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Effectiveness of poultry litter as fertilizer for rice cultivation: prospect of organic fertilizer in Bangladesh

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Abstract

Advances in knowledge and technology over recent decades favor the growth and intensification of poultry production in developing countries, simultaneously accumulation of large amount of wastes, especially manure and litter, generated by intensive production causes a major environmental problem. This study deals with the effectiveness of poultry litter as organic fertilizer for rice production. For that reason, the chemical characteristics viz Potassium (k), Total Nitrogen (N), Ammonium (NH4-N), Phosphorus (P) and the proficiency of broiler and layer poultry litter were determined. Five broiler poultry litter and five layer poultry litter samples were analyzed. The investigation shows that average concentration of Phosphorus (as P_2O_5) are 3.6%, 2.5%; Total N are 1.6% ,1.7% ; Ammonium (NH_4-N) are 0.4%,0.8% and Potassium (as K_2O) are 1.5% ,1.3% found in broiler and layer poultry litter respectively. Potassium (k), Total Nitrogen (N), Ammonium (NH_4-N) values are in standard level of organic fertilizer, but Phosphorus (P) values are exceeded the standard level of organic fertilizer. This study is believed to serve that poultry litter can be used as alternative of chemical fertilizer to enhance the rice production and effective strategy to manage the excessive poultry waste.

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Introduction

The poultry industry is one of the largest and fastest growing sectors of livestock production in the world with a 35% increase in meat and egg production in the period from 2000-2008 (FAO, 2010). Rearing of birds has grown from a side-line occupation into a commercial enterprise with single farms housing thousands of birds. The 2010 world annual census data, estimated the world flock to be over 18 billion birds with an estimated yearly output of 22 million tons of manure (FAO, 2010). As a result, poultry industry is producing increasing amounts of organic wastes, e.g. poultry litter (mixture of manure and bedding material), waste feed, dead birds, blood, broken eggs, and feathers (Kelleher *et al.,* 2002). This rapid expansion of the industry over the last several decades has increased the need to find economically viable and environmentally acceptable ways of utilizing such large quantities of waste.

Waste from the poultry industry includes a mixture of excreta (manure), bedding material or litter (e.g. wood shavings or straw), waste feed, dead birds, broken eggs and feathers removed from poultry houses. Other wastes include those from cage, conveyer belt and water flushing systems. The litter and manure component of this waste has a high nutritional value and is used as an organic fertilizer, thus recycling nutrients such as nitrogen, phosphorous and potassium. These components (poultry litter) have traditionally been land spread on soil as an amendment (Kelleher *et al.,* 2002).

Poultry litter is the most valuable of all manures produced by livestock. This is due to the high levels of nitrogen (4.0%), phosphorous (1.6%) and potassium (2.3%), in addition to lesser quantities of Ca, Mg, Mn, Cu, and Zn present in the litter. Close to 11 million tons of poultry litter is produced in United States annually (Gollehon *et al.,* 2001). Due to its excellent NPK (nitrogen:phosphorous:potassium) ratio (Nicholson *et al.,* 1996) and due to the high cost incurred in transporting low density poultry litter, this waste material has been traditionally used to fertilize the lands that are close (<10 miles) to the poultry production facilities. The use of poultry litter may be a way that rice farmers can improve productivity on poor ground. Growers are advised to have the content of the material tested to determine how much N, P, K and moisture are contained in the waste (Harrell *et al.,* 2012).

In Bangladesh, small and large-scale poultry farm are expanding rapidly, which are providing meat, eggs and employment. In the same time it is also produces large quantities of waste materials. There are 123 million chickens (FAO, 2002) and about 50,000 poultry farms (FFYP, 2003) are available in Bangladesh presently. However, from another census it was found that 12.89% poultry birds came from nonfarm source, 51.95% from small farms, 27.43% from medium farms and 7.73% from large farms (BBS, 2003). The waste products of these farms are polluting the environment, although a small portion of poultry waste come to the use of fish and crop production by farmers (Sarker *et al.,* 2009).

Bangladesh is an agricultural country, its economy and food production totally depends on rice cultivation. Every year numerous ton of fertilizer are used for rice production in order to meet increasing demand. At present organic matter content in the soil in Bangladesh is 0.5-1.5%.But required organic matter in soil >3%.So poultry litter can be easily used as organic matter to improve the soil condition. Apart this Poultry litter can be used as the alternative of chemical fertilizer. The aims of this study is to provide the effectiveness of poultry litter as fertilizer and reduce the chemical fertilizer as well as future prospect of organic fertilizer in the country.

Materials and methods

Sample collection

Poultry litter generally has a moisture content less than 30% and also includes a large percentage of bedding material. This material usually consists of sawdust but can also include wood chips or wood shavings. Manure and bedding materials are removed

together during the cleanout procedures of a poultry house. The wood fibers within the litter tend to become compacted over time adding to the difficulty in a collecting a representative samples. To avoid such difficulties raw poultry litter was collected from poultry house. Samples were collected from several reputed poultry firm who used standard feed for their birds. Standard process was maintained for the collection of sample.

Sample Analysis

Determination of Nitrogen

The available Nitrogen refers to the ammoniacal and nitrate forms of nitrogen. These forms are mainly formed by the mineralization of organic nitrogen. The ammoniacal and nitrate forms of nitrogen may be determined together as available nitrogen. Available nitrogen was extracted by 2M potassium chloride solution and nitrogen content of the extract was determined by Micro kjeldahl method as described by Jackson (1973)

Determination of Phosphorus content

Available Phosphorus was extracted with Bray-I reagent (Bray and Krutz,1945).The phosphorus content of the extract was determined by ascorbic acid blue color method (Murphy and Riley,1962).The intensity of blue color of each sample was determined using Chemita Visible Spectrophotometer(Model No:752) at 882 nm wavelengths.

Determination of Potassium content

Potassium content of the extract was determined by a flame photometer (Gallenkamp).The reading was compared with standard curves obtained from the known concentration of K^+

Results and discussion

Characteristics of Poultry Litter

As chicken raisers clean out their poultry houses the "litter" contains a combination of chicken manure, feathers, and natural bedding. This combination is moved into large piles where the high nitrogen level of the chicken manure quickly accelerates the composting process. The compost piles reach temperatures of up to 140 degrees which destroys pathogens and effectively sterilizes the material without destroying its nutritional content as a fertilizer. This compost has been used with great success in agriculture and has now found its way into the landscape industry and is now considered a premier organic lawn fertilizer.

A typical analysis was conducted of poultry litter from a survey of samples taken in 2012. Samples were collected for both broiler and layer poultry litter. Poultry litter is accumulated for several months and the litter materials base is sawdust, wood shavings also considered to collect the sample for testing. The test results for both the broiler and layer poultry manure are given in Table 1 and Table 2.

Table 1. Chemical characteristics of broiler poultry litter.

Parameters	Unit	Sample ID					Average	Percent (%)
		S-1	S-2	S-3	S-4	S-5		
Potassium (K)	Kg/t	14	16	17	15	13	15	1.5
Total Nitrogen (N)	Kg/t	15	18	14	17	16	16	1.6
Ammonium (NH_4-N)	Kg/t	5	4	3	3	5	4	0.4
Phosphorus (P)	Kg/t	34	42	35	38	31	36	3.6

Table 2. Chemical characteristics of layer poultry litter.

Parameters	Unit	Sample ID					Average	Percent (%)
		S-1	S-2	S-3	S-4	S-5		
Potassium (K)	Kg/t	13	15	11	16	10	13	1.3
Total Nitrogen (N)	Kg/t	18	15	19	16	17	17	1.7
Ammonium (NH_4-N)	Kg/t	8	7	9	10	6	8	0.8
Phosphorus (P)	Kg/t	27	25	24	26	23	25	2.5

Importance of litter as fertilizer

Manure is an excellent fertilizer containing nitrogen, phosphorus, potassium and other nutrients. The nutrient content of poultry litter varies quite a bit. Fertilizer value depends on the type of birds, age of the litter, and litter moisture content. It is always a good idea to take a sample and test the litter for nutrients prior to cleaning out a poultry house. Use the test results to calculate how much litter to apply to fields. Litter samples should be representative of the entire house or litter pile in the storage.

Phosphorus (P)

Recoverable P is the quantity of the nutrient available for land application or utilization for other purposes (Kellogg *et al*., 2000). It is estimated as the mass of nutrient per ton of manure remaining after nutrient losses during manure collection, transfer, storage and treatment (Barker and Zublena, 1995). The reuse of recoverable P from poultry litter can be of interest to farmers and the fertilizer industry because it would provide high quality P fertilizer. The quality of mined P is already a concern largely due to high levels of trace element impurities in the mined phosphate sources (Smil, 2000).

Amount of Phosphorus (P) in both broiler and layer poultry manure are graphically presented in Fig.1 and Fig. 2 respectively. In poultry manure Phosphorus is found as P_2O_5. From the two figures it can be said that Phosphorus content is higher in broiler poultry manure than the layer chicken manure.

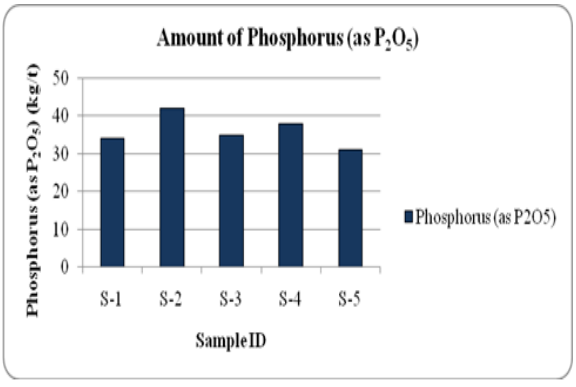

Fig. 1. Amount of Phosphorus (as P_2O_5) in Broiler Poultry Manure.

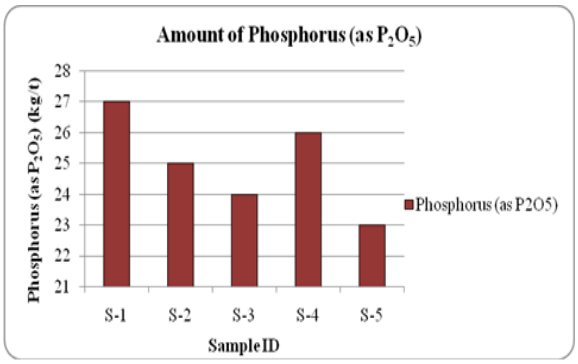

Fig. 2. Amount of Phosphorus (as P_2O_5) in Layer Poultry Manure.

According to Ministry of Agriculture, the standards of Phosphorus concentration in organic fertilizer must remain 0.50-1.50%. The average concentration of Phosphorus in broiler and layer chicken litter is 3.6% and 2.5% respectively. The content of Phosphorus is higher than the standard value so careful attention should be given before to apply in the field as organic fertilizer.

Nitrogen (N)

Nitrogen availability during the year of application varies greatly and ranges from about 30 to 80 percent. Nitrogen is present in both organic and inorganic forms. Organic Nitrogen must be converted (mineralized) into inorganic nitrogen to become available to plants. The amounts of organic N converted to plant-available forms during the first cropping year after application vary according to environmental conditions and manure handling systems. About 25% to 50% of the organic N becomes available during the year of application. All of the inorganic N, ammonium-N (NH_4-N) and nitrate-N (NO_3-N), is readily available to plants. However, if litter lays exposed on the soil surface, considerable NH_4-N may be released to the air as ammonia (NH_3) gas. Ammonium worked into the soil is subject to nitrification (rapid conversion to NO_3-N). Nitrate-N is readily available to plants, but if excess water is present, it can be lost through leaching or denitrification (conversion of NO_3-N to N_2 gas). Combining inorganic N and N available from organic

N, gives the total N available to crops. This is sometimes called plant available nitrogen, PAN.

Amount of total N in broiler poultry manure and layer poultry manure are presented in Fig. 3 and Fig. 4 respectively. From the figures it can be said that quantity of Nitrogen is comparatively higher in layer poultry manure than the broiler manure.

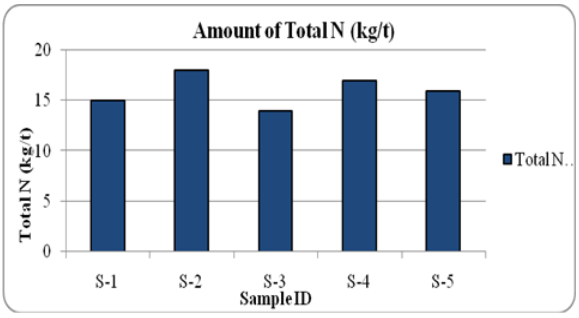

Fig.3. Amount of Total N (kg/t) in Broiler Poultry Manure.

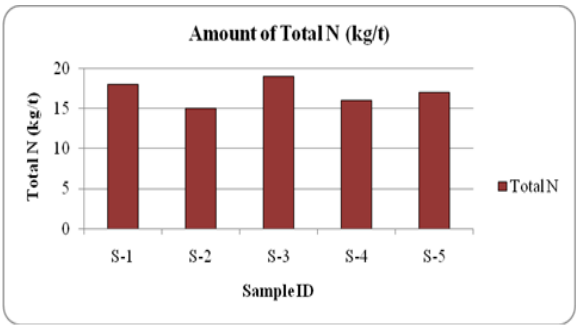

Fig. 4. Amount of Total N (kg/t) in Layer Poultry Manure.

The amount of Ammonium (NH_4-N) in layer poultry manure are presented in Fig. 5 and Fig. 6 respectively. From the figures it can be said that quantity of Nitrogen is comparatively higher in layer poultry manure than the broiler manure both as Ammonium (NH_4-N) consideration.

According to Ministry of Agriculture, the standards of Nitrogen concentration in organic fertilizer must remain 0.5-4.0 %. The average concentration of Total N in broiler and layer poultry litter is 1.6% and 1.7% respectively. The content of Ammonium (NH_4-N) in broiler and layer poultry litter is 0.4% and 0.8% respectively. The content of Nitrogen is within the standard value for the both type of manure

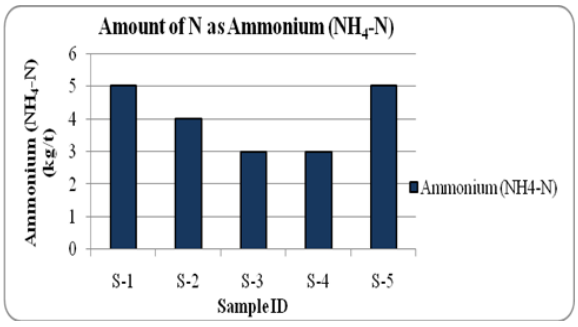

Fig. 5. Amount of N as Ammonium (NH_4-N) in Broiler Poultry Manure.

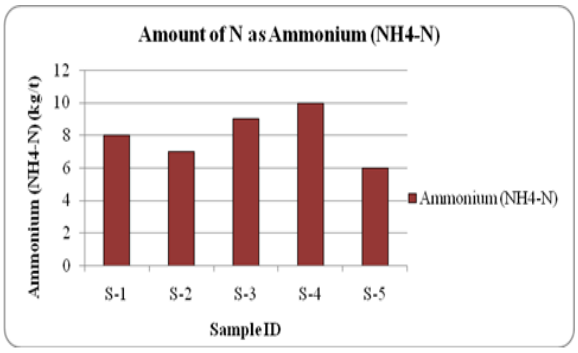

Fig.6. Amount of N as Ammonium (NH_4-N) in Layer Poultry Manure.

Potassium (K)

Potassium (K) is an essential nutrient for plant growth. Because large amounts are absorbed from the root zone in the production of most agronomic crops, it is classified as a macronutrient. The exact function of K in plant growth has not been clearly defined. Potassium is associated with movement of water, nutrients, and carbohydrates in plant tissue. If K is deficient or not supplied in adequate amounts, growth is stunted and yields are reduced (Olson *et al.,* 1987).

Amount of Potassium (K) in both broiler and layer poultry manure are statistically presented in Fig. 7 and Fig. 8 respectively. In poultry manure Potassium (K) is found as K_2O. From the two figures it can be said that Potassium content is higher in broiler poultry manure than the layer chicken manure.

According to Ministry of Agriculture, the standards of Potassium concentration in organic fertilizer must remain 1.0-3.0 %. The average concentration of Potassium in broiler and layer poultry litter are 1.5% and 1.3% respectively. The content of potassium is within the standard value for the both type of manure and it will be a good raw material for organic fertilizer.

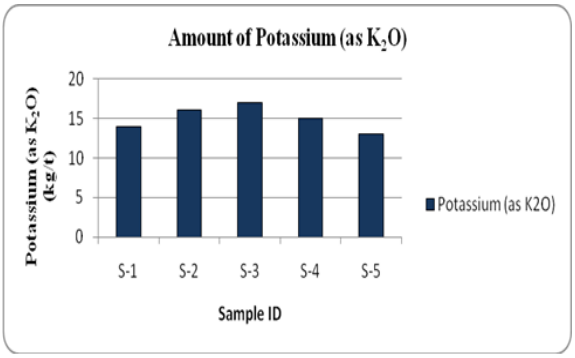

Fig. 7. Amount of Potassium (as K_2O) in Broiler Poultry Manure.

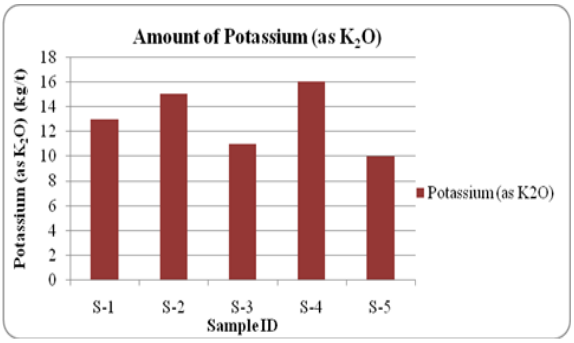

Fig. 8. Amount of Potassium (as K_2O) in Layer Poultry Manure.

Poultry Litter in Rice Production

Poultry litter contains multiple organic and inorganic forms of N. Rice takes up the inorganic forms of N including NH_4^+ and NO_3^- during the growth and development of the crop. Initially, the inorganic N content is only 10 percent or less of the total N content in the litter. Some of the inorganic N is mineralized during the first year and made available for uptake by rice. However, once the rice crop is flooded and the soil converts to an anaerobic (without oxygen) condition, NO_3-N quickly is lost because of denitrification and will no longer be available for uptake by rice. This is one of the reasons that N-use efficiency of poultry litter by rice is less compared to that of upland crops.

Research has shown the pre-flood urea-N equivalence for rice ranges from 25 to 41 percent of the N content of the poultry litter. Therefore, a conservative estimate is that 25 percent of the N contained in the poultry litter will count towards the normal recommended preflood N rate for a particular rice cultivar, and the rate of applied urea should be reduced to represent the litter N contribution. These estimates were developed from poultry litter applied the same day that rice was drill-seeded. Application of litter several weeks before planting may further reduce N availability for drill seeded rice (Harrell *et al,* 2012).

Research has not evaluated the urea-N equivalence of litter in water-seeded systems. The urea equivalence of litter in a water-seeded system, however, is expected to be slightly greater than a drill-seeded, delayed flood production system because the litter would be in a saturated anaerobic condition at an earlier point in the season, which would limit the nitrification and subsequent denitrification of mineralized NH_4-N.

Total P_2O_5 and K_2O concentrations of litter are often very close in concentration to that of total N. Like N, the total P and K found in litter are made up of both organic and inorganic forms. The alternating flooding and draining (flushing) associated with early-season, drill-seeded rice management and the establishment of the permanent flood tends to accelerate the mineralization of organic bound nutrients into inorganic, plant available forms. Research comparing the rice uptake efficiency of P and K between inorganic fertilizers and poultry litter when applied at equal concentrations of P_2O_5 and K_2O has shown that the P and K applied from poultry litter is an equivalent source of these nutrients. Therefore, 100 percent of the P and K found in poultry litter can be applied towards the needs of the rice crop during the

first year for a drill-seeded, delayed flood rice production system (Harrell *et al.,* 2012).

The P needs of rice are less than the N needs. It is estimated that a 7,000 lb/A (43 barrels) rice yield will remove approximately 112, 60 and 168 lb of N, P_2O_5 and K_2O from the soil, respectively. If poultry litter is applied based on the N needs of rice, an over-application of P will occur. The surplus P will build up soil test P to excessive levels with repeated applications over several years and has the potential to cause environmental problems. This excess P can be lost through run-off from fields that can contribute to eutrophication of nearby surface waters. This is a problem often seen in pastures grown for forage in areas near poultry facilities where poultry litter has been used repeatedly in this fashion. Therefore, it is important that poultry litter only be applied based on the P needs of the rice crop as indicated from a current soil test (Harrell *et al.,* 2012).

Conclusion

Poultry litter is a good organic source of nutrients for raising crops, such as rice. Poultry manure can be efficiently used for the crops after composting the same to save the nutrients. However, the loss of N through ammonia volatilization is a major issue during handling and land application of poultry litter. These losses can be minimized through proper composting process in the presence of organic amendments, such as cereal straw.

Now a day, the poultry of Bangladesh is producing a large quantity of litter, which needs special attention for the environment safety. The concern department can take initiative to motivate the producers, especially the small farm holders for disposing the litters in proper way or to aware them about its feed value. Poultry manure may be taken as a base for fertilizer recommendation at least in places of higher availability. Poultry litter can be a fruitful alternative of others chemical fertilizers and can enhance the overall rice production to accomplish the future food safety of Bangladesh.

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