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Effect of organic, phosphorus and zinc fertilization on yield and quality of flax

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Abstract

Organic, phosphorus and zinc fertilizations were proved to affect the straw, seed and fiber yields of flax. Therefore, two field experiments were conducted at the Experimental Farm of Gemmeiza Agriculture Research Station, El-Gharbia Governorate, Agricultural Research Center (ARC), Egypt, during 2012/2013 and 2013/2014 winter seasons to determine the effect of organic, phosphorus and zinc fertilization on yield and quality of flax. The experiment was conducted in split-split plot design with three replications. The main-plots were included farmyard manure (FYM) levels. The sub-plots were devoted to phosphorus fertilizer levels. The sub sub-plots were allocated to three levels of zinc in the form of Cheleated Zinc 13% as foliar application. The highest values of all studied characters were obtained by organic fertilized flax plants with the highest level of FYM (20 m^3/fed). Maximum means of all studied characters were resulted by fertilizing flax plants with 30 kg P_2O_5/fed in both seasons. Foliar spraying flax plants twice with 500 ppm zinc significantly surpassed other zinc levels and produced the highest values of all studied characters in both seasons. It could be concluded that best yield and quality of flax could be obtained in case of organic fertilized flax plants with 20 m^3 FYM /fed and 30 kg P_2O_5/fed besides foliar spraying twice with 500 ppm zinc under the environmental conditions of Gemmeiza district, El-Gharbia Governorate.

Keywords: Flax, farmyard manure (FYM), phosphorus levels, zinc foliar application, yields, quality.

Introduction

Flax (*Linum usitassimum* L.) has a long history of use its seed as a food and medicine. Where, plant stem gave high quality textile fiber. Flax seed oil is a unique oil in that it is composed of 73% polyunsaturated fatty acids, 18% monounsaturated fatty acids and 9% saturated fatty acids, making it a low-saturated fat food. It is also the richest known source of the omega 3 (n-3) fatty acid, which comprises 55% of the total fatty acids.

It is well known that high productivity of any crop is the final goal of many factors and operations. In addition, the pronounced role of the agronomical processes such as organic, phosphorus and zinc fertilizations have very important effect on yield, yield components and quality of flax crop.

Organic manures such as farmyard manure (FYM) contribute to plant growth through its effect on physical, chemical and biological properties of the soil as well as through its effect as a source of essential nutrients (**Haynes and Naidu, 1998**). **Toderi *et al.* (1999)** showed that the use of organic materials improved soil organic matter, nitrogen content, P_2O_5 concentration, exchangeable cations and apart of Fe consequently enhancement plant growth and development as well as yield. **Laila (2004)** found that organic manure plays an important role in nutrients solubility as it activate physiological and biochemical processes in plant leading to increase the plant growth and nutrients uptake. **Sheng-Mao et al. (2006)** suggest that integrated and balanced application of N, P, and K fertilizers and farmyard manure at proper rates is important for protecting soil and groundwater from potential NO_3-N pollution and for maintaining high crop productivity. **Zhi-Li et al. (2012)** revealed that number of capsules per plant, number of seeds per capsule, thousand-grain weight and straw and seed yields were higher when using farmyard manure than those of chemical fertilizer, but the differences were insignificant.

Phosphorus fertilizer is second only to nitrogen fertilizer in importance as an essential crop nutrient. Phosphorus is important in building energy for metabolism of plant growth through cellular productions such as ATP and ADP from the early stages to the end of the plant's life (**Marschner, 1995**). Phosphorus fertilizer is critical for plant growth and yield of flax. In this respect, **Khan *et al.* (2000)** reported that mean performances of flax differed for seed and straw yields with the application of phosphorus fertilizer. **Ali *et al.* (2002)** found that linseed had a significant response to phosphorus application. **Lafond et al. (2003)** stated that flax response to phosphorus fertilizer addition is highly variable, supporting the importance of maintaining medium to high soil P levels to optimize flax yields. **You et al. (2007)** concluded that to optimize crop nutrition, phosphorus must be available to the crop in adequate amounts during the growing season. **El-Nagdy et al. (2010)** indicated that increasing level of mineral phosphorus fertilizer induced significant increases in all investigated morphological and yield characters. **Bakry et al. (2012)** found that the highest phosphorus levels increased the yield and nitrogen use efficiency. **Esmail et al. (2014)** reported that increasing levels of applied phosphorus caused increases in seed index and seed yield of flax. **Emam and Dewdar (2015)** stated that soil application of single super phosphate significantly enhanced flax straw, seed and fiber yields and its components.

One of the important approaches is the use of foliar application for increasing flax production. Many researchers have reported the effect of micronutrient elements especially zinc on yield and crop performance. In this regard; **Marschner (1995)** stated that zinc, is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes. Thus, it is associated with saccharide metabolism, photosynthesis, nucleic acid, lipid metabolism and protein synthesis. **Cynthia et al. (2004)** showed that Zn is playing an important role in activity of enzymes or as functional, structural or regulatory cofactors. **Cakmak (2008)** reported that zinc is an essential micronutrient for synthesis of auxin, cell division and the maintenance of membrane structure and function. **Bybordi and Mamedov (2010)** concluded that zinc also plays an important role in the production of biomass and chlorophyll production. **Nofal et al. (2011)** concluded that Zn foliar application was important to correct the nutrient balance in flax plant undesirable soil conditions. **Bakry et al. (2012)** found that foliar application with Zn positively affected all the studied characters compared with control treatment. **Tahir et al. (2014)** reported that foliar spraying flax plants with zinc at the rate of 3.0 % at bud initiation and after capsule filling stage significantly improved plant height, stem length, fruiting branches, 1000-seed weight, straw yield and seed yield. **Bakry et al. (2015)** revealed that zinc foliar application at the rate of 5% gave the highest values of flax yield and it`s components and quality.

Thus, this research was aimed to determinate the effect of organic, phosphorus and zinc fertilization on yield and quality of flax under the environmental conditions of Gemmeiza district, El-Gharbia Governorate.

Materials and Methods

In order to find out the effect of organic, phosphorus and zinc fertilization on yield and quality of flax cultivar Giza 10, two field experiments were conducted at the Experimental Farm of Gemmeiza Agriculture Research Station, Agricultural Research Center (ARC), Egypt, during the growing winter seasons of 2012/2013 and 2013/2014. Giza 10 cultivar that used in this study was obtained from Fibers Research Section, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.

The experiments were conducted in split-split plot design with three replicates. Each experiment included twenty seven treatments comprising, three farmyard manure levels, three phosphorus fertilizer levels and three levels of zinc as foliar application. The main-plots were included three farmyard manure (FYM) levels as following:

1. Control treatment (without FYM).
2. 10 m^3 FYM/fed.
3. 20 m^3 FYM/fed.

Farmyard manure (FYM) was added after soil preparation to the experimental units at the previously mentioned rates on soil surface and then turned over via hack. Analysis of used FYM was shown in Table 1.

Table 1: Some chemical properties of used FYM in both seasons.

Properties	Value
Organic matter %	36.48
C %	21.16
N %	1.09
C/N	19.41 : 1
P %	0.35
K %	0.96
pH in FYM water extraction (1:5)	7.84
EC (ds m^{-1}) in FYM water extraction (1:10)	2.29

The sub-plots were devoted to three phosphorus fertilizer levels as follows:

1. Without (control treatment).
2. 15.0 kg P_2O_5/fed
3. 30.0 kg P_2O_5/fed

The mineral phosphorus fertilizer in the form of calcium superphosphate (15.5% P_2O_5) at the aforementioned rates was added after soil preparation to the experimental units.

The sub sub-plots were allocated to three levels of zinc in the form of Cheleated Zinc 13% as foliar application as follows:

1. Without (control treatment).
2. 250 ppm
3. 500 ppm

The foliar solution volume was 200 Liter/fed and twice spraying were conducted by hand sprayer (for experimental plots) until saturation point twice, the first at beginning flowering stage and the second after 15 days from first spraying.

Each experimental unit area was 2 × 3 m occupying an area of 6.0 m^2 *i.e.* 1/700 feddan. The preceding summer crop was maize (*Zea mays* L.) in both seasons. Soil samples were taken at random from the experimental field area at a depth of 0 - 30 cm from soil surface before the growing seasons to measure the physical and chemical soil properties as shown in Table 2.

Table 2: Some physical and chemical properties of the experimental site during 2012/2013 and 2013/2014 seasons.

Soil analysis		2012/2013	2013/2014
A: Mechanical analysis			
Sand (%)		14.84	15.08
Silt (%)		48.42	47.73
Clay (%)		36.74	37.19
Texture class		Silty clay loam	Silty clay loam
B: Chemical analysis			
pH, 1 : 2.5 (suspension)		7.84	7.88
E.C. (ds m^{-1})		1.31	1.45
$CaCO_3$ (%)		3.65	3.59
Available nitrogen (ppm)		29.17	30.29
Available P (ppm)		10.76	9.99
Available K (ppm)		348.00	340.00
Soluble cations (meq./100 g soil)	Ca^{++}	4.18	4.16
	Mg^{++}	4.25	4.31
	Na^{+}	4.63	5.01
	K^{+}	0.51	0.54
Soluble anions (meq./100 g soil)	HCO_3^{-}	3.85	4.07
	Cl^{-}	6.51	6.52
	SO_4^{--}	3.19	3.54

Giza 10 cultivar seeds were sown on the last week of October in both seasons by using broadcasting method at the rate of 63 kg/fed. The mineral potassium fertilizer in the form of potassium sulphate (48.0% K_2O) at the recommended rate were added before sowing and during seed bed preparation (after ploughing and before division).The mineral nitrogen fertilizer in the form of ammonium nitrate (33.5 % N) at the recommended rate was applied into two equal doses at 30 and 45 days from sowing, respectively. The common agricultural practices for growing flax according to the recommendations of Ministry of Agriculture were followed, except the factors under study.

Studied characters:

At full maturity, ten guarded plants were taken at random from each sub- plot to be used in recording the flax yields components. Straw yield/fed, seed yield/fed and long fiber yield/fed were recorded from the whole sub sub-plot area basis.

1- Plant height (cm). It was measured in cm from the soil surface up to the top of flax plant.
2- Technical length (cm). The length of main stem in cm from cotyledonary node to the lowest branching zone.
3- Stem diameter (mm). It was measured at the middle of technical length.
4- Number of fruiting branches.
5- Straw yield/plant (g). As the total weight in grams of the air dried straw per plant after removing the capsules.
6- Seed yield/plant (g).
7- Biological yield (t/fed).
8- Straw yield/fed (ton). It was estimated from the rest area of each plot.
9- Seed yield/feddan (kg).
10- Long fiber yield/feddan (kg).
Soil chemical analyses were conducted according to **Cottenie *et al.* (1982)**.
11- Nitrogen was determined by using method micro-kjeldahl described by **Jackson (1973)**.
12- Phosphorus was estimated colorimetrically at a wave length of 725 mm using Zeiss spectrophotometer (Spekol) as described by **Jackson (1973)**.
13- Potassium was determined by using flame photometer as described by **Jackson (1973)**.
14- Zinc determined by using atomic absorption spectrometry (AAS) according **to Chapman and Pratt (1961)** and was measured by Plazma (ICP) ultima II.

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-split plot design as published by **Gomez and Gomez (1984)** by using MSTAT statistical package (MSTAT-C with MGRAPH version 2.10, Crop and Soil Sciences Department, Michigan State University, USA). Least significant difference (LSD) method was used to test the differences between treatment means at 5 % level of probability as described by **Snedecor and Cochran (1980).**

Results and Discussion

1. Effect of farmyard manure (FYM) levels:

The obtained results obvious that total plant height, technical length, stem diameter, number of fruiting branches (Table 3), straw yield/plant, seed yield/plant, biological yield/fed, straw yield/fed, seed yield/fed, long fiber yield/fed (Table 4), N, P, K and Zn contents in flax seeds (Table 5), protein percentage in flax seeds and N-uptake, P-uptake, K-uptake and Zn-uptake (Table 6) were significantly affected by organic fertilization by farmyard manure (FYM) levels in both seasons, except number of fruiting branches in the first season only (Tables 3). The highest values of all these characters were obtained by organic fertilized flax plants with the highest level of FYM (20 m^3/fed). However, organic fertilized flax plants with 10 m^3 FYM/fed ranked after aforementioned FYM level in the two growing seasons. While, the lowest values of above mentioned characters were resulted from control treatment (without FYM) in the first and second seasons.

The increase of growth characters of flax, yields and its components as well as quality parameters due to organic fertilization with FYM may be ascribed to its effect on physical, chemical and biological properties of the soil as well as through it`s effect as a source of essential nutrients (**Haynes and Naidu, 1998**). In addition, use of organic materials improved soil organic matter, nutrients solubility as it activate physiological and biochemical processes in plant leading to increase the plant growth and nutrients uptake (**Laila, 2004**).

Table 3: Mean values of total plant height, technical length, stem diameter and number of fruiting branches as affected by farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels as well as their interactions during 2012/2013 and 2013/2014 seasons

Characters / Treatments / Seasons	Total plant height (cm)		Technical length (cm)		Stem diameter (mm)		Number of fruiting branches	
	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014
A- Farmyard manure levels:								
Without	123.8	124.0	109.5	107.7	2.23	2.21	3.06	3.03
10 m^3/fed	124.5	125.1	110.0	108.5	2.27	2.25	3.07	3.09
20 m^3/fed	125.2	125.8	110.6	110.1	2.35	2.32	3.08	3.18
LSD at 5 %	0.5	0.6	0.5	0.9	0.05	0.07	NS	0.04
B- Phosphorus fertilizer levels:								
Without	123.4	123.2	109.6	108.0	2.21	2.23	3.00	3.04
15 kg P_2O_5/fed	123.8	125.7	110.0	108.4	2.26	2.26	3.05	3.11
30 kg P_2O_5/fed	126.3	125.9	110.5	110.0	2.38	2.29	3.17	3.15
LSD at 5 %	0.6	0.8	0.4	0.7	0.04	0.03	0.05	0.06
C- Zinc levels:								
Without	123.3	124.5	109.6	108.5	2.18	2.18	3.02	3.05
250 ppm	124.3	125.1	110.0	108.7	2.32	2.29	3.08	3.13
500 ppm	125.9	125.2	110.4	109.1	2.34	2.31	3.11	3.13
LSD at 5 %	0.4	0.5	0.6	0.4	0.07	0.06	0.06	0.05
D- Interactions:								
A × B	NS	*	NS	NS	*	NS	NS	*
A × C	NS	NS	NS	*	NS	NS	NS	NS
B × C	NS	NS	NS	NS	NS	NS	NS	NS
A × B × C	NS	NS	NS	NS	NS	*	NS	*

2. Effect of phosphorus fertilizer levels:

Concerning the effect of phosphorus fertilizer levels, it was significant for total plant height, technical length, stem diameter, number of fruiting branches (Tables 3), straw yield/plant, seed yield/plant, biological yield/fed, straw yield/fed, seed yield/fed, long fiber yield/fed (Tables 4), N, P, K and Zn content in flax seeds (Tables 5), protein percentage in flax seeds and N-uptake, P-uptake, K-uptake and Zn-uptake (Tables 6) in the two seasons. All studied characters of flax plants gradually increased as a result of increasing phosphorus fertilizer levels from zero to15 and 30 kg P_2O_5/fed in both seasons. Generally, maximum means of all studied characters were resulted from fertilizing flax plants with 30 kg P_2O_5/fed in both seasons. On the contrary, the lowest values of these characters were obtained from plots did not receive phosphorus fertilizer (control treatment).

The increases in all studied characters as a result to increasing phosphorus fertilizer levels can be easily ascribed to phosphorus is important in building energy for metabolism of plant growth through cellular productions such as ATP and ADP from the early stages to the end of the plant's life (**Marschner, 1995**). These results are in agreement with those reported by many workers including **You et al. (2007), El-Nagdy et al. (2010), Bakry et al. (2012), Esmail et al. (2014) and Emam and Dewdar (2015)**.

3. Effect of zinc fertilizer levels:

All studied characters *i.e.* total plant height, technical length, stem diameter, number of fruiting branches (Tables 3), straw yield/plant, seed yield/plant, biological yield/fed, straw yield/fed, seed yield/fed, long fiber yield/fed (Tables 4), N, P, K and Zn content in flax seeds (Tables 5), protein percentage in flax seeds and N-uptake, P-uptake, K-uptake and Zn-uptake (Tables 6) were proved to be significant increases as a result of increasing zinc fertilizer levels as a foliar application. From obtained results, it could be recommend that foliar spraying flax plants twice

Table 4: Mean values of straw yield/plant, seed yield/plant, biological yield/fed, straw yield/fed, seed yield/fed and long fiber yield/fed as affected by farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels as well as their interactions during 2012/2013 and 2013/2014 seasons.

Characters / Treatments Seasons	Straw yield (g/plant)		Seed yield (g/plant)		Biological yield (t/fed)		Straw yield (t/fed)		Seed yield (kg/fed)		Long fiber yield (kg/fed)	
	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014
A- Farmyard manure levels:												
Without	2.349	2.244	0.360	0.348	4.524	4.466	4.472	4.389	694.7	689.4	260.4	262.0
10 m^3/fed	2.393	2.335	0.368	0.356	4.797	4.726	4.515	4.525	704.4	699.1	268.2	265.7
20 m^3/fed	2.396	2.394	0.370	0.358	5.107	4.738	4.835	4.601	763.3	758.0	285.4	272.3
LSD at 5 %	0.046	0.047	0.005	0.009	0.315	0.304	0.112	0.115	35.4	45.2	10.9	9.8
B- Phosphorus fertilizer levels:												
Without	2.287	2.233	0.332	0.320	4.531	4.391	4.529	4.458	699.9	694.6	261.0	241.0
15 kg P_2O_5/fed	2.326	2.368	0.363	0.351	4.826	4.715	4.572	4.514	706.5	701.2	275.9	274.5
30 kg P_2O_5/fed	2.525	2.373	0.403	0.391	5.070	4.823	4.721	4.541	756.1	750.8	277.1	284.4
LSD at 5 %	0.110	0.112	0.011	0.012	0.305	0.288	0.089	0.105	19.8	15.8	9.7	10.5
C- Zinc fertilizer levels:												
Without	2.211	2.209	0.348	0.336	4.469	4.591	4.466	4.415	698.5	693.2	252.4	253.4
250 ppm	2.393	2.31	0.353	0.341	4.978	4.634	4.555	4.418	721.2	715.9	268.0	262.4
500 ppm	2.534	2.455	0.397	0.385	4.981	4.704	4.800	4.681	742.7	737.4	293.7	284.2
LSD at 5 %	0.123	0.129	0.018	0.015	0.370	0.365	0.122	0.135	24.2	23.1	12.4	15.2
D- Interactions:												
A × B	*	NS	NS	NS	*	NS	NS	*	*	*	NS	NS
A × C	NS	*	NS	*	NS	NS	*	NS	NS	*	NS	*
B × C	NS	NS	NS	NS	NS	*	*	*	*	NS	*	NS
A × B × C	*	*	*	*	NS	NS	*	*	*	*	*	*

Table 5: Mean values of N, P, K and Zn content in flax seeds as affected by farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels as well as their interactions during 2012/2013 and 2013/2014 seasons.

Characters / Treatments/ Seasons	N (%)		P (%)		K (%)		Zn (ppm)	
	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014
A- Farmyard manure levels:								
Without	3.85	3.79	0.630	0.623	0.503	0.619	35.14	34.12
10 m^3/fed	4.12	4.06	0.700	0.693	0.546	0.689	37.36	36.34
20 m^3/fed	4.27	4.21	0.750	0.743	0.551	0.739	38.09	37.07
LSD at 5 %	0.10	0.10	0.083	0.076	0.010	0.009	0.02	0.03
B- Phosphorus fertilizer levels:								
Without	4.05	3.99	0.671	0.664	0.528	0.660	35.18	34.16
15 kg P_2O_5/fed	4.14	4.08	0.695	0.688	0.533	0.684	37.01	35.99
30 kg P_2O_5/fed	4.46	4.40	0.713	0.706	0.538	0.702	38.40	37.38
LSD at 5 %	0.13	0.12	0.076	0.081	0.010	0.009	0.03	0.03
C- Zinc fertilizer levels:								
Without	3.91	3.85	0.647	0.640	0.512	0.636	31.90	30.88
250 ppm	4.16	4.10	0.649	0.642	0.542	0.638	38.70	37.68
500 ppm	4.17	4.11	0.783	0.776	0.546	0.772	40.00	38.98
LSD at 5 %	0.13	0.12	0.127	0.125	0.022	0.023	0.03	0.04
D- Interactions:								
A × B	NS	NS	NS	NS	NS	NS	NS	NS
A × C	NS	NS	NS	NS	NS	NS	NS	NS
B × C	NS	NS	NS	NS	NS	NS	NS	NS
A × B × C	NS	NS	NS	NS	NS	NS	NS	NS

with 500 ppm zinc, which significantly surpassed other zinc levels (without and 250 ppm zinc) and produced the highest values of all studied characters in both seasons under the environmental conditions of this study. Whereas, spraying flax plants twice with 250 ppm zinc gave the best values of all studied characters after aforementioned treatment in the two growing seasons. On the other wise, control treatment (without zinc foliar fertilization) resulted in the lowest values of these characters in both seasons.

This increase in growth characters of flax, yields and its components as well as quality parameters by increasing zinc foliar fertilizer levels might be due to zinc, is known to have an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes **(Cynthia et al., 2004)**. Thus, it is associated with saccharide metabolism, photosynthesis, nucleic acid, lipid metabolism and protein synthesis (**Marschner, 1995 ; Cakmak, 2008 and Bybordi and Mamedov 2010).** Similar observation was reported by the investigators, among them **Bakry et al. (2012), Tahir et al. (2014) and Bakry et al. (2015)**.

4. Effect of the interaction:

There are many significant effects of the interactions among studied factors on studied characters. We present only the significant three way interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels on all studied characters in both seasons as presented in Tables 3 through 6.

As shown from results graphically illustrated, the best interaction treatment which produced the highest values of stem diameter in the first season (Fig. 1), number of fruiting branches in the first season (Fig. 2), straw yield/plant (Fig. 3), seed yield/plant (Fig. 4), straw yield/fed (Fig. 5), seed yield/fed (Fig. 6) and long fiber yield/fed (Fig. 7) in both seasons was organic fertilized flax plants with 20 m^3 FYM /fed and 30 kg P_2O_5/fed besides foliar spraying twice with 500 ppm zinc.

Table 6: Mean values of protein percentage in flax seeds and N-uptake, P-uptake, K-uptake and Zn-uptake as affected by farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels as well as their interactions during 2012/2013 and 2013/2014 seasons.

Characters / Treatments / Seasons	Protein (%)		N-uptake (kg fed^{-1})		P-uptake (kg fed^{-1})		K-uptake (kg fed^{-1})		Zn-uptake (g fed^{-1})	
	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014	2012/2013	2013/2014
A- Farmyard manure levels:										
Without	24.78	24.26	26.63	26.41	4.35	4.23	3.54	3.44	24.26	23.84
10 m^3/fed	25.73	25.21	27.29	27.07	4.90	4.78	3.55	3.45	25.02	24.60
20 m^3/fed	26.53	26.01	29.14	28.92	5.05	4.93	3.94	3.84	27.47	27.05
LSD at 5 %	0.89	0.85	0.91	0.89	0.52	0.53	0.47	0.45	1.39	0.30
B- Phosphorus fertilizer levels:										
Without	25.28	24.76	27.06	26.84	4.61	4.49	3.65	3.55	24.08	23.66
15 kg P_2O_5/fed	25.56	25.04	27.77	27.55	4.73	4.61	3.68	3.58	26.33	25.91
30 kg P_2O_5/fed	26.20	25.68	28.23	28.01	4.96	4.84	3.72	3.62	26.34	25.92
LSD at 5 %	0.72	0.71	0.85	0.83	0.46	0.47	0.32	0.30	0.32	1.31
C- Zinc fertilizer levels:										
Without	24.42	23.90	26.37	26.15	4.09	3.97	3.27	3.17	20.25	19.83
250 ppm	25.90	25.38	27.52	27.30	4.46	4.34	3.78	3.68	27.12	26.70
500 ppm	26.72	26.20	29.16	28.94	5.74	5.62	3.99	3.89	29.37	28.95
LSD at 5 %	0.66	0.65	0.79	0.76	0.41	0.42	0.29	0.26	1.13	0.11
D- Interactions:										
A × B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
A × B × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

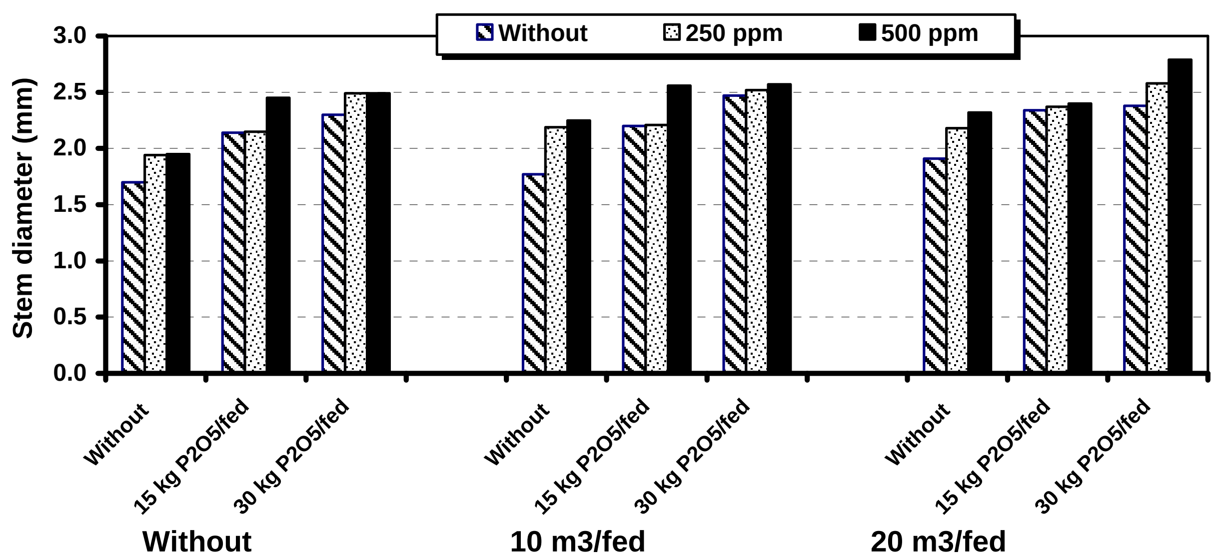


Fig. 1: Stem diameter (mm) as affected by the interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels during 2013/2014 season.

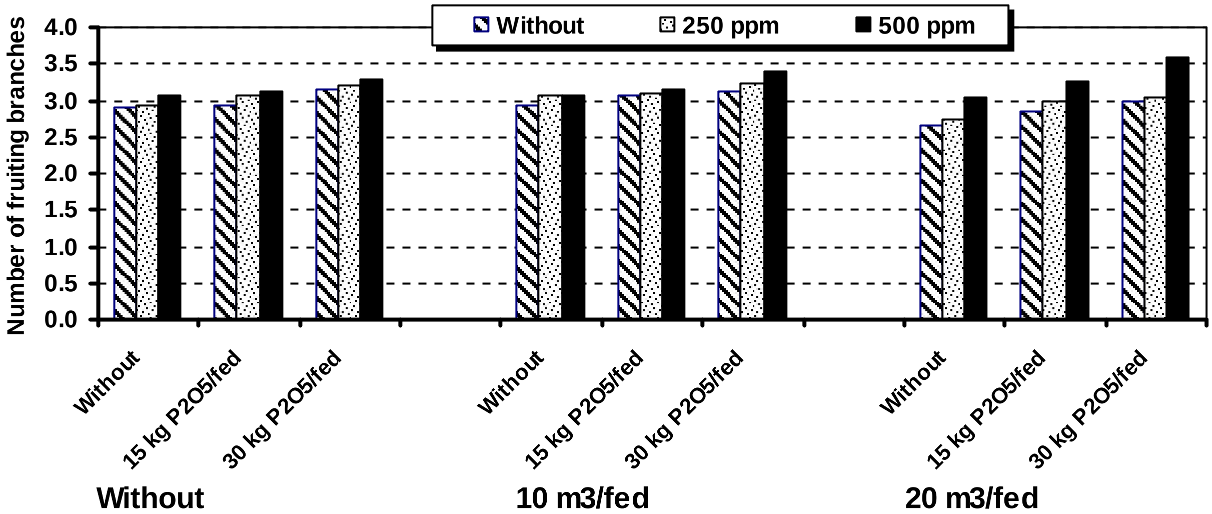


Fig. 2: Number of fruiting branches as affected by the interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels during 2013/2014 season.

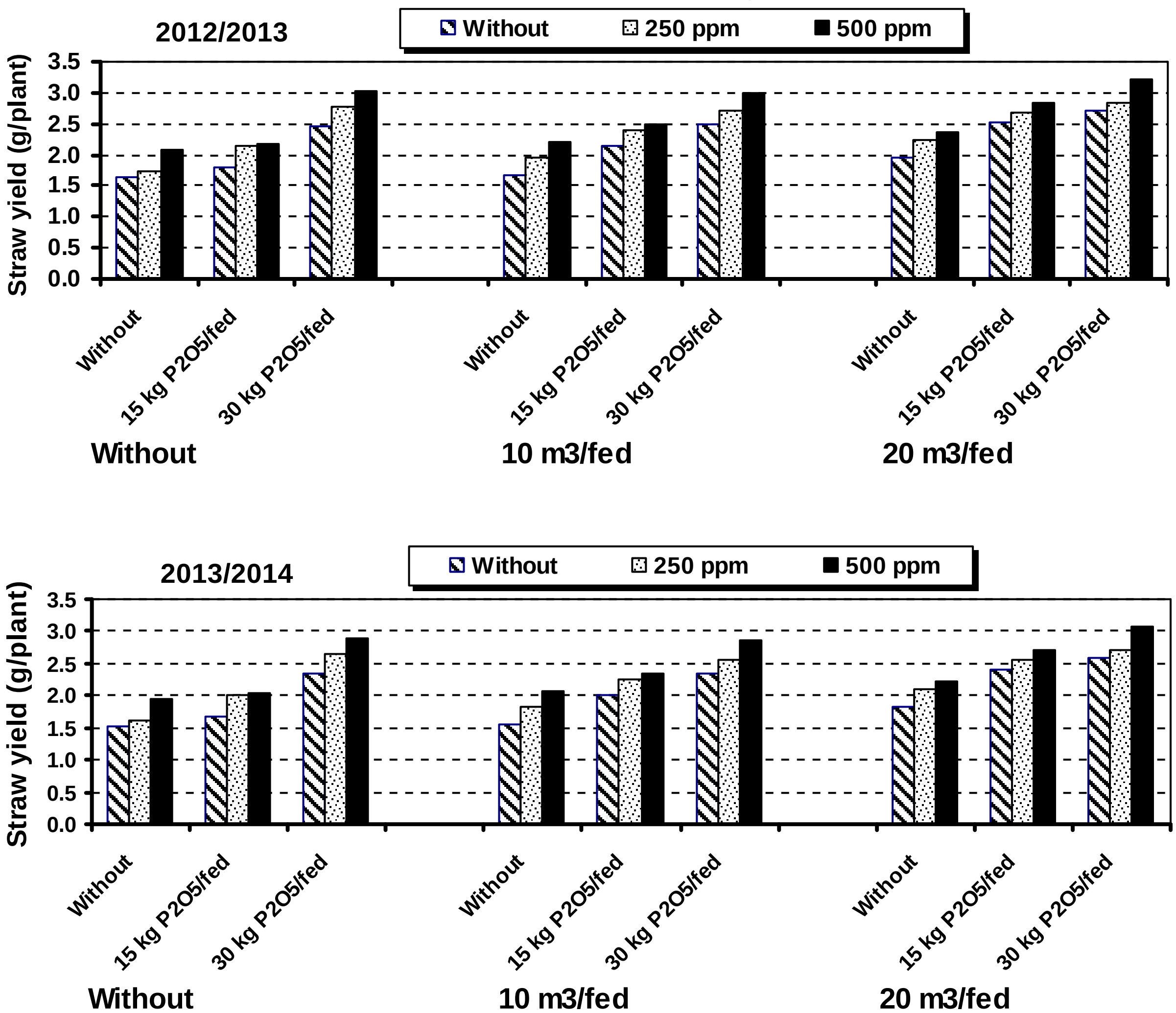
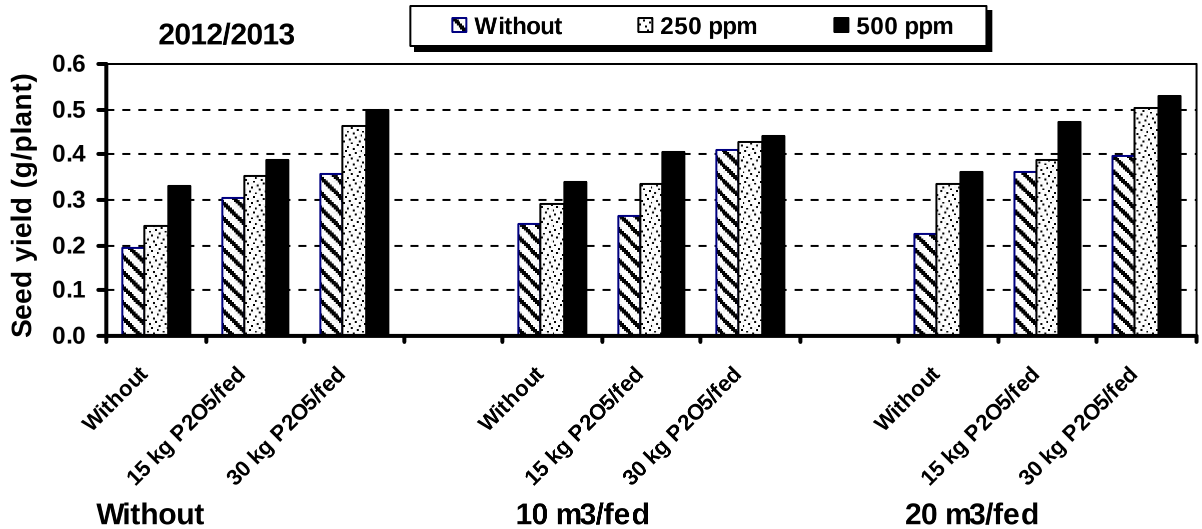


Fig. 3: Straw yield (g/plant) as affected by the interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels during 2012/2013 and 2013/2014 seasons.



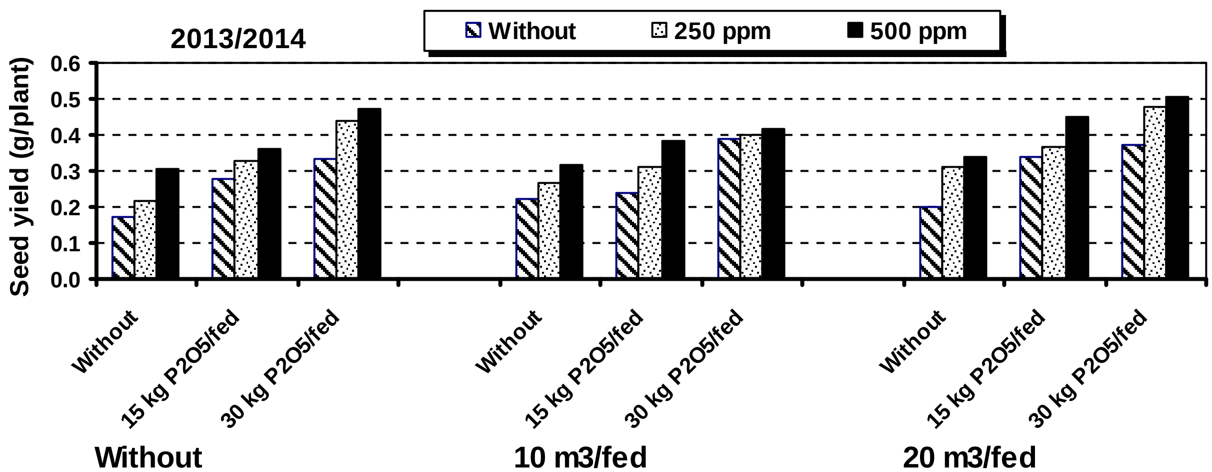
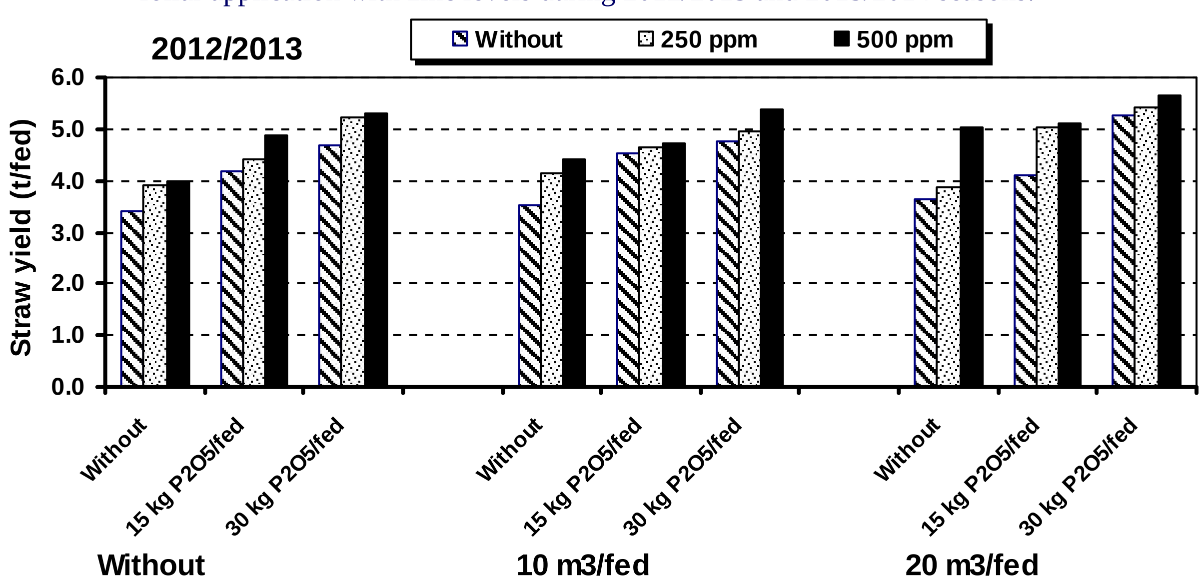


Fig. 4: Seed yield (g/plant) as affected by the interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels during 2012/2013 and 2013/2014 seasons.



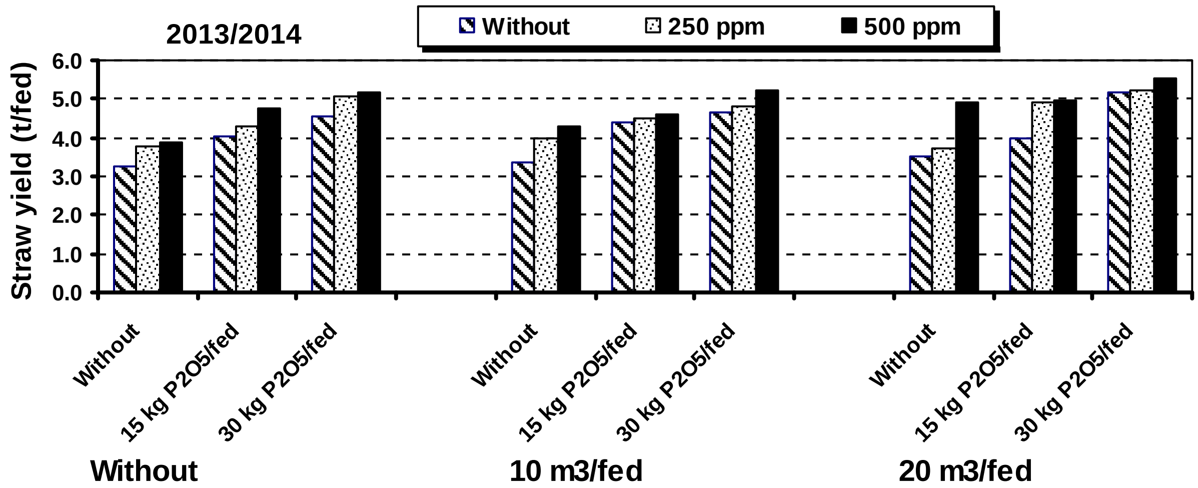


Fig. 5: Straw yield (t/fed) as affected by the interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels during 2012/2013 and 2013/2014 seasons.

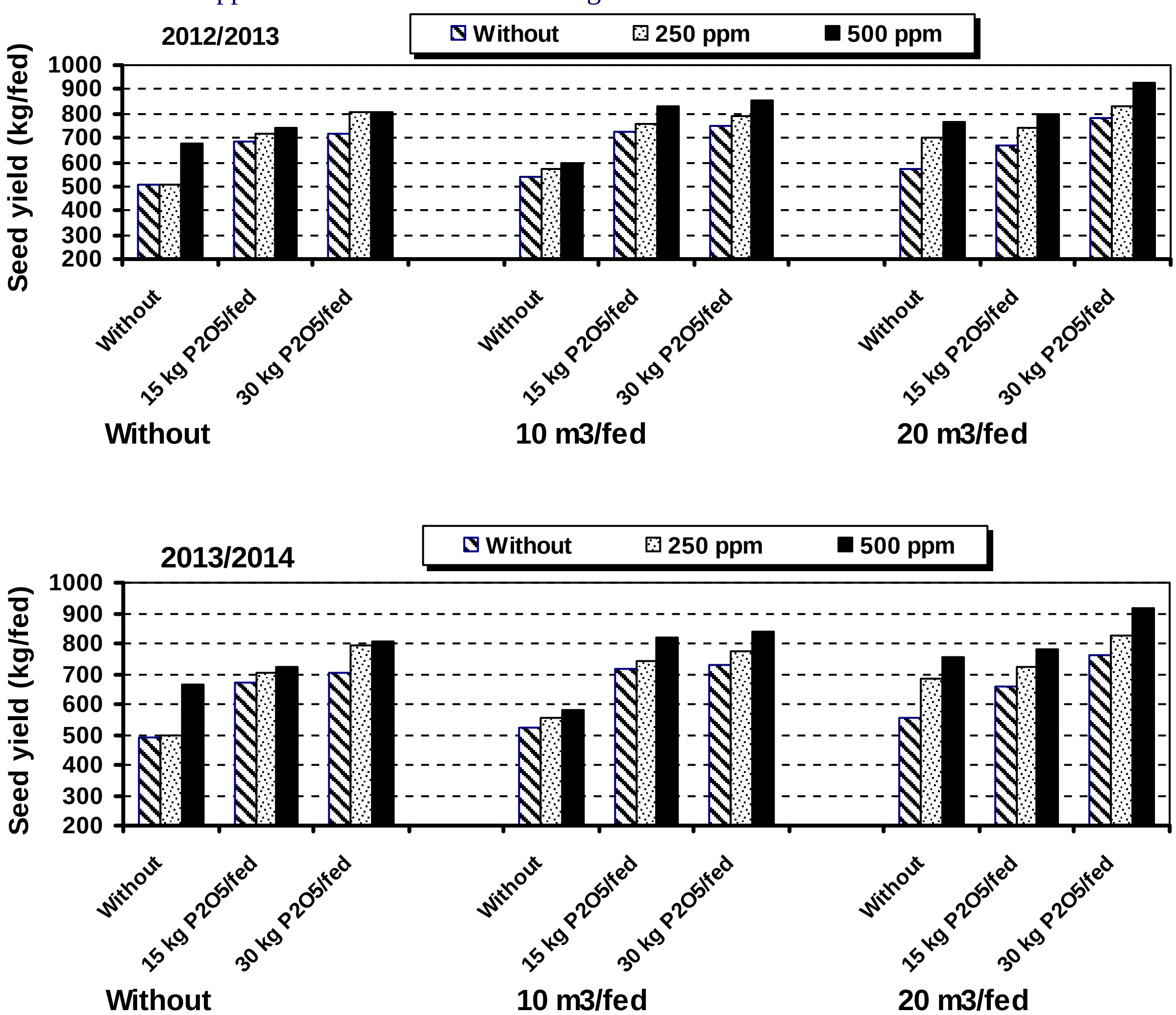
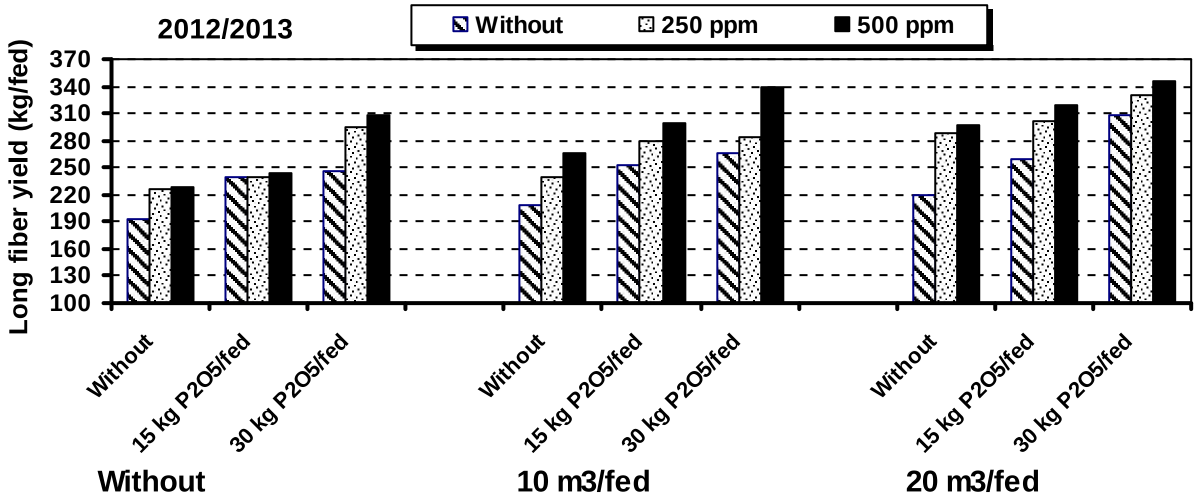


Fig. 6: Seed yield (kg/fed) as affected by the interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels during 2012/2013 and 2013/2014 seasons.



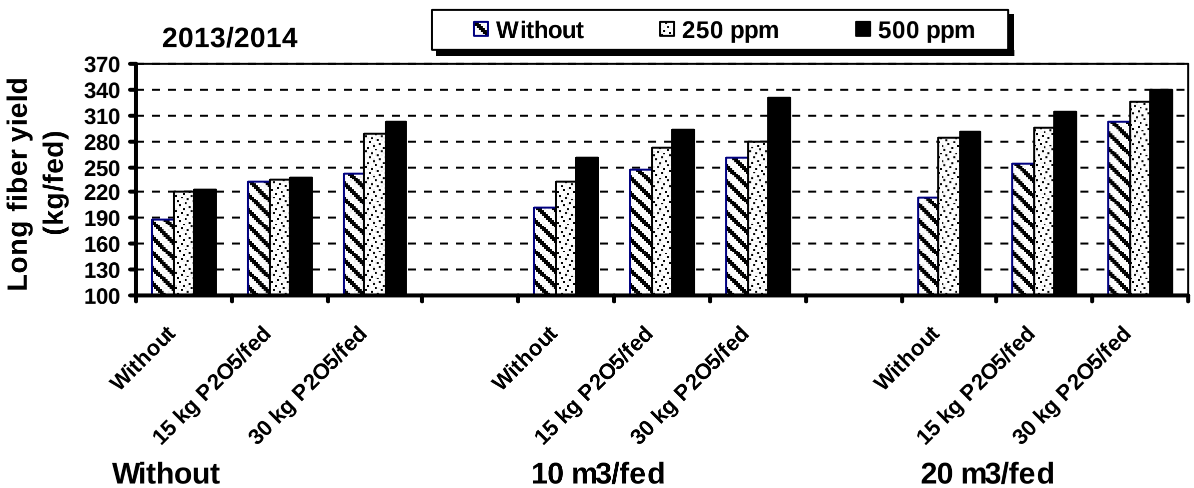


Fig. 7: Long fiber yield (kg/fed) as affected by the interaction among farmyard manure and phosphorus fertilizer levels and foliar application with zinc levels during 2012/2013 and 2013/2014 seasons.

Conclusion

It could be concluded that organic fertilized flax plants with 20 m^3 FYM /fed and 30 kg P_2O_5/fed besides foliar spraying twice with 500 ppm zinc under the environmental conditions of Gemmeiza district, El-Gharbia Governorate.

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