Effect of Organic Fertilizers on Bioavailability of Potassium in Corn (*Zea Mays* L.)

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Abstract

Organic fertilization to soil has become imperative need in order to achieve sustainable agricultural productivity. Because addition of organic sources of fertilizers support the soil to improve soil physical, chemical and biological properties and subsequently increased availability of nutrient particularly phosphorus (P) and potassium (K).It also helps the soil in increasing water holding capacity due to increased soil porosity by soil aggregation. A pot experiment was performed to identify the "effect of organic fertilizers on bioavailability of potassium in corn" by applying three types of organic sources to maize plants as farm yard manure, poultry manure and filter cake press mud (FCP). Five treatments were applied with four replications including T1 as control potassium or untreated with potassium fertilization (CK), T2 as inorganic fertilizers in recommended dose N: P : K @ 150: 100: 110 kg ha^{-1}, T3 as Farm yard manure (FYM) @ 10 tha^{-1} along chemical N:P:K application, T4 as poultry manure @ 10 t ha^{-1} also named as (compost-I) along chemical N:P:K application and T5 as press mud @ 10 t ha^{-1} along recommended chemical N:P:K application. The results had demonstrated that all the organic and inorganic fertilizers had increased plant growth and quality attributes (plant height, plant stem diameter, total leaf chlorophyll contents, leaf are index (LAI), shoot and root dry weight, seed germination %, leaf P %, leaf K %, crop growth rate CGR and relative growth rate RGR) significantly as compared to control. Similarly soil chemical properties including organic matter (O.M %) contents, available and extractable concentration of P (ppm) and K (ppm) in soil also increased. All the organic sources had

shown significant results but press mud application showed more availability of potassium element while poultry manure had increased P values in soil as well as in plant parts.

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1. Introduction

The annual production of maize throughout the globe is almost 875.22 million tons (FAO, 2012) in which contribution of Pakistan is nearly 10% of total agriculture productivity (FAO, 2014). Maize is considered as a fourth major crop of Pakistan after wheat, cotton and rice which is cultivated in the area of one million hectares giving annual production of 3.5 million metric tons (FAO, 2014; PARC, 2015). Among cereal crops maize ranks third after wheat and rice and is known as queen of cereal crops due to its high potential of yield and productivity (Sandhu et al., 2007). It belongs from poacea family and falls in category of C4 plants. It is botanically called as *Zea mays* which is combination of Greek letters Zea and mays. Zea means "sustained life" and mays means "life provider". It is abundant in nutritional values involving starch, protein and fats with percentage of 72%, 10% and 4% respectively. Maize is consumed as forages by animals and as food by human beings. It has also its significance in industry and feed products, alcohol and ethanol industry and in vegetable oil production (Kumar et al., 2013). Hybrid verities of maize which are responsible of high yield require optimum fertilization which subsequently minimize the fertility status of soil in the form of nutrient deficiency and low uptake of nutrients by plants. Consequently production of maize crop reduces and disturb the farming system which take part in threatening to food security. The need of over population could be fulfilled by using efficient organic fertilizers instead of inefficient chemical fertilizers (Cakmak, 2008; Jones and Healey, 2010). Application of chemical or inorganic fertilizers has increased due to its rapid output and sustainable production of crops. But due to injudicious and maximum use of chemical fertilizer, soil has depleted for plant nutrition especially for phosphorus (P) and potassium (K) and other trace elements because maximum farmers apply only nitrogen nutrient which are considered as among the main reasons of lower concentration of organic matter in soil (NFDC, 2003). Inorganic fertilizers with low use efficiencies and high costs has capture the attention of farmers to convert from inorganic to organic fertilization of crops. Various changes established by applying organic fertilizers like farm yard manure (FYM), Poultry manure (PM), press mud (PrM) in physical, chemical properties and biological attributes of soil. These attributes of soil involved soil aggregation, water holding capacity, cation exchange capacity (CEC), soil pH and microbial activity in soil or plant root zone. Soil pH (activity of hydrogen ions) is most important chemical character of soil which changes effectively by application of organic matter. By application of organic matter pH of soil changes and moves to neutral from acidic or basic scale of pH (Walker et al., 2004). In the same way organic matter is also acts as a binding agent in soil which is main cause of soil aggregation. Organic matter is also called as nutrient bank which increase availability of nutrients such as nitrogen (N), phosphorus (P) and potassium (K) and other elements required

in trace amount by plant. (Ewulo et al., 2008; Marschner, 1995; Walker et al., 2004; Clemente & Bernal, 2006; Agbede et al., 2008; Muhammad & Khattak, 2009).

Among all the macronutrient potassium also has a significant place in increasing nutrient use efficiency, water use efficiency and yield in maize. Potassium (K) pockets that are recoverable influence greatly availability and uptake of other nutrients in maize which is irrigated with sufficient water. It functions in regulating opening and closing pattern of stomata in leaves, play its key role in process of photosynthesis and storage of water (FAO, 2012). Because deficiency of potassium causes reduction in leaf size and number of leaves in plants subsequently photosynthetic activity reduced in plant (Pettigrew, 2008). Under arid climate with increased uptake of potassium (K) nutrient grain yield also increased (Rengel & Damon, 2008) but in present situation hybrid sees of maize respond differently due to different pattern of uptake, growth and absorption of potassium fertilizer (Minjian et al, 2007). It also promote osmotic modification under stress conditions by accumulating solutes and improving water turgor (Oosterhuis & Wullschleger, 1987). Application of organic matter to soil increases association of soil and water which throws its positive effect on soil structure due to its thermophilic nature (Abood et al., 2013; Huntington et al., 2014). Potassium availability depends upon organic matter concentration and type of minerals present in clay to plant uptake (Taiwo et al., 2018). Organic matter effects potassium response in soil owing to CEC (AL-Jabori et al., 2011). A study was performed by Taiwo et al. (2018) in which he demonstrated that application of organic manure to soil improve potassium release and reduce fixation of potassium due to application of high amount of organic manure in soil.

Pakistani soils are naturally poor in organic matter due to its arid to semi-arid climate. In our country level of organic matter is lower than sufficient level. Soils having almost 1.29 organic carbon are considered as organic soils while Pakistani soils varies in range of 0.52 to 1.38 % in different regions. Most of the regions in Pakistan have less than 1 % organic matter concentration (Azam et al., 2001). There could be so many reasons of low organic concentration in Pakistani soils including climatic conditions, intensive tillage and injudicious use of mineral fertilizers. Therefore it is necessary for these types of soils to apply organic fertilizers in different forms such as poultry manure, farmyard manure, press mud, compost and biogas compost. Similarly green manure, slaughter houses waste, silage and crop residues could be used as organic fertilizers. Because organic matter improves soil physical condition as well as provide nutrients in available form to plant instantly when plant need as compared to chemical and mineral fertilizers which helps the farmer in increasing yield and productivity of crop (Shazada, 2021). Therefore a judicious and balanced application of organic and inorganic manure in integrated formulation could increase crop yield as has been discussed in various studies performed by different researchers (Usman et al., 2003; Khaliq et al., 2004; Muhammad & Khattak, 2009). Therefore keeping in mind the above discussion it is estimated that application of different forms of organic manure will also improve potassium (K) availability without application of phosphorus (P) fertilizer because it also

hypothesized that organic matter application will increase availability of soil native P instead of applied chemical p fertilizer in maize crop.

Therefore a pot study was performed To explore best suited source of organic matter for potassium release and availability to define the combined role of organic manure and potassium for the yield of maize crop under potassium deficient soil and to estimate potassium availability from organic matter by maize crop grown with and Without organic manure enrichment.

1. Materials and methods

The research was conducted in pots at the research place of Department of Soil and environmental Science, in College of Agriculture, University of Sargodha, Sargodha, Pakistan in order to evaluate the effect of variant sources of organic fertilizers on potassium (K) bioavailability in maize crop and concentration of potassium in different parts of maize plant. Before conducting a pot experiment soil physical and chemical properties were determined by taking a random sample of soil from research area which is used to fill the plant pots for maize growth. A composite soil sample was prepared by taking it from different locations of research area with the help of sampling tools from the depth of 0-30 cm. After that soil sample was cleaned with the help of hand to remove debris and stones and then brought to the laboratory to make a final sample by using 2mm sieve under shadow to dry in air for analysis by using standard procedures mentioned in handbook 60 (1954) of US laboratory staff.

2.1. Experimental design and layout

The bioavailability and uptake of the potassium (K) was investigated in a pot experiment amended with equal amount (10 t/ha) of different sources of organic fertilizers (Farm Yard Manure, compost I and compost II). Compost I contained sewage sludge, wheat straw and poultry manure. Compost II was consists of green waste biomass. Soil was air-dried and passed through a 2 mm sieve, and 8 kg of soil (based on dry weight) was thoroughly mixed with organic materials and applied with recommended doses of N, P and K (100: 80 : 50 kg ha^{-1}). The rate of K was adjusted according to their highest amount in individual organic fertilizers and mineral nutrients were added to equilibrate the amount in all treatments. Plastic pots were filled with mixture of soil and organic materials for sowing of maize seeds. Four seeds were sown in each pot and each treatments were replicated four times. After emergence, maize plants were thinned to maintain only one plant for further determinations up to Harvesting. Soil moisture was regularly controlled and kept at 60% of its maximum water holding capacity. The amount of available portion of K in soil after harvesting was determined in the extract of Mehlich III (Mehlich, 1984). Potassium contents in both soil extracts and plant digests were determined by flame atomic absorption spectrometry.

Table .1 Pre sowing Physico-Chemical attributes of soil

Soil Attributes	Values
Physical Properties	
Sand (%)	38

Silt (%)	21
Clay (%)	30
Texture	Clay Loam
Saturation Percentage (%)	34
Chemical Properties	
pHs	7.78
ECe (dSm-1)	1.11
O. M (%)	0.80
Total soil N (mg kg^{-1})	1512
Available P (mg kg^{-1})	9.18
Available K (mg kg^{-1})	171.3

2.2 Sowing of Maize seeds

Maize is a kharif season crop. Hybrid Seeds of maize crop (FH 1046) were sown in growing season of maize in 2021 in pots that were filled with normal soil in required moisture level. Crop was equally irrigated with canal water. All the cultural activities were applied to maize throughout the growing time of crop. The data was recorded according to the growth of maize and some data was measured at crop maturity. All the physiological and chemical attributes of maize were recorded throughout the growing period including emergence of seeds, plant height (cm), stem diameter (cm), shoot dry weight (g pot^{-1}), root dry weight (g pot^{-1}), leaf P content (%), leaf K content (%), chlorophyll content, leaf area index (LAI), crop growth rate (CGR), relative growth rate (g $kg^{-1}day^{-1}$), soil organic matter content, soil available P content (ppm) and soil soluble K content by using standard procedures.

2.3 Soil analysis

Techniques other than these will be indicated separately. The samples that we used for all determination were dried in oven. Various Physio-chemical characteristics of soil before cultivation were determined including pH, EC, Carbonates, Bicarbonates, Chloride, Sulfate, Calcium, Magnessium, Sodium, SAR, N, P, K as well as Soil Texture.

Soil EC and pH of normal soil was determined by making soil saturated paste with the help of EC and pH meter. Soil texture was determined by using mechanical analysis which is known as hydrometer method described by Bouyoucos (1962). Saturation percentage of a known weight of soil paste was calculated by using following formula:

$$SP = \frac{\text{Loss in wt. (g)}}{\text{Oven dry wt. (g)}} \times 100$$

Organic Matter was determined by using method described by Walkely in 1934. Available soil P was determined by Olsen P method using spectrophotometer. Similarly Soil Available potassium (K) was determined in flame photometer (PFP-7)

2.4 Plant Analysis

The concentration of nutrients in plant tissue can be measured in a plant extract obtained from fresh plant material, (i.e., tissue analysis), as well as in whole dried plant material. Total plant analysis is quantitative in nature and is more reliable and useful (ICARDA, 2001). Take 0.5 g of all the samples in digestion tube and in each 10 ml tube of Di-acid mixture was added (HNO_3+$HCLO_4$). Place in digestion hood at 150-170 ° C until green to colorless endpoint appears. Take 25 ml flasks, add those digested solution to flasks and make volume.

Phosphorus was analyzed by using spectrophotometer and potassium was determined in flame photometer. Chlorophyll contents (a, band total) of maize leaves were determined by using spectrophotometer in specific wavelengths as suggested by Lichtenthaler (1987). Leaf area index (LAI) is explained as half the total developed area of green leaves per unit horizontal surface area. For leaf area index following modal is used described by Watson (1956).

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

Crop growth rate was measured by using formula as Crop growth rate = W2-W1 /P (T_2-T_1) Where, P = Ground area, W1 = Dry weight of plant/m2 recorded at time t1, W2 = Dry weight of plant/m2 recorded at time t2, T_1 and T_2 were the interval of time, respectively and it is expressed in g/m2/day while relative growth rate was determined by using formula as Relative Growth rate = $\log_e$ W2 – $\log_e$ W1 / T_2 – T_1 Where, In = Natural log, W1 = Dry weight of plant/m2 recorded at time t_1, W2 = Dry weight of plant/m2 recorded at time t_2, T_1 and T_2 were the interval of time, respectively and is expressed as g/g/day. Similarly plant height was measured by meter rod and plant width was determined by secure gauge. Shoot and root fresh and dry weights were recorded by using electric balance. All the data was analyzed at maturity and during plant growth period. The collected data was interpreted statistically

2.5 Statistical analysis

The collected information was interpreted in software statistics 8.1 to analyze data for analysis of Variance (ANOVA) approach and significant of means of treatments were compared by using Tukey's (HSD) test at the probability level of 5%.

2. Results

A pot experiment was conducted in research place of College of Agriculture University of Sargodha, Punjab, Pakistan in order to evaluate the effect of organic manure of maize growth and yield attributes. Study was comprised of five treatments and four replications under complete randomized design including T1 as control (unfertilized) without K fertilizer, T2 as chemical application of NPK @150: 100: 110 kg ha^{-1}, T3 as farmyard manure @ 10 t ha^{-1} along with NPK, T4 as poultry manure @ 10 t ha^{-1}Along with NPK indicated as compost-I and T5 as press mud (FCP) @ 10 t ha^{-1} along recommended NPK that was indicated as compost-II. Some growth and quality parameters of maize such as Plant height (cm), plant diameter (mm), leaf P concentration (%), leaf K concentration (%), Seed emergence rate (%) Total chlorophyll contents (µ g^{-1}) Shoot dry weight (g), root dry weight (g), crop growth rate and relative growth rate of maize crop were

determined as well as soil nutrient contents were also measured after harvesting of crop including soil organic matter concentration (%), soil P contents (ppm), soil K contents (ppm) in laboratory according to recommended and standard procedures. The results of these determined indicators in laboratory are explained one by one as under.

3.1 Plant growth and yield attributes

Data regarding plant height (cm) , stem diameter (mm), shoot dry weight (), root dry weight () of maize had indicated that all the treatments are different from each other significantly with respect to control which is untreated. Maximum plant height was observed in T5 (144.23 cm) treatment (compost-2) followed by T4 (compost-1, poultry manure along recommended NPK), T3 (FYM) and T2 (chemical fertilizer NPK) treatments and minimum plant height was indicated by (T1) control treatment (93.30 cm) which was without potassium fertilizer.

In the same way maximum stem diameter was observed in case of T5 treatment (17 mm) where press mud (compost-2) was applied @ 10 t/ha^{-1} along with recommended NPK to maize crop while minimum stem diameter (9.75 mm) was recorded in case of control (T1) treatment. Readings of T4 (poultry manure along with NPK), T3 and T2 (NPK) were also at par as compared to untreated control treatment. A significant behavior was observed between T5 and T4 treatment. All the treatments were different significantly from each other relative to control.

Shoot dry weight (g pot^{-1}) of maize plant was also maximum in case of T5 treatment (compost-2, press mud) followed by T4 (compost-1, poultry manure), T3 (FYM) and T2 (chemical fertilizer) treatments. Minimum shoot dry weight of maize was recorded in T1 (untreated) control treatment where no chemical and organic fertilizer was applied.

Root dry weight (g pot^{-1}) of maize plants elucidated that highest root dry weight was recorded in T5 treatment where organic fertilizer in the form of press mud (compost-2) was applied followed by T4 as compost-1 organic fertilizers (poultry manure), T3 as farmyard manure along recommended NPK and T2 as chemical application of N: P: K showed increased root dry weight gradually as compared to control treatment. While minimum reading of root dry weight was indicated by control treatment (T1) which is untreated. All treatments had shown significant increase in dry root weight relative to control. Overall It had noticed that organic sources of fertilizers performed best to promote agronomic and yield parameters as compared to chemical application of fertilizers in the form of N:P:K as urea, Di-Ammonium phosphate (DAP) and potassium (SOP).

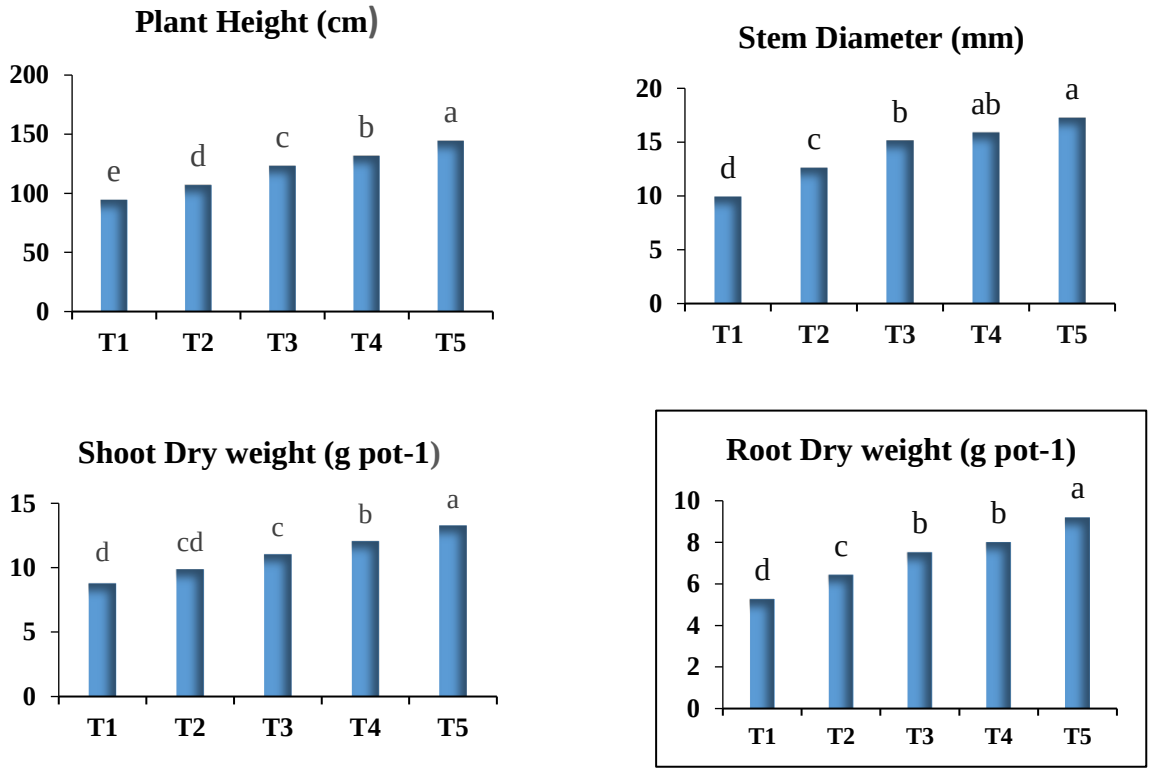

Figure 3.1: Effect of organic fertilizers (Control, NPK, FYM, Poultry Manure and Press mud on corn growth and yield under pot conditions.

3.2 Plant Physiological and chemical attributes

A non-significant effect of organic manure and chemical fertilizers (Table 1) was recorded in all the treatments relative to control which is untreated and without any fertilizer. The maximum value of leaf area index was noted in treatment (T5) where press mud was applied as compost-2 showing the value of (6.02) and followed by T4 (poultry manure) 5.02, T3 (farm yard manure) 4.55 and T2 (chemical application of NPK) 4.22 and minimum leaf area (3.25) was noted in control treatment. While a non-significant behavior was noted between T2 and T3 treatment.

Similar trend was observed in case of total chlorophyll contents (µg g^{-1}) showing the maximum value of total chlorophyll contents (5500 µg g^{-1}) in maize leaves in case of T5 treatment which was applied in the form of press mud and minimum chlorophyll contents were found in control treatment showing the value of 2570. All the treatments had shown a significant difference among each other and relative to control treatment. A non-significant behavior was observed between T1 and T2 treatments showing the values of 2570 and 2900 (µg g^{-1}) respectively.

All the treatments had shown maximum percentage of seed emergence or seed germination percentage as compared to control treatment (T1) which was untreated while almost all the treatments had shown maximum 100% seed emergence percentage. Only control treatment (T1) and treatment (T2) where chemical fertilizers were applied in the form of NPK showed 78 % and

84 % seed germination. While all other remaining treatments had shown 100 % seed germination. Overall, all a non-significant difference was noticed among all the treatments relative to control.

Results regarding phosphorus concentration (P) of maize leaf in graphical form indicated that maximum P concentration (0.78 %) in maize leaf were obtained in T4 treatment where organic manure was applied as poultry manure and minimum concentration of leaf P was indicated by T1 which was untreated and unfertilized with any organic or inorganic form. After T4 treatment T3 and T5 showed maximum values (0.74 % and 0.61 %) of P concentration respectively. While T2 where chemical fertilizer was applied in the form of N, P and K showed 0.57 % P value.

Graphical data of potassium concentration in maize leaf had demonstrated that all the chemical and organic sources of fertilizers had increased potassium concentrations in maize leaves relative to control treatment which remained untreated. Maximum value of potassium percentage in maize leaf was obtained by T5 treatment which was fertilized with press mud and followed by T4, T3, T2 and T1 respectively. Minimum potassium percentage of potassium was recorded in control (T1) treatment. All the treatments were significantly different from each other relative to control (untreated).

It was estimated from the graphical data regarding crop growth rate (CGR g $kg^{-1}day^{-1}$) in maize that maximum increase in crop growth rate was recorded in T5 treatment (32.23) which was fertilized to maize crop in the form of press mud followed by T4, T3, T2 and T1 treatments. Minimum reading (16.06) of CGR was estimated in control treatment (T1) which was unfertilized with any type of organic or chemical fertilizers.

Similarly values of relative growth rate (g $kg^{-1}day^{-1}$) were also presented that that maximum increase in crop growth rate was recorded in T5 treatment (0.065) which was fertilized to maize crop in the form of press mud followed by T4 (0.053), T3 (0.041), T2 (0.029) and T1 treatments. Minimum reading (0.018) of CGR was estimated in control treatment (T1) which was unfertilized with any type of organic or chemical fertilizers. All the treatments were different significantly from each other over untreated control.

Table 2 Effect of organic fertilizers (Control, NPK, FYM, Poultry Manure and Press mud on physiological attributes of corn) under pot conditions.

Treatments	Leaf P (%)	Leaf K (%)	Total Chlorophyll contents (mg g^{-1})	Leaf Area Index	Seed Emergence (%)	CGR (g $kg^{-1}day^{-1}$)	RGR (g $kg^{-1}day^{-1}$)
Control	0.43c	0.95e	2.52d	3.25cd	81.25b	16.06d	0.018e
N:P:K	0.57b	1.10d	3.00cd	4.22c	93.75a	20.55c	0.029d
FYM @ 10 t/ha^{-1}	0.74a	1.28c	4.07b	4.55bc	100a	24.87b	0.041c
Compost-1 (Poultry manure) @ 10 t/ha^{-1}	0.78a	1.44b	4.7ab	5.02b	100a	29.43a	0.053b
Compost-2 (press mud) @ 10 t/ha^{-1}	0.61b	1.61a	5.44a	6.02a	100a	32.23a	0.065a
CV	**5.52**	**7.93**	**12.67**	**10.20**	**8.32**	**10.64**	**12.06**

All the average values of five treatments are significantly different from each other at $p<0.05$

3.3 Post-harvest soil attributes

Concentration of soil organic matter after harvesting of maize crop was also increased where organic sources of fertilizers were applies in the form of farmyard manure, poultry manure and press mud as compared to control treatment which was untreated. A non-significant behavior was determined between control (T1) and T2 treatment (chemical NPK application) which was free from organic fertilization. Maximum concentration of organic matter (1.63 %) was determined in T5 (press mud compost-2) treatment followed by T4 (Poultry manure compost-1) with the value of 1.44 % and T3 (farmyard manure) with the value of almost 1 % treatments. A significant difference was noted among all the treatments except T2 relative to control.

Data regarding phosphorus concentration (P) in soil after harvesting of maize had indicated that maximum P concentration (6.4 ppm) in soil was obtained in T4 treatment where organic manure was applied as poultry manure (compost-I) along with NPK and minimum concentration of P in soil after harvesting was indicated by T1 (2.9 ppm) which was untreated and unfertilized with any organic or inorganic form. After T4 treatment T5 (compost-II FCP) and T3 showed maximum values (4.96 ppm and 4.3 ppm) of P concentration respectively. While T2 where chemical fertilizer was applied in the form of N, P and K showed 3.24 ppm P value.

Similarly potassium concentration in soil after harvesting of maize crop had demonstrated that all the chemical and organic sources of fertilizers had increased potassium concentrations in soil relative to control treatment which remained untreated. Maximum value (150.10 ppm) of potassium in soil was obtained by T5 treatment (Compost-II) which was fertilized with press mud (FCP) and followed by T4 (138.75 ppm), T3 (118.75 ppm), T2 (92.93 ppm) and T1 respectively.

Minimum potassium value (70.30) of was recorded in control (T1) treatment. All the treatments were significantly different from each other relative to control (untreated).

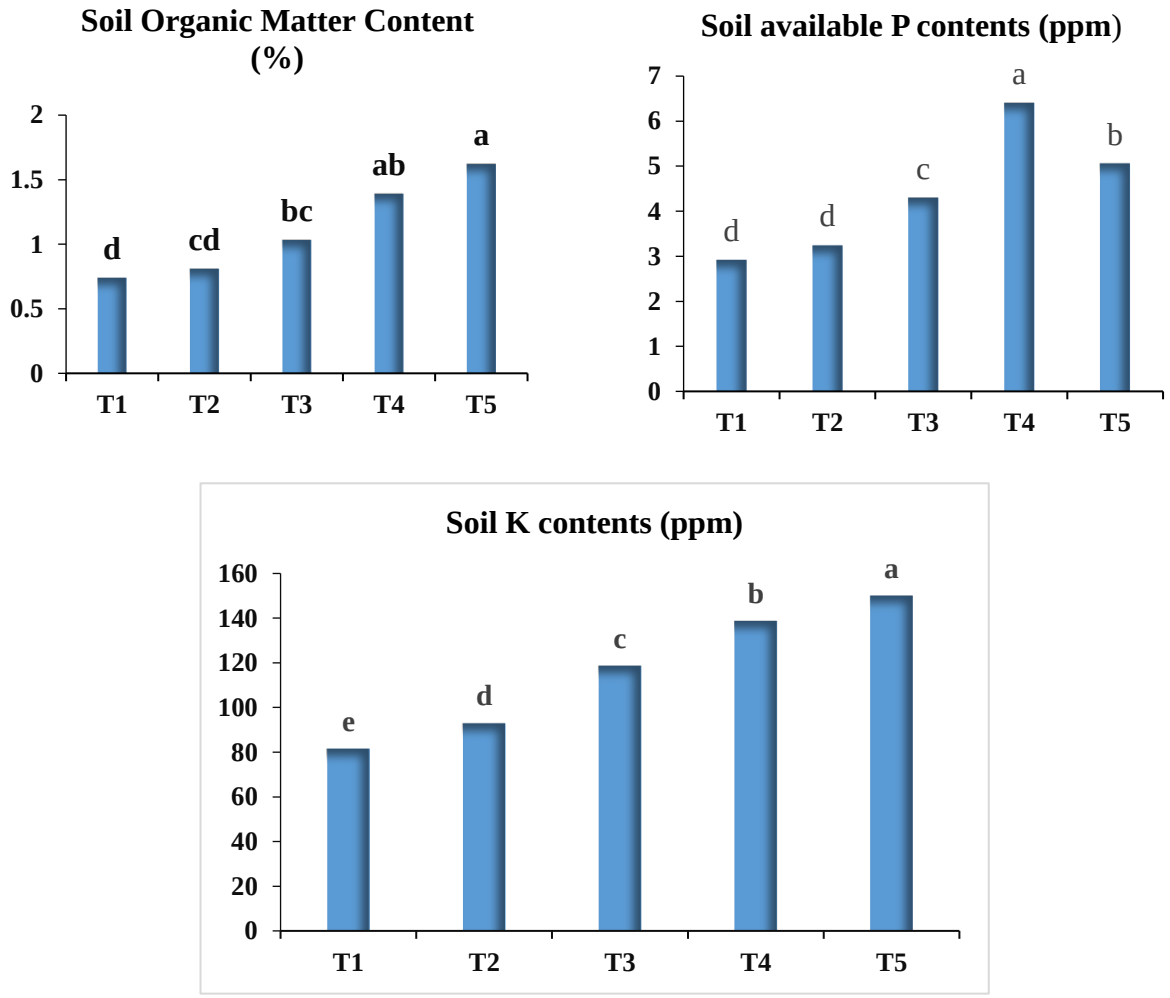

Figure 4.2: Effect of organic fertilizers (NPK, FYM, Poultry Manure (compost-I) and Press mud (compost-II) on available soil P (ppm), K (ppm) and organic matter (%) after crop harvesting under pot conditions.

4. Discussion

A pot study was conducted to evaluate the effect of different sources of organic manure on maize growth and yield attributes. Study was comprised of five treatments and four replications under complete randomized design including T1 as control (unfertilized), T2 as sole chemical application of NPK@150: 100: 110 kg ha^{-1}, T3 as farmyard manure @ 10 ton ha^{-1} along with NPK, T4 as poultry manure @ 10 ton ha^{-1} along with NPK, indicated as compost-I and T5 as press mud @ 10 ton ha^{-1} along with NPK that was indicated as compost-II. Some growth and quality parameters of maize such as Plant height (cm), plant diameter (mm), leaf P concentration (%), leaf K concentration (%), Seed emergence rate (%) Total chlorophyll contents (µg g^{-1}) Shoot dry weight (g), root dry weight (g), crop growth rate and relative growth rate of maize crop were determined

as well as soil nutrient contents were also measured after harvesting of crop including soil organic matter concentration (%), soil P contents (ppm), soil K contents (ppm) in laboratory according to recommended and standard procedures. The results of these determined indicators were discussed briefly below.

The results indicated that organic manure increased plant growth attributes. Plant height (cm) and stem diameter (mm) was increased in maximum ratio in T5 treatment where press mud was applied as compost-II to maize plant as an organic source as than poultry manure (compost-I), farm yard manure (FYM) and chemical application of N: P: K fertilizers. Subsequently leaf area index (LAI) was also increased with same trend. Maximum leaf area was noted in case of T5 treatment when press mud was applied to maize crop than other organic sources such as poultry manure and farmyard manure application and as well as chemical application of NPK fertilizers. The same results were noted by Boateng et al., 2006; Muhammad & Khattak, 2009. Similarly shoot and root dry weights of maize plant were also recognized in press mud application as organic fertilizer than other organic and in organic sources of fertilizers. All these improvements in plant growth attributes may be due to increased mineral nutrition to plant especially phosphorus due to poultry manure and potassium due to press mud application. The improvement in plant growth parameters were also determined by Muhammad & Khattak, 2009; Boateng et al., 2006; Hirzel et al., 2007. They also suggested that this improvement in plant growth attributes might be due to increased availability of K and P due to organic sources of fertilizers which take part in increasing fertility status of soil particularly nitrogen and phosphorus nutrients (Marschner, 1995) which plays significant function in enlargement of plant cell. The similar results were also found by Ziadi et al. (2006) and Dikinya & Mufwanzala (2010) and reported that organic sources of fertilizers increased soil fertility and subsequently crop production. Similarly germination percentage of maize seeds was also recorded in which it was also identified that there was a no significant difference in treatments of organic fertilizers application. All the organic sources shown immediate germination after 3 days of sowing than control treatment. This could be attributed to high moisture contents in pots of organic fertilizers. Because due to organic manure application water and nutrient availability to seeds in soil increased which ultimately promote seed germination rate. The similar results were found in the study of Soro et al., 2014 and he reported that corn seeds germinate well when germination percentage is more than 75 %.

Increase in potassium concentration in plant leaf was also maximum in treatments where organic sources of fertilizers were applied as compared to in organic sources fertilizers or without any fertilizers. Maximum potassium concentration in maize leaves were noticed where press mud was applied @ 10 t ha^{-1} followed by poultry manure, farmyard manure and chemical fertilizers showed best concentrations of maize shoots and leaves. This increased concentration of K values in plant vegetative parts could be attributed to high uptake of nutrients from soil due increased root mass and growth. More roots or roots proliferation increased uptake of nutrients in plants. Our findings are in the same line of results of Aziz et al., (2006).

Similarly it was also observed in our study that maximum phosphorus concentration in maize leaves were observed in case of poultry manure treatment. Because P was not fertilized chemically to any pot soil. Other organic sources also increased P concentration in plant leaves than in the pots of without organic manure application. Higher concentration of P is also due to high availability of nutrients because of organic matter application which promote availability of nutrients present in soil natively. (Mohanty et al., 2006; Hirzel et al., 2007; Ewulo et al., 2008; Garg & Bahl, 2008). Total chlorophyll contents were also increased by application of organic sources of fertilizers than chemical fertilizers and control pots which were remained untreated. Maximum chlorophyll contents were increased where press mud was applied as organic source followed by poultry manure and farm yard manure relative to control. This may be due to the fact that most of the nutrients could be available at the site of activity of photosynthesis process which is ultimately responsible of crop yield. The same results were obtained by Bamidele Amujoyegbe et al., (2010) who also suggested that organic manure is source of nutrients which increase the availability of other nutrients in soil and make available to plant to regulate plant metabolism and other reactions in plant like photosynthesis to increase total chlorophyll contents and plant production.

It was also revealed from the results that addition of different sources of organic manure increased organic matter concentration in soil after harvesting of maize crop. All the organic sources increased organic matter concentration in soil but maximum organic percentage was found in T5 treatment where press mud was applied as organic sources of fertilizers. This may be due to the effect of increased activity of microbes in plant roots as compared to T1 control which is untreated. Increased organic matter concentration in soil could also be due to microbial activity and releasing of organic substances by plants into soil (Marschner, 1995). Other reason of increased concentration of organic matter could also be itself addition of organic sources of organic matter into soil (Agbede et al., 2008).

Addition of organic fertilizers improve organic matter concentration in soil which is ultimately a bank of nutrients that increased availability of nutrient in increased concentration in soil to uptake by plant. Therefore concentration of potassium (K) and Phosphorus (P) in soil also increased due to addition of organic sources of fertilizers than chemical application of N, P and K or without any fertilizer. Maximum concentration of soil available potassium (K) was reported in T5 treatment where press mud (Compost-II) was applied while maximum concentration of available P was obtained in case of T4 treatment where poultry manure was applied as organic source. This may be due to availability of respective nutrients in organic sources. The similar results were obtained from the study of Cavigelli and Thien (2004). They also found that addition of organic sources may increase bioavailability of phosphorus which is immobile nutrient in soil and controlled by diffusion process. Addition of organic matter increase water concentration in soil which helps in availability of P to plant from soil through diffusion (Marschner, 1995; Boateng et al., 2006).

Crop growth rate (CGR) and relative growth rate (RGR) in maize plant was also increased by all applied organic sources from including press mud, poultry manure and farmyard manure.

Maximum values of CGR and RGR were indicated by press mud than other organic sources over control treatment which was unfertilized. Overall increase in CGR and RGR was observed in all treatments of organic sources. This may be due to the fact that organic sources increased vegetative growth of maize at different stages during growth period by nutrient availability due to addition of organic sources. The same results were determined by Tabrizi et al. (2009) and Tariq et al. (2014) who demonstrated that application of organic manure increased rate of crop growth and relative rate of growth in maize to its application at initial stages of growth which support plant to uptake nutrients for entire vegetative growth. This could increase higher growth of crop and subsequently increased crop growth rate and relative growth rate. Similar findings were obtained by Banga et al. (1994) and Afifi et al. (2011) in maize.

Conclusion

It is concluded from the results that all the organic sources are beneficial as compared to in organic fertilization in order to achieve maximum agricultural yield. Similarly it is also revealed from the data that availability of potassium (K) and phosphorus (P) also increased in optimum level in soil and plant where press mud and poultry manure were applied respectively. Organic sources also increased porosity of soil which subsequently increased water holding capacity in soil and more water concentration in soil convert the fixed nutrients into available forms in soil.

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