a good source for organic matter and plant nutrients mainly phosphorus (P) and others such as nitrogen (N), calcium (Ca), sulfur (S), and micronutrients (Korndorfer & Anderson, 1997). Continued decomposition of FM as a stable organic N source over a sustained period regulates the subsequent mineralization of available N in soil which is balanced by partial biological immobilization by soil microbes and this balance provides a residual source of N available for plant uptake (Kumar et al., 2017). Furthermore, if FM is left without economic use it could be an environmental pollutant. Yassen et al. (2010) indicated that increased grain and strawweight, total yield, crude protein, P and K uptake in grain with increasing filter mud rate applied from 1 % and 2 %. Muhammad et al. (2011) indicated that press mud improved the growth and yield attributes of wheat significantly over control. Application 20 t ha^{-1} press mud improved spikes number, 1000-grain weight, biological and grain yields compared to control. Khan et al. (2012) reported that organic matter, total nitrogen, and available P and K in soil increased progressively with rates of press mud application. Their highest values were registered at the highest level (100 tons ha^{-1}) of press mud application, while maximum wheat grain yield, spikes number, number of grains per spike, and 1000-grains weight were recorded in 40 t ha^{-1} rate. Hadad et al. (2015) found that the residual of available N, P, and K in the studied soil after wheat harvest as well as the uptake of these nutrients by plants increased gradually by increasing filter mud from 5 to 30 tons/fed where the use of filter mud at 30 ton/fed gave the best results. The application of filter mud significantly increased the soil organic matter content and N, P, and K in the soil after harvested (Abo-baker, 2017). Sameen et al. (2002) reported that with the increasing of NPK fertilizer doses the protein contents significantly increased in wheat grains. The highest protein content was recorded with the application of 175-125-50 kg NPK ha^{-1}. Laghari et al. (2010) found that application of 120-60-60 NPK kg ha^{-1} was optimum fertilizer treatment, which recorded maximum biological yield, grain yield, grains $spike^{-1}$, and NPK uptake. Abdel-Lateef (2018) reported that a significant increase in yield and yield components resulted from the rate of 100 % NPK without a significant difference between 80 and 100 % levels. However, the highest number of spikes/m^2, number of grains/spike, 1000-grain weight, and grain and biological yields/fed were recorded with 80 % of the recommended dose. Hadis et al. (2018) reported that the application of NPK fertilizers significantly increases the nutrient uptake of wheat. Singh (2017) indicated that the effect of press mud and NPK fertilizers was significant on the uptake of N, P, and K by the grain of wheat and organic carbon and NPK in the soil after harvesting. Treatment (3t/ha) press mud with 75 % NPK from recommended doses (RD) was better than 100 % RD NPK in NPK contents in the soil after harvesting while, 100 % RD NPK was the best in grain yield and uptake of N, P and K by the grain. Grains/spike increased significantly with 100 % RD NPK over control. Therefore, the objective of this research aimed at evaluating the impact of integrated use of three filter mud rates with four NPK fertilizer levels on wheat productivity and some chemical soil properties of desert land after wheat harvest.

2. Materials and Methods

A 2-year field experiment was conducted at Research Farm (El-kawamel) desert land site (26° 28' N and 31° 40' E), Faculty of Agriculture, Sohag University, Egypt in 2016/17 and 2017/18 winter seasons. The physical and chemical soil properties of the experimental site are presented in Table 1. The experiment was done to study the integrated effect of NPK levels with filter mud rates on yield, yield components, protein content in grain, NPK uptakes by wheat grain, and residual NPK and organic matter in the soil after harvest of wheat. The used experimental design was a randomized complete block design in split-plots arrangement with three replicates. The main plots were assigned to the four levels of NPK treatments (0, 50, 75, and 100 %) of the recommended dose, while the sub-plots were specified for the three rates of filter mud (0, 3, and 6 t/fed). The recommended fertilizer dose (NPK 100 %) was 100, 23.3, and 25 kg/fed of N, P_2O_5, and K_2O, respectively. The subplot area was 12 m^2 (4 m by 3 m).

Table 1. The Physical and chemical properties of the experimental soil site

	Texture	Bulk Density (g /cm^3)	Particle Density (g /cm^3)	Total Porosity (%)	Saturation Percent (%)	Field capacity (%)	Wilting point (%)	pHe	ECe (dS m^1)
2016/17	Sandy Loam	1.44	2.60	46.00	36.02	16.98	9.78	7.64	1.90
2017/18	Sandy Loam	1.36	2.46	43.4	33.98	16.02	9.22	8.10	1.80
	Ca CO_3 (%)	Total N (%)	Available P (ppm)	Available K (ppm)	O. M (%)	Available Fe (ppm)	Available Zn (ppm)	Available Cu (ppm)	Available Mn (ppm)
2016/17	3.30	0.08	11.63	154.40	0.30	1.98	0.67	0.36	1.58
2017/18	3.12	0.08	10.97	145.60	0.28	1.86	0.63	0.34	1.50

Filter mud fertilizer was added 10 days before planting to the soil surface. Chemical composition data of filter mud used in the two seasons are shown in Table 2. The total amounts of fertilizer P treatments were broadcasted once as mono-superphosphate (15.5 % P_2 O_5) on the treated plots. Fertilizer N (ammonium nitrate 33.5 % N) amount was split into four-equal doses, the 1st broadcasted at planting, the 2nd applied at Tillering stage, the 3rd given at the booting stage, and the 4th added at anthesis. Fertilizer K as potassium sulfate (46 % K_2O) was applied once with the 2nd portion of the N application.

Table 2. Chemical composition of filter mud used in the two seasons

	pH	EC dS m^{-1}	Total C (%)	O.M. (%)	Total N (%)	Available P (%)	Available K (%)	C/N, Ratio	Available Fe (ppm)	Available Zn (ppm)	Available Cu (ppm)
2016/17	7.76	3.97	22.43	38.66	1.22	0.97	0.91	18.67	19.99	12.32	17.66
2017/18	7.54	3.85	21.77	37.54	1.18	0.95	0.89	18.13	19.41	11.96	17.14

2.1. Soil analysis

The used particle size analysis was done according to the method described by Black (1965). Bulk density and Particle density were determined as described by Blake and Harge (1986). Moisture retention characteristics described by Richard (1954) was followed. Available Soil reaction (pH) using standard pH meter and electrical conductivity (EC) was done as the procedure given by Jackson (1973). Calcium carbonate (CaCO3) was determined as mentioned by Ryan et al. (2001), also the organic matter (O.M.) using the volumetric method of Walkley and Black (1934) was done. Total N was determined using the Kjeldahl digestion method as described by Black, (1965). Available P was extracted by 0.5 M NaHCO3 buffered at pH 8.5 as the method elaborated by Olsen (1954) and determined colorimetrically according to Page et al. (1982). Available K was extracted in 1.0 N ammonium acetate adjusted at pH 7.0 as the method recommended by Toth and Prince (1949) and was determined using the flame photometer according to Page et al. (1982). Available Fe, Zn, Mn, and Cu were extracted by the DTPA-TEA method and determined using an atomic absorption spectrophotometer (Landsay & Norvell, 1978). Plant analysis: total N was determined using the Kjeldahl digestion method as described by Black (1965). Total P was determined colorimetrically in the acid digest according to Page et al. (1982). Total K was determined using the flame photometer according to Page et al. (1982). Grain protein percentage was calculated by multiplying total N % by a factor of 5.83 according (Jones, 1931).

2.2. Recorded data

The recorded data were: Number of spikes/m^2, grains number /spike, 1000-grain weight, biological yield (t/fed), grain yield (ardab/fed), protein content in grain, grain N, P, and K uptakes. Where grain NPK uptakes were calculated by the formula: (NPK concentration in treatment sample × grain yield in the plot)/100. While after harvesting the wheat crop, soil N, P, and K contents, as well as soil organic matter, were recorded.

Statistical analysis: all collected data from both experiments in each season were statistically analyzed in each experiment by analysis of variance (ANOVA) procedures using the SAS System for windows release v. 9.2 according to SAS Institute (2008). Differences between means were compared by Least Significance Difference (LSD) at a 5% level of significance (Gomez & Gomez, 1984).

3. Results and Discussion

3. 1. Number of spikes/m^2

Data in Table 3 indicate that increasing NPK fertilizer level from 0 to 100 % increased the number of spikes/m^2. However, the differences among NPK fertilizer levels didn't reach the 5 % level of significance in both seasons. The reason for this observation might be due to the shortage of soil fertility (Table 1). These results are in agreement with those obtained by Abdel-Lateef (2018). Spikes' number didn't significantly respond to filter mud treatments in both seasons. Since the main effects of the two factors had slight differences on spike number/m^2, it's expected that the interaction effect among them would be insignificant.

3. 2. Grains number/spike

Data presented in Table 4 indicate that Grains number/spike was significantly affected by NPK fertilizer levels in both seasons. Applying NPK fertilizer level at 100 % gave the highest values of the number of grains/spike in the two seasons with no significant differences were detected between 50 %, 75 %, and 100 % NPK levels in both seasons. This result might be due to the essential functions of N, P, and K nutrients in wheat plant physiology during the vegetative growth and reproductive stages. These results are in agreement with those reported by Singh (2017). Slight differences in grains number/spike as a function of the effects of filter mud rate were observed in both seasons of study. Yet, the highest grains number/spike was found with the 6 t/fed filter mud rate in both seasons. Yet, the interaction effect was not significant on this trait in both seasons and this may be due to the independence of the studied factors.

3. 3. 1000-grain weight

Data presented in Table 5 indicate that Increasing NPK fertilizer level from 0 to 100 % caused an irregular increase in 1000-grain weight. Yet, the maximum 1000-grain weight was recorded with 75 % NPK level in the 1st season and 100 % NPK level in the 2nd season. The slight differences among 50, 75, and 100 % NPK in both seasons might return to the soil heterogeneity in the experiment's site in both seasons. These results are in agreement with those obtained Abdel-Lateef (2018). Increasing filter mud rates did not affect the 1000-grain weight, where didn't find significant differences between 0 t/fed and 6 t/fed filter mud, 0 t/fed recorded maximum 1000-grain weight value. Yet, the interaction effect was not significant on this trait in both seasons and this may be due to the independence of the studied factors.

Table 3. Effects of NPK fertilizer level, filter mud rate, and their interaction on spikes number/m^2 of wheat in 2016/17 and 2017/18 seasons

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean

0	223	287	250	290	263	99	117	142	166	131
3	225	277	269	278	262	85	143	171	137	134
6	256	251	258	269	259	119	125	157	157	139
Mean	235	272	259	279	261	101	129	156	153	135
					L.S.D. 5 %					
M					n.s.					n.s.
F					n.s.					n.s.
M*F					n.s.					n.s.

n.s. = Not significant at the 0.05 level

Table 4. Effects of NPK fertilizer level, filter mud rate and their interaction on grains number/spike of wheat in 2016/17 and 2017/18 seasons

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	31	43	53	53	45	34	44	44	40	41
3	22	51	48	47	42	34	46	46	48	43
6	29	48	52	56	46	43	49	47	53	48
Mean	27	47	51	52	44	37	47	45	47	44
					L.S.D. 5 %					
M					7.2					9.6
F					n.s.					n.s.
M*F					n.s.					n.s.

n.s. = Not significant at the 0.05 level

Table 5. Effects of NPK fertilizer level, filter mud rate and their interaction on 1000-grain weight (g) of wheat in 2016/17 and 2017/18 seasons

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	38.8	41.8	44.3	41.3	41.6	26.8	35.7	38.2	38.0	34.7
3	37.0	39.9	41.5	39.3	39.4	28.0	37.7	39.7	39.5	36.2
6	38.0	42.6	40.5	42.5	40.9	31.0	36.4	35.3	40.9	35.9
Mean	37.9	41.5	42.1	41.1	40.6	28.6	36.6	37.7	39.5	35.6
					L.S.D. 5%					
M					3.87					6.46
F					1.51					n.s.
M*F					n.s.					n.s.

n.s. = Not significant at the 0.05 level

3. 4. Biological yield

Data in Table 6 revealed that increasing NPK fertilizer levels from 0 to 50, 75, and 100 % led to significant increases in biological yield by 1.51, 2.31, and 3.60 t/fed in the 1st season and with 0.94, 1.18, and 2.00 t/fed in the 2nd season over the control (0 % NPK). The level of NPK at 100 % produced the maximum biological yield of 5.35 and 2.82 t/fed in the 1st and 2nd seasons, respectively. However, the difference in biological yield between the effects of 50 % and 75 % NPK levels was not significant in both seasons. Results reported by Laghari et al. (2010) and Mosaad and

Fouda (2016) are supporting these results. Increasing the rate of filter mud from 0 to 3 to 6 t/fed had no significant effect on biological yield at the 0.05 level, meanwhile, the highest values were recorded with 6 t/fed in both seasons. The obtained results are in agreement with those obtained by Yassen et al. (2010). The interaction effect between NPK levels and filter mud rates was significant on biological yield in the 1st season only, where the combined treatment of 100 % NPK level and 6 t/fed filter mud produced the highest biological yield.

3. 5. Grain yield

Data presented in Table 7 indicate that grain yield positively responded to increasing NPK fertilizer level from 0 to 100 % in both seasons. Since the increasing level of the applied NPK to 50, 75 and 100 % gradually caused increases amounted to 4.95, 7.45, and 11.38 ardab/fed in the 1st season, being 3.08, 3.37 and 5.70 in the 2nd season, respectively compared to control. The level of NPK at 100 % produced the maximum grain yield of 15.97 and 7.34 ardab/fed in the 1st and 2nd seasons, respectively. These increases in grain yield as a function of increasing NPK mineral fertilizer levels might again indicate the importance of N, P, and K nutrition in such infertile soil as the case of this experiment as shown in Table 1. Similar results were reported by Laghari et al. (2010) and Abdel-Lateef (2018). In general, figures of the data on grain yield in the 2nd season were smaller than those recorded in the 1st season. This observation might be due to the soil infertility or/and the higher temperature that were prevalent in the 2nd season of study. Slight insignificant increases were detected in grain yield as responded to filter mud rate increases from 0 to 3 to 6 t/fed in both seasons. The highest grain yield was recorded for the highest filter mud rate of 6 t/fed in both seasons of study. The insignificant role of filter mud in improving the grain yield in this study might be returning to that the used amount in this study wasn't big enough. Also, the used filter mud in this study was in raw material phase (without any added- enrichments) and wasn't yet decomposed to release the available plant nutrients to affect plant growth and yields. The interaction effect between the two factors was significant on grain yield in the 1st season only.

3. 6. Grain protein content

Data presented in Table 8 indicate that grain protein content was affected significantly by the main effects of the two studied factors and their interaction in both seasons. Increasing the level of NPK fertilizers from 0 to 50, 75, and 100 % caused a gradual increase in grain protein content in both seasons. This result is expected since increasing the availability of NPK nutrients would increase their absorbed and accumulated amounts in wheat grains. These results are in agreement with those reported by Sameen et al. (2002). Increasing the applied filter mud rates from 0 to 3 and 6 tons/fed caused a significant increase in protein content in grain in both seasons. The maximum value of grain protein content in the two seasons was recorded with 6 t/fed. While minimum value was recorded with 0 t/fed filter mud in the two seasons. Yassen et al. (2010) found similar results. Significant variation was remarked for protein content in grains due to the interaction effect between NPK fertilizer levels and filter mud rate in both seasons. Yet, the highest grain protein content resulted from the combined treatment of 75 % NPK fertilizer level and 6 t/fed filter mud rate in both seasons.

Table 6. Effects of NPK fertilizer level, filter mud rate, and their interaction on biological yield (t/fed) of wheat in 2016/17 and 2017/18 seasons

Filter mud	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0%	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean

Filter mud rate (F) (t/fed)	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	2.04	3.20	3.31	5.93	3.62	0.52	1.91	1.91	3.10	1.86
3	1.35	3.66	3.96	5.02	3.50	0.67	1.75	1.91	2.39	1.68
6	1.87	2.93	4.90	5.11	3.70	1.26	1.62	2.16	2.97	2.00
Mean	1.75	3.26	4.06	5.35	3.61	0.82	1.76	2.00	2.82	1.85
					L.S.D. 5 %					
M					0.958					0.469
F					n.s.					n.s.
M*F					1.010					n.s.

n.s. = Not significant at the 0.05 level.

Table 7. Effects of NPK fertilizer level, filter mud rate, and their interaction on grain yield (ardab/fed) of wheat in 2016/17 and 2017/18 seasons

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	5.03	9.02	9.67	16.75	10.12	1.08	5.23	4.61	7.98	4.73
3	3.76	10.86	12.21	15.01	10.46	1.41	4.67	4.72	6.01	4.20
6	5.00	8.75	14.25	16.15	11.04	2.42	4.26	5.70	8.04	5.10
Mean	4.59	9.54	12.04	15.97	10.54	1.64	4.72	5.01	7.34	4.68
					L.S.D. 5 %					
M					3.144					1.093
F					n.s.					n.s.
M*F					2.81					n.s.

n.s. = Not significant at the 0.05 level

Table 8. Effects of NPK fertilizer level, filter mud rate, and their interaction on protein content in grain (%) of wheat in 2016/17 and 2017/18 seasons

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	6.73	8.89	8.89	11.22	8.93	5.94	7.84	7.84	9.90	7.88
3	6.72	11.20	11.20	11.96	10.27	5.93	9.88	9.88	10.55	9.06
6	8.90	13.46	15.58	14.82	13.19	7.86	11.88	13.75	13.07	11.64
Mean	7.45	11.18	11.89	12.66	10.80	6.57	9.87	10.49	11.17	9.53
					L.S.D. 5 %					
M					0.353					0.312
F					0.466					0.411
M*F					0.932					0.822

3. 7. Grain N uptake

The data illustrated in Table 9 show that the application of NPK fertilizer significantly affected the grain N uptake. Increasing NPK levels from 0 to 50, 75, and 100 % led to a significant and gradual increase in grain N uptake. Maximum grain N uptake was observed with the treatment of 100 % NPK fertilizer level during both seasons. This result might be due to the fact that application of NPK improves the root growth and this will increase the ability of roots to absorb more soil nutrients and this, in turn, increases the uptake of nutrients. These results are in line with those obtained by Hadis et al. (2018). Increasing the applied filter mud rates from 0 to 3 and 6 t/fed caused a significant increase in grain N uptake in both seasons. Maximum grain N uptake was observed from the treatment of 6 t/fed in both seasons. These results agree with those obtained by Hadad et al. (2015). The interaction effect between NPK fertilizer levels and filter mud rate had a significant effect on grain N uptake in the 1st season only. The highest value of grain N uptake was recorded with 100 % NPK fertilizer level and 6 t/fed filter mud rate in both seasons.

3. 8. Grain P uptake

There was a significant increase in grain P uptake in both seasons as NPK fertilizer levels increased, whereas non-significant differences of grain P uptake between 50 and 75 % NPK in both seasons (Table 10). The highest grain P uptake was recorded with a 100 % NPK level. These results are in line with those reported by Hadis et al. (2018). Regarding the effect of the addition of filter mud, there was a significant increase in grain P uptake in both seasons as a result of increasing filter mud rate from 0 to 3 and 6 t/fed. The highest value for P content in grains was observed with the application of a 6 t/fed filter mud rate in both seasons. Similar results were found by Yassen et al. (2010) and Hadad et al. (2015). The interaction effect between NPK fertilizer levels and filter mud rates had a significant effect on grain P uptake in the 1st season only. Maximum grain P uptake was obtained from 100 % NPK fertilizer level and 6 t/fed filter mud rate in both seasons.

3. 9. Grain K uptake

Results in Table 11 reveal that increasing NPK level from 50 to 100 % significantly increased grain K uptake over the control with no significant difference in grain K uptake was found between the effects of 50 and 75 % levels in both seasons. Similar results were reported by Mosaad and Fouda (2016). Also, grain K uptake increased significantly as filter mud rate increased from 3 to 6 t/fed with no significant difference was detected between the control and 3 t/fed rates in both seasons. Hadad et al. (2015) found similar results. The interaction effect between NPK fertilizer level x filter mud rate caused a significant increase in K content in grains in 1st season only. The highest K content in grains was recorded with a 100 % NPK fertilizer level and 6 t/fed filter mud rate.

Table 9. Effects of NPK fertilizer level, filter mud rate, and their interaction on grain N uptake (kg/fed) of wheat in 2016/17 and 2017/18 seasons

Filter mud	2016/17					2017/18				
rate (F)	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
(t/fed)	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	8.69	20.63	22.12	48.37	24.95	1.64	10.52	9.29	20.29	10.43
3	6.48	31.34	35.17	46.21	29.80	2.16	11.88	12.01	16.38	10.61
6	11.42	30.33	57.16	62.09	40.25	4.93	12.98	20.29	26.83	16.26
Mean	8.87	27.43	38.15	52.23	31.67	2.91	11.79	13.86	21.17	12.43
L.S.D. 5 %										
M					11.247					4.542
F					5.191					3.533
M*F					10.380					n.s.

n.s. = Not significant at the 0.05 level

Table 10. Effects of NPK fertilizer level, filter mud rate, and their interaction on grain P uptake (kg/fed) of wheat in 2016/17 and 2017/18 seasons

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	1.63	5.25	4.50	12.38	5.94	0.33	2.82	1.96	5.54	2.66
3	1.54	5.21	7.66	9.35	5.94	0.50	2.08	2.74	3.48	2.20
6	2.04	5.73	9.54	12.45	7.44	0.91	2.60	3.67	5.82	3.25
Mean	1.74	5.40	7.23	11.39	6.44	0.58	2.50	2.79	4.95	2.70
					L.S.D. 5 %					
M					2.167					0.844
F					0.911					0.840
M*F					1.820					n.s.

n.s. = Not significant at the 0.05 level

Table 11. Effects of NPK fertilizer level, filter mud rate, and their interaction on grain K uptake of wheat in 2016/17 and 2017/18 seasons.

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	5.49	17.64	15.11	41.59	19.96	1.17	9.92	6.89	19.49	9.37
3	5.16	17.52	25.73	31.43	19.96	1.77	7.31	9.64	12.25	7.75
6	6.84	19.24	32.05	41.84	25.00	3.19	9.15	12.92	20.47	11.43
Mean	5.83	18.14	24.30	38.28	21.64	2.04	8.80	9.82	17.40	9.51
					L.S.D. 5 %					
M					7.281					2.967
F					3.062					2.955
M*F					6.120					n.s.

n.s. = Not significant at the 0.05 level

3. 10 . Soil N content

Data presented in Table 12 revealed that soil N content after harvesting was significantly and gradually increased by increasing NPK fertilizers levels from 0 to 50, 75, and 100 % in both seasons. These results are consistence with those obtained by Rakshit et al. (2015). Increasing filter mud rate from 0 to 6 t/fed led to a significant increase in soil N content after harvesting where 6 t/fed recorded the highest value of soil N content in both seasons. Yet, the difference between 6 and 3 t/fed filter mud rate was insignificant in both seasons. These results are consistent with those reported by Hadad et al. (2015), Abo-baker (2017), and Kumar et al. (2017). Yet, the interaction effect was not significant on this trait in both seasons and this may be due to the independence of the studied factors.

3. 11 . Soil P content

Data presented in Table 13 reveal that the NPK fertilizer levels exhibited a significant effect on P content in the soil after wheat harvest where the applied levels i.e. 50, 75, and 100 % NPK were significantly the same and higher in soil P content than that of the control in both seasons. These results are in agreement with those obtained by Rakshit et al. (2015). Soil P content was significantly and steadily increased by increasing filter mud rate from 0 to 3 to 6 t/fed in both seasons. These results are in agreement with those reported by Khan et al. (2012) and Abo-baker

(2017). The interaction effect between NPK fertilizers level and filter mud rate had a significant effect on P content in the soil after harvesting in both seasons. Yet, the 75 % NPK level combined with 6 t/fed filter mud rate recorded the highest value of soil P content after harvest in both seasons.

3. 12 . Soil K content

Soil K content after harvesting increased significantly by increasing NPK fertilizer levels from 0 to 100 % with no significant difference in K content being found between 75 % and 100 % in both seasons (Table 14). These results are in agreement with those observed by Rakshit et al. (2015). The increasing rate of filter mud from 0 to 6 t/fed led to a significant increase in soil K content after harvesting in the two seasons. However, there was no significant difference in K content in both seasons was noticed between 3 t/fed filter mud and the control. Similar results were also observed by Khan et al. (2012) and Abo-baker (2017). The interaction between NPK fertilizer levels x filter mud rate had a significant effect on soil K content after wheat harvest in both seasons. Yet, the combined treatment of 100 % NPK level and 6 t/fed filter mud gave the highest value of soil K content after harvest.

3. 13 . Soil organic matter (OM) content

Soil OM content after the wheat harvest had a significant and irregular increase by increasing NPK fertilizer levels from 0 to 100 % with no significant difference was found between the effects of 50 and 75 % levels in both seasons (Table 15). Yet, the highest soil OM content was recorded with the highest 100 % NPK level in both seasons. The same trend was obtained by Singh (2017). Increasing the rate of filter mud from 0 to 6 t/fed led to a significant increase in soil OM content after harvesting in the two seasons with no significant difference found in soil OM content between the effect of 3 and 6 t/fed rates. These results are in agreement with those obtained by Abo-baker (2017) and Kumar et al. (2017). The interaction effect between NPK fertilizers level and filter mud rate had a significant effect on OM content in the soil after harvesting in both seasons. The highest soil OM content after harvesting resulted from combined treatment of 3 t/fed filter mud rate and 50 % NPK level in both seasons. However, the difference in OM content between 3 and 6 t/fed filter mud under 50 % NPK level wasn't significant in both seasons.

Table 12. Effects of NPK fertilizer level, filter mud rate, and their interaction on soil N content (%) after harvesting of wheat in 2016/17 and 2017/18 seasons.

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	0.10	0.59	0.69	0.79	0.54	0.09	0.55	0.63	0.73	0.50
3	0.13	0.65	0.67	0.82	0.57	0.12	0.60	0.62	0.76	0.52
6	0.16	0.66	0.73	0.83	0.59	0.15	0.61	0.67	0.76	0.55
Mean	0.13	0.63	0.70	0.81	0.57	0.12	0.59	0.64	0.75	0.52
					L.S.D. 5 %					
M					0.026					0.024
F					0.033					0.030
M*F					n.s.					n.s.

n.s. = Not significant at the 0.05 level

Table 13. Effects of NPK fertilizer level, filter mud rate, and their interaction on soil P content (ppm) after harvesting of wheat in 2016/17 and 2017/18 seasons.

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	13.7	29.1	29.1	32.1	26.0	12.6	26.8	26.9	29.6	24.0
3	25.5	37.3	33.2	33.4	32.4	23.5	34.5	30.6	30.8	29.9
6	30.8	39.6	44.2	36.1	37.7	28.4	36.6	40.8	33.3	34.8
Mean	23.3	35.4	35.5	33.9	32.0	21.5	32.6	32.7	31.3	29.5
					L.S.D. 5 %					
M					3.600					3.321
F					2.533					2.337
M*F					5.071					4.670

Table 14. Effects of NPK fertilizer level, filter mud rate and their interaction on soil K content (ppm) after harvesting of wheat in 2016/17 and 2017/18 seasons.

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	130.6	183.5	181.7	188.9	171.2	120.5	169.3	167.6	174.3	157.9
3	179.9	185.3	182.3	170.7	179.5	166.0	171.0	168.2	157.5	165.6
6	189.9	217.1	265.4	287.0	239.9	175.2	200.3	244.9	264.8	221.3
Mean	166.8	195.3	209.8	215.5	196.9	153.9	180.2	193.6	198.9	181.6
					L.S.D. 5 %					
M					21.94					20.24
F					15.75					14.54
M*F					31.51					29.07

Table 15. Effects of NPK fertilizer level, filter mud rate and their interaction on soil organic matter (%) after harvesting of wheat in 2016/17 and 2017/18 seasons

Filter mud rate (F) (t/fed)	2016/17					2017/18				
	NPK mineral fertilizer level (M)					NPK mineral fertilizer level (M)				
	0 %	50 %	75 %	100 %	Mean	0 %	50 %	75 %	100 %	Mean
0	0.27	0.86	0.94	1.78	0.96	0.25	0.79	0.87	1.64	0.89
3	0.92	2.09	1.75	1.94	1.68	0.85	1.93	1.62	1.79	1.55
6	1.62	1.93	1.74	1.78	1.77	1.50	1.78	1.61	1.65	1.63
Mean	0.94	1.63	1.48	1.83	1.47	0.86	1.50	1.37	1.69	1.36
					L.S.D. 5 %					
M					0.184					0.170
F					0.199					0.184
M*F					0.400					0.370

4. Conclusions

Application of 100 % NPK fertilizer level produced the highest quantity and quality of wheat grain and straw yields, in addition to its good effects on soil properties. The used filter mud as organic fertilizer improved the quality of wheat grains and soil properties with no effective increases in wheat yields. The integrated use of filter mud and NPK fertilizer was better than using each fertilizer separately.

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الملخص العربي

تأثير الاستخدام المتكامل لطينة المرشحات والسماد المعدني للنتروجين والفوسفور والبوتاسيوم علي إنتاجية القمح والخصائص الكيميائية للتربة في أرض صحراوية

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أجريت تجربة حقلية لموسمين متتاليين في المزرعة البحثية لكلية الزراعة بالكوامل، جامعة سوهاج وذلك لدراسة تأثير الاستخدام المتكامل لثلاث معدلات من طينة المرشحات (صفر ، 3 ، 6 طن/فدان) و أربع مستويات من السماد المعدني للنتروجين و الفوسفور و البوتاسيوم (صفر ، 50 ، 75 ، 100 % من المعدل الموصي به) علي إنتاجية قمح الخبز و معدل امتصاص النتروجين و الفوسفور و البوتاسيوم وبعض خصائص التربة الكيميائية. أظهرت النتائج أن مستويات السماد المعدني كان لها تأثير معنوي علي عدد الحبوب بالسنبلة و وزن الالف حبة و المحصول البيولوجي و محصول الحبوب و نسبة البروتين في الحبوب و معدل امتصاص النتروجين و الفوسفور و البوتاسيوم و نسبة النتروجين و الفوسفور و البوتاسيوم و المادة العضوية في التربة بعد الحصاد. اضافة مستوى السماد المعدني 100 % من النتروجين والفوسفور والبوتاسيوم ادى الى اعلى كمية وافضل جودة من الحبوب والقش بالإضافة الى اثره الجيد في تحسين صفات التربة. استخدام طينة المرشحات كسماد عضوي للقمح حسن من جودة الحبوب و الخصائص الكيميائية للتربة و لم يكن له زيادات مؤثرة في المحصولين البيولوجي و الحبوب. الاستخدام المتكامل لطينة المرشحات والسماد المعدني كان أفضل من استخدام كلا منهما منفصلين.

الكلمات المفتاحية

القمح، السماد المعدني، طينة المرشحات، خصائص التربة الكيميائية