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Prospects and Potential of Poultry Manure

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Abstract: Utilization of poultry litter has been a common practice in India since long time as manure. Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In deep litter manure, the litter absorbs moisture and helps keep the manure friable. In recent years, the problem of poultry waste utilization in concentrated areas has been augmented by confined feeding operations as much of the manure produced now contains no litter. Litter is not used when birds are reared in cages. The nutritional value of fresh poultry manure deteriorates rapidly. Hence, the immediate processing of poultry manure to prevent its rapid decomposition and save its nutrient properties is, thus essential. In addition, increased public consciousness of environmental pollution has challenged the animal and agricultural scientists to expand and to improve the disposal system, recycling the waste nutrients effectively, wherever feasible. Now-a-days composting poultry manure has been shown to be useful in providing a stable end product without much loss to the nutrients *per se*. In this context, the characteristics, types of poultry manure, the effect of poultry manure on soil properties, yield and quality of crops, nutrient availability, residual effects and the method of composting and its effect on crops are reviewed in this study.

Key words: Poultry manure, nutrients, composting, soil properties, yield, quality

INTRODUCTION

Poultry population is raising every year leaving large amount of poultry refuse. The poultry population in India is 489 million and the manure availability is estimated to be 12.1 million tonnes (Livestock Census, 2003). The poultry population is not spread throughout, but is concentrated in some pockets only. Normally, the manure is stored in most of the farms before disposal, at least for a period of one month and this leads to loss of nearly 40% N which reduces the value of the manure.

There are different types of poultry manure such as deep litter manure, broiler manure, cage manure and high rise manure. Nutrient values of poultry manure vary considerably depending upon the conditions under which it is processed. The ratio of litter to manure and the moisture content causes considerable variation among manures from different houses. Poultry manure contains about 3-5% nitrogen, 1.5-3.5% phosphorous and 1.5-3.0% potassium and micro-nutrients at considerable amount.

Land application of poultry manure for crops has been the traditionally and still the most important use. But, modern methods of rearing poultry have complicated the problem. Much of the manure now produced contains no litter. Litter is not used when birds are used in cages or slots. When poultry litter is used it absorbs moisture and helps keep the manure friable so a large surface area is exposed to the air. Manure free litter on the other hand contains 60-70% moisture making the process of application difficult. At the same time, if stored to reduce the moisture content, nutrient losses occur and handling cost increases. Another problem peculiar to this manure is that N is too quickly available so that, if care is not taken in applying it, burning occurs.

Characteristics of poultry manure: Poultry manure contains all the essential plant nutrients that are used by plants. These include nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe) and molybdenum (Mo). The amounts of these nutrients can vary depending upon many factors including the age and diet of the flock, as well as the moisture content and age of the manure.

Poultry manure contains nutrient elements that can support crop production and enhance the physical and chemical properties of the soil. It increases the moisture holding capacity of the soil and improves lateral water movement, thus improving irrigation efficiency and decreasing the general droughtiness of sandy soils. Poultry manure application improves soil retention and uptake of plant nutrients. It increases the number and

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diversity of soil microorganisms, particularly in sandy conditions. This effect enhances crop health by increasing water and nutrient availability, as well as suppressing harmful levels of plant parasitic nematodes, fungi and bacteria.

Types of poultry manure: There are different types of poultry manure such as deep litter manure, broiler manure, cage manure and high rise manure.

Deep litter poultry manure: This refers to the manure produced by layers during the laying period. Deep litter for laying hens usually consists of peanut hulls, rice husk or wood shavings in a layer of 10-15 cm deep. During production, the accumulating manure gets mixed with the litter. When excreta are added, the litter becomes moist but remains aerobic. Aerobic fermentation occurs with the production of heat and loss of CO_2 and ammonia (Simpson, 1986).

In this system, the poultry birds are kept in large pens up to 250 birds each, on floor covered with litters like straw, saw dust or leaves up to depth of 8-12 inches. Deep litter is the accumulation of the material used for litter with poultry manure until it reaches a depth of 8 to 12 inches. Suitable dry organic materials like saw dust, leaves, dry grasses, groundnut shells, broken up maize stalks and cobs, bark of trees in sufficient quantity to give a depth of about 6 inches in the pen should be used. The droppings of the birds gradually combine with the materials used to build up the litter.

Broiler house manure: This manure is similar to deep litter poultry manure but the litter is changed more frequently and there is less ammonia loss because of restricted decomposition. This results in manure richer in N than deep litter manure.

Cage manure: This manure contains 60-70% moisture since it is not mixed with litter materials. Litter is not used when birds are used in cages or slots. Enormous loss of ammonia occurs in this manure if it is not used the earliest Two types of poultry cages viz., pyramid and stack type cages are in use. These are available in different standard sizes to meet the specific poultry producer's needs. The pyramid-style layer cages come in 2, 3, 4 or 5 tier models, each model with a choice of automation features. These include: automated feed delivery, automated egg-gathering and automated manure removal. In the laying systems, each cage contains 1-25 birds and is suspended above a pit (Overcash *et al*., 1983).

Deep pit or high-rise manure: The deep pit solid manure system, or high-rise building, has a concrete floor and masonry or concrete side walls and is typically constructed 2-6 feet below the ground. Pens or cages are then built on slotted flooring 8 feet or more above the pit floor. Because the pit is often built below ground level, care must be taken to insure that surface and ground water are not contaminated. Foundation drains and external grading to direct surface water away help to keep manure dry, so that natural composting might occur. High rates of air movement from mechanical fans located in the pit help to keep the manure relatively dry. A benefit of the deep pit system is that manure can be stored for several months before removal.

Nutrient content in poultry manure: The chemical composition of poultry manure vary because of several factors such as source of manure, feed of animals, age and condition of animals, storage and handling of manure and litter used (Mariakulandai and Manickam, 1975).

Nutrient values of poultry manure vary considerably depending upon the conditions under which it is processed. The ratio of litter to manure and the moisture content causes considerable variation among manures from different houses. In fresh poultry excreta, uric acid or urate is the most abundant nitrogen compound (40-70% of total N) while, urea and ammonium are present in small quantities. The nutrient content of different types of poultry manure is furnished in Table 1.

Prospects for utilization: For quick disposal to avoid loss of nutrients and to avoid environmental pollution, the manure can be utilized in the following ways.

Land application to crops as manure, activator for button mushroom production, generation of energy (bio gas, electricity) feed for fish and feedstuff for livestock. But, land application of poultry manure for crops has been the traditionally and still the most important use.

Problems in usage: Many problems such as ammonia emission, nitrate pollution, surface water contamination, underground water contamination, fly attraction and breeding, public nuisance and nutrient loss are encountered while handling, storage and direct application of poultry manure.

Table 1: Nutrient content of different types of poultry manure

Particulars	Deep litter	Broiler house	Cage manure
C/N ratio	9.5-11.5	9.4-11.2	5.8-7.6
Total N (%)	1.70-2.20	2.40-3.60	3.63-5.30
Total P_2O_5 (%)	1.41-1.81	1.56-2.80	1.54-2.90
Total K_2O (%)	0.93-1.30	1.40-2.31	2.5-2.90
Fe (ppm)	930-1380	970-1370	970-1450
Zn (ppm)	90-308	160-315	290-460
Cu (ppm)	24-42	27-47	80-172
Mn (ppm)	210-380	190-350	370-590
Ca (%)	0.90-1.10	0.86-1.11	0.80-1.02
Mg (%)	0.45-0.68	0.42-0.65	0.40-0.56

Amanullah *et al*. (2007a)

Limitations on the use: Fresh poultry manure is difficult to handle because of its high water content and cannot be applied to crops due to caustic effects on foliage. The nitrogen availability is too quick that, if care is not taken, burning occurs. Nutrient losses occur and handling cost increases, if poultry manure is stored. Hence, immediate processing of poultry manure is suggested to prevent rapid decomposition.

Problems during storage: During storage of the poultry manure, it poses lot problems such as ammonia emission, nitrate pollution, surface water contamination, underground water contamination, fly attraction and breeding, public nuisance and nutrient.

Ammonia emission: Ammonia (NH_3^-) is a gas and can be readily lost to the air by volatilization. Volatilization is a process that is similar to evaporation. Volatilization losses can occur from the surface of manure whenever it is exposed to air. Ammonia-N can be lost from litter while it is in the house, while it is in storage

Flies: House flies will lay eggs and can complete their larval development on manure with a moisture concentration of 40-70% (Fatchurochim *et al*., 1989). Similar moisture requirements have been shown for *Fannia* flies (Mullens *et al*., 2002), which are often a greater nuisance near poultry operations than are house flies.

Water pollution: The high solubility of poultry manure in water provides a strong possibility for the occurrence of water pollution. The storage of excessive amounts of poultry manure can result in the leaching of nutrients especially nitrate through the soil and into the local surface and groundwater.

Manure gases: The decomposition of the poultry manure can take place in one of two ways. If oxygen is present then the decomposition is said to be aerobic. The aerobic decomposition of poultry manure is basically an odourless process which produces stabilized organic matter, some carbon dioxide and water. On the other hand, in manure practices involving anaerobic decomposition which is typical of liquid manure handling systems the process is characterized by obnoxious odours and the production of considerable amounts of gases which are hazardous to both man and livestock. The gases are carbon dioxide, ammonia, hydrogen sulphide, methane and carbon monoxide.

Loss of nutrients: Poultry manure is difficult to handle because of high water content and semi solid in nature. The fresh poultry manure contains 60-70% moisture.

During storage, considerable N is lost. Deep litter with 22% moisture, when stored in open air, rapidly loses its N due to high proteolytic activity. In litter of meat poultry, losses up to 30% are found. Immediate processing is essential to prevent the decomposition.

Loss of nutrients after application: Poultry manure is one of the richest sources of N. The N availability from the manure is subject to volatilization, denitrification, immobilization, mineralization, leaching and plant uptake (Bremner, 1965).

Shortly following application, conditions generally favour volatilization of the ammoniacal-N. Wolf *et al*. (1988) found that 37% of the total-N in surface applied poultry manure was volatilized in 11 days. Immobilization is responsible for reducing inorganic N shortly (1-2 weeks) following application of poultry waste. Mineralisation occurs quite rapidly following application of poultry waste. Bitzer and Sims (1988) found that approximately 69% of organic N in poultry litter incorporated into a sandy loam soil was mineralized in 140 days.

Volatilization loss: A portion of the nitrogen in poultry manure is in the ammonium (NH_4^+) form. Ammonium (NH_4^+) and ammonia (NH_3^-) can interchange rapidly depending on the pH. Ammonium will convert to ammonia at a pH greater than 6.5. Increasing the pH (more alkaline or less acid) increases the amount of ammonia and decreases the amount of ammonium. Most manure has a pH close to 7.0.

Ammonia volatilization occurs because ammonia-N in manure or solution is converted to dissolve ammonia gas, by the reaction:

$$NH_4^+\text{-N} \leftrightarrow NH_3 \text{ gas} + H^+$$

The reaction produces more NH_3 gas as the pH or temperature increases and as the NH_3-N concentration increase. The rate of ammonia release to the atmosphere is a function of the difference in NH_3 gas concentration in the manure and air.

Although NH_4-N and NH_3-N both exist in manure and soil they have extremely different properties. Ammonium (NH_4^+) is a charged molecule dissolved in the soil water and can be readily used by plants. Ammonia (NH_3^-) is a gas and is not significantly taken up by plants.

Ammonia (NH_3^-) is a gas and can be readily lost to the air by volatilization. Volatilization is a process that is similar to evaporation. Volatilization losses can occur from the surface of manure whenever it is exposed to air. Ammonia-N can be lost from litter while it is in the house, while it is in storage and after land application. The nutrient content of manure is typically measured using a representative sample of the form of manure that is to be land applied.

The amount of ammonium nitrogen that is lost from poultry manure depends on the method of land application. If manure is spread on the ground without being mixed into the soil by tillage operation (called incorporation), then a large portion of the ammonia nitrogen can be lost to the atmosphere. Ten to fifteen percent of the NH_4-N is lost from surface applied manure each day if rain does not fall on the field. Shortly following application, conditions generally favour volatilization of the ammoniacal-N. Wolf *et al*. (1988) found that 37% of the total-N in surface applied poultry manure was volatilized in 11 days. Volatilization losses may significantly reduce the amount of N available for plant uptake.

A significant rain (0.25 inches or more) will carry most of the ammonium nitrogen into the soil. All of the NH_4^+ can be converted to ammonia and can be lost if it does not rain for several weeks. Incorporation of manure on the same day it is applied can reduce the volatilization losses to 5 to 30%. Incorporation of manure conserves valuable nitrogen and increases the precision of using manure as a fertilizer.

Denitrification: Denitrification is the process of conversion of nitrate to nitrogen. *Pseudomonas bacillus* aids in denitrification process. If the nitrate form of N is not utilized by the plants, the unassimiable nitrogen is denitrified and lost.

Immobilization: Immobilization is responsible for reducing inorganic N shortly (1-2 weeks) following application of poultry waste (Chescheir *et al*., 1986). Undigested feed and the manure bedding materials have been identified as immobilizing agents.

Mineralization: Organic nitrogen (organic-N) is the most abundant form of nitrogen in animal manure with high solids content (10% total solids or more). Organic-N is not available to plants until it has been decomposed by microbes to ammonium-N. The process of converting organic nitrogen to ammonium-N is called mineralization. Conversion of organic-N to ammonium-N does not occur immediately and not all of the organic-N is mineralized. Sometimes animal manure with high solids content is referred to as a slow-release N source because the organic-N is made available over time and not all at once. How fast and how completely this occurs depends on a number of factors including: soil temperature, soil moisture, soil pH, type of manure and the extent of incorporation.

The C: N ratio is lower in fresh poultry manure, which probably contributes to higher mineralization rates with fresh poultry manure. C: N ratio of 9:1 in fresh poultry manure support the mineralization rate of 56%. As the C: N ratio of composted poultry manure is high 16:1; N mineralization rate are generally less than 24%. Mineralization occurs quite rapidly following application of poultry waste. Bitzer and Sims (1988) found that approximately 69% of organic N in poultry litter incorporated into a sandy loam soil was mineralized in 140 days. Composting yields a more predictable and reliable source of mineralizable N than fresh manure.

Leaching: Poultry manure contains nitrogen in the form of ammonium which typically is converted in the soil to Nitrate-N (NO_3-) which can be easily leached from soil. Nitrogen in the nitrate form is water soluble and leaches readily. Applying litter to growing crops helps prevent leaching.

Processing poultry manure: Before field application immediate processing of poultry manure is needed to prevent rapid decomposition and loss of nutrients (Muller, 1984). Overcash *et al*. (1983) pointed out that there were several commonly practised methods of storing poultry manure, each of which could affect the quality of the manure at the time of application.

Several researchers (McNeill *et al*., 1980; Kroodsma, 1985) have investigated drying to improve the physical characteristics of the poultry manure. Although, drying improves the physical characteristics of the manure while achieving acceptable N conservation, it is limited by cost and mechanical considerations (Flegal, 1988). Similar work has been conducted regarding centrifugation (Ross *et al*., 1971), vacuum filtration (Cassell *et al*., 1966) and electro-osmosis (Cross, 1966). The reports indicated that all these methods have proven successful, but the economic feasibility has not been conclusively established.

There are several ways in which poultry manure can be collected and processed. Several factor such as operation size, climate, animal type etc. will determine what type of system is used in what kind of circumstances. It should be noted that in many instances, the strongest influence on which system is used is the economics (costs) of the system. Each system has its own merits and costs, but careful consideration must be used in order to select a system which will make the most efficient use of the factors in which it will be operated.

Composting: Composting is a controlled natural process in which beneficial microorganisms (bacteria and fungi) reduce and transform organic waste into a useful end product called compost (Sander *et al*., 2002). These include both anaerobic processing of poultry manure and aerobic processing of poultry manure.

Composting poultry manure: The C: N ratio of poultry manure is very less, 7.9 as reported by Kirchman and Witter (1992) and as per Nodar *et al*. (1992) the C/N ratio was 9.7 (for poultry slurry) and 6.3 as per Nicholson *et al*. (1996) for stilt house manure. Composting, or the controlled biological decomposition of organic waste, has been investigated as a method of stabilizing poultry litter and manure prior to land application. This process produced a material with several advantages with respect to handling by reducing volume, mass of dry matter, odours, fly attraction and breeding and weed seed viability (Sweeten, 1980). The heat generated during composting may also destroy pathogens (Golueke, 1977).

Conservation of nitrogen was also better under anaerobic storage conditions (Kirchmann, 1985). Kirchmann and Witter (1989) reported that low losses of N occurred under anaerobic conditions but it was higher under aerobic conditions. Composting poultry manure and poultry carcasses, with straw as carbon source successfully decomposed the manure and carcasses and produced a stable organic material physically and chemically similar to the manure used in the composting process (Sims *et al*., 1992).

Kirchmann and Witter (1992) reported that the C:N ratio of anaerobically decomposed poultry manure was 17.9 as against 11.7 in aerobically decomposed poultry manure. Sims *et al*. (1992) found that the C:N ratio of poultry compost was 18.3.

An incubation study conducted by Amanullah (2007a) to examine the changes in availability of N in soil applied with poultry manure either singly or in combination with FYM revealed that the nitrogen mineralization rates of manure varied widely from 19% to 56% in 105 days. The N mineralization rate was rapid up to 30 days and thereafter slowed down even though continued up to 105 days. Fresh poultry manure had higher mineralization rates followed by fresh poultry manure applied in conjunction with FYM. Fresh poultry manure had higher mineralization rates than composted manure (Hartz *et al*., 2000). Fresh manure probably contained recently formed organic N that was less stable than N previously incorporated into the organic fraction which is often found in composted manure (Preusch *et al*., 2002).

The C: N ratio was lower in fresh poultry manure, which probably contributed to higher mineralization rates with fresh poultry manure. C: N ratio of 9:1 in fresh poultry manure supported the mineralization rate of 56%. As the C: N ratio of composted poultry manure was high 16:1; N mineralization rate was generally less than 24%. Composting yielded a more predictable and reliable source of mineralizable N than fresh manure.

Aerobic method of composting: Aerobic method of composting of poultry droppings is done by adding straw and *Pleurotus sajar caju*. Poultry manure and straw of about 2 cm is mixed in the ratio of 1:1.5 and plerotus can be inoculated at the rate of 5 packets tonne^{-1}. The composting material is heaped under the shade. Sufficient quantity of water is sprinkled in order to maintain the moisture content of about 50-60%. Periodical watering is done once in 15 days. In order to maintain aerobic condition turning is done on 21st and 35th and 42nd day. The compost is ready on 60th day.

Anaerobic composting: Composting of poultry manure can be initiated using poultry manure and chopped sorghum straw. Poultry manure is mixed with bits of sorghum straw at the rate of 10:1 and packed in dug pits of size 1 m^3 (1×1×1 m) and closed with mud plaster. To maintain optimum moisture, water is sprinkled before it is being packed and left under anaerobic conditions for 75 days as suggested by Sims *et al*. (1992).

Composting of dead birds: Dead birds constitute an appreciable proportion of the wastes generated in commercial poultry farms and the proper disposal of the same represents a considerable practical problem for producers. Burial, incineration and anaerobic digestion in closed pits are the common methods employed at present for the disposal of dead birds but it is very costly. Anaerobic digestion pits creates problem of obnoxious odour if not maintained properly and it will not ensure bio safety also (Blake, 2004). An alternative to all the above methods composting mixed with poultry manure and straw which is feasible (Sims *et al*., 1992).

Aerobic composting is done in mini composter specially designed with a specification of 1.2 m length x 1.2 m width x 1.2 m height as suggested by Kumar *et al*. (2007). The floor of the compost bin is made up of concrete slabs and the side walls of the compost bins are made up of wooden planks of 10 cm wide and 2.5 cm thick. An air space (2.5 cm) is provided between wooden planks for the purpose of aeration to compost piles. These bins are arranged under roofed shed to protect the bins from entry of rainwater.

Farm yard manure is utilized as manure substrate. Dead birds are collected from the commercial farms. Paddy straw (*Oryza sativa*) and sorghum hay (*Sorghum bicolor*) are used as added carbon source. After analyzing the chemical composition of ingredients, the C: N ratio of the compost recipe is adjusted to 20:1 by addition of carbonaceous materials. The moisture content is kept as 60% by sprinkling sufficient water over the compost materials.

The compost bins are filled as per recommendation of Donald *et al.* (1996) by sequential layering of carcass, manure substrate and carbon source with addition of moisture. The compost bins are opened when the bin temperature is below 40°C (primary stage) and the content is mixed thoroughly, remoistened and aerated and filled again for secondary stage heating. When the second heating cycle is completed, the compost materials are moved to a storage yard.

A study of an aerobic composting experiment revealed that total nitrogen content was significantly higher in composting of dead birds+FYM+straw (13. 8 g kg^{-1}) and followed by dead birds 3+FYM+ sorghum hay (12.8 g kg^{-1}) than control Composting of FYM alone (9.97 g kg^{-1}) (Sivakumar *et al*., 2007).

Effect of composting poultry manure: An incubation experiment carried out under aerobic and anaerobic conditions to study the chemical changes during composting of poultry manure blended with sorghum straw for duration of 75 days by Amanullah (2007b) revealed that composting of poultry manure blended with sorghum straw reduced the nitrogen loss as a consequence of widening the C: N ratio to a desirable level (18:1). This process led to retain larger amounts of N under aerobic decomposition. The loss in N reduced in the decomposition was 41.3 and 24.4%, respectively, in aerobic and anaerobic methods of composting.

The composting of poultry manure blended with straw would enable to enhance the N, P and carbon status of the manure and thus improving its quality. Further, the desirable level of C: N ratio was achieved in 60 days under aerobic conditions while the anaerobic method of it was slower and took 75 days to reach the C: N ratio at a desirable level of 18. The study suggested that incubating the poultry manure with straw under aerobic condition is beneficial to improve the quality of the manure.

Effect of application on soil physical properties: Poultry manure application improves the physical properties of the soil. It significantly decreases bulk density and increases total porosity, infiltration capacity and water holding capacity.

Poultry manure application at 10 t ha^{-1} was observed to improve the physical properties of soil (Ravikumar and Krishnamoorthy, 1975). Soil physical properties such as bulk density, water holding capacity and percent water stable aggregation were noted to be favouarbly influenced by poultry waste addition to soil (Weil and Kroontje, 1979). Mbagwu (1992) reported that poultry manure significantly decreased bulk density and increased total and macroporosity, infiltration capacity and available water capacity. Mullens *et al.* (2002) revealed that poultry litter contains a considerable amount of organic matter due to the manure and the bedding material. Litter can also have an impact on soil pH and liming due to varying amounts of calcium carbonate in poultry feed. Poultry manure improved soil physical properties significantly by reducing soil bulk density and temperature and increasing total porosity and moisture content in Nigeria (Agbede *et al*., 2008).

Effect on nutrient availability: Land applied poultry litter supplies nutrients necessary for crop growth, the most prevalent being nitrogen (Sims, 1987; Bitzer and Sims, 1988). Adding single super phosphate and poultry manure together to soil resulted in higher P availability. Application of poultry manure decreased the adsorption capacity and increased the soluble P and phosphorus desorption (Reddy *et al*., 1980).

Increase in available N was noticed when poultry manure; swine manure and FYM were applied to the soil (Rayar, 1984). Sims (1987) reported that corn grain and stover removed 16% of N per year from the slowly mineralized fraction of broiler litter, which left considerable part of soil N. The combination of nitrogen from different organic manures was comparable on equivalent N basis in which poultry manure proved to be a better source (Ketkar, 1993).

Ravikumar and Krishnamoorthy (1983) reported that application of poultry manure increased the available P content of the soil. More and Ghonsikar (1988) reported that the availability of P increased when super phosphate was mixed with poultry manure and applied to soil than application of super phosphate alone. Sharma and Saxena (1990) confirmed that poultry manure followed by castor cake and FYM were found to increase the P availability in soil and nutrient uptake in maize. A marked increase in the exchangeable K due to application of poultry manure upto 24th day after incubation was observed in an incubation study by Madhumita Das *et al.* (1991a).

Table 2: Nutrient status of the soil applied with poultry manure

	Organic matter (%)		N (%)		P (mg kg^{-1})		K (c mol kg^{-1})	
Treatment	2005	2006	2005	2006	2005	2006	2005	2006
No manure	1.35	1.31	0.11	0.11	10.2	9.6	0.45	0.39
Poultry manure	1.88	2.09	0.29	0.43	14.4	16.4	0.77	1.12
LSD (0.05)	0.08	0.06	0.01	0.02	0.25	0.24	0.01	0.04

Agbede *et al.* (2008)

Poultry manure increased soil nutrient status as indicated by increases in soil OM, N, available P, exchangeable K, Ca and Mg (Table 2). The overall mean values of soil OM for 2005 and 2006 were 1.88 and 2.09% respectively, the N values were 0.29 and 0.43%, available p-values were 14.4 and 16.4 mg kg^{-1} and exchangeable K values were 0.77 and 1.20 cmol kg^{-1}.

Effect on nutrient uptake: Iyengar *et al.* (1984) reported that poultry manure resulted in significantly higher build up of P concentration in leaf sample of banana five months after planting. Prasad *et al.* (1984) reported that addition of poultry manure alone or in combination with N, P, K, Zn and Fe increased the uptake of Zn and Fe by wheat and rice. More and Ghonsikar (1988) reported that the P content in wheat was significantly higher due to the application of poultry manure with super phosphate. Faiyard *et al.* (1991) recorded an increase in N, P, K, Fe, Mn and Cu contents in faba beans due to the application of poultry manure in comparison with FYM.

An experiment conducted by Amanullah *et al.* (2007b) indicated that application of organic manure registered higher uptake of NPK than control. The study revealed that uptake of nutrient was higher with Composted Poultry Manure (CPM). The added organic manure not only acted as a source of nutrient might have influenced their availability. Highest uptake of nutrients due to application of composted poultry manure either alone or with FYM might be due to increased availability of nutrients (Table 3).

Application of poultry manure+ FYM was found to increase the availability in soil and subsequently the nutrient uptake in maize (Sharma and Saxena, 1990). Similarly Iyengar *et al.* (1984) reported higher build up of P concentration in leaf sample of banana due to application of poultry manure.

Effect on yield of crops: Poultry manure and FYM recorded higher yields of rice and ragi when combined with inorganic fertilizers (Ravikumar and Krishnamoorthy, 1983). Highest grain yield of rice was recorded with the application of poultry manure by Prasad *et al.* (1984). Increase in the yield of wheat due to application of poultry manure along with super phosphate was obtained by More and Ghonsikar (1988).

Table 3: Influence of poultry manure on the nutrient uptake in cassava

	Uptake (kg ha^{-1})					
	2001			2002		
Treatment	N	P	K	N	P	K
Control	136.0	17.66	131.9	120.6	15.14	22.03
FYM (25 t ha^{-1})	198.7	24.75	188.8	193.4	23.15	32.35
PM (10 t ha^{-1})	199.2	24.84	191.0	195.4	23.72	32.48
CPM (10 t ha^{-1})	224.2	28.48	220.6	221.6	27.07	35.44
FYM (12.5 t ha^{-1}) +PM (5 t ha^{-1})	207.0	25.92	202.5	203.4	24.67	34.10
FYM (12.5 t ha^{-1}) +CPM (5 t ha^{-1})	213.0	26.91	210.3	209.1	25.31	34.92
CD (0.05)	5.5	0.68	5.0	5.4	0.63	5.1

Amanullah *et al.* (2007b)

Higher grain yields of rice by incorporation of farm wastes and green manures, with the highest yield by poultry manure was obtained under lowland conditions by Budhar *et al.* (1991) indicating the superiority of poultry manure. Savithri *et al.* (1991) reported that application of coir pith based poultry litter at 6.35 t ha^{-1} along with recommended levels of NPK registered highest yield of sorghum. Das *et al.* (1991b) recorded highest grain yield of maize by application 5t of poultry manure + 28 kg P_2O_5 ha^{-1} as single super phosphate.

Giardini *et al.* (1992) reported an increased yield of onion bulbs due to poultry manure, which produced yields of more than 35 t ha^{-1}. They have also reported that the highest yield of tomato and marketable yield of tomato due to combined application of poultry manure and mineral fertilizers. In ferralitic soils of Nigeria, Oikeh and Asiegbu (1993) obtained highest tomato yields (10 t ha^{-1}) out of poultry and swine manures. Nakamoto *et al.* (1994) reported that application of 25% recommended commercial fertilizer with 75% biodigested poultry manure slurry was superior and concluded that poultry manure has potential for supplementing or replacing commercial fertilizer in sweet corn production.

Jayanthi (1995) reported that application of recycled and composted poultry manure resulted in higher grain yield of rice. In a degraded soil in Southern Nigeria, Obi and Ebo (1995) found that average maize grain yield was significantly improved due to 100% poultry manure application and also in 50% poultry manure + 50% inorganic fertilizer application. Abdel-Magid *et al.* (1995) reported that grain and straw yield of wheat increased with increased rate of chicken manure in Saudi Arabia and obtained the greatest economic return at 8.25 t ha^{-1}.

In Nigeria, Ugbaja (1996) found that castor seed yields were the highest with poultry manure or swine manure applied at the rate of 10 t ha^{-1}. Opara and Asiegbu (1996) observed an increase in the fruit yield of eggplant with increased rates of poultry manure upto 15 t ha^{-1}. Akande *et al.* (2005) reported that complementary application of rock phosphates with poultry manure

Table 4: Yield of cassava as influenced by different organic manure

	Tuber yield (t ha^{-1})	
Treatments	2001	2002
Control	21.8	22.03
FYM (25 t ha^{-1})	31.63	32.35
PM (10 t ha^{-1})	32.16	32.48
CPM (10 t ha^{-1})	34.67	35.44
FYM (12.5 t ha^{-1})+PM (5 t ha^{-1})	33.62	34.10
FYM (12.5 t ha^{-1})+CPM (5 t ha^{-1})	34.15	34.92
CD (p = 0.05)	0.07	0.07

Amanullah *et al*. (2007c)

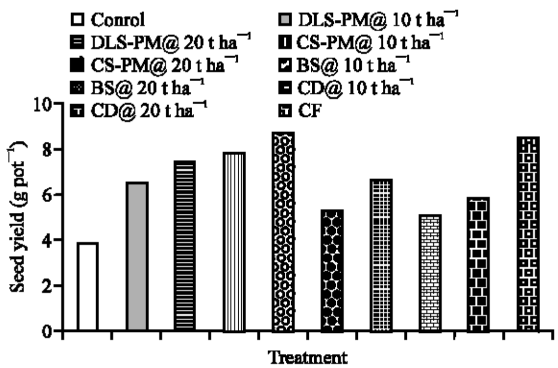

Fig. 1: Mustard Seed yield as influenced by organic manures and fertilizer. DLS-PM = Deep litter system poultry manure, CS-PM = Cage system poultry manure. BS = Biogas slurry, CD = Cow dung, CF = Chemical fertilizer (Zamil *et al*., 2004)

increased maize grain yield by 33%, while cowpea yield was increased by 25%.

In India, Amanullah *et al*. (2007c) found that the tuber yield was the highest with Composted Poultry Manure (CPM) followed by FYM + CPM (Table 4) which was due to higher availability of soil nutrients and uptake by the crop as influenced by composted poultry manure.

In an experiment conducted by Zamil *et al*. (2004) the highest mustard seed yield (8.68 g pot^{-1}) was obtained in cage system poultry manure (CS-PM) @ 20 t ha^{-1} which was statistically similar to chemical fertilizer (CF) (8.49 g pot^{-1}). The lowest seed yield was obtained from the control. Cage system poultry manure showed better performance in producing seed yield. Highest concentration of nutrients especially N and P in cage system poultry manure is probably one of the main reasons for producing highest seed yield (Fig. 1).

Effect of poultry manure on quality of crops: In a study to find out the effect of organic and inorganic form of N on fruit qualities of Okra, Saleha (1992) observed an increase in the total carbohydrate, protein and ascorbic acid and a decrease in the crude fiber content due to the application of 10 kg N as ammonium sulphate +50 kg N as poultry manure.

Table 5: Effect of organic manure on the industrial starch of cassava.

	Industrial starch yield (t ha^{-1})	
Treatments	2001	2002
Control	3.92	4.09
FYM (25 t ha^{-1})	5.94	6.15
PM (10 t ha^{-1})	6.04	6.20
CPM (10 t ha^{-1})	6.56	6.88
FYM (12.5 t ha^{-1}) +PM (5 t ha^{-1})	6.29	6.50
FYM (12.5 t ha^{-1}) +CPM (5 t ha^{-1})	6.47	6.69
CD (0.05)	0.20	0.20

Amanullah *et al*. (2007c)

Table 6: Effect of organic manure and fertilizer on protein and oil content of Mustard

Treatment	Protein content (%)	Increase over control (%)	Oil content	Increase over control (%)
Control	21.25	-	40.25	-
DLS-PM@ 10 t ha^{-1}	22.42	5.22	41.41	2.80
DLS-PM@ 20 t ha^{-1}	23.78	10.64	42.35	4.96
CS-PM@10 t ha^{-1}	23.75	10.53	43.71	7.92
CS-PM@20 t ha^{-1}	24.31	12.59	44.11	8.75
BS@ 10 t ha^{-1}	22.25	4.50	41.26	2.44
BS@ 20 t ha^{-1}	23.04	7.77	43.14	6.70
CD @ 10 t ha^{-1}	22.69	6.35	41.18	2.26
CD @ 20 t ha^{-1}	23.68	10.26	42.44	5.16
CF	24.05	11.64	43.20	6.83
LSD (0.05)	1.43	-	2.69	-
CV (%)	3.62	-	3.74	-

Zamil *et al*. (2004). DLS-PM: Deep litter system poultry manure, CS-PM: Cage system poultry manure. BS: Biogas slurry, CD: Cow dung, CF: Chemical fertilizer

Pimpini *et al*. (1992) observed the best results of processing suitability index in potato for production of both chips and sticks with 4 t ha^{-1} poultry manure. In a similar study on sugarbeet, Pimpini *et al*. (1992) reported higher total and extractable sucrose and a lesser extractable sucrose ratio at 4 t ha^{-1} of poultry manure.

Among the organic manurial treatments, higher starch content was registered with Composted Poultry Manure (CPM) either alone or with FYM which is shown in the Table 5. This might be due to increase the uptake of nutrients in this treatment especially P and K along with the uptake of micronutrients (Amanullah *et al*., 2007c).

The highest quantity of protein in seed was found in CS-PM@ 20 t ha^{-1} which was statistically identical to CF, DLS-PM @ 20 t ha^{-1}. The minimum seed protein was recorded from the control. The highest seed oil content was recorded from CS-PM@ 20 t ha^{-1} (44.11%) and lowest from the control (40.25%) (Table 6).

Residual effects: While evaluating the comparative efficacy of poultry manure with or without FYM on the residual effect of wheat grain yield, it was concluded that the residual effect was in the order of poultry manure + FYM followed by poultry manure, FYM and no manure (Gupta *et al*., 1988).

The relative efficacy of organic manures with respect to residual effect in all soils was the highest in poultry manure followed by FYM and pig manure in Meghalaya

(Das *et al.*, 1991b). Savithri *et al.* (1991) reported that application of 6.25 t ha^{-1}poultry manure to the first crop of sorghum had significant residual effect on succeeding crop yield and that also increased the nutrient content of the soil. The postharvest soil sample analysis indicated that Sesbania, FYM, biogas slurry and poultry manure application resulted in higher amount of residual N, P and K in the soil (Budhar *et al.*, 1991). Ibeawuchi *et al.* (2006) reported that in a degraded soil of Nigeria, poultry manure application increased the residual soil N, K, Ca, Mg and organic matter. The high organic matter with increase in other soil chemical components is an indication that poultry manure has high potential of gradual nutrient release to the soil that can help to improve the fertility of a degraded soil thereby sustaining yield in a continuous cropping system.

CONCLUSIONS

The foregoing review revealed the importance of poultry manure, its effect on soil properties, nutrient supplying ability, yield and quality of crops and also the limitations to the use and the method of composting poultry manure before application. It can be concluded that poultry manure can be efficiently used for the crops after composting the same to save the nutrients. Poultry manure may be taken as a base for fertilizer recommendation at least in places of higher availability.

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