J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 7 (5): 325 – 333,2016

The Impact of Long-Term Fertilization on Depletion and Accumulation of Some Elements in Soil and Wheat Yield in Permanent Experiment at Bahtim Station.

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ABSTRACT

In the long-term experiment which was established in 1912 and modified in 1989 at Bahtim in Kaliobia Governorate, Egypt (Latitude 30°8'22"'N, Longitude N 31°15'50") where wheat plants (Triticum aestivum L., var. Gemmaza 9) were planted during 2014 and 2015 winter seasons. Design of the two experiments is a randomized completely block. The current investigation aimed to study the effects of long-term fertilization on the depletion and accumulation of some elements in the soil and its effect on yield of wheat crop. The results confirmed that, highest values of straw, grain biological yield and 1000-grain weight were obtained with complete fertilizers application of N, P and K compared with fertilizer alone. The relative increase of wheat biological yield, N, P and K % and their uptake by grain of wheat resulted from adding fertilized N_{60} + $P_{19.5}$ + K_{48} kg.fed^{-1} were higher than those from N_{30} + $P_{19.5}$ + K_{48} and N_{15} + $P_{19.5}$ + K_{48}, respectively. In addition, the effect of (FYM) with long term was parallel to that noticed for complete fertilization treatments in both old and new experiment. In addition, in the old experiment, values of Fe, Mn, Zn, Cu and Pb were significantly increased in grain under organic fertilizers FYM compared to those of inorganic fertilizers treatments. While, in both of old and new experiments the concentrations of Fe, Mn, Zn, Cu and Pb in grain of wheat under inorganic fertilization treatments were higher in the plots fertilized by super phosphate than those of other inorganic treatments. Also, the significant increase of Fe, Mn, Zn, Cu and Pb concentrations of wheat grains were achieved by adding fertilizers at N_{60} + $P_{19.5}$ + K_{48} kg. fed-1 comparing with that gained by N_{30} + $P_{19.5}$ + K_{48} and N_{15} + $P_{19.5}$ + K_{48}, respectively. In the old experiment, the highest values of available forms of N-NO_3^-, N-NH_4^+, N and K of soil were obtained by applying FYM fertilizer treatments but available P in soil inorganic treatment was higher than that of FYM. On the contrary, the highest values of available Mn, Zn, Pb and Cu in inorganic NPK treatment were higher than FYM, while, Fe in soil treated with FYM was higher than that of NPK fertilizer. In addition, in soil of new experiment the available Form N-NH_4^+, N, P and K were higher in the plots resaving N_{30} + $P_{19.5}$ + K_{48} than those in N_{60} + $P_{19.5}$ + K_{48}. On the contrary, the available Fe, Mn, Zn, Pb and Cu under N_{60} + $P_{19.5}$ + K_{48} was higher than those of N_{30} + $P_{19.5}$ + K_{48} treatments. Values of available N, P and K in soil were decreased with decreasing of N levels and depletion of P, K with long-term experiment and with increasing plants requirement. While, accumulation micronutrients in soil were found as a result of using inorganic fertilizers in long term experiment. After more than 104 years of establishing these experiments and with low productivity, there is little doubt that current nutrient management practices are not sustainable and more efficient management systems need to be developed. Therefore, it must take into account crop types, high fertilizer requirements and combining between mineral fertilizers and FYM or crop residues but with retention of old plots to compare with new treatments.

Keywords: long-term fertilization, depletion, accumulation, some elements in wheat crop, biological yield.

INTRODUCTION

Long-term field experiments are crucially important for understanding of dynamic soil, nutrient, crop, management and weather processes and interactions, and provide one of the few means for evaluating sustainable agricultural management systems and better prediction of the future (Richter et al., 2007). Some of soil processes cannot be reliably determined with short-term studies and may only be seen over a period of time (Girma et al., 2007). Long-term fertilization experiment is considered a sustainable scientific methodology, which aim to study the impact of resource use fertilization in the long term and its effect on soil properties and crops. In Egypt two experiments have been established. The first one has been in the year (1912). The experimental plots were treated with mineral fertilizer (0, N, NP and NPK) compared to organic fertilization (FYM). Fertilizers were used under three systems of the agricultural rotation, which the cotton is main crop. The nitrogen fertilization rate is 15 units N fed^{-1} only. However, with increase the plants requirement from nitrogen. The second experiment has been established during 1989 by the same treatments with increasing the rate of nitrogen to 60 and 30 unit's N fed^{-1}. Sustainable high crop production needs appropriate fertilization strategies, which must take into account crop types, agronomic management practices, and soil and climatic conditions. On the other hand, the continuation of agriculture of such experiments for more than 104 years, low productivity may be due to other factors.

A long-term experiment at Changwu station in China showed that fertilization is a common driving force increasing crop yield, subsoil water deficit, and NO_3^--N accumulation in the soil profile in dryland (Guo et al., 2005). Although fertilizer consumption is increasing quantitatively, the corresponding yield increase per unit of nutrient has diminished over the years (Samra and Sharma, 2011). K application has been neglected in many developing countries, including Egypt, which has resulted in soil K depletion in agricultural ecosystems and a decline in crop yields (Lal et al., 2007). Balancing the fertilizer N application of different crops with fertilizer K is an urgent need to achieve higher nitrogen use efficiency. Balanced use of N and K fertilizers in cereals and other crops will not only prove more profitable for farmers but also lead to reduce environmental degradation and climate change effects caused by dissipation of N originating from agricultural soils (Brar et al., 2011).

The application of P fertilizers leads to increased crop biomass production and a corresponding increase in the amount of organic matter returned to soil. However, conflicting reports on the effect of long-term application of fertilizers and manure on crop production and soil quality, and on nutrient cycling in dry land soil–plant systems. Some investigations have shown that long-term use of increased amounts of chemical fertilizers may degrade soil structure and the productive capacity of the soil (Doran et al., 1996) and cause serious environmental damage to water, air, and soil (Chalk et al., 2003). Other studies have revealed positive effects of fertilization on soil quality and productivity (Sheng-Mao et al., 2006).

In addition, soil application of N or P, K fertilizers does not fully meet the nutrient demand of crops in the long run. Eventually, it results into deficiency of many other macronutrients and micronutrients (Prasad and Power 1995). Balanced fertilization enhances biomass production that protects soil from erosion and increases crop residues critical for soil aggregation (Buol and Stokes 1997). Organic carbon contents are also lowered down under inadequate fertilization. On the other hand, they noted that further, continuous cropping with chemical fertilizers alone could decline crop yields over the time (Saleque et al., 2004).

The recycling of livestock manure in cropping systems is considered to enhance soil fertility and crop productivity. Therefore, in Egypt, there has been systematic experiment long-term to study the effects of manure application on soil and crops and effect of macro and micronutrients, heavy metals on crop yield production. Application of animal manures can contribute in providing substantial amounts of N, P, K and other nutrients in crop production (Fageria, 2009). (Korsaeth et al., 2002) reported that sustainable agriculture, organic manure is a good source for N supply to crop plants. (Kang et al., 2005) found that long-term use of organic amendments in rice/corn–wheat cropping system enhanced the value of soil quality index due to increase in the indices of nutrients, microbes and crop attributes. Further use of FYM at 10 t ha−1 prior to corn sowing turned the system more sustainable compared with 100 % NPK in corn–wheat system.

The main objective of this study is to test the effects of long-term fertilization on the depletion and accumulation of some elements in the soil as a result of the continuation of fertilization and its effect on yield of wheat crop.

MATERIALS AND METHODS

This study was conducted in the long-term experiment which was established in 1912 and modified in 1989 at Bahtim Agricultural Research Station, Agricultural Research Center (ARC), in Kaliobia Governorate, Egypt (Latitude 30°8'22"'N, Longitude E 31°15'50") during winter season 2014/2015, where wheat plants (Triticum aestivum L., var. Gemmaza 9) were planted. The design used for the two experiments was a randomized complete block with three replicates as follows: the treatments from T1 to T5 of old plots established in 1912 and those from T6 to T12 of new plots established in 1989, were used for this study:

T1 = Control (soil without fertilization).

T2 = inorganic fertilizer at level of 15 kg. N fed^{-1}.

T3 = inorganic fertilizer at level of 15 kg. N fed^{-1} + 19.5 kg. P_2O_5 fed^{-1}.

T4 = inorganic fertilizer at level of 15 kg. N fed^{-1} + 19.5 kg. P_2O_5 fed^{-1}+ 48 kg. K_2O fed^{-1}.

T5 = farmyard manure 15 tons fed^{-1} (FYM).

T6 = Control (soil without fertilization) established in 1989.

T7 = inorganic fertilizer at level of 30 kg. N fed^{-1}.

T8 = inorganic fertilizer at level of 30 kg. N fed^{-1}. + 19.5 kg. P_2O_5 fed^{-1}.

T9 = inorganic fertilizer at level of 30 kg. N fed^{-1} + 19.5 kg. P_2O_5 fed^{-1}+ 48 kg. k_2O fed^{-1}.

T10 = inorganic fertilizer at level of 60 kg. N fed^{-1}.

T11 = inorganic fertilizer at level of 60 kg. N fed^{-1}. + 19.5 kg. P_2O_5 fed^{-1}.

T12 = inorganic fertilizer at level of 60 kg. N fed^{-1}. + 19.5 kg. P_2O_5 fed^{-1} + 48 kg. K_2O fed^{-1}.

Treatments of the farmyard manure (FYM)15 tons fed^{-1} (FYM) was added before sowing. Phosphorus and potassium were applied before planting in the forms of superphosphate (15 % P_2O_5) and potassium sulfate (48 % K_2O) respectively. Nitrogen was applied in the form of ammonium nitrate (33.5 % N), where 20 % of the total dose was applied at sowing, 40 % before the first irrigation and 40 % before the second irrigation. The irrigation was 100% of the field capacity. Wheat grains were sown at the rate of 60 $kg.fed^{-1}$. Some physical and chemicals of the cultivated soil are given in Table 1a, while farmyard manure, and NPK mineral fertilizers M.F. used are given in Table 1b. Soil and plant were sampled at tow stage the first at 45 days the second at harvest. Surface soil samples (0-30 cm depth) also were collected from each plot at tow stage the first at 45 days the second at after harvesting, then dried, grounded and subjected to determine available NO_3^- , NH_4^+ and total N as (NO_3^- and NH_4^+) as outlined by Black (1983). And available P, K, Fe, Mn, Zn, Cu and Pb, were extracted by using AB-DTPA according to (Soltanpour and Schwab 1991). FYM, NPK (M.F.) and soil were digested by using aqua regia according to (Cottenie et. al., 1982).

After wheat maturity (165 days), 1000-grain weight, grain yield and straw yield of each plot were recorded, plant samples of wheat were collected from each plots were collected by using 1 m^2 wooden frame to determine wheat yield and its components. Samples of grains and straw were oven dried at 70°C up to a constant dry weight, grounded and prepared for digestion method as described by (Page et al. 1982).

Table 1a: Some physical and chemical analysis of the used soil of a long-term experiment located at Bahtim region.

Characteristics Pore size distribution		Values	Characteristics Soluble cations and anions		Values
Sand	%	21.60	Ca^{2+}	me L^{-1}	2.10
Silt	%	25.66	Mg^{2+}	me L^{-1}	1.96
Clay	%	52.74	Na^{+}	me L^{-1}	1.27
Texture class		Clay	K^{+}	me L^{-1}	0.32
$CaCO_3$	%	2.50	$CO3^{=}$	me L^{-1}	0.00
OM	%	1.30	HCO_3^{-}	me L^{-1}	1.84
pH	(1:2.5)*	7.85	Cl^{-}	me L^{-1}	1.49
CEC	mg 100 g $soil^{-1}$	53.4	$SO4^{=}$	me L^{-1}	2.32
EC	dS m^{-1}	0.57			
SP	%	52.00			

Available elements mg kg^{-1}

N	P	K	Fe	Mn	Zn	Cu	Pb
40.68	4.20	220.00	5.71	4.32	3.18	3.39	0.54

***=In soil and water suspension.**

Table 1b: Analysis of farmyard manure (cattle manure) and mineral fertilizers used in this study:

Items	FYM		Fertilizer types N		P_2O_5		K_2O	
Moisture %	47.80		---		---		---	
OM %	50.10		---		---		---	
OC %	18.20		---		---		---	
C/N ratio	1:18		---		---		---	
pH (1:100)	8.90*		6.02**		2.61**		5.93**	
EC (dS m^{-1})	2.90*		16.01**		4.05**		12.57**	
	Total	Soluble	Total	Soluble	Total	Soluble	Total	Soluble
N %	1.00	0.06	Nd	33.53	Nd	Nd	Nd	Nd
P_2O_5 %	0.916	0.114	Nd	Nd	Nd	15.89	Nd	Nd
K_2O %	1.46	0.0.52	Nd	Nd	Nd	Nd	Nd	47.00
Fe mg.kg^{-1}	2527.5	35.64	2.08	1.55	8002.9	54.60	99.10	3.30
Mn mg.kg^{-1}	149.00	23.00	1.30	0.50	454.73	94.4	1.83	0.80
Zn mg.kg^{-1}	68.70	20.60	28.1	4.90	174.85	145.01	5.30	0.85
Cu mg.kg^{-1}	12.00	2.49	1.20	0.70	7.95	1.70	1.60	0.65
Pb mg.kg^{-1}	16.29.	4.21	20.0	0.60	30.00	4.03	23.00	0.45

***= Suspension 1:10 **= Extract 1:100**

The digests were then subjected to measurement of macronutrients (N, P and K) using the procedure described by (Ryan et al., 1996). The digests were then subjected for measurement of macro and micro nutrients and Pb. Available, NO_3^- , NH_4^+ and total N as forms (NO_3^- and NH_4^+) in soil, FYM , soluble in M.F., content in grains and strew were determined by Kjeldahel technique. Available K in soil, FYM, soluble in M.F., grains and strew content ware determined by flame photometer as described by (Jackson 1973). Available P, Fe, Mn, Zn, Cu and Pb in soil, FYM ,soluble in M.F., grains & strew content and total P, Fe, Mn, Zn, Cu and Pb in FYM ,and M.F., ware were determined by inductively coupled plasma spectrometry (ICP) (Ultima 2 JY Plasma) according to the procedure of EPA. (Environmental Protection Agency 1991).

Data for each reading were collected in triplicates, the analysis of variance (ANOVA) was done and Least Significant Differences (L.S.D.) was calculated. The statistical analysis was done by using (Co-stat program SAS Institute 1985).

RESULTS AND DISCUSSION

Sustainable fertilization experiments were designed in Egypt to study the addition of only mineral fertilizers and organic fertilizers only and its impacts on crop yields in the long term. Data in Table 2 show that the straw, grain and biological yield of wheat as well as weight of 1000-grain were significantly increased due to the complete mineral fertilization (NPK) as compared with control treatments in both of old and new experiments. The highest values of straw, grain, biological yield and 1000-grain weight were obtained with fertilizers application of N, P and K. Also results show general positive responses to the applied N dose in both of old and new experiments. The relative increase for biological yield of wheat resulted from adding fertilizers at $N_{60} + P_{19.5} + K_{48}$ kg.fed^{-1} which was higher than the other fertilizer treatments.

Sustainable high grain production needs appropriate fertilization strategies, which must take into account crop types, agronomic management practices, and soil and climatic conditions. In this connection, (Sheng-Mao et al., 2006) mentioned that, nitrogen is the main and most frequently yield-limiting nutrient for high yields of most field crops they added that, interactions among chemical fertilizers and between chemical fertilizers and farmyard manure may have a profound effect on the yield response of crops to applied fertilizers.

Data also indicated that straw, grain and biological yield of wheat were increased in the plots received farmyard manure as compared with non manure ones.

Table 2: Effect of permanent fertilization on straw, grain and biological yield (kg.fed^{-1}) as well as relative increase in biological yield and weight of 1000 grain (g.) of wheat plants grown on both old and new experiments.

Fertilizer treatments	Straw Yield (kg.fed^{-1})	Grain yield (kg.fed^{-1})	Biological yield (kg.fed^{-1})	The relative increase in Biological yield (%)	Weight of 1000 grains (g)
Old experiment					
Control	493	576	1069	0	32.5
N_{15}	678	570	1257	15	37.54
$N_{15}+ P_{19.5}$	749	580	1326	19	32.81
$N_{15}+P_{19.5+} K_{48}$	714	619	1333	20	41.77
FYM	646	640	1286	17	40.68
LSD at 0.05	4.09***	3.63***	3.64***	-	0.36***
New experiment					
Control	453	510	1009	0	31.4
N_{30}	549	637	1186	10	36.44
$N_{30} + P_{19.5}$	633	688	1321	19	39.84
$N_{30} +P_{19.5\ +} K_{48}$	741	670	1411	24	42.99
N_{60}	799	905	1704	37	40.15
$N_{60} + P_{19.5}$	999	852	1852	42	45.23
$N_{60} +P_{19.5\ +} K_{48}$	935	1069	2004	47	45.6
LSD at 0.05	3.50***	3.50***	3.51***	-	0.53***

The effect of farmyard manure was parallel to that noticed for complete fertilization treatments. This finding is quite similar to those found by (Bhata and Shukla 1982) who found that the highest value of dry matter yield of wheat crop were realized under either complete mineral fertilization (NPK) or farmyard manure. (Werner 1997) observed that increase in soil organic matter following the transition to organic management occurs slowly, generally, it takes several years, still contributing to long-term productivity. In most long-term experiments, combinations of chemical fertilizers and farmyard manure have produced the highest crop yields in many parts of the world (Yang et al., 2004). There is little doubt that current nutrient management practices are not sustainable and more efficient management systems need to be developed. Therefore, we recommend developing the treatment plots in both old and new experiments by combining addition of mineral fertilizers and organic ones or organic crop residues, but with notes the old treatment should continue in plots to compare with new treatments. (Yuxin et al., 2011) indicated that, a review of long-term experiments conducted around the world indicated that chemical fertilizer alone is not enough to improve or maintain soil fertility. Organic fertilizers can improve soil fertility and quality, but long-term application at high rates can also lead to more nitrate leaching, and accumulation of P, if not managed well. Well-managed combination of chemical and organic fertilizers can overcome the disadvantages of applying single source of fertilizers and sustainably achieve higher crop yields and improve soil fertility.

Concentrations of macro, micro nutrients and Pb in grain yield of wheat under organic and inorganic fertilization systems for both old and new experiments.

Data presented in Table 3 show that the highest significant values of N, P and K% and their uptake in grain of wheat were obtained when fertilizers N, P and K were applied. This may be due to application of NH_4^+ ion release from soil as a result of K application and helped the crop for better uptake of nitrogen (Sharma and Ramna 1993). Presented results clearly show that a balanced fertilizer N, P and K ratio is an effective method for increasing crop yields, enhancing N uptake, this result was confirmed with those obtained by (Fan et al., 2010). Also, the highest increase of N, P and K % and their uptake in wheat grain was noticed by increasing nitrogen levels. The significant increase for wheat grain in N, P and K % and uptake resulted from adding $N_{60} + P_{19.5} + K_{48}$ kg.fed^{-1} compared to the other treatments. This result confirmed that depletion of P and K in the unfertilized plots as well as control treatments were reason for the decrease of grain yield and N, P and K content. Similar results were obtained in a 90-years field study in Denmark, application of N, P and K fertilizer that increased soil organic matter content as compared to unfertilized control soil (Schjønning et al., 1994).

On the other hand, data in Table 3 show macro, micro nutrients and Pb elements concentrations in grain of wheat under organic and inorganic fertilization systems for both old and new experiments. In the old experiment, the concentrations of Fe, Mn, Zn, Cu and Pb in grain under organic fertilizers (FYM) were significantly higher than inorganic fertilizer treatments. Obtained results may be attributed to the effects of manure decomposition on improving the availability of different heavy elements through produced organic acids of the indicated organic matter. This may agree with results of Ross (1994) who reported a chelating action with various elements as well as decreases in pH of soils, both resulting in more available form. Also, Qian et al., (2003) found significant increases in DTPA extractable Zn and Cu following the use of cattle manures and with the accumulation of mentioned heavy metals in soil. Fan et al., (2016) found that compost application increased the soil total N and the available K, Fe, Zn and Mn concentrations in soil, whereas the available P in soil was not affected, and the available Cu was decreased.

On the other hand, in both old and new experiments, the concentrations of Fe, Mn, Zn, Cu and Pb in grain of wheat under inorganic fertilization treatments were higher in plots fertilized with super phosphate than other inorganic treatments. Also, The significant increase in Fe, Mn, Zn, Cu and Pb concentrations in wheat grains resulted from adding N_{60} + $_{P19.5}$ + K_{48} kg.fed^{-1}was higher than those of N_{30} + $P_{19.5}$ + K_{48} kg.fed^{-1} and N_{15} + $P_{19.5}$ + K_{48} kg.fed^{-1} treatments, respectively. These results may be attributed to using mineral fertilizers contaminated with macro, micro nutrients and heavy metals which may contribute to the high concentration of heavy metals in soil and the studied crops. Such results were agree with those obtained by Brady and Weil (2002) who reported that plant roots take up N from the soil solution principally as nitrate (NO_3^-) and ammonium (NH_4^+) and the effects of these two ions on the pH of the root rhizosphere is known to influence the uptake of other companion ions, such as phosphate.

Table 3: Effect of permanent fertilization on macro micro-nutrients and Pb content in grain of wheat plants grown on both old and new experiments.

Treatments	N %	N Uptake	P %	P uptake	K %	K uptake	Fe mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	Cu mg kg^{-1}	Pb mg kg^{-1}
Old experiment											
Control	0.6	3.46	0.346	1.99	0.21	1.21	115	43.3	41.25	164	3.30
N_{15}	0.7	3.99	0.463	2.64	0.25	1.43	110	44.0	42.25	86	2.30
N_{15}+ $P_{19.5}$	0.84	4.87	0.452	2.62	0.28	1.62	162	45.8	42.75	90	4.80
N_{15}+$P_{19.5+}$$K_{48}$	0.91	5.63	0.412	2.55	0.26	1.61	238	46.5	48.75	149	3.80
FYM	0.74	4.74	0.401	2.57	0.23	1.47	252	52.3	49.25	211	3.30
LSD at 0.05	0.01	0.13	NS	NS	0.01	0.12	1.81	1.81	1.81	1.81	NS
New experiment											
Control	0.8	4.61	0.405	2.33	0.24	1.38	186	43.3	43.50	37	1.80
N_{30}	1.19	7.58	0.357	2.28	0.23	1.47	185	37.0	47.25	45	3.30
N_{30} + $P_{19.5}$	1.05	7.22	0.461	3.17	0.29	2.00	122	55.8	60.25	141	5.80
N_{30}+$P_{19.5+}$$K_{48}$	1.16	7.77	0.536	3.59	0.31	2.08	276	68.5	59.25	83	3.00
N_{60}	1.3	11.77	0.443	2.79	0.23	1.50	177	61.3	52.25	74	4.50
N_{60} + $P_{19.5}$	0.98	8.35	0.503	4.01	0.24	2.04	275	49.0	46.00	128	7.30
N_{60}+$P_{19.5+}$$K_{48}$	1.19	12.72	0.261	4.29	0.14	2.08	319	57.8	61.25	176	7.30
LSD at 0.05	0.017	0.17	NS	1.39	0.01	0.14	1.75	1.75	1.75	1.75	1.75

Concentration of macro, micro nutrients and Pb in soil

Data presented in Table 4 show the amount change in available major elements in soil, at growth stage after (45 days from planting) and harvest stage of wheat plants (after 165 days) in both old and new permanent experiments. In the old experiment, the highest significant increase of available NO_3^- , NH_4^+ and total N as (NO_3^- and NH_4^+) as well as K were noticed by applying FYM fertilizer but the significant increase of available P in inorganic treatment was higher than that of FYM fertilizer one. This result may be attributed to accumulations of soil organic matter in long term experiment. Application of animal manures can contribute substantial on increase the amounts of N, K and other nutrients in soil as well as crop production. On the other hand, for sustainable agriculture, organic manure is a good source for N supply to crop plants. This agrees with results of (Reganold. 1988, Korsaeth et al., 2002 and Fageria, 2009).

Concerning the new experiment, data clear that, available forms of N-NO_3^- N-NH_4^+, N, P and K in soil at the studied two stages of wheat were higher in N_{30}**$P_{19.5}$**K_{48} and N_{60}**$P_{19.5}$**K_{48} fertilizer treatments, respectively. This result indicated that increasing depletion of elements from the soil and its positive impact on the crop was affected in available N, P and K after wheat harvesting. Similar results were obtained by. (Thomas et al., 2012) who reported that total Zn, Cu, and Cd concentrations showed an increase in the soil concentration with an increase in levels of phosphate fertilizer. In addition, (Atafar et al., 2010) reported that total Cd and Pb concentrations were increased in the cultivated soils due to fertilizer application While, the results, clear that the accumulation of available NO_3^- in plots received N alone was higher than those treated with P and K fertilizers. This may be attributed to non use of the organic manure with mineral fertilization. The current work shown that accumulation of N-NO_3^- in soil is increased with increasing amounts of applied N fertilizer (Wu et al., 2005) but application of P fertilizer can reduce NO_3-N accumulation in soil (Fan et al., 2003). (Yang et al., 2004) found that in a long-term experiment, unbalanced fertilization with N, P and K also causes high NO_3^- accumulation in soil.

As far as the elements status in soil of Bahtim experiments is concerned, the available Fe, Mn, Zn, Cu and Pb in soil was evaluated during and after wheat harvest in both old and new experiments, which are shown in Table 5. In old experiment, data show that the highest available concentration values of Mn, Zn, Cu and Pb in inorganic NPK treatment were higher than those in FYM, except Fe a component which increases its concentration in FYM. This may be attributed to permanent use of FYM fertilizer in long time experiment and decrease of micro element content in soil treated with FYM compared with mineral fertilizer. This agrees with results obtained by (Czarnecki and Düring 2015) who found that, Cd, Cu, Mn, Pb and Zn contents in the soils increased due to application of 14 years of mineral fertilizer treatments (N, P, NP, and NPK) when compared to control plots.

With regard to new permanent fertilizer experiment, results show that the available Fe, Mn, Zn, Cu and Pb under inorganic fertilizer (NPK) treatments were increased with increasing N levels. The availability of Fe, Mn, Zn, Cu and Pb under $N_{60}P_{19.5}K_{48}$ fertilizer treatment was higher than $N_{30}P_{19.5}K_{48}$ at growth stage and after wheat harvesting. In addition, the availability of Fe, Mn, Zn, Cu and Pb under NPK fertilizer treatment was higher than that of NP, N, 0 fertilizer application treatments, respectively at growth stage and after wheat harvesting. This agrees with results obtained by (Nicholson et al., 2003) who predicted that P fertilizers, in particular, are an important source of metals, particularly for Zn, Cu, and Cd entering agricultural soils. The increase in Cu and Zn in soils is associated mainly with NPK fertilizers (Kabata-Pendias, 2011). Also, high application rates of nitrogen fertilizer to agricultural soils resulted in increased accumulation of some heavy metals such as Cd and Pb in agricultural products (Zhou, 2003).

Table 4: Amount change in available major elements ($mg.kg^{-1}$) in soil, at growth stage and harvest of wheat plants in both old and new permanent experiments.

Treatments	$N\text{-}NO_3^-$			$N\text{-}NH_4^+$			N			P			K		
	G.S	H.S.	Mean	G.S	H.S.	Mean	G.S	H.S.	Mean	G.S	H.S.	Mean	G.S	H.S.	Mean
Old experiment															
Control	0.00	0.00	0.00	62.48	45.0	53.74	62.48	45.00	53.74	0.10	1.66	0.88	132	92.18	112
N_{15}	19.16	0.00	9.58	62.48	54.5	58.49	81.64	54.50	68.07	2.53	2.22	2.37	136	95.77	115
$N_{15}+P_{19.5}$	0.00	0.00	0.00	83.30	60.0	71.65	83.30	60.00	71.65	2.83	3.50	3.16	143	110.2	126
$N_{15}+P_{19.5}+K_{48}$	0.00	0.00	0.00	62.48	61.0	61.74	62.48	61.00	61.74	4.12	3.88	4.00	144	120.2	132
FYM	12.49	18.2	15.34	87.48	90.0	88.74	99.97	108.2	104.8	1.35	1.56	1.45	358	288.0	323
Mean	6.33	3.64		71.64	62.1		77.97	65.74		2.19	2.56		182	141	
LSD at 0.05	A=0.16*** B=0.10***			A=0.25*** B=0.16***			A=0.25*** B=0.16***			A=0.44*** B=0.28*			A=0.2.55*** B=1.61***		
New experiment															
Control	24.99	0.00	12.49	41.65	25.20	33.42	66.64	25.2	45.92	0.76	1.65	1.20	123	106	114
N_{30}	29.16	0.00	14.58	45.82	38.12	41.97	74.98	38.12	56.55	4.22	2.50	3.36	143	148	145
$N_{30}+P_{19.5}$	14.17	3.50	8.830	62.48	42.00	52.24	76.65	45.50	61.07	4.22	2.65	3.43	158	201	179
$N_{30}+P_{19.5}+K_{48}$	4.170	2.00	3.885	104.1	80.16	92.14	108.3	82.16	95.23	5.68	4.88	5.28	308	240	247
N_{60}	32.49	0.00	10.74	95.81	52.80	74.30	133.3	52.80	93.05	2.89	2.22	2.55	222	180	201
$N_{60}+P_{19.5}$	0.000	12.6	6.300	108.2	42.00	75.14	108.2	54.60	81.44	3.43	2.44	2.93	189	206	197
$N_{60}+P_{19.5}+K_{48}$	54.15	11.6	32.91	95.81	83.93	89.87	149.9	93.95	121.9	4.12	6.01	5.06	290	266	278
Mean	23.44	4.25		79.14	52.03		102.5	56.04		3.61	3.19		207	192	
LSD at 0.05	A=0.23*** B=0.12***			A=0.94*** B=0.50***			A=0.25*** B=0.13***			A=0.03*** B=0.01***			A=2.5*** B=1.34***		

G.S = growth stage H. S. = harvest stage

Table 5: Amount of change in available micro nutrients and Pb ($mg.kg^{-1}$) in soil, at growth stage and harvest of wheat plants grown on both old and new permanent experiments.

Treatments	Fe			Mn			Zn			Cu			Pb		
	G.S.	H.S.	Mean	G.S.	H.S.	Mean	G.S.	H.S.	Mean	G.S.	H.S.	Mean	G.S.	H.S.	Mean
Old experiment															
Control	9.50	7.50	8.50	1.85	1.06	1.45	0.74	0.74	0.74	3.92	2.66	3.29	1.04	0.82	0.93
N_{15}	10.89	8.20	9.54	2.16	2.31	2.23	0.91	0.83	0.87	3.96	3.60	3.78	1.66	0.94	1.30
$N_{15}+P_{19.5}$	11.96	8.56	10.26	2.26	2.90	2.58	1.66	1.12	1.39	4.43	4.20	4.31	2.11	0.96	1.53
$N_{15}+P_{19.5}+K_{48}$	12.80	9.66	11.23	3.66	3.40	3.53	2.56	1.54	2.05	4.46	6.55	5.50	2.11	1.37	1.74
FYM	10.85	11.8	11.32	4.50	1.89	3.19	1.59	1.32	1.45	4.79	2.28	3.53	1.88	1.25	1.56
Mean	11.2	9.14		2.88	2.31		1.54	1.11		4.31	3.85		1.76	1.06	
LSD at 0.05	A=0.02*** B=0.01***			A=0.024*** B=0.15***			A=0.017*** B=0.01***			A=0.017*** B=0.011***			A=0.01*** B=0.01***		
New experiment															
Control	9.98	4.66	7.32	1.77	1.46	1.61	0.99	0.90	0.94	2.29	3.70	2.99	0.22	0.91	0.56
N_{30}	11.38	6.88	9.13	2.12	2.66	2.39	1.66	0.91	1.28	4.22	4.50	4.36	1.10	1.19	1.14
$N_{30}+P_{19.5}$	11.96	10.5	11.2	3.27	2.76	3.01	2.18	1.25	1.71	4.60	4.54	4.57	1.22	1.28	1.25
$N_{30}+P_{19.5}+K_{48}$	12.10	11.2	11.6	4.54	2.76	3.65	2.56	1.25	1.98	4.66	4.80	4.73	2.16	1.18	1.67
N_{60}	10.74	8.51	9.62	2.22	2.04	2.13	1.66	0.99	1.32	4.22	4.01	4.11	1.16	1.10	1.13
$N_{60}+P_{19.5}$	10.95	11.1	11.0	2.44	2.38	2.41	2.18	1.18	1.68	6.00	4.36	5.18	1.28	1.14	1.21
$N_{60}+P_{19.5}+K_{48}$	11.24	12.6	11.9	6.00	2.76	4.38	2.80	1.57	2.18	6.77	4.38	5.57	2.55	1.39	1.97
Mean	11.19	9.370		3.19	2.40		1.97	1.14		4.68	4.32		1.38	1.17	
LSD at 0.05	A=0.02*** B=0.012***			A=0.023*** B=0.01***			A=0.016*** B=0.008***			A=0.017*** B=0.009***			A=0.01*** B=0.008***		

G.S = growth stage H.S. = harvest stage

The correlation between elements concentration in soil, plant and grain yeild:

Data presented in Table 6 show the correlation between available elementals in soil, grain yield and grain content of N, P, K, Fe, Mn, Zn, Cu and Pb after harvesting. In the old experiment, highly positively significantly correlation between availability of N-NH_4^+, total N as (NO_3^- and NH_4^+), and K in soil with Mn content in wheat grain was positive. Also, found correlation of available Fe, Mn, Zn and Pb in soil with N uptake in wheat grain yield. Found correlation between available Pb in soil and K uptake in wheat grain. As well as found positive correlation in available Fe and Mn in soil and Fe and Zn wheat content in grain yield. While, in the new experiment, the correlation between available N-NH_4^+ in soil and P uptake. Also found correlation in total N as (NO_3^- and NH_4^+) in soil, and grain yield, N and P uptake in wheat grain yield, coloration between available K in soil and N uptake. As well as available K, Fe, Mn, Zn, Cu and Pb in soil with P, and K uptake in wheat grain. On the other hand non-significant with other elements under testing.

Concerning available (N-NH_4^+ and K),(P, K, Fe, Mn, Zn and Pb), (Fe, Zn and Cu) and (Cu) in soil fund positive correlation with (Mn), (Zn), (Cu) and (Pb) content in grain yield of wheat respectively. N, and P content were high significant (N added 30 and 60 unit). But the correlation was non-significant with K content in soil and grain yield. Therefore, it has to be the development of rates added nutrients commensurate with the needs of plants. This result may be due to decrease N, P and K fertilizers levels especially added N and depletion of P, K with long-term experiment with increasing plant requirements. This result was in agreement with the findings obtained by (Prasad and Power 1995). (Schulthess et al., 1997) pointed out that increasing levels of N and P application and their interaction significantly and positively affected grain yield of wheat and its concentration of N and P in the plants

Table 6: The correlation between the available concentration of nutrients in soil and plant content.

Soil Properties Y	Elements content in grain wheat X								
	Grain yield	N uptake	P uptake	K uptake	Fe	Mn	Zn	Cu	Pb
	Old experiment								
N-NO_3^-	r = 0.45 NS	r = -0.09 NS	r = 0.39 NS	r = -0.07 NS	r = 0.28 NS	r = 0.67 NS	r = 0.39 NS	r = 0.38 NS	r =- 0.56 NS
N- NH_4^+	r = 0.73 NS	r = 0.41 NS	r = 0.48 NS	r = 0.40 NS	r = 0.78 NS	r = 0.94 *	r = 0.63 NS	r = 0.48 NS	r = 0.25 NS
NO_3^- and NH_4^+	r = 0.69 NS	r = 0.26 NS	r = 0.49 NS	r = 0.26 NS	r = 0.61 NS	r = 0.93 *	r = 0.60 NS	r = 0.49 NS	r =- 0.02 NS
P	r = 0.09 NS	r = 0.82 NS	r = 0.63 NS	r = 0.87 NS	r = 0.32 NS	r =- 0.06 NS	r = 0.31 NS	r = -0.47 NS	r =- 0.43 NS
K	r = 0.82 NS	r = 0.22 NS	r = 0.24 NS	r = 0.08 NS	r = 0.70 NS	r = 0.95 **	r = 0.69 NS	r = 0.74 NS	r = -0.06 NS
Fe	r = 0.84 NS	r = 0.89 *	r = 0.70 NS	r = 0.78 NS	r = 0.92 *	r = 0.80 NS	r = 0.91 *	r = 0.32 NS	r = 0.30 NS
Mn	r = 0.79 NS	r = 0.93 *	r = 0.69 NS	r = 0.80 NS	r = 0.90 *	r = 0.69 NS	r = 0.90 *	r = 0.25 NS	r = 0.27 NS
Zn	r = 0.69 NS	r = 0.98 **	r = 0.49 NS	r = 0.80 NS	r = 0.85 NS	r = 0.49 NS	r = 0.81 NS	r = 0.20 NS	r = 0.49 NS
Cu	r = 0.26 NS	r = 0. 86 NS	r = 0.43 NS	r = 0.76 NS	r = 0.47 NS	r =- 0.08 NS	r = 0.46 NS	r =- 0.21 NS	r = 0.42 NS
Pb	r = 0.64 NS	r = 0.96 **	r = 0.79 NS	r = 0.93 *	r = 0.80 NS	r = 0.58 NS	r = 0.77 NS	r = 0.03 NS	r = 0.40 NS
	New experiment								
N-NO_3^-	r = 0.61 NS	r = 0.56 NS	r = 0.28 NS	r = 0.05 NS	r = 0.38 NS	r =- 0.11 NS	r = 0.28 NS	r = 0.43 NS	r = 0.36 NS
N- NH_4^+	r = 0.69 NS	r = 0.70 NS	r = 0.82 *	r = 0.72 NS	r = 0.74 NS	r = 0.80 *	r = 0.61 NS	r = 0.58 NS	r = 0.50 NS
NO_3^- and NH_4^+	r = 0.86 *	r = 0.87 *	r = 0.78 *	r = 0.59 NS	r = 0.74 NS	r = 0.69 NS	r = 0.62 NS	r = 0.63 NS	r = 0.56 NS
P	r = 0.38 NS	r = 0.48 NS	r = 0.66 NS	r = 0.75 NS	r = 0.58 NS	r = 0.58 NS	r = 0.80 *	r = 0.55 NS	r = 0.35 NS
K	r = 0.74 NS	r = 0.75 *	r = 0.84 *	r = 0.76 *	r = 0.71 NS	r = 0.76 *	r = 0.76 *	r = 0.71 NS	r = 0.57 NS
Fe	r = 0.55 NS	r = 0.54 NS	r = 0.86 *	r = 0.93 **	r = 0.50 NS	r = 0.65 NS	r = 0.79 *	r = 0.82 *	r = 0.71 NS
Mn	r = 0.52 NS	r = 0.54 NS	r = 0.75 *	r = 0.79 *	r = 0.60 NS	r = 0.57 NS	r = 0.86 *	r = 0.73 NS	r = 0.48 NS
Zn	r = 0.58 NS	r = 0.55 NS	r = 0.89 **	r = 0.92 **	r = 0.64 NS	r = 0.63 NS	r = 0.81 *	r = 0.82 *	r = 0.64 NS
Cu	r = 0.69 NS	r = 0.64 NS	r = 0.86 *	r = 0.83 *	r = 0.63 NS	r = 0.36 NS	r = 0.58 NS	r = 0.82 *	r = 0.82 *
Pb	r = 0.64 NS	r = 0.68 NS	r = 0.78 *	r = 0.77 *	r = 0.66 NS	r = 0.60 NS	r = 0.81 *	r = 0.71 NS	r = 0.55 NS

This result may be attributed to the accumulation of micronutrients in soil as a result of use inorganic fertilizers for long term. This result is in agreement with the findings obtained by (Hejcman and Schnellberg 2009) who said that, fertilization is one of the major paths for metal input in agricultural soils. Also (Ure, 1990) concluded that, pseudo-total metal contents in soils increased due to application of long-term chemical fertilizer treatments when compared to control plots.

CONCLUSION

Sustainable fertilization experiments have great importance in the study of sustainability and increasing crop productivity, also to develop recommendations for farmers depending on studies of the long term. The study recommends the importance of updating factors sustainable experiments in proportion to increasing needs of plant varieties from fertilizers.

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تـأثير التسميد علـى المدى الطويـل على إستنزاف وتـراكم بعض العناصـر فـي التربـة وإنتاجيـة محصـول القمـح فـي التجربـة المستديمة ببهتيم.

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فى التجربة المستديمة التي تأسست في عام 1912 وعدلت في عام 1989 فى محطة البحوث الزراعية ببهتيم محافظة القليوبية، مصر (خط العرض 30 N "31.316" 8 o وخط الطول E "53.714 '16 o 31) وخلال موسم الشتاء 2014/2015 تم زرعة التجربتين بالقمح (.Triticum aestivum L) صنف جميزه 9. وكان تصميم التجربتين هو قطاعات كاملة العشوئية. بهدف دراسة تأثير التسميد على المدى الطويل على استنزاف وتراكم بعض العناصر فى التربة وتأثيرها على إنتاجية محصول القمح. وتؤكد النتائج أن القيم التي تم الحصول عليها من محصول القش والحبوب والمحصول البيولوجي ووزن 1000 حبة مع إستخدام الأسمدة المتكاملة (ن فو بو) أعلى مقارنة مع القطع المسمدة منفردة. وكانت الزيادة النسبية للمحصول البيولوجي ونسبة ن فو بو % والممتص فى حبوب القمح نتيجة إضافة الأسمدة $N_{60} + P_{19.5} + K48$ كجم فدان$^{-1}$ كانت أعلى من $N_{30} + P_{19.5} + K_{48}$ و $N_{15} + P_{19.5} + K_{48}$ على التوالي. أيضا، كان تأثير السماد البلدى على المحصول مع المدى الطويل موازية لتلك التى لوحظت لمعاملات التسميد المعدني الكامل (ن فو بو) في كل من التجربة القديمة والجديدة. أيضا، فى التجربة القديمة، تزايدت قيم تركيزات الحديد والمنجنيز والزنك والنحاس والرصاص زيادة كبيرة فى محصول الحبوب للقمح المعاملة بالسماد البلدى بالمقارنة بالأسمدة المعدنية. وأوضحت النتائج أن تركيزات الحديد والمنجنيز والزنك والنحاس والرصاص فى محصول حبوب القمح تحت معاملات التسميد المعدني فى التحارب القديمة والجديدة أعلى فى القطع المسمدة بالسوبر فوسفات مقارنة بالمعامله بالأسمدة المعدنية الأخرى. أيضا وجد زيادة كبيرة فى تركيزات الحديد والمنجنيز والزنك والنحاس والرصاص في محصول حبوب القمح نتيجة إضافة الأسمدة $N_{60} + P_{19.5} + K_{48}$ كجم فدان$^{-1}$ أعلى من ($N_{30} + P_{19.5} + K48$) و ($N_{15} + P_{19.5} + K_{48}$) على التوالي. في التجربة القديمة ، كانت أعلى قيم ميسره من NO_3، NH_4، والنتروجين الكلى المعدنى والبوتاسيوم بالقطع المسمدة بالسماد البلدى بينما كان الميسر من الفوسفور فى معاملة التسميد المعدنى أعلى من المعاملة بالسماد البلدى. على العكس من ذلك، كانت أعلى قيم من المنجنيز والزنك والرصاص والنحاس الميسره فى القطع المسمدة بالسماد المعدني الكامل (ن فو بو) أعلى من المسمدة بالسماد البلدى. في حين، كان الحديد فى التربة المسمدة بالسماد البلدى أعلى من القطع المسمدة بالسماد المعدنى الكامل. أيضا، فى تربة التجربة الجديدة كان الميسر من NH_4، والنتروجين المعدني الكلي، والفوسفور والبوتاسيوم أعلى فى معاملات $N_{30} + P_{19.5} + K_{48}$ أعلى من المعاملات N60 + P19.5 + K48. وعلى العكس من ذلك، ما هو ميسر من الحديد والمنجنيز والزنك والرصاص والنحاس تحت المعاملات $N_{60} + P_{19.5} + K_{48}$ أعلى من المعاملات $N_{30} + P_{19.5} + K_{48}$. فى التربة أيضا، كان الميسر من (ن فو بو) ينخفض مع إنخفاض مستويات إضافة النتروجين كما تم إستنزاف الفوسفور والبوتاسيوم فى التجربة على المدى الطويل ومع زيادة إحتياجات النباتات. في حين تم العثور على تراكم فى المغذيات الدقيقة في التربة نتيجة لإستخدام الأسمدة المعدنية على المدى الطويل. بعد مرور أكثر من 104 عاما على إنشاء هذه التجربة ومع إنخفاض الإنتاجية هناك شك فى أن ممارسات إدارة المغذيات الحالية ليست مستدامة وتحتاج إلى تطوير نظم إدارة أكثر كفاءة. لذلك يجب أن نأخذ بعين الاعتبار أنواع المحاصيل وإحتياجاتها من السماد والجمع بين الأسمدة المعدنية والعضوية أو مخلفات المحاصيل الزراعية ولكن مع الإبقاء على القطع التجريبية القديمة للمقارنة بالمعاملات الجديدة.