17

Egypt. J. Soil. Sci. Vol. **61**, No. 2, pp. 241-258 (2021)

Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Integrated Influence of Phosphorus and Zinc Along with Farmyard Manure on the Yield and Nutrients Uptake in Spring Maize

Ishaq Ahmad Mian[(1)*], Yasir Anwar[(1)], Shadman Khan[(1)], Mamoona Wali Muhammad[(2)], Maria Mussarat[(1)], Muhammad Tariq[(1)], Aiman Usman[(1)], Bushra Khan[(3)], Muhammad Adnan[(4)], Khadim Dawar[(1)], Khair Ullah[1], Jawad Ali[(1)]

[(1)]Department of Soil and Environmental Sciences, The University of Agriculture Peshawar, Khyber Pakhtukhwa (25000), Pakistan;

[(2)]Pakistan Forest Institute, Peshawar, Khyber Pakhtunkhwa 25000, Pakistan;

[(3)]Department of Environmental Sciences, University of Peshawar, Khyber Paakhtunkhwa 25000, Pakistan;

[(4)]Department of Soil Sciences, The University of Sawabi, Khyber Pakhtunkhwa, Pakistan.

THE MAXIMUM requirement of primary nutrients by hybrid maize crop deteriorate the fertility of soil, therefore farm yard manure (FYM) in combination with mineral zinc (Zn) and phosphorus (P) was selected for the increasing crop productivity, rehabilitate and sustain the precious soil. The research was carried out at the farm of the university of Agriculture Peshawar (UAP)during year 2019-20.To investigate the impact of mineral P from di-ammonium phosphate (DAP) and Zn from zinc sulphate ($ZnSO_4$) in combination with FYM on maize yield. The experiment was carried out in randomized completed block design (RCND) having eight different combinations of FYM, P and Zn were used excluding control. Spring hybrid variety of maize (CS-200) was used as a test crop. Basal dosage of nitrogen (N) 120 and potassium (K) 60 kg ha^{-1} were also applied. Physio-chemical properties of soil and concentration of Zn, P and K in maize leaves at silking stage and post harvested stage were measured. The objectives of this study was to determine the impact of FYM, P and (Zn) alone and in combination on yield of maize and soil properties and to gives best combination of organic fertilizers with mineral. From this research it was concluded that the combine application mineral P and Zn with FYM have linearly influenced the thousand grains weight, grain and biological yield of hybrid maize (CS- 200). The combine used of P and FYM @ of 90 kg ha^{-1} and 10 ton ha^{-1} shows influential impact on 1000 grains weight and grain yield, respectively. The soil organic matter and total N were significantly ($P \leq 0.05$) influenced by FYM applied alone, whereas the uptake of N, P and K by hybrid maize crop was found maximum in the plot where P in combination with FYM was added. Based on results the application of FYM @ 10 t ha^{-1} applied with 90 kg P ha^{-1} have the potential to improve maize yield as well as soil fertility and physical condition, also enhance the plant nutrient uptake and yield of hybrid maize, while the concentration of zinc in soil and plant were also greatly affected by the applied treatment. It shows antagonistic effect with P and its concentration become linearly decreased with the increase in P rates, while the maximum Zn concentration was showed by the sole application of zinc fertilizer.

Keywords: Nutrient uptake, Nitrogen-phosphorous-potassium, Soil fertility, Soil extractable.

Introduction

Maize is one of Pakistan's main crops, but its production is very limited in Khyber Pakhtunkhwa Province. (Amanullah et al., 2012, 2016; Iqbal et al., 2019). Among the cereals its rank is on third because of its importance (Morris, 1998; Lang & Heasman, 2015; Pierre & Peters, 2019). It is a

*Corresponding author email: ishaqmian@aup.edu.pk
DOI: 10.21608/ejss.2021.78515.1450
Received : 31/5/2021 ; Accepted: 1/8/2021
©2021 National Information and Documentation Centre (NIDOC)

short-term plant with the ability to produce large quantities of food grain. It is becoming popular amongst growers because of its multifunctional use and uses such as food for humans, raw materials for various industries and animal feed. Grain is a good fat, minerals, starch, protein, vitamin source (Khan et al., 2012; Toum et al., 2018). Maize has an important nutrient value with about 72% starch, protein approximately 10%, and fiber up to 12% and oils approximately 3% (Ali et al., 2014). Maize is an important staple cereal crop in Pakistan, and is a major source of income and food security for many farmers (Ahmad et al., 2020). The actual yield of maize is however far lower than the yield potential (i.e. typical yield gap of 2000 kg ha^{-1}) with the major constrains being extreme weather events (Ahmad et al., 2018).

Phosphorus (P) is the second macro factor following nitrogen needed to grow the plant and needed more than other plant-specific nutrients (Wahid et al., 2015, 2019). It plays a vital role in boosting plant growth by promoting root propagation and outgrowth (Scervino et al., 2011; Della et al., 2018) where more soil surface is remediated and hence more nutrients and water absorption are expected (Brady & Weil, 2007; Fageria et al., 2010; Elephant et al., 2019). For primary and secondary orthophosphate the plant consumes P. This ion has a reliable pH and $H_2PO_4^{-1}$ dominates the acidic soil while the alkaline soil has an abundance of HPO_4^{-2} (Olibone et al., 2010; Frazão et al., 2019; Pogorzelski et al., 2020). Organic phosphate in a small amount can be taken up by plants. The P content of the surface soil may be approximately 0.05% by average (Calvo et al., 2014). P is present in different soil forms, such as iron phosphates, Ca, Al and Mg along with other elements (Tisdale et al., 1985; Duput el et al., 2013; Wang & Lambers, 2020). The P occurs as an inorganic and organic component in soil, Inorganic P comes from rock mineral apatite weathering while residues of plants and animals are sources of organic P (Shen et al., 2011; Rowe et al., 2016). Much of the P compounds used as fertilizer are consumed.

Phosphorus plays a primary role in root development, stem and stalk strength, the development of flora and seed and the maturity of crops (Xiang et al., 2012; Srinivasan et al., 2012; Yong et al., 2018). Additionally, the key characteristic linked with Phosphorus supplementation facilitates legume N-fixation, crop efficiency and resistance to various crop diseases (Khan et al., 2010a; Plaxton et al., 2017; Lambers & Oliveira, 2019). Soil P dynamics are described by biological (immobilization-mineralization) and physico-chemical (sorption-desorption) processes (Condron et al., 2005; Stutter et al., 2012; Razaq et al., 2017; Saleem et al., 2020). Substantial use of P fertilizer precipitated in highly reactive Ca_2 + pools in calcareous or normal soils and Fe^{3+} and Al^{3+} in acidic soils (Ezawa et al., 2002; Hao et al., 2002; Khan et al., 2009). Phosphorous fertiliser's efficacy is around 10-25 per cent worldwide and has a very low level of soil bio-availability, reaching a level of 1.0 mg / kg soil (Goldstein, 2000; Adnan et al., 2020).

Zinc (Zn), a key element in all forms of life, including animals, human and plant organisms, is important and plays a key role (Alloway, 2004; Palai et al., 2020). Zn deficiency is an increasingly important risk factor in human health and global agriculture. For cereal production worldwide the bulk of the soil is considered Zn deficient (Bhutta et al., 2007; Rasheed et al., 2019, 2020). As far as plants of cultivation are concerned, it is a significant micronutrient restriction that alkaline soils in Pakistan and over the world interfere with cultivation growth. Susceptible crops include cereals, citrus and beans etc (Shahzad et al., 2014). Around 70% of the region grown in Pakistan is lacking Zn (Rashid & Fox, 1992; Kanwal et al., 2010; Wasaya et al., 2017).

Chlorophyll biosynthesis required Zinc (Graham et al., 1999; Huq et al., 2020). Zn typically plays an important part in enzyme enhancement, protein synthesis, oxidation and reaction reactions and metabolism of carbohydrates. The use of fertilizers with other micronutrients and Zn increases the quality of crops. Zn deficiency can lead to a decrease in photosynthesis and RNA destruction, reduce making of protein and therefore affect crop performance and quality. Improves the effectiveness of these nutrients through microelements.

Farm yard manure (FYM) is an organic fertilizer containing the organic nutrients, nitrogen, phosphorus, potassium and certain micro-nutrients organic and useful source (Berry et al., 2003; Van Bueren et al., 2011; Tadesse et al., 2013). Farmyard manure (FYM) is the most important organic source (Mahajan et al., 2008; Khan et al., 2010b), because, albeit in small amounts, It contains all necessary nutrients for crop growth, even in trace elements (Satyanarayana et al., 2002; Khan et al., 2010a). The efficiency of manure use is determined by the method, time of incorporation and the decomposition rate in the soil (Mahajan et al., 2008; Mengistu & Mekonnen, 2011). Startlingly, after incorporation in the soil, not all the nutrients in manure are directly available. First of all, organic sources of nutrients should be limited to plant forms available such as nitrate (Swift et al., 1994; Khan et al., 2010b). Farmed manure offers the possibility to preserve soil organic matter and to provide large macro and micronutrients with chemical fertilizer (Izhar et al., 2020). Specific nitrogen levels should be combined with farm manure levels in order to increase maize yield (Timsina & Connor, 2001; Adimassu et al., 2017).

This research was conducted on the following objectives, to study the impact of FYM, P and (Zn) alone on yield of maize and soil properties, to inspect the interactive effect of FYM, P and Zn on yield of maize and soil properties, to recommend the most appropriate levels of FYM and inorganic source of P and Zn for sustainable improvement in maize yield and soil properties.

Materials and Methods

In spring 2019, a field trial was determined at the University Research Farm, The University of Agriculture, Peshawar, to examine the impact of Phosphorous and Zinc applied alone and with farm yard manure on spring maize yield. The experiment was performed with three replications in RCB design. The individual experimental unit measure was kept 3m x 5m and distances between rows were 75 cm, and each replication contains 8 treatments. Maize variety CS-200 was sown. NPK were applied @ 120, 90.0 & 60.0 kg ha^{-1} from their respective sources of urea, SSP & MOP at the time of sowing whereas P as DAP, $ZnSO_4$ and FYM were broadcasted @ 90.0 kg/ha, 15 kg/ha and 10 t ha^{-1} as a whole before sowing respectively. FYM was analyzed for total N, P, K and zinc content prior to application, the nitrogen, phosphorus, potassium and zinc concentration in FYM was (0.69%, 0.17%, 0.63% and 72.4ppm). Before the sowing of maize composite soil sample was collected from the study site and was analyzed for the physicochemical properties of the soil. After harvesting of maize, soil was collected from every treatment plot and then analyzed for soil properties. Throughout the maize season, all other management practices were kept uniform.

The treatment arrangements were as follows:

T_1= Control, T_2= FYM 10 t ha^{-1}, T_3= Zinc alone (15 kg ha^{-1}), T_4= P alone (90 kg ha^{-1}), T_5= Zinc+P, T_6= Zinc+FYM, T_7= P+ FYM, T_8= Zn+P+FYM.

Analysis of soil samples

Before the crop sowing and after harvest from each experimental unit, a composite soil sample (0-20 cm) depth was taken in plastic bags and carried to soil and en-vironmental sciences laboratory at UAP for various physio-chemical properties analysis. For pH determination (McLean, 1982) described procedure 10 gram of soil along with distilled water was shaken on mechanical shaker for 15 minutes. After shaking the sample was analyzed for pH under pH meter. However, for OM analysis, Nelson & Sommer (1983) described procedure, 1 gram of shade dried sample along with 10.0 ml of 0.50 N $K_2Cr_2O_7$ was taken in a conical flask and 20 ml of conc. H_2SO_4 annexed to it. After adding these chemicals, the reaction was completed in 30 min. After the completion of the reaction, 200 ml of distilled water was added and then filtration was done. Few drops (2-3) of Orthophenopthalein were added to the sample. After that titration against 0.5 N $Fe_2SO_4.7H_2O$ was done till the color was turned dark brown, and the endpoint was indicated. The OM percentage was calculated by the following formula.

$$\%O.M = \frac{(\text{blank-sample}) \text{x N x } 0.69}{\text{weight of sample}}$$

For soil total N determination (Bremner, 1982) Kjeldhal procedure was followed. In this procedure, a ground soil sample of 0.2 g was taken in digestion tubes along with concentrated 3 ml of H_2SO_4 for digestion purpose. After complete digestion the volume was made 100 ml with distilled water. The solution obtained was then analyzed for total N under Kjeldhal apparatus, in which 10 ml of NaOH solution was added with 5 ml of sample. The distillate was gathered in a flask containing 5 ml of boric acid, and was used kept under titration against 0.01 M HCl.

$$\% \text{N} = \frac{(\text{Blank} - \text{Sample}) \text{ x N of HcL x meq N x } 100}{\text{Wt of sample x volume distilled}} \text{ X } 100$$

For determination of P and K in soil, the Soltanpour & Schwab (1977) method was followed. In this method a well air dried ground soil sample (10 g) was taken in 250 ml conical flask and added to it 20 ml AB-DTPA solution. The aliquot obtained was then used for P and K analysis. The P was analyzed under spectrophotometer while the K analysis was done under flame photometer.

The method prescribed by Kuo (1996) was used to determine total P and K in the plant. In this process an oven dried ground plant sample (0.5 g) was taken in conical flask (250 ml). The sample was added with 10 ml concentrated nitric acid for digestion purpose and left overnight for complete digestion. The next day perchloric acid ($HClO_4$) 4 ml was added to the sample and kept on hot plate in order to digest the remains of plant sample in flask. The analysis for P was done on spectrophotometer at (880 nm) and the for K analysis the aliquot solution was directly used under flame photometer. Zinc concentrations in plant sample were measured through (Benton, 1991) procedure. The volume was made 100 ml with distilled water and brought to lab for Zn analysis under atomic absorption spectrophotometer.

Procedure for recording agronomic parameters

The grain yield for all treatment plots was determined randomly by counting the thousand grains and then weight of thousand grains of maize was recorded via the electronic balance (Donald & Hamblin, 1976). Yield of wheat grain in kg ha^{-1} was recorded from the two central rows for every treatment plot after proper harvesting and thorough sorting and cleaning the grain. To convert grain yield to kg/ha the following equation is used.

$$\text{Grain yield(kg/ha)} = \frac{\text{Grain yield in two central rows}}{\text{Row} - \text{row distance x Row length x No. of rows}} \text{X } 10000$$

After harvesting, two middle lines of every experimental unit, it was suns dried and then weighed. At maturity stage the dry matter kg ha^{-1} was measured by using the equation (Donald & Hamblin, 1976).

$$\text{Biological yield (kg ha}^{-1}) = \frac{\text{Biological yield in 2 rows}}{\text{R}-\text{R distance x No of rows x row length}} \text{X } 10000$$

Statistical analysis

The data was statistically evaluated using the analysis of the variance technique where LSD value was kept 0.05 for significance in randomized complete block design in this experiment (Steel & Torrie, 1960).

Results

Soil samples were collected from experimental site before the execution of this experiment. Analysis of soil samples showed that the experimental site was non saline and alkaline in nature, whereas textural class was silt clay loam. The experimental site was deficient in organic matter (0.16%), total nitrogen (0.05%) phosphorous (2.67 ppm) and Zn (1.02 ppm), however adequate K (68.2 ppm) concentration was found in the soil under investigation.The N, P, K and Zn concentration of FYM are 0.69%, 0.17%. 0.63%, 72.4 ppm.

The 1000 grains weight

After the analysis of data it was concluded that the thousands grains weigh of hybrid maize (CS-200) was linearly enhanced by amendments of FYM and mineral nutrients. There was statistically significant increase occur use of Zn and P alone and in combination with FYM as show in Table 1. Our results concluded that highest 1000 grains weight of maize was recorded maximum from the plots where P and FYM were applied in combination, which is statistically at par with the use of P, Zn in combination with FYM. Lowest 1000 grains mass of maize were recorded in control plots where no fertilizers were amended.

Biological yield (kg ha^{-1})

Data analysis for biological yield of maize showed that the FYM and mineral applied P and Zn significantly enhanced the biological yield of hybrid maize crop as stated in Table 1. The combine use of FYM with P has an influential effect on biological yield of hybrid maize and the maximum biological yield was also recorded with this combinations. While the minimum biological yield of maize was noted in control where no treatment was used.

Grain yield (kg ha^{-1})

The statistics recorded on grains yield as influenced by the use of Zn & P applied alone and in combination with FYM. Analysis of variance indicated that the various applied fertilizers have a significantly influence on maize grain yield as show in Table 1. Results indicated that superior grains yield was measured in experimental units where P with FYM were applied in combination, followed by the use of P at 90 kg ha^{-1} and FYM at 10 t ha^{-1}. Lowest grain yield was noted in control plot where no fertilizers were applied.

TABLE 1. Effect of phosphorous and zinc with and without farmyard on 1000 grains weight (g), Biological and Grain Yield (kg ha^{-1}) of spring maize

Treatments	1000 grains w.t	Biological yield	Grain yield
	Gram	--------------- kg ha^{-1}	----------------
Control	234.3 d	8175 g	2656 d
Farmyard Manure 10 t ha^{-1} (FYM)	313.7 c	12140 c	4329a
Zinc 15 kg ha^{-1} (Zn)	258.3 d	10107 e	3992 c
Phosphorous 90 kg ha^{-1} (P)	330.3 bc	11167d	4425 a
Zn+ P	347.0 abc	9009 f	4083 bc
Zn + FYM	341.7 abc	12967 b	4111 bc
P + FYM	369.3 a	14460 a	4448 a
P + Zn + FYM	364.7 ab	13702 ab	4278 ab
LSD (□ 0.05)	35.31	792.24	198.27

The means followed by different letters in each column are significantly different from each other at $\alpha = 0.05$.

Post-harvest, soil pH and organic matter content

The impact of Zn and P with and without FYM on soil chemical properties is given in Table 2. Data analysis shows that the application of Zn and P alone and in combination with farmyard manures has significantly affected pH and soil fertility of the experimental site. Soil organic matter and pH has linearly effected by the application of FYM and mineral fertilizers, the highest pH was recorded in control which is at par with the combine application of mineral applied Zn and P. while the lowest pH was indicated in the plots amended with the combine application of P, Zn and FYM. Organic matter was increase with the application of FYM and highest percent of organic matter was shown in plots which amended with FYM.

Soil nitrogen (%)

Percent soil nitrogen was significantly affected by the combine and sole application of FYM with mineral fertilizers as depicted in Table 2. The results indicated that the maximum nitrogen content was recorded from the plots where FYM was applied alone at the rate of 10 t ha^{-1}. Lowest nitrogen content was recorded in control plot where no fertilizers were applied as shown in Fig. 1.

Soil phosphorus (mg kg^{-1})

Phosphorus concentration in soil as affected by the use of zinc (Zn) and phosphorous (P) alone and in combination with farmyard manure (FYM) is shown in Table 2. Phosphorus in soil was significantly affected by the use of Zn and P alone and in combination with farmyard. Maximum soil phosphorus content was calculated in the treatment where P and FYM were used in combine form, followed by the use of P with zinc and FYM respectively. Minimum phosphorus concentration was recorded in plot where zinc (15 kg ha^{-1}) was applied. Plots that showed minimum P concentration with the application of Zn were due to the antagonistic effect of Zn with P (Fig. 2). Which results in depressing its availability. Phosphorus was increased due to the application of farmyard manure because it contained high concentration of phosphorus after nitrogen in farmyard manure.

Soil AB-DTPA extractable K

Data analysis of soil potassium revealed that the K concentration of soil was statistically affected by the application of FYM, mineral P and Zn and their combination as described in Table 2. The integrated use of fertilizers had also significant impact on soil K concentration. Highest potassium concentration was noticed from the plots where Zn and FYM were applied in combination, followed by the use of FYM alone, P with Zn and FYM, and P with FYM. Minimum soil K content was recorded in treatment where no fertilizer was applied as graphically shown in Fig.3.

Soil zinc

Statistical analysis of zinc concentration revealed that the sole and combine application of organic and in organic fertilizers significantly enhanced the concentration of Zn in soil as presented in Table 2. Maximum zinc concentration were recorded from the plots where Zn and FYM were applied in combination, followed by the use of Zinc with P, P with FYM and alone Zinc, lowest zinc concentration was recorded in the plot where phosphorus was broadcasted @ 90 kg ha^{-1}. Decline in soil Zn content was due to the antagonistic effect of P with Zn shown in Fig.4.

TABLE 2. Soil chemical properties pH, organic matter (%), soil nitrogen (%) and soil P, K and Zn (mg kg-1) affected by the use of phosphorous and zinc with and without farmyard manure on yield of hybrid spring maize

Treatments	pH	O.M (g kg^{-1})	Soil N (%)	Soil P (mg kg^{-1})	Soil K (mg kg^{-1})	Soil Zn (mg kg^{-1})
Control	7.84 a	6.6 d	0.04 d	2.66 d	68 bc	1.58 e
Farmyard Manure 10 t ha^{-1} (FYM)	7.43 c	12.3 a	0.08 a	5.87 ab	85 a	1.73 d
Zinc 15 kg ha^{-1} (Zn)	7.65 ab	6.5 d	0.06 bc	2.56 d	72 b	2.06 c
Phosphorous 90 kg ha^{-1} (P)	7.59 bc	6.0 d	0.06 bc	5.07 bc	67 bc	1.54 e
Zn+ P	7.83 a	6.7 d	0.06 c	4.19 c	62 c	1.83 d
Zn + FYM	7.61 bc	10.2 b	0.07 ab	5.70 ab	85 a	2.54 a
P + FYM	7.62 bc	9.2 b	0.07 ab	6.27 a	81 a	2.18 c
P + Zn + FYM	7.53 bc	8.0 c	0.07 ab	6.03 ab	83 a	2.32 b
LSD (≤ 0.05)	0.20	0.11	0.01	1.15	7.59	0.14

The means followed by different letters in each column are significantly different from each other at □ = 0.05.

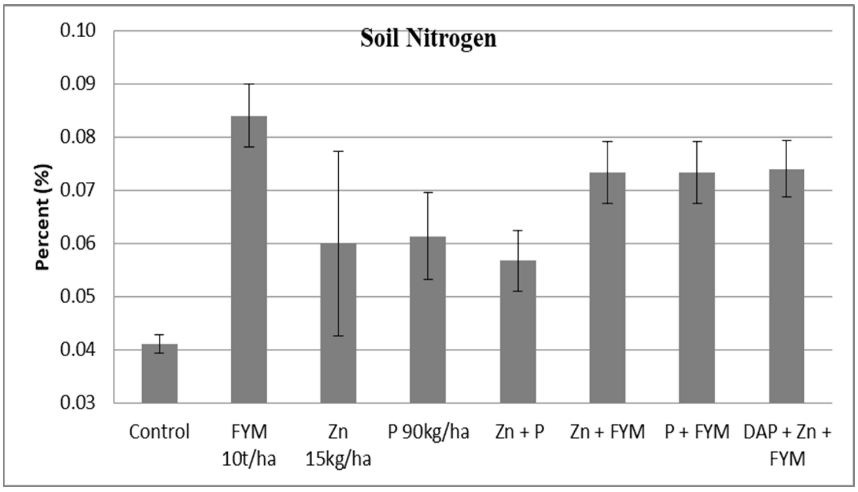

Fig. 1. Graphical representation of nitrogen concentration in soil (Error bars represent standard error of mean for n=3)

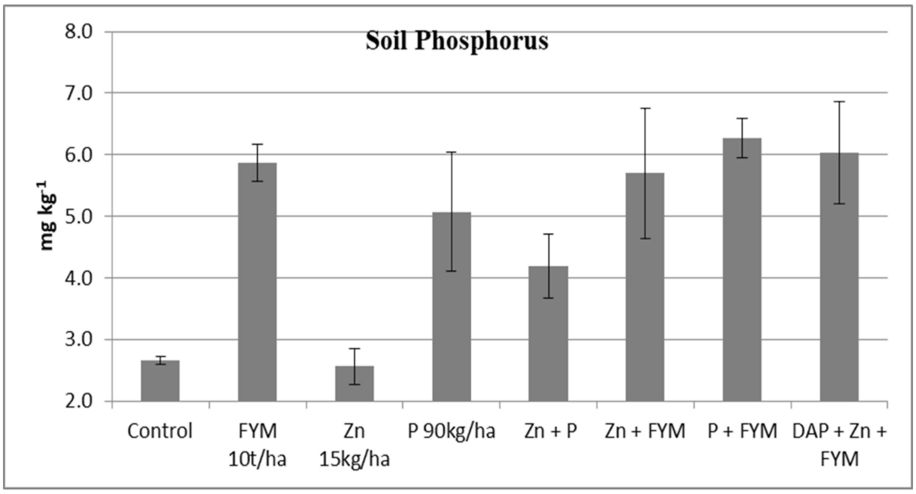

Fig. 2. Graphical representation of phosphorus concentration in soil (Error bars represent standard error of mean for n=3)

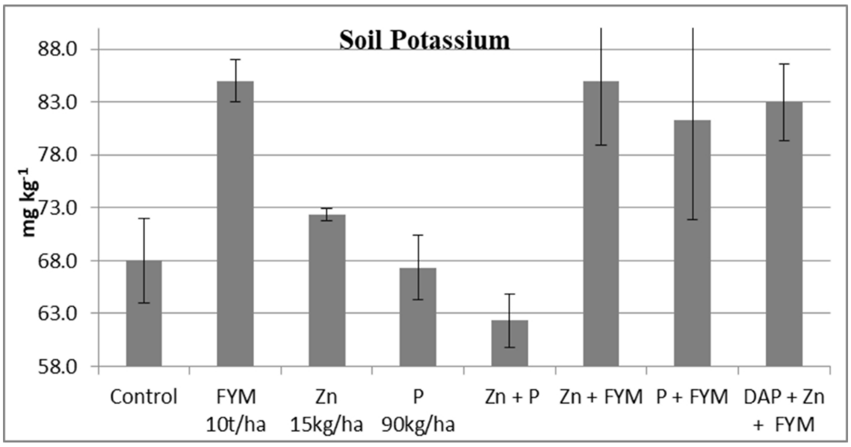

Fig. 3. Graphical representation of potassium concentration in soil (Error bars represent standard error of mean for n=3)

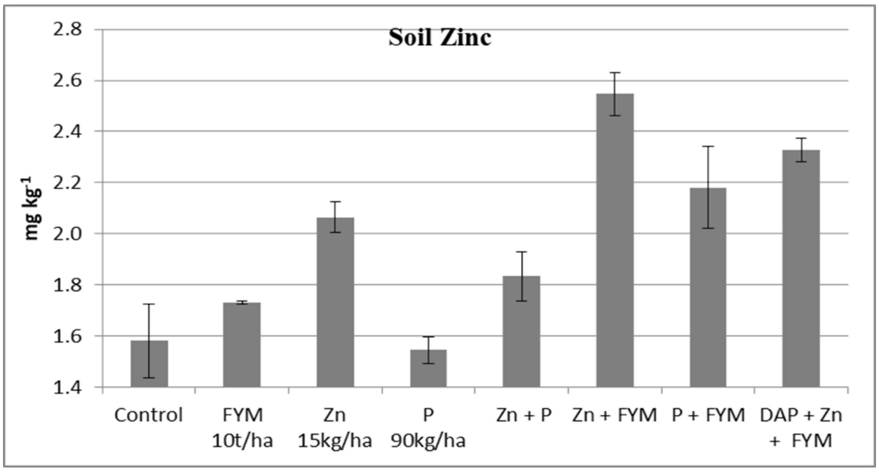

Fig. 4. Graphical representation of potassium concentration in soil (Error bars represent standard error of mean for n=3)

Concentration of N (%) in maize leaves at silking and harvesting stage

Nitrogen content in leaves of maize as affected by Zn and P application with farmyard manure is presented in Table 3. Statistical analysis of the data shows that N content in leaves at different stages shows that N content in leaves was significantly affected by Zn and P and its combined use with farmyard manure. Among the two stages (silking and post-harvest), maximum concentration of N in leaves was found at silking stage as declared in Fig. 5. Nitrogen content in leaves varied with treatments as treatments were of different nutritional status.

Phosphorus content (%) at silking and post-harvest stages of maize leaves

Data in Table 3 show the results of P content in maize leaves as affected by alone and combined application of Zn, P and farmyard (FYM). Analysis of variance revealed that phosphorus concentration in maize leaves was influenced significantly by the use of Zn, P and FYM alone and in combinations. Each treatment showed its effect on P content of maize leaves. Among different organic and inorganic treatments applied alone and in combinations, FYM and P proved to maximized P content of maize leaves at silking stage rather than post-harvest stage of maize. Among the different treatments applied FYM and P proved to be the best due to which P contents in maize leaves was raised as shown in Fig. 6. Minimum P content in maize leaves was found in plots that has received mineral zinc in the form of $ZnSo_4$. Decreased P with 15 kg $ZnSo_4$ is due to the antagonistic effect of Zinc and Phosphorus depressing each other availability.

TABLE 3. Plant "P" and "N" content at silking and after harvesting as influenced by the use of phosphorous and zinc with and without farmyard manure on yield of spring maize

Treatments	N contents in leaves (%)		P content in maize leaves (%)	
	Silking stage	Post-harvest stage	Silking stage	Post-harvest stage
Control	1.28 c	0.723 d	0.2800 d	0.187 c
Farmyard Manure 10 t ha^{-1} (FYM)	2.47 a	1.241 a	0.3933 ab	0.303 ab
Zinc 15 kg ha^{-1} (Zn)	1.89 b	0.965 bc	0.2833 d	0.263 b
Phosphorous 90 kg ha^{-1} (P)	1.86 b	0.930 c	0.3867 ab	0.267 b
Zn + P	1.87 b	0.952 bc	0.3800 b	0.313 a
Zn + FYM	1.79 b	0.885 c	0.3700 bc	0.297 ab
P + FYM	2.49 a	1.068 b	0.4100 a	0.320 a
P + Zn + FYM	1.95 b	0.965 d	0.3500 c	0.290 ab
LSD (≤ 0.05)	0.13	0.20	0.04	0.03

The means followed by different letters in each column are significantly different from each other at □ = 0.05.

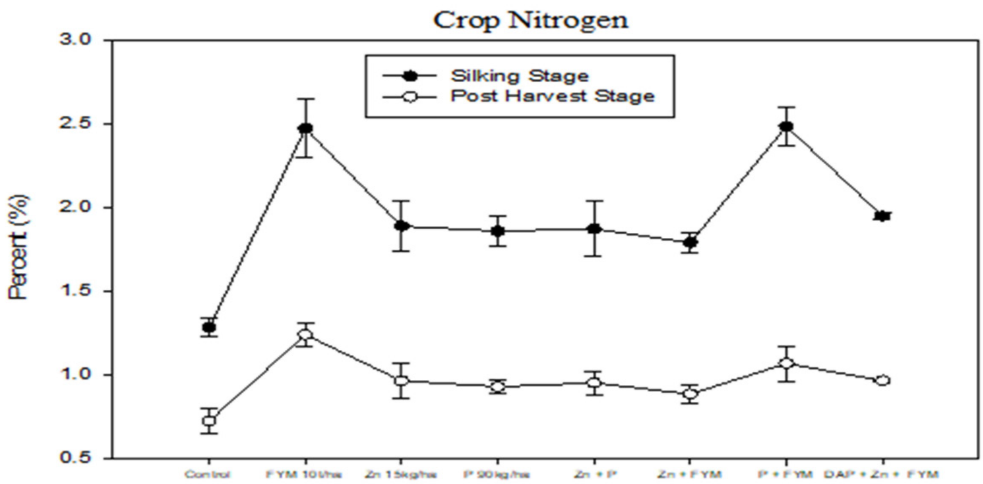

Fig. 5. Graphical representation of nitrogen (%) at different stages of crop (Error bars represent standard error of mean for n=3)

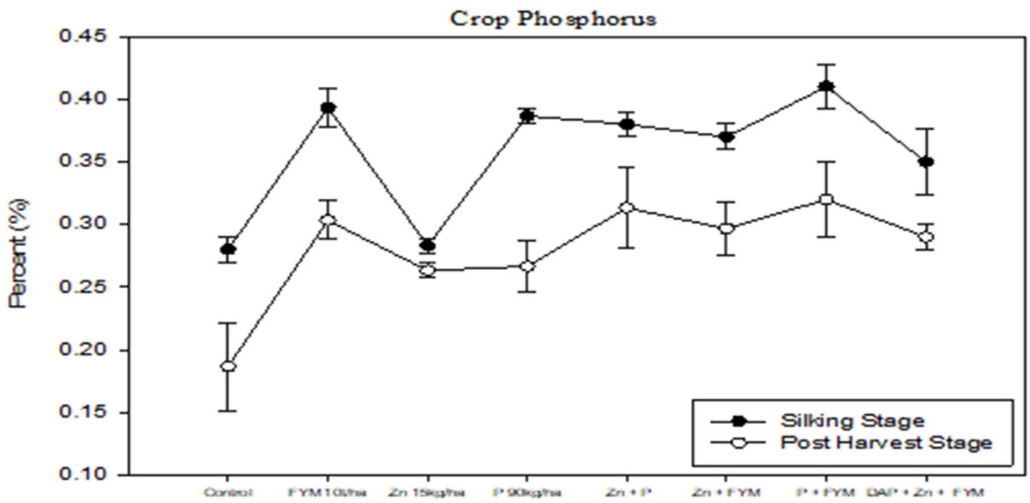

Fig. 6. Graphical representation of phosphorus (%) at different stages of crop (Error bars represent standard error of mean for n=3)

Potassium content (%) in maize Leaves at silking and post-harvest stage

Data of potassium (K) content (%) of maize leaves at two different stages as influenced by the application of zinc, phosphorus and Farmyard alone and in combination is described in Table 4. Data analysis showed that K content in maize leaves at different stage was significantly affected with the incorporation of organic and inorganic sources used alone and in combinations. Among the different stages, K content (%) was higher in maize leaves collected at silking stage followed by post-harvest stage. Maximum potassium content in maize leaves was observed with the application of FYM and P applied at 10 t ha^{-1}, 90 kg/ha. According to Fig.7, control plots possessed minimum K content in maize leaves.

Zinc content (mg kg^{-1}) in maize leaves at silking and post-harvest stage

Zinc content in maize leaves at two different stages influenced by zinc, farmyard manure and phosphorus is presented in Table 4. Analysis of variance showcased that zinc content (mg/kg) was significantly affected by alone and integrated use of zinc, farmyard and phosphorus. In both stages zinc content of maize leaves was higher in plots supplemented with Zn and FYM @ 15 kg ha^{-1} and 10 t ha^{-1}. Among the treatments, FYM and Zn proved to have higher content of zinc in maize leaves, whereas plots supplemented with 90 kg of P in the form of DAP was reported to have minimum zinc content in maize leaves as declared in Fig.8.

TABLE 4. Plant "K" and "Zn" content at silking and after harvesting as influenced by the use of phosphorous & zinc with and without farmyard manure on yield of spring maize

Treatments	K contents in leaves (%)		Zn content in leaves (mg/kg)	
	Silking stage	Post-harvest	Silking stage	Post-harvest
Control	2.14 e	1.29 de	28.3 e	17.9 ef
Farmyard Manure 10 t ha^{-1} (FYM)	2.83 e	1.51 cd	32.2 cd	19.8 de
Zinc 15 kg ha^{-1} (Zn)	2.17 de	1.30 de	39.0 b	28.5 b
Phosphorous 90 kg ha^{-1} (P)	2.16 de	1.29 de	28.1 e	16.1 f
Zn + P	2.19 cd	1.20 e	34.9 c	22.1 cd
Zn + FYM	2.21 c	1.89 b	42.7 a	31.3 a
P + FYM	2.90 a	2.20 a	33.1 cd	23.7 c
P + Zn + FYM	2.29 b	1.73 bc	31.4 de	21.8 cd
LSD (≤ 0.05)	0.38	0.29	3.49	2.45

The means followed by different letters in each column are significantly different from each other at α = 0.05.

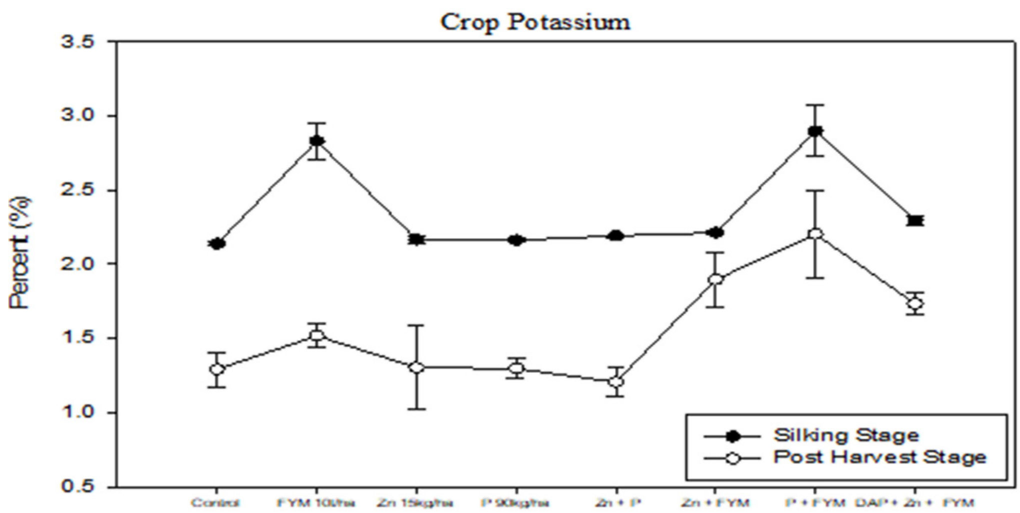

Fig. 7. Graphical representation of potassium (%) at different stages of crop (Error bars represent standard error of mean for n=3)

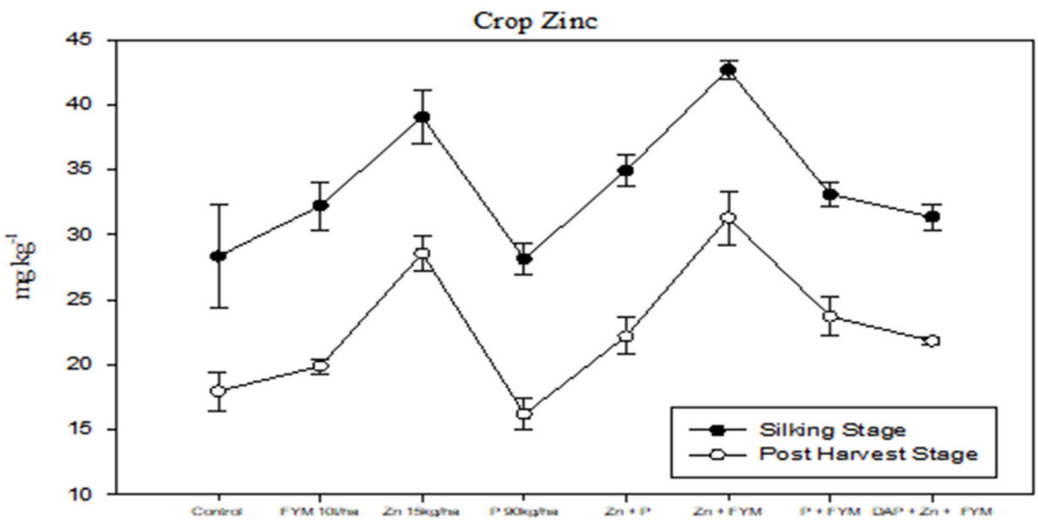

Fig. 8. Graphical representation of zinc (%) at different stages of crop (Error bars represent standard error of mean for n=3)

Discussion

With the application of FYM in to the soil increase the exchanging and holding capacity of soil. When mineral fertilizers applied in combination with FYM it hold the available nutrients on its surface and not don't make it to leach down and release slowly the nutrients to the crop and the plant take up the nutrient at the time of its needs. Availability of macro and micro nutrients due to farmyard application, their uptake and accumulation along with P in maize grains has significantly increases 1000 grains weight. Our results are in accordance to the data recorded by Shamim-ul-Sibtain et al. (2015), Chauhan et al. (2020) where they applied FYM at rate of 20 kg ha^{-1} and Phosphorus at the rate of 40 kg ha^{-1} to wheat where it showed significant effect on 1000 grain weight. Similarly, the findings of current research are in conformity with Aatif et al. (2017), Verma et al. (2019) who declared that the application of FYM @ 9 t ha^{-1} with phosphorus @ 120 kg ha^{-1} to Wheat crop significantly enhances wheat 1000 grain weight, thus conforming the results of our current study to be in accordance with their research outputs. Greater biological yield can be subjected to maximum uptake of nutrients with less stress conditions, taller plant height, lengthy leaves and heavy stem mass. And it is attained by the maize hybrid in the organic in combination with in organic fertilizer condition. These results are similar to Yousif et al. (2010), Chand et al. (2017) who confirmed the combine application of phosphorous fertilizers in combination with organic fertilizers enhanced the biological yield of maize crop. Likewise Shamim-ul-Sibtain et al. (2015), Chauhan et al. (2020) also confirmed that findings where they applied P @ 120 kg ha^{-1} and FYM at 9 t ha^{-1} to wheat by which maximum biological yield of maize was recorded. The use of P_2O_5 @ 60 kg ha^{-1} and FYM @ 15 t ha^{-1} to chickpea crop significantly enhances crop biological yield. Greater grain yield can be subjected to heavy grains weight and number of grain in ears. When plant grain maximum number of grain per cob it will enhanced the grain yield. The crop attains maximum grain per cob in the presence of maximum nutrients availability such as FYM and P. These results are similar to Hassanien et al. (2017) findings where they applied FYM at the rate of 3 0m^3/fed and P_2O_5 at the rate of 200 kg/fed to Corn and significantly increases grain yield of corn (18.2 to 21.4 arda/fed). Similarly, Aatif et al. (2017) also confirmed that the use of 120 kg ha^{-1} Phosphorus and 9 t ha^{-1} FYM to Wheat has significantly enhances crop grain yield. Our results are in thee line of Meena et al. (2013), Anees et al. (2016), and Kumar & Salakinkop (2018) who concluded the maximum grain yield of maize with the application of mineral fertilizers with the combination of mineral fertilizers such as phosphorous.

Our results of organic matter and total nitrogen concluded that FYM linearly enhanced the fertility of soil and N%, due to the slow release of nutrients from FYM. The findings of Tadesse et al. (2013), Adimassu et al. (2017), Hammouda et al. (2019) described that FYM at 15 t ha^{-1} to rain-fed low land rice ecosystem significantly enhanced the N content of soil and maintain the fertility of soil. These findings were similar with Kanaujia (2016) who confirmed that the use of FYM to rice-wheat crops at 10 t ha^{-1} has significantly decreased soil pH. Shirani et al. (2002) and Busari et al. (2015) concluded linearly enhancement of soil organic matter with the application of FYM as rapid amended after maize harvesting. Bayu et al. (2006) and Basak et al. (2020) also reported that farm yard manure significantly enhanced the organic carbon of soil with respect to control. The use of farm yard manure enhanced nitrogen content in soil, because the major content of farmyard manure on average basis is nitrogen which in turn increased nitrogen content in soil. Our results are in accordance to the findings narrated by Mahala et al. (2006) and Sarkar et al. (2018) where they applied farmyard manure 10 t ha^{-1} to maize and conclude that the N content of soil linearly enhanced by FYM. Similarly, Tadesse et al. (2013) and Nie et al. (2018) also concluded that the use of FYM to rice at 10t ha^{-1} has significantly enhances rice crop nitrogen content, thus conforming the results of our current study to be in accordance with their research outputs. Likewise the phosphorus content of soil results are in line to the findings narrated by Singh et al. (1983), Thamaraiselvi et al. (2012) and Srinivasarao et al. (2019) where they applied farmyard manure with phosphorous to Maize and wheat crop rotation, and reported that the yield of crops and there vigoristy enhanced with the maximum availability of P. Similarly, Tadesse et al. (2013) and Nie et al. (2018), also concluded that the use of 15 t ha^{-1} FYM and P_2O_5 @ of 100 kg ha^{-1} to rice crop has significantly enhances rice crop phosphorus content, thus conforming the results of our current study to be in accordance with their research outputs. With the application of FYM the pH of soil decreased and it make the P available to the crops (Roba, 2018). FYM and mineral P have significantly enhanced the available phosphorus portion of soil and soil fertility (Bodruzzaman et al., 2010; Biratu et al., 2019).

The results on the extractable K and Zn increase with the use of farmyard due to microbial activities, enabling the availability of macro and many micro nutrients aiding in increasing potassium content in soil. Our findings are similar to the results narrated by Badiyala & Chopra (2011) and Suganya et al. (2020) where they applied farmyard manure at 5 t ha^{-1} with $ZnSO_4$ @ 25 kg ha^{-1} to Maize. Similarly and reported similar outcomes, Wahid et al. (2019) also concluded that the use of FYM to green gram at 5 t ha^{-1} ha has significantly enhances soil potassium level, thus conforming the results of our current study to be in accordance with their research outputs. Our findings are in line to the results narrated by Badiyala & Chopra (2011) and Suganya et al. (2020) where they applied $ZnSo_4$ and FYM at 25 kg ha^{-1} and 5 t ha^{-1} to maize and linseed cropping system. Our results of zinc concentration in soil are in line with the findings of Mosaad (2019), thus conforming the results of our current study to be in accordance with their research outputs. Nandini et al. (2020) concluded that the maximum availability of K is due to the high organic matter in soil. K enhanced the resistance ability of plant to diseases and there uptake can be enhanced by the use of FYM (Kumar & Salakinkop, 2018), Zn and K increased with the application of FYM (Hekmat et al., 2019).

Maximum percent of N were recorded among the treatments, applied maximum N content in leaves was noted in plot receiving farmyard manure and P broadcasted @10 t ha^{-1}, and 90 kg ha^{-1} respectively, whereas minimum N content in leaves was found in plot receiving zero inputs. Miller et al. (2007) and Wessells & Brown (2012) reported that N content was found significant when they applied organic fertilizer in combination with inorganic fertilizer. Similarly the application of 40 kg/ha phosphorus significantly increases the concentration of N in plant by Nazim et al. (2008) and Zaman et al. (2018). While maximum P % results was also declared by Nziguheba et al. (1998), Hossain et al. (2010) and Muhmood et al. (2018) who applied P alone and in combination with FYM to the field and maximum P concentration was recorded in leaves of P along with FYM amended plots (Tiwari et al., 2010; Chesti et al., 2015; Yaseen et al., 2020). The mineral P was taken by the plant at the time of application while the FYM released P slowly and it will take up by the plant at the time of its need.

Results of K content of maize leaves in current study are found in accordance with the findings published by Ranjan et al. (2005) and Guan et al. (2020) who applied FYM alone and in combination with inorganic fertilizers, and concluded maximum concentration of K at silking stage of the crop. The decrease in zinc content in maize leaves supplemented with 90 kg ha of P was due to antagonism of zinc with phosphorus. Results of this experiment were same as reported by Ranjan et al. (2005) where they applied organic manure along with inorganic fertilizer to maize.

Conclusions

The application of 90 kg P ha^{-1} along with 10 t FYM ha^{-1}significantly improved maize growth, grain and biological yield compared to the rest of treatment combination. Similarly, maximum soil total nitrogen, AB-DTPA extractable P and K as well as plants N, P and K were observed with application of FYM alone and in combination with P. Furthermore, the FYM was effective in reducing soil pH and Bulk Density. Therefore the application of FYM in combination with 90 kg P ha^{-1}is recommended for improving maize yield, soil physical and chemical properties under the existing agro-climatic conditions. Zn concentration was significantly decreased in leaves and soil with the increase in P concentration because of antagonistic effect.

Acknowledgement

We are very thankful to The University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan, for their support and providing field space for our experiment.

Authors contributions:

Ishaq Ahmad Mian conceived and designed the experiments, prepared figures and/or tables, and approved the final draft. Yasir Anwar conceived and designed the experiments, analyzed the data, prepared figures and/or tables, and approved the final draft. Shadman Khan performed the experiments, prepared figures and/or tables, and approved the final draft. Bushra Khan performed the experiments, analyzed the data, prepared figures and/or tables, approved the final draft, and response the comments.Muhammad Tariq performed the experiments, analyzed the data, and approved the final draft.Aiman Usman performed the experiments, analyzed the data, prepared figures and/or tables.Muhammad Adnan performed the experiments, prepared figures and/or tables. Khadim Dawar performed the experiments, authored or reviewed drafts of the paper, and approved the final draft.Khair Ullah performed the experiments, reviewed drafts of the paper, and approved the final draft. Maimoona Wali Muhammad performed the experiments, and approved the final draft. Jawad Ali performed the experiments, and approved the final draft.

Conflict of interest:

The authors declare that they have no competing interests.

Fundings:

This experiment received no funding from any external source.

References

Aatif, M., Khan, H., Anjum, M.M., Ali, N. and Hamid, M. (2017) Effect of farm yard manure and phosphorus levels on yield and yield components of wheat. *Inter. J. Enviro.Scie.& Nat. Reso.* **2**(4), 133-137.

Adimassu, Z., Langan, S., Johnston, R., Mekuria, W. and Amede, T. (2017) Impacts of soil and water conservation practices on crop yield, run-off, soil loss and nutrient loss in Ethiopia: Review and synthesis. *Enviro. Mana.* **59**(1), 87-101.

Adnan, M., Fahad, S., Zamin, M., Shah, S., Mian, I.A., Danish, S., Zafar-ul-Hye, M., Battaglia, M.L., Naz, R.M.M., Saeed, B. and Saud, S. (2020) Coupling phosphate-solubilizing bacteria with phosphorus supplements improve maize phosphorus acquisition and growth under lime induced salinity stress. *Plants*, **9**(7), 900.

Ahmad, I., Saeed, U., Fahad, M., Ullah, A., ur Rahman, M.H., Ahmad, A. and Judge, J. (2018) Yield forecasting of spring maize using remote sensing and crop modeling in Faisalabad-Punjab Pakistan. *J. Indian Society of Remote Sensing*, **46**(10), 1701-1711.

Ahmad, I., Ahmad, B., Boote, K. and Hoogenboom, G. (2020) Adaptation strategies for maize production under climate change for semi-arid environments. *Euro. J. Agro.* **115**, 126040.

Ali, M.E., Islam, M.R. and Jahiruddin, M. (2009) Effect of integrated use of organic manures with chemical fertilizers in the rice-rice cropping system and its impact on soil health. *Bangladesh J. Agric. Rese.* **34**(1), 81-90.

Ali, Q., Ahsan, M., Tahir, M.H.N. and Basra, S.M.A. (2014) Gene action and correlation studies for various grain and its contributing traits in maize (*Zea mays* L.). *Bothalia*, **44**(2), 80-91.

Alloway, B. (2004) Zinc in soils and crop nutrition. Areas of the World with Zinc Deficiency Problems. *International Zinc Association.* Brussels, Belgium pp. 1-16.

Amanullah, Asif, M., Almas, L.K., Jan, A., Shah, Z., Rahman, H.U. and Khalil, S.K. (2012) Agronomic efficiency and profitability of P-fertilizers applied at different planting densities of maize in Northwest Pakistan. *J. Plant Nutr.* **35**(3), 331-341.

Amanullah, S.A., Iqbal, A. and Fahad, S. (2016) Foliar phosphorus and zinc application improve growth and productivity of maize (*Zea mays* L.) under moisture stress conditions in semi-arid climates. *J. Microb. Biochem. Technol*. **8**, 433-439.

Badiyala, D. and Chopra, P. (2011) Effect of zinc and FYM on productivity and nutrient availability in maize (*Zea mays*)–linseed (*Linum usitatissimum*) cropping sequence. *Indian J. Agro.* **56**(2), 88-91.

Basak, B.B., Jat, R.S., Gajbhiye, N.A., Saha, A. and Manivel, P. (2020) Organic nutrient management through manures, microbes and biodynamic preparation improves yield and quality of Kalmegh (*Andrograghis paniculata*), and soil properties. *J. Plant Nutr.* **43**(4), 548-562.

Bayu, W., Rethman, N.F.G., Hammes, P.S. and Alemu, G. (2006) Application of farmyard manure improved the chemical and physical properties of the soil in a semi-arid area in Ethiopia. *Biol. Agri. & Horti.* **24**(3), 293-300.

Benton Jones Jr, J. (1991) Plant tissue analysis in micronutrients. *Micronutrients in agriculture*, **4**, 477-521.

Berry, P.M., Stockdale, E.A., Sylvester-Bradley, R., Philipps, L., Smith, K.A., Lord, E.I., Watson, C.A. and Fortune, S. (2003) N, P and K budgets for crop rotations on nine organic farms in the UK. *Soil Use and Manag.* **19**(2), 112-118.

Bhutta, Z.A., Jiwani, A., Feroze, A., Kissana, N. and Monasterio, I.O. (2007) Assessment of human zinc deficiency and determinants in Pakistan: Implications for interventions. In: *Proceeding of International Zinc Association conference 'Zinc Crops*, (24-26).

Biratu, G.K., Elias, E. and Ntawuruhunga, P. (2019) Soil fertility status of cassava fields treated by integrated application of manure and NPK fertilizer in Zambia. *Environ. Syst. Rese.* **8**(1), 1-13.

Bodruzzaman, M., Meisner, C.A., Sadat, M.A. and Hossain, M.I. (2010) August. Long-term effects of applied organic manures and inorganic fertilizers on yield and soil fertility in a wheat-rice cropping pattern. In *Proceedings of the 19th World Congress of Soil Science*, (10-15).

Brady, N.C. and Weil, R.R. (2007) "*The Nature and Properties of Soils*", 14th edn. (Pearson Prentice Hall: Upper Saddle River, NJ).

Bremner, J.M. (1982) Nitrogen-total. (No. Colección general/631.41 M592m v. 2). In: "*Methods of Soil Analysis: Part 2; Chemical and Microbiological Properties*", pp. 595-624. Winsconsin, US: American Society of Agron. 1986.

Busari, M.A., Kukal, S.S., Kaur, A., Bhatt, R. and Dulazi, A.A. (2015) Conservation tillage impacts on soil, crop and the environment. *Intern. Soil and Water Conser.Resea.* **3**(2), 119-129.

Calvo, P., Nelson, L. and Kloepper, J.W. (2014) Agricultural uses of plant biostimulants. *Plant and Soil*, **383**(1), 3-41.

Chand, S.W., Susheela, R., Sreelatha, D. and Hussain, M.S.S. (2017) Effect of zinc fertilization on yield and economics of baby corn (*Zea mays* L.). *Journal of Pharmacognosy and Phytochemistry*, **6**(5), 989-992.

Chauhan, N., Sankhyan, N.K., Sharma, R.P., Singh, J. and Gourav (2020) Effect of long-term application of inorganic fertilizers, farm yard manure and lime on wheat (*Triticum aestivum* L.) productivity, quality and nutrient content in an acid alfisol. *J. Plant Nutr.* **43**(17), 2569-2578.

Chesti, M.H., Kohli, A., Mujtaba, A., Sofi, J.A., Qadri, T.N., Peer, Q.J.A., Dar, M.A. and Bisati, I.A. (2015) Effect of integrated application of inorganic and organic sources on soil properties, yield and nutrient uptake by rice (*Oryza sativa* L.) in intermediate zone of Jammu and Kashmir. *J. Indian Society of Soil Sci.* **63**(1), 88-92.

Condron, L.M., Turner, B.L. and Cade-Menun, B.J. (2005) Chemistry and dynamics of soil organic phosphorus. *Phosphorus: Agriculture and the Environment*, **46**, 87-121.

Della Mónica, I.F., Godoy, M.S., Godeas, A.M. and Scervino, J.M. (2018) Fungal extracellular phosphatases: their role in P cycling under different pH and P sources availability. *J. Appl. Microbial.* **124**(1), 155-165.

Donald, C.M. and Hamblin, J. (1976) The biological yield and harvest index of cereals as agronomic and plant breeding criteria. *Advances in Agro.* **28**, 361-405.

Duputel, M., Van Hoye, F., Toucet, J. and Gérard, F. (2013) Citrate adsorption can decrease soluble phosphate concentration in soil: Experimental and modeling evidence. *Appl. Geochem*. **39**, 85-92.

Elephant, D.E., Miles, N. and Muchaonyerwa, P. (2019) Accounting for potassium reserves and fixation in developing sugarcane fertiliser requirements. *Soil Research*. **57**(1), 66-74.

Ezawa, T., Smith, S.E. and Smith, F.A. (2002) P metabolism and transport in AM fungi. *Plant and Soil*. **244**(1), 221-230.

Fageria, N.K., Baligar, V.C. and Jones, C.A. (2010) "*Growth and Mineral nutrition of Field Crops*". CRC Press.

Frazão, J.J., de Melo Benites, V., Ribeiro, J.V.S., Pierobon, V.M. and Lavres, J. (2019) Agronomic effectiveness of a granular poultry litter-derived organomineral phosphate fertilizer in tropical soils: Soil phosphorus fractionation and plant responses. *Geoderma*. **337**, 582-593.

Goldstein, A.H. (2000) October. Bioprocessing of rock phosphate ore: essential technical considerations for the development of a successful commercial technology. In *Proceedings of the 4th international fertilizer association technical conference, IFA, Paris* (Vol. 220).

Graham, R., Senadhira, D., Beebe, S., Iglesias, C. and Monasterio, I. (1999) Breeding for micronutrient density in edible portions of staple food crops: conventional approaches. *Field Crops Res*. **60**(1-2), 57-80.

Guan, X.K., Wei, L., Turner, N.C., Ma, S.C., Yang, M.D. and Wang, T.C. (2020) Improved straw management practices promote in situ straw decomposition and nutrient release, and increase crop production. *J. Cleaner Prod.* **250**, 119514.

Hammouda, I., Elbaalawy, A.M. and Elf-fishy, M. (2019) Effect of compost additives and application time of phosphorus in different methods on growth, productivity and quality of peanut in sandy soils. *Egyptian J. Soil Sci.* **59**(4), 339-352.

Hao, X., Cho, C.M., Racz, G.J. and Chang, C. (2002) Chemical retardation of phosphate diffusion in an acid soil as affected by liming. *Nutrient Cycling in Agroecosys,* **64**(3), 213-224.

Hassanien, H.G., Abd El-mola, S.E., Amin, A.A. and El-Sayed, H.K. (2017) Effect of Farmyard Manure and Rate of Phosphatic Fertilizer on Phosphorus Availability and Yield of Corn. *Assiut J. Agri. Sci.* **48**, 347-355.

Hekmat, A.W., Mohammadi, N.K., and Ghosh, G. (2019) Effect of NPK, biofertilizer and zinc foliar nutrition on growth and growth attributes of babycorn (*Zea mays* L.). *IJCS*, **7**(4), 2432-2436.

Hossain, A.T.M.S., Rahman, F., Saha, P.K. and Solaiman, A.R.M. (2010) Effects of different aged poultry litter on the yield and nutrient balance in boro rice cultivation. *Bangladesh J. Agri. Res.* **35**(3), 497-505.

Huq, M.E., Fahad, S., Shao, Z., Sarven, M.S., Khan, I.A., Alam, M., Saeed, M., Ullah, H., Adnan, M., Saud, S. and Cheng, Q. (2020) Arsenic in a groundwater environment in Bangladesh: Occurrence and mobilization. *J. Environ. Manag.* **262**, 110318.

Iqbal, A., Song, M., Shah, Z., Alamzeb, M. and Iqbal, M. (2019) Integrated use of plant residues, phosphorus and beneficial microbes improve hybrid maize productivity in semiarid climates. *Acta Ecologica Sinica*, **39**(5), 348-355.

Izhar Shafi, M., Adnan, M., Fahad, S., Wahid, F., Khan, A., Yue, Z., Danish, S., Zafar-ul-Hye, M., Brtnicky, M. and Datta, R. (2020) Application of single superphosphate with humic acid improves the growth, yield and phosphorus uptake of wheat (*Triticum aestivum* L.) in calcareous soil. *Agronomy*, **10**(9), 1224.

Kanaujia, V.K. (2016) Effect of FYM and fertilizers nutrition on production potential, nutrients uptake and soil properties under rice-wheat cropping system. *J. Agri. Search*. **3**(2), 101-105.

Kanwal, S., Rahmatullah, A.R. and Ahmad, R.A.S.H.I.D. (2010) Zinc partitioning in maize grain after soil fertilization with zinc sulfate. *Inter. J. Agri. Biol.* **12**(2), 299-302.

Khan, A.A., Jilani, G., Akhtar, M.S., Naqvi, S.M.S. and Rasheed, M. (2009) Phosphorus solubilizing bacteria: occurrence, mechanisms and their role in crop production. *J. Agric. Biol. Sci*. **1**(1), 48-58.

Khan, N., Khan, N.W. and Khan, I.A. (2012) Integration of nitrogen fertilizer and herbicides for efficient weed management in maize (*Zea mays*) crop. *Sarhad J. Agric*. **28**(3), 457-463.

Khan, N.I., Malik, A.U., Umer, F. and Bodla, M.I. (2010a) Effect of tillage and farm yard manure on physical properties of soil. *Inter. Res. J. Plant Sci*. **1**(4), 75-82.

Khan, Q.U., Khan, M.J. and Ullah, S. (2010b) Comparison of different models for phosphate adsorption in salt inherent soil series of Dera

Ismail Khan. *Soil and Environment*, **29**(1), 11-14.

Kumar, N. and Salakinkop, S.R. (2018) Agronomic Biofortification of Maize with Zinc and Iron Micronutrients. *Mod Concep. Dev. Agrono*. **1**(4), 87-90.

Kuo, S. (1996) Phosphorus. 869-920. In: "*Methods of soil analysis. Part 3 Chemical Methods*", Sparks, D.L., Page, A.L., Helmke, P.A., Loeppert, R.H. (Eds.), SSSA Book Series No.5, Soil Science Society of America Inc., Madison, WI.

Lambers, H. and Oliveira, R.S. (2019) Mineral nutrition. In" "*Plant Physiological Ecology*", pp. 301-384. Springer, Cham.

Lang, T., Heasman, M. (2015) "*Food Wars: The Global Battle for Mouths, Minds and Markets*". Routledge.

Mahajan, A.N.I.L., Bhagat, R.M. and Gupta, R.D. (2008) Integrated nutrient management in sustainable rice-wheat cropping system for food security in India. *SAARC J. Agri.* **6**(2), 29-32.

Mahala, H.L., Shaktawat, M.S. and Shivran, R.K. (2006) Direct and residual effects of sources and levels of phosphorus and farmyard manure in maize (*Zea mays*)-mustard (*Brassica juncea*) cropping sequence. *Indian J.Agron.* **51**(1), 10-13.

McLean, E.O. (1983) Soil pH and lime requirement. In: "*Methods of Soil Analysis: Part 2 Chem. Microbial. Prop.*", Vol. 9, pp. 199-224.

Mengistu, D.K. and Mekonnen, L.S. (2011) Integrated agronomic crop managements to improve tef productivity under terminal drought. *Water Stress. Vienna: InTech*, 235-254.

Miller, L.V., Krebs, N.F. and Hambidge, K.M. (2007) A mathematical model of zinc absorption in humans as a function of dietary zinc and phytate. *J. Nutr.* **137**(1), 135-141.

Morris, M.L. ed. (1998) "*Maize Seed Industries in Developing Countries*". Lynne Rienner Publishers.

Mosaad, I. S. (2019) Influence of Integrated In-soil Zinc Application and Organic Fertilization on Yield, Nitrogen Uptake and Nitrogen Use Efficiency of Rice. *Egyptian J. Soil Sci.* **59**(3), 241-250.

Muhmood, A., Majeed, A., Niaz, A., Shah, A., Shah, S. and Shahid, M. (2018) Evaluation of anaerobic digestate potential as organic fertilizer in improving wheat production and soil properties. *Inter. J. Plant & Soil Sci.* **24**(1), 1-10.

Nandini, P., Laxminarayana, P., Bhanu Rekha, K. and Anjaiah, T. (2020) Growth and yield of maize as influenced by zinc enrichment through agronomic options. *Inter. Jour. Chemi. Society*, **8**(5), 2087-2091.

Nazim, H., Khan, M.B. and Riaz, A. (2008) Improving wheat productivity in calcareous soils through band replacement of farmyard manure with phosphorus. *Intern. J. Agri. and Biol.* **10**(6), 709-714.

Nelson, D.W. and Sommers, L. (1983) Total carbon, organic carbon, and organic matter. In: "*Methods of Soil Analysis: Part 2 Chemical and Microbial. Prop.*" Vol. 9, pp. 539-579.

Nie, J., Feng, H., Witherell, B.B., Alebus, M., Mahajan, M.D., Zhang, W. and Yu, L. (2018) Causes, assessment, and treatment of nutrient (N and P) pollution in rivers, estuaries, and coastal waters. *Current Pollution Reports*, **4**(2), 154-161.

Nziguheba, G., Palm, C.A., Buresh, R.J. and Smithson, P.C. (1998) Soil phosphorus fractions and adsorption as affected by organic and inorganic sources. *Plant and Soil,* **198**(2), 159-168.

Olibone, D. and Rosolem, C.A. (2010) Phosphate fertilization and phosphorus forms in an Oxisol under no-till. *Scientia Agricola*, **67**(4), 465-471.

Palai, J.B., Jena, J. and Lenka, S.K.(2020) Growth, yield and nutrient uptake of maize as affected by zinc application—A review. *Ind. J. Pure App. Biosci*. **8**(2), 332-339.

Pierre, J. and Peters, B.G. (2019) "*Governance, Politics and the State*". Red Globe Press.

Plaxton, W. and Lambers, H. eds. (2015) *Annual plant reviews, phosphorus metabolism in plants* (Vol. 48). John Wiley & Sons.

Pogorzelski, D., Lustosa Filho, J.F., Matias, P.C., Santos, W.O., Vergütz, L. and Melo, L.C.A. (2020) Biochar as composite of phosphate fertilizer: Characterization and agronomic effectiveness. *Sci. Total Environ*. **743**, 140604.

Prasad, B. and Sinha, S.K. (2000) Long-Term Effects of Fertil-izers and Organic Manures on Crop Yields, Nutrient Balance, and Soil Properties in Rice-Wheat Cropping System in Bihar. *Long-Term Soil Fertility Experiments in Rice-Wheat Cropping Systems. Rice-Wheat Consortium Paper Series*. **6**, 105-119.

Ranjan, R., Swarup, D., Naresh, R. and Patra, R.C. (2005) Enhanced erythrocytic lipid peroxides and reduced plasma ascorbic acid, and alteration in blood trace elements level in dairy cows with mastitis. *Veterinary Res. Commun.* **29**(1), 27-34.

Rasheed, N., Maqsood, M.A., Aziz, T., Rehman, M.Z.U., Bilal, H.M., Ayub, M.A., Irfan, M. and Sanaullah, M. (2019) Zinc application methods affect its accumulation and allocation pattern in maize grown in solution culture. *Intern. J. Agri. Biol.* **21,** 1197-1204.

Rasheed, N., Maqsood, M.A., Aziz, T. and Jabbar, A. (2020) Characterizing lentil germplasm for zinc biofortification and high grain output. *J. Soil Sci. Plant Nutr.* **20**, 1336–1349.

Rashid, A. and Fox, R.L. (1992) Evaluating internal zinc requirements of grain crops by seed analysis. *Agronomy J.* **84**(3), 469-474.

Razaq, M., Zhang, P. and Shen, H.L. (2017) Influence of nitrogen and phosphorous on the growth and root morphology of Acer mono. *PloS One*, **12**(2), 0171321.

Roba, T.B. (2018) Review on: The effect of mixing organic and inorganic fertilizer on productivity and soil fertility. *Open Access Library Journal*, **5**(6), 1.

Rowe, H., Withers, P.J., Baas, P., Chan, N.I., Doody, D., Holiman, J., Jacobs, B., Li, H., MacDonald, G.K., McDowell, R. and Sharpley, A.N. (2016) Integrating legacy soil phosphorus into sustainable nutrient management strategies for future food, bioenergy and water security. *Nutrient Cycling in Agroecosystems*, **104**(3), 393-412.

Saleem, M.H., Ali, S., Rehman, M., Rana, M.S., Rizwan, M., Kamran, M., Imran, M., Riaz, M., Soliman, M.H., Elkelish, A. and Liu, L. (2020) Influence of phosphorus on copper phytoextraction via modulating cellular organelles in two jute (*Corchorus capsularis* L.) varieties grown in a copper mining soil of Hubei Province, China. *Chemosphere*, **248**, 126032.

Sarkar, D., Baishya, L.K., Meitei, C.B., Naorem, G.C., Thokchom, R.C., Singh, J., Bhuvaneswari, S., Batabyal, K., Das, R., Padhan, D. and Prakash, N. (2018) Can sustainability of maize-mustard cropping system be achieved through balanced nutrient management?. *Field Crops Res.* **225**, 9-21.

Satyanarayana, V., Vara Prasad, P.V., Murthy, V.R.K. and Boote, K.J. (2002) Influence of integrated use of farmyard manure and inorganic fertilizers on yield and yield components of irrigated lowland rice. *J. Plant Nutr.* **25**(10), 2081-2090.

Scervino, J.M., Papinutti, V.L., Godoy, M.S., Rodriguez, M.A., Della Monica, I., Recchi, M., Pettinari, M.J. and Godeas, A.M. (2011) Medium pH, carbon and nitrogen concentrations modulate the phosphate solubilization efficiency of *Penicillium purpurogenum* through organic acid production. *J. Appl. Microbio.* **110**(5), 1215-1223.

Shahzad, Z., Rouached, H. and Rakha, A. (2014) Combating mineral malnutrition through iron and zinc biofortification of cereals. *Comprehensive Reviews in Food Science and Food Safety*, **13**(3), 329-346.

Shamim-ul-Sibtain, S., Khan, M.A., Khalid, F., Imran, M. and Gurmani, Z.A. (2015) Effects of phosphorus levels alone or in combination with farm yard manure on growth, yield and nutrient contents of wheat in rainfed conditions. *Inter. J. Bio. Biotech.* **12**(1), 113-117.

Shen, J., Yuan, L., Zhang, J., Li, H., Bai, Z., Chen, X., Zhang, W. and Zhang, F. (2011) Phosphorus dynamics: from soil to plant. *Plant Physiology*, **156**(3), 997-1005.

Shirani, H., Hajabbasi, M.A., Afyuni, M. and Hemmat, A. (2002) Effects of farmyard manure and tillage systems on soil physical properties and corn yield in central Iran. *Soil and Tillage Res.* **68**(2), 101-108.

Singh, B., Rana, D.S., Kapur, M.L., Sharma, K.N. and Bhandari, A.L. (1983) Evaluation of farmyard manure applied along with fertilizers to maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.). *Indian J. Agronomy*, **28**, 285-289

Soltanpour, P.N. and Schwab, A.P. (1977) A new soil test for simultaneous extraction of macro- and micro-nutrients in alkaline soils. *Commun. Soil Science and Plant Analysis*, **8**(3), 195-207.

Srinivasan, R., Yandigeri, M.S., Kashyap, S. and Alagawadi, A.R. (2012) Effect of salt on survival and P-solubilization potential of phosphate solubilizing microorganisms from salt affected soils. *Saudi J. Boil.Scie.* **19**(4), 427-434.

Srinivasarao, C., Kundu, S., Kumpawat, B.S., Kothari, A.K., Sodani, S.N., Sharma, S.K., Abrol, V., Chary, G.R., Thakur, P.B. and Yashavanth, B.S. (2019) Soil organic carbon dynamics and crop yields of maize (*Zea mays*)–black gram (*Vigna mungo*) rotation-based long term manurial experimental system in semi-arid Vertisols of western India. *Tropical Ecology*, **60**(3), 433-446.

Steel, R.G.D. and Torrie, J.H. (1960) Principles and procedures of statistics. *Principles and Procedures of Statistics*.

Stutter, M.I., Shand, C.A., George, T.S., Blackwell, M.S., Bol, R., MacKay, R.L., Richardson, A.E., Condron, L.M., Turner, B.L. and Haygarth, P.M. (2012) Recovering phosphorus from soil: a root solution?.

Suganya, A., Saravanan, A. and Manivannan, N. (2020) Role of zinc nutrition for increasing zinc availability, uptake, yield, and quality of maize (*Zea Mays* L.) grains: An overview. *Commun. Soil Sci. Plant Anal*. **51**, 2001-2021.

Swift, M.J., Seward, P.D., Frost, P.G.H., Qureshi, J.N. and Muchena, F.N. (1994) Long-term experiments in Africa: developing a database for sustainable land use under global change. In" "*Long-term Experiments in Agricultural and Ecological Sciences*,"pp. 229-251.

Tadesse, T., Dechassa, N., Bayu, W. and Gebeyehu, S. (2013) Effects of farmyard manure and inorganic fertilizer application on soil physico-chemical properties and nutrient balance in rain-fed lowland rice ecosystem. *American Journal of Plant Sciences,* **4**(02), 309-316

Thamaraiselvi, T., Brindha, S., Kaviyarasi, N.S., Annadurai, B. and Gangwar, S.K. (2012) Effect of organic amendments on the bio chemical transformations under different soil conditions. *Intern. J. Adva. Biol. Res.* **2**(1), 171-173.

Timsina, J. and Connor, D.J. (2001) Productivity and management of rice–wheat cropping systems: issues and challenges. *Field crops res.* **69**(2), 93-132.

Tisdale, S.L. and Nelson, W.L. (1966) Soil fertility and fertilizers. *Soil Science*, **101**(4), 346.

Tiwari, K.R., Sitaula, B.K., Bajracharya, R.M. and Børresen, T. (2010) Effects of soil and crop management practices on yields, income and nutrients losses from upland farming systems in the Middle Mountains region of Nepal. *Nutrient Cycling in Agroecosystems*, **86**(2), 241-253.

Toum, G.A.E., Dagash, Y.M. and Mahagoub, S.A. (2018) Nitrogen use efficiency of three maize (*Zea mays* L.) cultivars. *Malays J Sustain Agric*. **2**, 12-4.

Van Bueren, E.L., Jones, S.S., Tamm, L., Murphy, K.M., Myers, J.R., Leifert, C. and Messmer, M.M. (2011) The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: a review. *NJAS-Wageningen J. Life Sci.* **58**(3-4), 193-205.

Verma, V.K., Pyare, R., Singh, D., Pandey, A., Kumar, S. and Sachan, P. (2019) Studies on the rhizosphere, yield attributes and yield of wheat (*Triticum aestivum* L.) influenced by micronutrients, FYM and biofertilizers. *Journal of Pharmacognosy and Phytochemistry*, **8**(4), 1236-1239.

Wahid, F., Sharif, M., Khan, M.A., Ali, A., Khattak, A.M. and Saljoqi, A.R. (2015) Addition of rock phosphate to different organic fertilizers influences phosphorus uptake and wheat yield. *Journal of Ciencia E TecnicaVitivinicola*, **30**, 91-100.

Wahid, F., Sharif, M., Fahad, S., Adnan, M., Khan, I.A., Aksoy, E., Ali, A., Sultan, T., Alam, M., Saeed, M. and Ullah, H. (2019) Arbuscular mycorrhizal fungi improve the growth and phosphorus uptake of mung bean plants fertilized with composted rock phosphate fed dung in alkaline soil environment. *J. Plant Nutr.* **42**(15), 1760-1769.

Wang, Y. and Lambers, H. (2020) Root-released organic anions in response to low phosphorus availability: recent progress, challenges and future perspectives. *Plant and Soil*, **447**(1), 135-156.

Wasaya, A., Shahzad Shabir, M., Hussain, M., Ansar, M., Aziz, A., Hassan, W. and Ahmad, I. (2017) Foliar application of zinc and boron improved the productivity and net returns of maize grown under rainfed conditions of Pothwar plateau. *J. Soil Science and Plant Nutr*. **17**(1), 33-45.

Wessells, K.R. and Brown, K.H. (2012) Estimating the global prevalence of zinc deficiency: results based on zinc availability in national food supplies and the prevalence of stunting. *PloS One*, **7**(11), e50568.

Xiang, D.B., Yong, T.W., Yang, W.Y., Gong, W.Z., Cui, L. and Lei, T. (2012) Effect of phosphorus and potassium nutrition on growth and yield of soybean in relay strip intercropping system. *Scientific Research and Essays*, **7**(3), 342-351.

Yaseen, R., Hegab, R., Kenawey, M. and Eissa, D. (2020) Effect of super absorbent polymer and bio fertilization on Maize productivity and soil fertility under drought stress conditions. *Egyptian J. Soil Sci.* **60** (4), 377-395.

Yong, T.W., Ping, C.H.E.N., Qian, D.O.N.G., Qing, D.U., Feng, Y.A.N.G., Wang, X.C., Liu, W.G. and Yang, W.Y. (2018) Optimized nitrogen application methods to improve nitrogen use efficiency and nodule nitrogen fixation in a maize-soybean relay intercropping system. *J.Integr. Agri.* **17**(3), 664-676.

Yousif, A.A.A., Ali, H.K., Books, R.U.F.O.R.U.M., OER, R., SCARDA, R. and Tenders, R.U.F.O.R.U.M. (2010) Effects of chicken and cattle manure on wheat production and soil properties in the high terrace and Karu soils in River Nile State in the Sudan. In: *Second RUFORUM Biennial Regional Conference on" Building capacity for food security in Africa", Entebbe, Uganda,* pp.20-24, September 2010 (153-156). RUFORUM.

Zaman, Q.U., Aslam, Z., Rashid, M., Khaliq, A. and Yaseen, M. (2018) Influence of zinc fertilization on morpho-physiological attributes, growth, productivity and hematic appraisal of paddy rice. *J. Anim. Plant Sci*. **28**(3), 778-790.