

## DISTRIBUTION AND EVALUATING PHOSPHORUS, POTASSIUM, CALCIUM AND MAGNESIUM IN THE FRESH AND COMPOSTED POULTRY LITTER

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### Abstract

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Organic farming is a system that promotes the use of organic fertilizers. Organic matter is an essential component of healthy soils, and all sound farming practices integrate and allocate available organic materials to maintain or improve soil fertility. An experiment was conducted to assess the influence of composted poultry litter (CPL) and fresh poultry litter (FPL) on the extractability of phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). Extractability of these nutrients was found highly dependent upon the type of waste use. The examined nutrients were found in the order of P>Ca>K>Mg from poultry waste after 100 days of composting process as well as fresh manure. The concentrations of these nutrients were found apparently higher in composted material as compared to fresh one. The mean level for the release of phosphorus obtained in water-soluble was greater in compost amended soil as compared to fresh amendment with 0.2115 mg kg<sup>-1</sup>. The phosphorus with double acid was greater in compost where as lowest was found in fresh manure with 0.2 g kg<sup>-1</sup>. The efficiency of manure used is highly dependent upon source of manure used. The applications of CPL to fields could reduce both synthetic fertilizer inputs and improve soil qualities. Therefore, this investigation was aimed to compare the extractability and bioavailability of plant nutrients to maize crop following composted poultry litter application.

*Key words:* Poultry litter, composting, biodiversity, phosphorus

### Introduction

Organic fertilizers are low in nutrient content, therefore high application rates are needed to meet crop nutrient requirements. The use of manure in agricultural land is beneficial to the physical, chemical and biological properties of the soils (Little, 1997; Olayinka 1997) because of their valuable ingredients and characteristics (Clark et al., 1998; Eneji et al., 2001). Agronomic practices aimed at reducing the dependence on the chemical fertilizers can contribute to the sustainability of agriculture. The efficiency of manure use is highly dependent upon soil type and source of manure

added. The environmental impacts of the industrial waste of poultry have gained worldwide importance. Increasing interest in the recycling of waste has also raised concerns over the possible contamination of soil and water. The intensive use of chemical fertilizer inputs has aggravated the global environmental system since nutrients are usually subjected to different losses in the soils. The form in which fertilizer is applied may influence the nutrient dynamics in the soil plant system.

Composted manure can be an alternative source of fertilizer in organic farming where the use of manufactured chemicals is prohibited. Composting poultry litter may pro-

vide a beneficial alternative method for handling litter due to immobilization of nutrients and a reduction of litter volume (Prreusch et al., 2002). Compost is safer due to pathogen reduction and is easier handle, store, transport, and apply than non-composted organic residues. Among the plants nutrients, phosphorus is important and is often supplied to the field crops in organic forms such as manures or bio solids. Organic waste application for the reduced P losses and enhanced environmental quality is also an important consideration when recycling farm wastes as soil amendment. Because of the repeated applications of the manure in areas with intensive livestock farming, soils are often enriched with P levels, which exceed those removed in the harvested crops (Koopmans et al., 2001; Sims, 2000).

The use of poultry litter on the agricultural lands with elevated phosphorus levels needs special management. Efforts should be made to reduce P input into the poultry waste. Mismanagements of fertilizer or manure can lead to the P build up in surface soils above threshold levels and increases its potential for movement in the drainage water. This may cause eutrophication of streams and lakes leading to surface water quality problems (Carpenter et al., 1998; Correll, 1998). It is reported that bio solids applications to the soils not only increase availability P, but also decrease P binding affinity by soils and increase P desorption capacity (Sui and Thompson, 2000). Poultry manure is managed primarily for its nitrogen (N) value. The amount of N available for plant uptake is ammonium nitrogen plus the amount of organic nitrogen that mineralizes during the growing season. The management of livestock or poultry manure with consideration for environmental quality should be an important goal when recycling farm wastes as soil amendments (Eneji et al., 2003; Bolan et al., 2004). Application of undecomposed wastes or non-stabilized compost to land may lead to immobilization of plant nutrients and cause phytotoxicity (Butler et al., 2001). Continued disposal of large amounts of raw manure may result in soil and water contamination via leaching of toxic elements, nutrient imbalances and phytotoxicity in crops (Milan and Fernandes, 1996).

Agricultural production is adversely affected by the presence in soil of either excessive quantities of toxic elements or insufficient amounts of essential elements. Thus it is important to have information on the nutritional and toxic element status of manure amendments. Research reports on the comparison of composted and fresh organic wastes on various crops are sufficient, but the nutrients release and their bio availability to maize crop from composted poultry litter are scanty. Therefore, this investigation was aimed to compare the extractability and bio availability of plant nutrients to maize crop following composted poultry litter application.

## Materials and Methods

Two types of poultry litter (PL), fresh (FPL) and composted (CPL), were collected from the poultry farm in Abbotabad, KPK. Litters were air dried, crushed, and sieved (< 0.5 mm) to ensure homogeneity and digested in a mixture of duplicate acids ( $\text{HNO}_3$  and  $\text{HClO}_4$ ). Total elements i.e. K, Ca, Mg in the extract of digested manure samples, were determined by atomic absorption spectrophotometer. Total phosphorus (TP) and Water soluble phosphorus (WSP) in the digest was determined by blue colour method using a spectrophotometer at 710 nm wavelength. The pH of the manure with water suspension (1:5) was determined using pH meter.

Total elements (P, K, Ca, Mg) in the samples were determined with a mixture of  $\text{HClO}_4$ - $\text{HNO}_3$  (IBSRAM.1994). Sample weighing 0.25 g was digested with 5 mL concentrated  $\text{HClO}_4$  by gradual heating it over a hot plate for 1 h. After drying 20%  $\text{HNO}_3$  was added to the sample and it was heated again for 1h. The solution was diluted to 50 mL with deionized water and passed through a 0.22  $\mu\text{m}$  filter. The P was determined on a spectrophotometer using the phosphomolybdate blue method (Murphy and Riley, 1962). Absorbance was determined at a wavelength of 710 nm. Treatments were replicated thrice. Ca, Mg and K were extracted with water to determined water soluble cations. The soil samples weighing 3g were measured in soil– water (1:5; w:v) suspensions placed in a 100 mL centrifuge tube and shaken mechanically for 1 h and filtered into a 100 mL volumetric flask.

The material was shaken for 2 h at room temperature. After each end-to-end shaking the tubes, were centrifuged at 10000 rpm for 10 min., and the supernatants were filtered by a 0.2  $\mu\text{m}$  filter. The contents were determined using a Polarized zeeman atomic absorption spectrophotometer (Model Z-2300 Hitachi corp., Japan).

Data were statistically analyzed using Stat view software (SAS, 1999), and results were expressed on oven-dry basis. The overall differences among treatments were tested using analysis of variance. A probability level of < 0.05 was considered significant and means were compared by least significant difference (LSD-test).

## Results and Discussion

The application of various manure composts to agricultural soils is associated with several benefits. However, certain composts may contain high concentrations of trace elements that may be detrimental to plants and environment. When rates of manure application are greater than crop demand, crop nutrient imbalance and soil or water pollution often occur. An experiment was conducted to assess the influence of

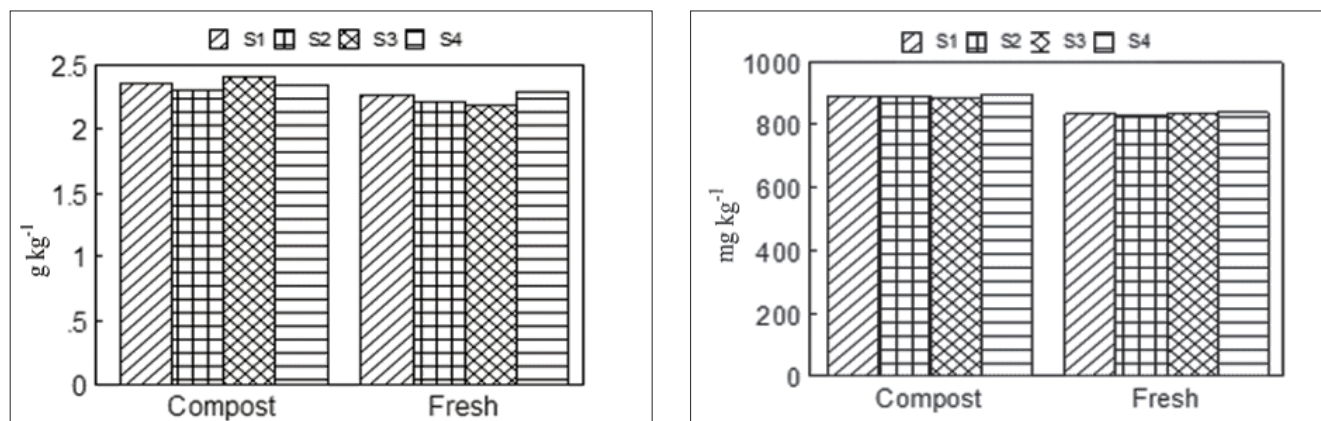
composted and fresh poultry litter on the extractability of P, K, Ca, and Mg. The nutrients were found in the order of  $P > Ca > K > Mg$  from poultry waste. The concentrations of these nutrients were found apparently higher in composted material as compared to fresh one. The mean level for the release of phosphorus obtained in water soluble was greater in compost amended soil as compared to fresh with  $891 \text{ mg kg}^{-1}$ . Studies have shown that the composting process immobilizes N in the litter and produces humus that can be used as a source of organic materials and slow the release of nutrients (Paul and Clark, 1996). The slow release of nutrients from composted poultry litter (CPL) may lessen adverse environmental effects from leaching of N in runoff from farmlands (Chang and Janzen, 1996). Increased soil organic matter and cation exchange capacity from CPL applications may improve nutrient retention in soils. Thus, applications of CPL to fields could reduce both synthetic fertilizer inputs and improve soil qualities. However, loss of P from fields where composted manures have been applied is less well understood.

The phosphorus with double acid was greater in compost where as lowest was found in fresh manure with 2.35 and  $2.24 \text{ g kg}^{-1}$  respectively (Figure 1). The concentration of nutrients varied in the order of  $P > Ca > K > Mg$  both in compost and fresh amended soil (Table 1). There has recently been a renewed interest in using livestock manure to improve soil fertility and crop production (Janzen et al., 1999; Mooleki et al., 2004). The manure may be applied fresh or composted prior to application in fields. However, composted manure is preferred because of its reduced volume and ease of handling due to smaller particle size that facilitates more uniform application (Eneji et al., 2001; Larney and Blackshaw, 2003; Richard and Choi, 1999). Reider et al. (2000) reported that corn yields were usually similar under composted and fresh manure but Loecke et al. (2004) observed that yields were sometimes greater with composted manure. Eneji et al. (2001) reported severe ammonium toxicity on direct-seeded rice seedlings fertilized with fresh chicken manure. It is known that the fertility of soil is directly related to the level

**Table 1**  
**Chemical property of fresh and composted poultry litter used in this study**

Treatment	Sample	$\text{H}_2\text{SO}_4 + \text{HNO}_3$ Digested, $\text{mg kg}^{-1}$				Water soluble, $\text{mg kg}^{-1}$			
		P, $\text{g kg}^{-1}$	K	Ca	Mg	P	K	Ca	Mg
Fresh	S1	2.3	721	1234	409.8	834	257	431	183
	S2	2.2	718	1227	412.1	829	249	439	177
	S3	2.2	714	1232	415.4	833	243	442	171
	S4	2.3	728	1239	419.3	841	251	429	169
Compost	S1	2.4	812	1378	437.7	893	293	472	194
	S2	2.3	817	1368	439.9	889	308	482	197
	S3	2.4	821	1375	433.2	888	301	477	191
	S4	2.4	816	1371	435.6	897	298	488	201

Note: S1 to S4 denotes Samples collected from different sites



**Fig. 1.** Total and water soluble P in compost and fresh manure

of organic matter. Recently, interest has increased in the land application of organic wastes, for several reasons, including supply of plant nutrients, soil improving and conditioning and energy conservation (Loehr, 1977). It is known that, for an efficient application, organic material must be previously decomposed to a humus-like product. This condition is achieved when readily degradable constituents in the organic matter have been biologically transformed into more stable intermediates. Many studies have shown that the addition of immature organic materials to the soil can cause severe damage to plants owing to nitrogen starvation and the creation of anaerobic environments (Yietjen, 1975; Zucconi et al., 1981).

The determination of the nutrient level contained in any manure is essential for its safe and balanced use as soil amendment. Appropriate management of various manures and organic wastes is one of the best means of improving agricultural soils. Generally the order of acid digested nutrients in poultry litter was found as  $P > Ca > K > Mg$  with 1373 mg Ca, 816.5 mg K and 436.6 mg Mg  $kg^{-1}$  were recorded for

composted manure Table. 1 whereas 1233 mg Ca, 720 mg K and 414.1 mg Mg  $kg^{-1}$  was noted from fresh manure amended soils respectively (Figure 3). The data of water soluble K, Ca and Mg, also showed that water soluble cations were higher in composted material as compared to fresh poultry manure (Figure 2).

There was a progressive increase in the concentrations of K, Ca and Mg during composting. These increases could be due to the concentration effect as compost volume decreased with time accompanied by losses of the more volatile elements such as carbon and nitrogen under aerobic conditions. It has also been reported elsewhere that the principal metal forms in manure and manure-treated soils are soluble, exchangeable, adsorbed, organic-bound, oxide-bound, and precipitated (Miller et al., 1986; Canet et al., 1997). The available metals are considered easily utilizable by plants and soil microbes (Putruzelli et al., 1989). Eneji et al. (2001, 2003) reported that the major concern of soil pollution with available heavy metals by the use of manures can be minimized through com-

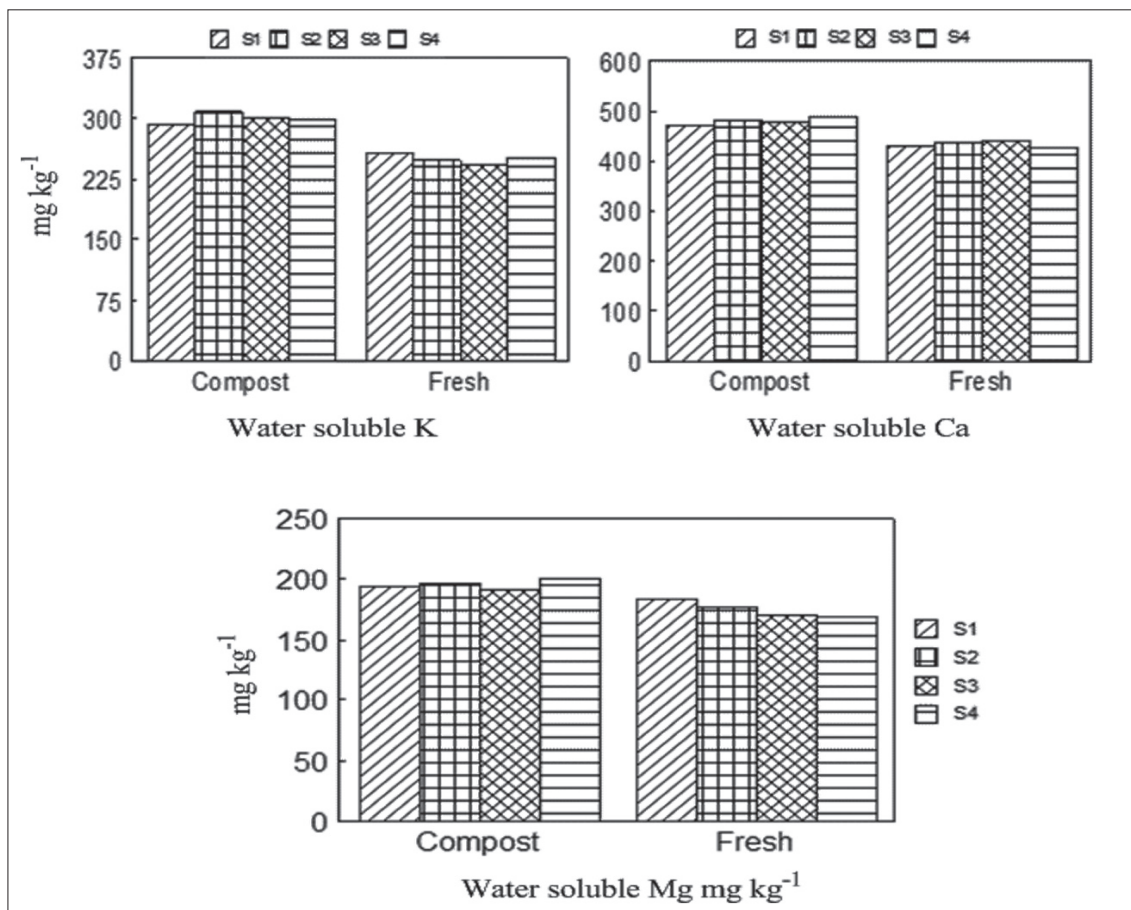


Fig. 2. Water soluble K, Ca and Mg in fresh and composted poultry manure



posting under aerobic conditions. Pare et al. (1999) reported decreases in the extractability of some heavy metals during composting of biosolids and municipal solid wastes, indicating a reduced risk of their entering the food chain through crops and water. According to Pare et al. (1999), proportionally greater increases in humic compounds during composting will cause more heavy metals to interact with sites of greater complexing strengths where they become less accessible and available to plants and extracting agents.

Phosphorus is the second most important component, after nitrogen, required for the plant growth. Phosphorus plays key role both as a structural element of biologically important compounds and as catalyst for several biological reactions. Therefore, it is quite necessary to determine the water extractable phosphorus (WEP) contents of manure. In this study, we have compared fresh and composted poultry litter for water extractable P (WEP), total P (TP) and other nutrient contents and the results show that the composted poultry litter is rich in WEP in compared to FPL. The WEP contents

of FPL and CPL are 833 mg kg<sup>-1</sup> and 889 mg kg<sup>-1</sup>, respectively (Table 1). This is quite contrary to the observations of Tworowski and co-workers 2002. They have compared WEP contents of poultry litters from two different regions; Delmarwa and Moorefield and it was shown that WEP contents in CPL were not significantly different from FPL after composting. There may be multiple explanations for this difference; WEP contents of FPL are non-volatile and therefore on composting the relative ratio of WEP increases. This implies that the phosphorus is present primarily in non-labile form such as non labile phospholipids or non degradable fulvic and humic acids. The measurement of water soluble-P in the manure is important because it include forms of P that can immediately be bio- available and thus have potential to contribute to the environmental contamination (Dou et al., 2000) concluded that the environmental risk of applying organic amendments depends on their total P content as well as forms of P (Sims et al., 2000). The results have important implication from environmental point of view because according to

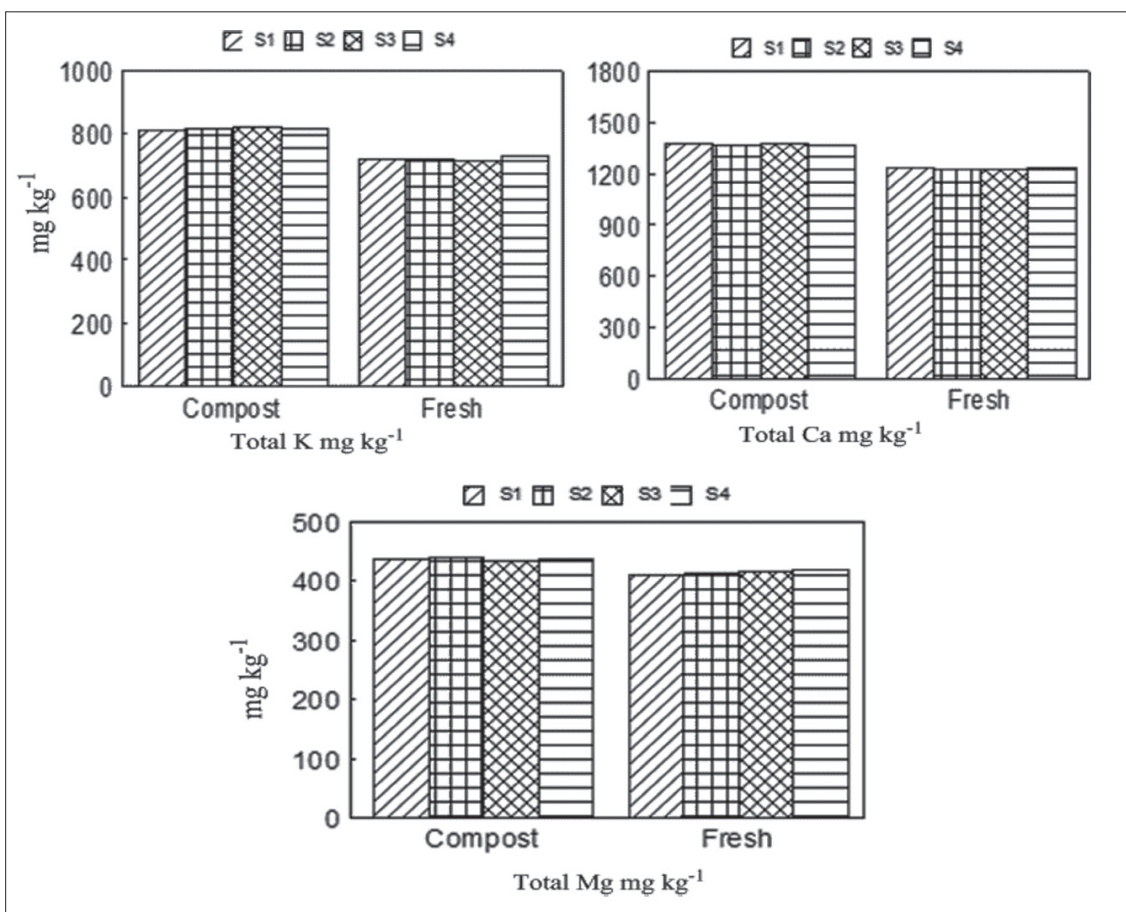


Fig. 3. Total K, Ca, mg kg<sup>-1</sup> in fresh and compost manure

Edwards and Daniel (1993), 80% to 90% of P in the run off water from poultry litter amended pasture was water soluble, most of which is readily available for algal uptake (Sonzogni et al., 1982).

Figure 1 shows total phosphorus in  $\text{g kg}^{-1}$ . The higher phosphorus was observed in compost as compared to fresh with (2.35 and  $2.24 \text{ g kg}^{-1}$ ). Phosphorus is an essential nutrient both as a part of several key plant structure compounds and as a catalysis in the conversion of numerous key biochemical reactions in plants. Phosphorus is noted especially for its role in capturing and converting the sun's energy into useful plant compounds. Significance differences were observed between fresh and compost amended soil. The pH was slightly higher for poultry fresh manure as compare to composted manure. pH of the poultry litter may also play an important role. pH of the FPL and CPL in our case are 7.75 and 7.8 respectively, which is considerably different than the pH of the samples from Tworkoski and co-worker (pH 6.0-7.0). The slightly higher pH values may stabilize the phosphorous in ionic form by making salt which will prevent volatilization of phosphates. The environmental impacts of the industrial waste of poultry have gained worldwide importance. Increasing interest in the recycling of waste has also raised concerns over the possible contamination of soil and water. The intensive use of chemical fertilizer inputs has aggravated the global environmental system since nutrients are usually subjected to different losses in the soils. The form in which fertilizer is applied may influence the nutrient dynamics in the soil plant system.

## Conclusions

Extractability of plant nutrients was found highly dependent upon the type of PL applied. Nutrient concentrations were higher in Composted litter as compared to fresh. Application of composted PL to the soils produced higher maize (*Zea mays*) biomass yield as compared to fresh PL chemical fertilizer and control. The concentrations of other nutrients were also higher in composted manure. The general increase in nutrient content and uptake of maize shoot in amended soils indicated that compost could result in a greater pool of plant available nutrients. Poultry compost litter exhibited less water soluble P fraction, which may reduce the risk of P transfer from soil to the surface water. The total P was higher in compost poultry litter than fresh poultry litter. For the sustainable soil fertility management, it is important to understand the impacts of poultry litter on the chemical forms of elements in soils. It is known that the fertility of soil is directly related to the level of organic matter. Research reports on the comparison of composted and fresh organic wastes on various crops are sufficient, but the nutrients release and their bio availabil-

ity to maize crop from composted poultry litter are scanty. Therefore, this investigation was aimed to compare the extractability and bio availability of plant nutrients to maize crop following composted poultry litter application.

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