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Centrifugal spreader mass and nutrients distribution patterns for application of fresh and aged poultry litter

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ABSTRACT

A spin-type centrifugal spreader was evaluated using fresh and aged poultry litter upon dry mass, product nitrogen (N), phosphorus (P) and potassium (K), incubation study soil available N and particle size distribution patterns. Relative to the aged litter (37% moisture content), the fresh litter (17% moisture content) had greater <1.00 mm particle size fraction weights and atmospheric particulate was launched, which posed as a potential fallout to adjacent fields, waterways and residences. Relative to the aged litter, the broadcast fresh litter resulted in higher coefficients of variation (CV) over its transverse distance, a narrower calculated space distance between passes for uniform spread and lower soil available N concentrations. For nitrogen application over the broadcast transverse distance the fresh litter displayed a high R^2 best fit 4th order polynomial distribution pattern, while the aged litter showed high R^2 best fit 6th order polynomial distribution pattern. A soil incubation study of the fresh and aged broadcast litter resulted in a more variable or lower R^2 best fit 2nd order polynomial distribution pattern. For both the fresh and aged litter, the calculated distance between passes to achieve a uniform mass distribution was greater than that required for the broadcast of soil available N. For the fresh litter, the soil available N and litter P concentration levels strongly correlated (relatively high p and R^2 values) with the <1.00 mm fraction weight, while for the aged litter this relationship was not as significant. In addition to reducing the health risk (i.e. pathogens, antibiotic residues and resistant bacteria) and/or environment issues (particulate fallout onto waterways, adjacent fields and/or residences) our study mass, particulate and N distribution patterns results suggest that poultry litter should be allowed to age before broadcast application is attempted.

1. Introduction

The poultry industry globally and in Canada, is intensive and continues to expand (Bernhart and Fasina, 2009; López-Mosquera et al., 2008). For some regions, the management of the industry's manure continues to be an environmental challenge. Poultry litter (PL) consists of chicken or turkey manure, feathers and bedding material – which is typically wood shavings, sawdust, wheat straw, peanut hulls or rice hulls. As a soil amendment for crop production, it is an excellent fertilizer in having a relatively consistent nutrient content, high levels of N (nitrogen), P (phosphorus) and K (potassium) (Bernhart and Fasina, 2009; Kelleher et al., 2002). However, excessive and repeated use in crop production is common within the industry where the concentration of poultry barns occurs and the economic costs associated with transporting a bulky product is a limiting factor. For our region, the Fraser Valley Soil Nutrient Study of 2005 reported 80% of all fields in the study were in the high to very high environmental risk class for P leaching (Kowalenko et al., 2007). For fall residual nitrate – nitrogen, 93% of fields exceed environmental thresholds. Significant non-point source of nutrients, especially N and P, via runoff and leaching to local water bodies can lead to degradation of surface and groundwater quality, potentially contributing to environmental and human health problems (Laguë et al., 2005; Liechty et al., 2009; Maguire et al., 2009; Smith and Schindler, 2009). More recently, there have been several human and environmental health concerns regarding poultry litter barn clean-out and litter storage and use with respect to antibiotic residues and as a source of antibiotic resistant and pathogenic bacteria. In this respect, the bioaerosols associated with poultry barns have been identified as potential health hazards to those persons who work in such barns and/or

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handle such dry and dusty poultry litter (Brooks et al., 2010; Diarra et al., 2007; Furtula et al., 2010; Graham et al., 2009; Mangalappalli-Illathu et al., 2010; Merchant et al., 2012; Vela et al., 2012).

There are factors which can limit poultry litter as a replacement for granular fertilizers, such as variable storage conditions, moisture contents, particle sizes, and N and P availability combined with problems spreading these nutrient-rich materials at appropriate rates and in a timely manner. The availability of spreading equipment which can distribute the material both uniformly and at the right time; and optimizing associated spreading costs are important for effective and relevant use of poultry litter as a replacement fertilizer (Bernhart and Fasina, 2009; Bernhart et al., 2010; Campbell et al., 2008, 2010; Laguë et al., 2005). There have been some recent innovations in centrifugal “spin-type” manure spreading equipment for poultry manure broadcast applications (i.e. “Stoltzfus” Bulk Material Spreaders; built in Morgantown, Pennsylvania). This “spin type” spreader (characterized by a horizontal dual-spinner carried at the rear of a wheeled vehicle moving over the ground and generally rotated about a vertical axis) is specifically designed for spreading poultry litter and is relatively inexpensive to produce. Moreover, it is capable of high volume loads and wide swath/spreading patterns, hence fewer and/or more timely passes over the field.

Limited studies have been carried out to examine the spread pattern or distribution of nutrients for poultry litter (Campbell et al., 2008, 2010; Wilhoit et al., 1993). Broadcast applications of both fresh and aged poultry litter are common amongst conventional vegetable producers; while the use of composted litter is a regulated certified organic production practice (USDA, 2000). Development of best management practices (BMPs) will increase farmer confidence with respect to minimizing health issues associated with its handling, more environmentally responsible application practices that are effective in meeting crop nutrient demands and equipment that requires less time or expense associated with the spreading of poultry litter. The objective of this investigation was to evaluate mass and nutrient (N, P and K) distribution effects and transverse distance broadcast patterns following the use of a spin-type spreader (Stoltzfus) to apply either “fresh” (from a recent poultry barn clean-out; dry) or “aged” (stored over-winter in the field; moist) poultry litter.

2. Materials and methods

Fig. 1 shows the Stoltzfus centrifugal or spin-type spreader and its movable conveyor belt/floor which feeds the litter onto the horizontal dual-plate propellers. In our investigation the guillotine gate – which controls the flow onto propellers was half open at 0.15 m.

Fig. 1. Close up of dual-plate horizontal spinners and conveyor delivery system.

Fig. 2. Spreading fresh **(a)** and aged **(b)** poultry litter.

2.1. Spreader evaluations and analysis in terms of poultry litter distribution uniformity

The procedures used for evaluating the spreaders closely followed the methods described by Wilhoit et al. (1993) citing ASAE S341.2, Procedures for Measuring Distribution Uniformity and Calibration Granular Broadcast Spreaders (ASAE, 1990). We used the Stoltzfus bulk spreader to apply “fresh” and “aged” broiler poultry litter. The fresh litter had been removed from a poultry barn clean-out two days prior to broadcast, hence dry; while the aged poultry litter had been delivered in late November and left in a storage bunker till the time of application in mid-May. During this time, the stored poultry litter was exposed to over-winter rainfall with limited static (no turning) composting effects, hence moist.

Three replicates of collection trays were placed across the swath and perpendicular to the spreader's directional transect. Each set was located 20 m apart along the linear transect. Each of the three replicate sets consisted of a linear series of 12 trays (6 on each side left-right of centre) spaced 0.2, 2, 3, 4, 5 and 6 m apart. No trays were placed in the vicinity of the tractor/spreader wheel wells (see Fig. 2b). Each cardboard tray measured 0.4 × 0.6 × 0.05 m and was placed inside a light plastic garbage bag that then lined and baffled the inside tray catchment area for subsequent sample collection. Small rocks were placed in the tray's four corners to keep the light plastic lining secured to the bottom of the tray. The fully-loaded spreader with tractor then began to spread the litter 50 m prior to its broadcast application onto the collection trays. The ground speed was 4 km h^{-1}. A target application of 5 t ha^{-1} was tested to provide an estimated 75–100 kg ha^{-1} soil available N, which is a common spring-time soil nutrient application for several crops such as bean, corn, potatoes and some cereals.

Both the fresh and aged litter were well mixed using a front-end loader prior to placement in the spreader's hopper. When the fresh and aged poultry litter pile was being loaded into the spreader, a single 10 L composite grab-sample was scooped into a pail using a trowel, well mixed and then 1 kg samples were transferred to plastic bags. Both the tray-collected and pile-loaded samples were transported to the laboratory in a cooler. Samples were weighed