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Effects of Farmyard Manure (FYM) and Zinc Fertilizer Rates on Zinc Content and Uptake by Wheat (*Triticum aestivum* L.) on Sandy Clay Loam of Borno State, Nigeria

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ABSTRACT

A pot experiment was carried out in Faculty of Agriculture Screen house, University of Maiduguri to study the effects of Farmyard manure (FYM) and Zinc fertilizer rates on Zinc content and uptake by wheat (*Triticum aestivum* L.) grown on sandy clay loam, from November 2019 to February, 2020 in a Completely Randomized Design (CRD) with 3 replications. Ten (10) Kg soil was weighed into each pot, four levels of FYM; 0, 5, 10 and 15t/ha and three levels of Zn fertilizer; 0, 5 and 10 mg/kg treatment combinations with basal NPK fertilization were added to the appropriate pot. Soil, FYM and plant analyses for Zn concentrations were carried out for wheat grain, leaf and straw and their uptake. Agronomic data on wheat were collected. Result obtained showed improved Zn uptake by wheat with FYM and Zn fertilizer rates. Fertilizer rates of 0 t/ha FYM + 5 ppm Zn gave the maximum wheat grain Zn content and uptake of 84.00 µg/g (by 55%) and 1632.2 µg/pot respectively. It was concluded that application of FYM and Zn fertilizer had increased wheat Zn content and uptake. For sustainable soil and improved wheat grain Zinc content and uptake, 15t/ha FYM + 10 ppm Zn increased wheat grain Zn content by 51% and the combination ensures sustainable soil quality.

Keywords: Zinc; wheat; farmyard manure; uptake; content.

1.0 INTRODUCTION

Wheat (*Triticum aestivum* L.) is grown on more land area than any other food crop, approximately 220.4 million hectares (FAOSTAT, 2014). It is grown all over the world for its highly nutritious and useful grain, as one of the top three most produced crops, along with corn and rice. It is used in the production of bread, biscuits, feeds, confectionary, amongst many utilization.

Wheat has been cultivated in Nigeria for centuries (Ohiagu *et al*., 1987). Ample evidence exists to show that wheat has been cultivated in Nigeria as early as 200BC, although the currently cultivated varieties are relatively recent introduction (Olabanji *et al*., 2007). However, Nigeria's domestic wheat production has remained at a very low level in spite of the ever rising demand for the crop. Development of improved agronomic practices in respect of land preparation, planting, nutrition, water management, crop protection, harvest and postharvest technology have been the major areas where researchers have concentrated their efforts. Wheat is a major staple food crop in the world. Increasing grain yield and improving quality are of great importance for the increasing human population (Curtis and Halford, 2014). The grain structure of wheat is generally divided into bran, embryo and endosperm which account for 14-16, 2-3, and 81-84% of the grain respectively (Mousia *et al*., 2004).

Zinc (Zn) is one of the 17 essential elements necessary for the normal growth and development of plants. Zn plays a key role in plants with enzymes and proteins involved in carbohydrate metabolism, protein synthesis, gene expression, auxin (growth regulator) metabolism, pollen formation, maintenance of biological membranes, protection against photo-oxidative damage and heat stress, and resistance to infection by certain pathogens (Alloway, 2008a). Zn is important in photosynthesis and respiration, and its deficiency decreases photosynthetic rate, chlorophyll content, activity of carbonic anhydrase, and protein biosynthesis (Fu *et al*., 2016).

Wheat grains produced without optimum soil Zn levels is resulting in human Zn deficiency (Alloway, 2008a). Among micronutrients, Zn deficiency is occurring in both crops and humans (Welch and Graham, 2004). Zn deficiency results in a series of problems for humans, especially infants, such as loss of appetite and digestion, growth retardation, and brain and immune system dysfunction (Prasad, 2014). Zinc deficiency in soils and plants is a global micronutrient deficiency problem reported in many countries (Alloway, 2004). Zn deficiency is the fifth major factor affecting human health in developing countries (Anthony *et al*., 2002).

Application of Zn fertilizers could be a viable option to satisfy the crop demand for Zn and also to increase grain Zn contents ultimately taken up by human beings. Application of organic amendments can influence Zn availability to crops through modification of various adsorption desorption process, chelation of Zn, cation exchange capacity, pH, soil structure and microbial transformation and increase or decrease the Zn availability to plants. Organic matter especially the soluble C fraction acting as chelating agent decreases the Zn adsorption and increases formation of soluble organic-Zn complexes (Shuman, 1985).

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle (Reddy, 2005).FYM is one of the oldest manure used by farmers for growing crops because of its early availability and presence of almost all the nutrient required by plant (Parshottam *et al*., 2018).

Shukla *et al*. (1978) reported the beneficial effect of farmyard manure on crop yield and the availability of zinc to plants. Gondek and Mazur (2005) observed that the application of FYM also increased the concentration of N and Zn. Similarly, enhanced Zn concentration and uptake by plant available NPK and Zn contents of soil can be significantly increased by the use of FYM. Rupa *et al*. (2003) reported that wheat crop also enhanced Zn utilization with FYM application. The objective of the study was to determine the effect of farmyard manure and zinc fertilizer rates on wheat Zn content and uptake.

2.0 MATERIALS AND METHOD

2.1 Pot Experiment

A pot experiment was conducted in Screen House Facility at the Faculty of Agriculture, University of Maiduguri from November 2019 to February, 2020. Borno state is characterized with annual mean rainfall and temperature of 552 mm and 35 ^{o}C and record high and low temperatures of 47 and 5 ^{o}C in the month of May and December (Climate Charts, 2017). Ten (10 kg) of soil sample was weighed into each pot and the appropriate treatment applied. Wheat crop (LACRI WHIT 6 REYNA-28) obtained from Lake Chad Research Institute (LCRI) Maiduguri was used as the test crop. Nine (9) wheat seeds were sown and thinned to six (6) seedlings one week after germination which were allowed to grow to maturity. Weeds were removed by hand picking using hand when necessary to ensure that crops were kept weed free throughout the experiment.

2.2 FYM and Zn fertilizer application

Cow dung FYM was applied at four levels viz., 0, 5, 10 and 15 tonnes per hectare equivalent to 0, 25, 50, 75g FYM per 10 kg pot soil to appropriate treatment and thoroughly mixed with the soil two (2) weeks before sowing. Zinc fertilizer as $ZnSO_4.7H_2O$ at three levels 0, 5 and 10 mg/kg equivalent to 0, 10 and 20kg Zn/ha was also surface applied as solution to the appropriate pot. Basal NPK fertilizer was also surface applied to all pots at the rates of 50mg kg^{-1} N, 22.5 mg Kg^{-1} P and 28.38 mg Kg^{-1} K equivalent to100Kg N ha^{-1}, 45Kg P ha^{-1} and 57Kg Kha^{-1} respectively in the form of NH_4NO_3 and KH_2PO_4 at sowing. Equal quantity of water was supplied to each pot to maintain soil moisture at field capacity.

2.3 Treatment and experimental design

The pot experiment was carried out with four levels of cow dung FYM (0, 5, 10 and 15t/ha) and three levels of Zn fertilizer (0, 5 and 10 ppm) giving a total of twelve (12) treatments which were replicated thrice giving a total number of 36 pots. The experiment was laid out in a Completely Randomized Design (CRD) as shown in Fig. 1.

Composite soil sample collected was analysed before the experiment for physico-chemical properties and DTPA extractable Zn. The particle size distribution was determined using hydrometer method (Bouyoucos, 1962). Soil pH was determined in soil-water ratio of 1:2.5 using glass electrode pH meter. The suspension used in the determination of pH was used for the determination of EC following the same process with the use of an EC meter.

Percentage organic carbon of the soil was determined by the use of Walkley and Black (1934) dichromate wet oxidation method as described by Nelson and Sommers (1982). Exchangeable cations of the soil was determined by using 1N NH_4OAc (pH7.0) saturation method (Chapman, 1965). Sodium and potassium were determined using flame photometric method while calcium (Ca) and Magnesium (Mg) were determined by titration method against EDTA using eriochrome black TEA indicator. Exchangeable acidity was extracted with 1N KCl and measured according to the procedure of Mclean (1982). Total nitrogen was determined by micro-Kjeldahl digestion method (Jackson, 1962), while available phosphorus was determined using Bray II method as described by Olsen and Sommers (1982). The analysis of FYM was done following the method of plant analysis by Marr and Cresser (1983). 0.2g of prepared cow dung FYM was weighed into a beaker and 2.5ml concentrated H_2SO_4 and $HClO_4$ acid and placed on a hot plate and heated at 180-200 ^{0}C until a clear digest is obtained. NPK and Zn was then determined from the digest.

Soil zinc was extracted using diethylene triamine penta acetic acid (DTPA); 10g of soil was shaken with 20ml of DTPA extractant (0.005M, DTPA and 0.01M $CaCl_2$+0.1M triethanol amine adjusted to pH 7.3) (Lindsay and Norvell, 1978) and then determined using VGP 210 atomic absorption spectrophotometre.

2.4 Plant analysis

Leaf, straw and grain samples were analysed for N, P, K and Zn following the method of Marr and Cresser (1983). The samples were oven dried at 65 °C and ground for the determination of N, P and K. 200mg of the sample was weighed into a clean 100ml Kjeldahl flask and 5ml of concentrated H_2SO_4 added. The flask was swirled gently and then heated for 40 minutes. Five millilitre (5ml) of 4% V/V solution of 62% $HClO_4$ and concentrated H_2SO_4 was added and heated for 10 minutes to obtain a clear digest. The digest was cooled and transferred to a 50 ml volumetric flask and diluted with distilled water to the mark and used for the determination of N, P and K. A blank was also prepared.

For Zn analysis, 500mg of the ground sample was weighed into a digestion tube and mixture of HNO_3 and perchloric acid were added. The content was heated and after getting a clear digest, the content was transferred into a 50ml volumetric flask and made up to mark and used for determination of Zn with an Atomic Absorption Spectrophotometre model number VGP210 at Adamawa State University, Mubi. Blank was also included.

2.5 Statistical Analysis

Data obtained from the pot experiment were statistically analyzed according to the technique of analysis of variance (ANOVA) for the Completely Randomized Design (CRD) using Statistix computer software package. The treatment means were compared using Duncan Multiple Range Test (DMRT) at 1 and 5 % level of significance as described by Gomez and Gomez (1984).

3.0 RESULTS AND DISCUSSION

3.1 Results

3.1.1 Characteristics of the Experimental Soil

The physicochemical properties of the soil used are presented in Table 1. The textural class of the soil was Sandy clay loam with clay 304g/kg soil, silt 114g /kg soil and sand 582g/kg soil. The pH of the soil was 7.20 which is slightly alkaline. The soil had EC of 0.02 mmhos/cm which is non saline. Phosphorus (16.10 mg/kg), organic carbon (12.99g/kg), potassium (0.50 Cmol(+)/kg and sodium (0.48 cmol(+)/kg soil) were all moderate. Base saturation (94.86%) and calcium (24.4 cmol(+)/kg) were very high. Cation exchange capacity (38.78 Cmol(+)/kg soil) was high, total nitrogen (0.76%) was very low and DTPA extractable zinc (1.12mg/kg) was moderate.

3.1.2 Characteristics of Cow Dung Farmyard Manure Used

The composition of cow dung FYM used is presented in Table 2. The content of N, P, K and Zn were 3.22, 0.38, 0.43 % and 1.84 µg/g respectively.

3.1.3 Effect of FYM and Zn Fertilizer Rates on Wheat Leaf NPK and Zn Content

The content of nitrogen (N), phosphorus (P), potassium (K) and zinc (Zn) in wheat leaf as affected by rates of FYM and Zn are presented in Table 3. Significant ($P<0.01$) difference was observed between the treatments in wheat leaf N content. The mean N content of wheat leaf ranged from 1.68 - 3.33 % given by control and 10 t/ha FYM + 0 ppm Zn rate.

Mean P content of wheat leaf was also significantly ($P<0.01$) affected by rates of FYM and Zn fertilizer. The highest leaf P (0.19%) in the treatment 5 t/ha FYM + 5 ppm Zn rates and lowest (0.06%) in the control. Percentage K content of wheat leaf ranged from 0.76 in control to 2.18% in treatment 15t/ha FYM and 0 ppm Zn rate. Significant ($P<0.01$) difference was observed between the treatments. Wheat leaf Zn content was significantly ($P<0.01$) affected by rates of FYM and Zn fertilizers. The highest (30.00 µg/g) wheat leaf Zn content was observed with application of 10 t/ha FYM + 10 ppm Zn and lowest (20.00 µg/g) in control.

3.1.4 Effect of FYM and Zn Fertilizer Rates on Wheat Grain NPK and Zn Content

Result in Table 4 shows wheat grain N, P, K and Zn contents as affected by FYM and Zn fertilizer rates. Mean wheat grain N content varied significantly ($P<0.01$) between treatments. N content ranged from 1.93 - 3.19 % in control and 5 t/ha FYM + 10 ppm Zn respectively.

Significant ($P<0.01$) difference was observed between the treatment means of wheat grain P content with application of FYM and Zn fertilizers. Mean grain P contents ranged from 0.06 to 0.15 % in control and 5 t/ha FYM + 5 ppm Zn rate, respectively. Wheat grain K showed significant ($P<0.01$) difference between the treatments with application of FYM and Zn fertilizers. Wheat grain K ranged from 0.27% in control to 0.47% in the application of 5t/ha FYM + 5 ppm Zn and 15t/ha FYM + 0 ppm Zn. Wheat grain Zn content differed significantly ($P<0.01$) between treatments with FYM and Zn fertilizer applied at different rates. The mean Zn content of wheat grain ranged from 35.00 µg/g in control to 84.00 µg/g in 0 t/ha FYM + 5 ppm Zn.

3.1.5 Effect of FYM and Zn Fertilizer Rates on Wheat Straw NPK and Zn Content

Wheat straw N content showed significant ($P<0.01$) difference between control and 0 t/ha FYM + 10 ppm Zn (0.95 %), 5 t/ha FYM + 0 ppm Zn (1.16 %), 10 t/ha + 5 ppm Zn (1.34 %) and 10 t/ha + 0 ppm Zn rates (Table 5). Higher (1.34 %) N content was given by 10 t/ha FYM + 5 ppm Zn while lowest (0.60 %) N content was observed in control.

FYM and Zn fertilizer rates application had significantly ($P<0.05$) influenced mean wheat straw P content. The highest (0.06%) mean wheat straw P content was observed in the application of 10 t/ha FYM + 0 ppm Zn and lowest (0.02 %) in control. Mean wheat straw K content varied significantly ($P<0.01$) between treatments. Mean wheat straw K content ranged from 0.47% in 5 t/ha FYM + 0 ppm Zn to 1.08 % in 10 t /ha FYM + 5 ppm Zn rates.

Wheat straw Zn content was significantly (P<0.01) affected with FYM and Zn fertilizer application rates. The highest (25.00 µg /g) wheat straw Zn content was observed in 0 t/ha FYM + 5 ppm Zn rates and lowest (16.33 µg/g) was observed with 10 t/ha FYM + 0 ppm Zn rates.

3.1.6 Effect of FYM and Zn Fertilizer Rates on Wheat Grain NPK and Zn Uptake

Effect of FYM and Zn fertilizer rates on wheat grain NPK and Zn uptake is presented in Table 6. Mean wheat grain N uptake was significantly (P<0.01) affected between treatments. Wheat grain N uptake ranged from 320.38 mg/pot in control to 650.252 mg/pot in 5t/ha FYM + 5 ppm Zn rates. Wheat grain P uptake had showed significant (P<0.01) difference between treatments. Highest (35.10 mg/pot) grain P uptake was observed in 5 t/ha FYM + 5 ppm Zn and lowest wheat grain P uptake (9.96 mg/pot) in control.
Mean wheat grain K uptake showed significant (P<0.01) effect with FYM and Zn fertilizers application rates. The highest (109.98 mg/ pot) was yielded by 5 t /ha FYM + 5 ppm Zn rate and the lowest (44.82 mg/pot) by the control.

Table 1: Physico-chemical properties of the soil sample

Characteristic	Value
Particle size distribution (g/kg)	
Sand	582
Silt	114
Clay	304
Textural class	Sandy clay loam
Chemical properties	
pH 1:2.5 (H_2O)	7.20
EC (mmhos/cm)	0.02
Organic carbon (g/kg)	12.99
Total N (g/kg)	7.60
C:N ratio	1.71
Available P (mg/kg)	16.10
Available Zn (mg/kg)	1.12
Exchangeable cations (Cmol/kg)	
Ca	24.40
Mg	13.40
K	0.50
Na	0.48
Exchange acidity (H +Al)	2.10
CEC	38.78
ECEC	40.88
Base saturation (%)	94.86

Table 2: Characteristics of cow dung Farmyard manure used

Nutrient	Content
N (%)	3.22
P (%)	0.38
K (%)	0.43
Zn (µg/g)	1.84

Table 3: Effect of FYM and Zn fertilizer rates on NPK and Zn content in wheat leaf

Treatment	N (%)	P (%)	K (%)	Zn (µg/g)
Control	1.68[g]	0.06[f]	0.76[j]	20.00[e]
0t/ha FYM + 5 ppm Zn	1.79[fg]	0.09[e]	1.67[i]	22.00[de]
0t/ha FYM + 10 ppm Zn	2.68[b]	0.11[d]	1.46[i]	23.67[cd]
5t/ha FYM + 0 ppm Zn	2.35[bcde]	0.14[bc]	1.79[ef]	21.00[e]
5t/ha FYM + 5 ppm Zn	2.66[b]	0.19[a]	2.01[bc]	24.00[cd]
5t/ha FYM + 10 ppm Zn	2.59[bc]	0.14[b]	1.65[gh]	25.67[bc]
10t/ha FYM + 0 ppm Zn	3.33[a]	0.11[d]	2.13[ab]	20.67[e]
10t/ha FYM + 5 ppm Zn	2.21[de]	0.12[d]	1.96[cd]	22.00[de]
10t/ha FYM + 10 ppm Zn	2.52[bcd]	0.15[b]	1.68[fg]	30.00[a]
15t/ha FYM + 0 ppm Zn	2.28[cde]	0.11[d]	2.18[a]	24.00[cd]
15t/ha FYM + 5 ppm Zn	2.07[ef]	0.12[d]	1.84[de]	28.00[ab]
15t/ha FYM + 10 ppm Zn	2.38[bcde]	0.12[cd]	1.55[hi]	27.00[b]
SE±	0.1177	6.67×10^{-3}	0.0430	0.8498

Means followed by same letter(s) within a column are not significantly different at 5 % level of probability according to Duncan Multiple Range Test

Table 4: Effect of FYM and Zn fertilizer rates on NPK and Zn content in wheat grain

Treatment	N (%)	P (%)	K (%)	Zn (µg/g)
Control	1.93[c]	0.06[g]	0.27[g]	38.00[e]
0t/ha FYM + 5 ppm Zn	3.18[a]	0.12[bcd]	0.37[de]	84.00[a]
0t/ha FYM + 10 ppm Zn	2.77[b]	0.0933[ef]	0.35[de]	35.00[e]
5t/ha FYM + 0ppm Zn	2.71[b]	0.13[ab]	0.46[ab]	77.33[ab]
5t/ha FYM + 5 ppm Zn	2.78[b]	0.15[a]	0.47[a]	45.00[de]
5t/ha FYM + 10 ppm Zn	3.19[a]	0.13[abc]	0.37[cde]	58.33[cd]
10t/ha FYM + 0 ppm Zn	2.71[b]	0.14[ab]	0.40[bcd]	63.00[bc]
10t/ha FYM + 5 ppm Zn	2.66[b]	0.10[def]	0.39[cde]	62.67[bc]
10t/ha FYM + 10 ppm Zn	2.70[b]	0.11[cde]	0.43[abc]	67.00[bc]
15t/ha FYM + 0 ppm Zn	2.63[b]	0.10[def]	0.47[a]	40.67[e]
15t/ha FYM + 5 ppm Zn	2.66[b]	0.08[fg]	0.28[fg]	45.67[de]
15t/ha FYM + 10 ppm Zn	2.80[b]	0.10[def]	0.34[ef]	78.00[ab]
SE±	0.0743	7.52×10^{-3}	0.0197	5.3220

Means followed by same letter(s) within a column are not significantly different at 5 % level of probability according to Duncan Multiple Range Test

Mean wheat grain Zn uptake was observed to have significant (P<0.01) difference with FYM and Zn fertilizer application rates. Control varied significantly ((P<0.01) with all the treatments with the exception of 0t/ha FYM + 10 ppm Zn (737.5µg/pot) and 15 t/ha FYM + 0 ppm Zn (781.3 µg/pot) which are statistically similar to the control (632.1 µg/pot). The highest (1632.2 µg/pot) mean wheat Zn uptake was observed with 0t/ha FYM + 5 ppm Zn rate and the lowest (632.1 µg/pot) with the control.

3.1.7 Effect of FYM and Zn Fertilizer Rates on Wheat Straw NPK and Zn Uptake

The effect of the treatments on N, P, K and Zn uptake by wheat straw are presented in Table 7. Mean wheat N uptake by wheat straw showed significant (P<0.01) difference between control (143.4 mg/pot) and 0 t/ha FYM + 5 ppm Zn, 0 t/ha FYM + 10 ppm Zn, 5 t/ha FYM + 0 ppm Zn, 5 t/ha FYM + 5 ppm Zn, 10 t/ha FYM + 0 ppm Zn and 10 t/ha FYM + 5 ppm Zn rates with values of 243.81, 280.92, 323.29, 239.76, 408.46 and 401.06 mg/pot N respectively while the remaining treatments were similar to the control (143.40 mg/pot) and no significant (P>0.05) difference was recorded. The highest (408.46 mg/pot) wheat straw N uptake was recorded with 10 t/ha FYM + 0 ppm Zn and 10 t/ha FYM + 5 ppm Zn rates while the lowest (127.01 mg/pot) wheat straw N uptake was observed with control and 10 t/ha FYM + 10 ppm Zn rates.

Mean wheat straw P uptake was significantly (P<0.01) affected by FYM and Zn fertilizer application. This ranged from 4.78 mg/pot in control to 21.88 mg/pot in 10 t/ha FYM + 0 ppm Zn rate. Wheat P straw uptake were similar among treatments except with 10 t /ha FYM + 0 ppm Zn rate with value of 21.88 g/pot.

Mean wheat straw K uptake also showed significant (P<0.01) difference with treatment rates. The values ranged from 131.45 - 375.64 mg/pot by control and 10 t/ha FYM + 0 ppm Zn rate. Significant (P<0.01) difference between the control and all the treatment means was observed with respect to wheat straw Zn uptake. It ranged from 488.00 µg/pot (control) to 829.53 µg/pot (15 t/ha FYM + 5 ppm Zn rates).

Table 5: Effect of FYM and Zn fertilizer rates on wheat straw NPK and Zn content
Means followed by same letter(s) within a column are not significantly different at 5 % level of probability according to Duncan Multiple Range Test

Treatment	N (%)	P (%)	K (%)	Zn (µg/g)
Control	0.60^{de}	0.02^{c}	0.55^{c}	18.67^{cd}
0t/ha FYM + 5 ppm Zn	0.81^{cd}	0.05^{ab}	0.51^{c}	25.00^{a}
0t/ha FYM + 10 ppm Zn	0.95^{bc}	0.04^{b}	0.88^{b}	22.67^{ab}
5t/ha FYM + 0ppm Zn	1.16^{ab}	0.05^{ab}	0.47^{c}	17.67^{cd}
5t/ha FYM + 5 ppm Zn	0.81^{cd}	0.05^{ab}	0.85^{b}	18.00^{cd}
5t/ha FYM + 10 ppm Zn	0.63^{de}	0.05^{ab}	0.57^{c}	21.00^{bc}
10t/ha FYM + 0 ppm Zn	1.12^{b}	0.06^{a}	1.03^{ab}	16.33^{d}
10t/ha FYM + 5 ppm Zn	1.34^{a}	0.05^{ab}	1.08^{a}	21.00^{bc}
10t/ha FYM + 10 ppm Zn	0.49^{e}	0.04^{ab}	1.03^{ab}	19.00^{cd}
15t/ha FYM + 0 ppm Zn	0.60^{de}	0.05^{ab}	1.02^{ab}	18.33^{cd}
15t/ha FYM + 5 ppm Zn	0.60^{de}	0.05^{ab}	0.88^{b}	16.67^{d}
15t/ha FYM + 10 ppm Zn	0.49^{e}	0.05^{ab}	0.86^{b}	24.00^{ab}
SE±	0.0757	5.69×10^{-3}	0.0627	1.2247

Table 6: Effect of FYM and Zn fertilizer rates on wheat grain NPK and Zn uptake
Means followed by same letter(s) within a column are not significantly different at 5 % level of probability according to Duncan Multiple Range Test

Treatment	N (mg/pot)	P (mg/pot)	K (mg/pot)	Zn (µg/pot)
Control	320.38^{g}	9.96^{g}	44.82^{g}	632.1^{f}
0t/ha FYM + 5 ppm Zn	616.92^{ab}	23.28^{cd}	71.78^{def}	1632.2^{a}
0t/ha FYM + 10 ppm Zn	584.47^{bcd}	19.69^{def}	73.85^{cde}	737.5^{ef}
5t/ha FYM + 0ppm Zn	490.51^{e}	23.53^{bcd}	83.26^{bc}	1399.8^{ab}
5t/ha FYM + 5 ppm Zn	650.52^{a}	35.1^{a}	109.98^{a}	1050.7^{cd}
5t/ha FYM + 10 ppm Zn	620.46^{ab}	25.29^{bc}	$72.00c^{def}$	1125.6^{bc}
10t/ha FYM + 0 ppm Zn	533.06^{de}	27.54^{b}	71.97^{bcd}	1237.3^{bc}
10t/ha FYM + 5 ppm Zn	427.46^{f}	16.07^{f}	62.67^{f}	1007.1^{cde}
10t/ha FYM + 10 ppm Zn	560.25^{cd}	22.83^{cde}	89.23^{b}	1393.3^{ab}
15t/ha FYM + 0 ppm Zn	504.96^{e}	19.20^{def}	90.24^{b}	781.3^{def}
15t/ha FYM + 5 ppm Zn	593.18^{bc}	17.84^{ef}	62.44^{ef}	1018.1^{cde}
15t/ha FYM + 10 ppm Zn	576.8^{bcd}	20.60^{def}	70.04^{def}	1603.5^{a}
SE±	26.9397	1.8040	7.8872	1037.90

Table 7: Effect of FYM and Zn fertilizer rates on wheat straw NPK and Zn uptake

Treatment	N (mg/pot)	P (mg/pot)	K (mg/pot)	Zn (µg/pot)
Control	143.4^{e}	4.78^{c}	131.45^{e}	488.00^{f}
0t/ha FYM + 5 ppm Zn	243.81^{cd}	15.05^{b}	153.51^{e}	619.97^{de}
0t/ha FYM + 10 ppm Zn	280.92^{bc}	11.83^{b}	260.22^{cd}	699.47^{bcd}
5t/ha FYM + 0ppm Zn	323.29^{b}	13.94^{b}	130.99^{e}	564.90^{ef}

5t/ha FYM + 5 ppm Zn	239.76[cd]	14.80[b]	251.60[d]	707.87[bcd]
5t/ha FYM + 10 ppm Zn	173.69[de]	13.79[b]	157.15[e]	671.12[cd]
10t/ha FYM + 0 ppm Zn	408.46[a]	21.88[a]	375.64[a]	729.80[bc]
10t/ha FYM + 5 ppm Zn	401.06 [a]	14.97[b]	323.24[ab]	618.60[de]
10t/ha FYM + 10 ppm Zn	127.01[e]	10.37[b]	266.98[bcd]	780.15[ab]
15t/ha FYM + 0 ppm Zn	188.82[de]	15.74[b]	320.99[abc]	754.70[abc]
15t/ha FYM + 5 ppm Zn	178.74[de]	14.85[b]	261.36[cd]	829.53[a]
15t/ha FYM + 10 ppm Zn	127.74[e]	13.04[b]	224.20[d]	704.87[bcd]
SE±	28.6381	1.1404	23.3277	33.727

Mean followed by same letter(s) within a column are not significantly different at 5 % level of probability according to Duncan Multiple Range Test

4.0 DISCUSSION

4.1 Wheat NPK Content and Uptake

Wheat leaf, grain and straw NPK contents and their uptake were significantly ($P<0.05$) influenced by various rates of FYM and Zn fertilizers. This shows judicious use of the fertilizers by wheat crop. 10 t/ha FYM + 0 ppm Zn rate was the best in wheat leaf N content. This can be attributed to the presence of FYM that could have reduced N loss from the soil as well as release of N to the soil for uptake by wheat crop.

Wheat leaf P content have not showed better content with higher doses of FYM and Zn fertilizer (15 t/ha FYM + 10 ppm Zn). This could have been possibly due to phosphorus fixed by the high dose of FYM which may take considerable time to decompose completely or as a result of P dilution with Zn within the wheat crop as reported by Jansen (1998) that dilution effect within a plant results in lower nutrient content despite their higher application. 10 t/ha FYM + 0 ppm Zn resulted into maximum wheat leaf K content which is a par with sole15 t/ha FYM with no Zn fertilizer applied. This signifies that sole FYM application can be good enough to enhance and increase wheat leaf K.

Wheat N, P and K content and their uptake were observed to have better result with FYM and Zn fertilizer rates. Wheat grain N content was optimum with the highest rate containing Zn fertilizer (5t /ha FYM + 10 ppm Zn). Tao (2018) also reported enhanced wheat grain N content with increasing Zn levels. Wheat grain N uptake was also increased by FYM and Zn fertilizer rates. 5 t/ha FYM + 5 ppm Zn rate have showed similar result with higher dose of 15 t/ha FYM + 10 ppm Zn which revealed that luxury consumption may be suspected above 5t/ha FYM + 5 ppm Zn rate. Enhanced N uptake by wheat through FYM and Zn fertilizer combination shows synergistic effect which augmented their effectiveness in wheat grain N uptake. Improved and significant wheat grain N uptake could be attributed to decrease in N loss through leaching in addition to reduction in N-fixation by clays as reported by Misra and Jesse (1984).

Wheat grain P and K content and their uptake were both significantly ($P<0.05$) enhanced by FYM and Zn fertilizer rates applied. Lower 5 t/ha FYM + 5 ppm Zn rate showed better result over higher application rate of 15 t/ha FYM + 10 ppm Zn regarding wheat P and K grain content and their uptake. This increase in P and K uptake can be as a result of two mechanisms as reported by Misra and Hesse (1984); firstly, the mineralization of organic P in the manure, possibly through the release of organic acids and secondly, the organic manure might have formed complexes with iron (Fe) and aluminum (Al) thus reducing P-fixation and consequently increased its availability. The superiority of wheat grain NPK content and their uptake with various FYM rates over control could have been due to the higher mineralization rates of carbon and nitrogen in the manure amended soils than in control, which had a short term beneficial effects of increasing base status and water holding capacity of the soil as reported by Murwira and Kirchmann (1993).

Wheat straw NPK content and uptake have showed viable and significant result with rates of FYM and Zn fertilizer application. Wheat grain showed better utilization of N and P than wheat straw. Enhanced uptake of N and P by wheat straw may have resulted from important role of organic matter in supplying plant nutrients, enhancing cation exchange capacity, improving soil aggregation and henced water retention and supporting soil biological activity as reported by Dudal and Deckers (1993). The lower level of N, P and K contents of wheat straw despite higher application could be as a result of immobilization as reported by Rego *et al*. (2002) after fertilization.

4.2 Wheat Zinc Content and Uptake

Statistical analysis has shown significant increase in wheat leaf, grain and straw Zn contents and their uptake with varying rates of FYM and Zn fertilizers. Similar result was obtained by Raj and Gupta (1986) who reported marked improvement in Zn concentration and uptake resulted from increased rates of Zn application. This is attributed to the production of humic and fulvic acids from organic manures during their decomposition. These acids act as chelating agents and are capable of complexing Zn, thereby rendering it more available to the plants (Stevenson and Ardakani, 1972).

Wheat leaf Zn content was best supplied by 10 t/ha FYM + 10 ppm Zn rate which can relatively be attributed to the supply of degradable FYM supplied that effectively dissolves originally insoluble Zn. This could improve its solubility and availability in soil-plant systems because of water-soluble or labile organic compounds that have strong chelating abilities as reported by Fuente *et al*. (2012). Similar result was also obtained by Math and Trivedi (2001).

Wheat grain and straw Zn contents and their uptake increased significantly over control with various rates of FYM and Zn fertilizers. Although treatment receiving 0 t/ha FYM + 5 ppm Zn rate gave maximum wheat grain and straw Zn contents and uptake over control and all other treatments. Similar result was reported Saleem *et al*. (2017). Sole application of Zn fertilizer might have revealed better result due to their immediate and fast availability but may easily be adsorbed by soils having clay minerals (e.g smectites) that have greatest affinity to Zn as reported by Shukla (2002). For sustainable productivity, combined use of chemical with organic fertilizers has proved to be highly beneficial in terms of balanced nutrient supply as reported by Ayeni and Adetunji (2010). Considering soil sustainability and balanced nutrient supply, in this study, FYM and Zn fertilizer rate applied at 15 t/ha FYM and 5 ppm Zn rate which differed by approximately 7% decrease in wheat grain and straw Zn contents compared to sole 5 ppm Zn applied could have been a better option as combined application of organic and inorganic fertilizers improve soil fertility, productivity and reduce the impact of inorganic fertilizer on environment which is an alternative way for sustainable soil fertility and productivity. The lower Zn wheat grain and straw contents and uptake resulting from 15 t/ha FYM + 10 ppm Zn could be as a result of slower nutrient release by organic fertilizers as reported by Akhtar *et al*. (2009). Math and Trivedi (2001) who found similar results of an increased Zn in wheat and maize crop by combined application of organic amendment and Zn fertilizers. Combined application of FYM and Zn fertilizer can enhance long time Zn availability as organic manures are characterized with consistent rate of nutrient release and mobilization (Lal, 2006).

Lower wheat grain and straw Zn contents and uptake resulting from combined 15 t/ha FYM + 10 ppm Zn compared to 0 t/ha FYM + 5 ppm Zn with higher grain and straw Zn content and uptake from this studies can as well be as a result of possibly the FYM containing less labile pool and scavenges higher Zn concentrations due to formation of Zn complexes as supported by the findings of Catlett *et al.* (2002). The author reported that a strong inverse relationship between soil organic matter and soluble Zn in the rhizosphere. This can as well be reflected by the higher adsorption of Zn by FYM at 15t / ha used for adsorption in this study.

5.0 CONCLUSION

Pot experiment result obtained generally showed improved wheat Zn content and uptake. 0t/ha FYM + 5 ppm Zn was much promising which increased wheat grain Zn by 55%. To ensure soil sustainability and improved wheat grain Zn content, 15 t/ha FYM + 10 ppm Zn was better. This combination could as well be encouraged as it is friendly to sustainable soil improvement. Considering wheat grain Zn content and uptake, 0 t/ha FYM + 5 ppm Zn rate was much promising which increased wheat grain Zn by 55%. To ensure soil sustainability and improved wheat grain Zinc content and uptake, 15t/ha FYM + 10 ppm Zn increased wheat grain Zn content by 51%. This rate remains the best to enhance grain Zn and sustainable soil quality.

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