Effects of Pelleting and Wet Extrusion on Organic Fertilizer Nutrient Availability by Net Nitrogen Mineralization

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ABSTRACT
Homogenous organic fertilizers provide a composite product with a complete mix of ingredients in each prill. The most commonly utilized manufacturing technology to homogenize organic fertilizers is a pelleting process. Another specialized and unique method to manufacture homogenized organic fertilizers, adopted by the producers of Natural Origins, is wet extrusion technology, a process that provides improved physical characteristics. Wet extrusion is a process in which the ingredients are cooked under exceedingly high pressure with high-temperature steam. The fertilizer is then pushed through a die, which gives it a precise and uniform shape, visually enhancing the product appearance and nutrient consistency. Wet extrusion has been used to process specialty animal feeds and studies have successfully shown that the cooking process in extrusion improves digestibility and energy availability by breaking down lengthy and complex bonds of starches, proteins and oils. Furthermore, extrusion technology may also produce specialty fertilizers with additional benefits, possibly improving the dispersion and availability of organic nutrients in soil.

A laboratory experiment was conducted at a Minnesota university to determine the difference in the effects of pelleting versus wet extrusion on the availability of organic fertilizer nutrients in soil. The products analyzed in the experiment were commercial organic fertilizers made from equally similar protein rich nitrogen (N) sources of plant and animal by-products from two different manufacturers: one produced by the pelleting method and, Natural Origins, produced by the wet extrusion method. The chemistry of soil in the nitrogen (N) cycle was measured for net mineralization of extractable soil ammonium and nitrate to determine the amount and length of controlled N release over time affected by each fertilizer source. Samples were measured from four main soil groups: (1) soil treated with a pelleted organic fertilizer; (2) soil treated with Natural Origins, wet extruded organic fertilizer; (3) a positive control group of soil treated with inorganic urea; and (4) a negative control group of soil that was not treated with any kind of fertilizer. Soil nitrogen results were examined for each group. Differences were found between manufacturing processes, prill sizes, organic and inorganic products.

Soil testing showed that both organic fertilizers had statistically slower rates in converting N to ammonia and a statistically slower rate of nitrification compared to the inorganic urea control group, which contains all N in the ammonium form and is eventually converted further to nitrate (NO3), the second inorganic N component. Inorganic fertilizers, such as urea, contain all N in the ammonium (NH4) form, which is rapidly converted into nitrate (NO3) form within 4-6 weeks. Commercial inorganic fertilizers may release N very quickly within a predictable short period of time, when the soil no longer contains available N for plant uptake, causing a deficiency in N.

INTRODUCTION
Nitrogen is the primary limiting plant nutrient and adequate intake of nitrogen from the soil is essential for healthy, sustained growth. Nitrogen (N) becomes available to the plant as it undergoes a cycle of changes in the soil through microbial breakdown of organic matter, referred to as net mineralization. In this cycle, ammonium (NH4) is the first inorganic N component released and is eventually converted further to nitrate (NO3), the second inorganic N component. Inorganic fertilizers, such as urea, contain all N in the ammonium (NH4) form, which is rapidly converted into the nitrate (NO3) form within 4-6 weeks. Commercial inorganic fertilizers may release N very quickly within a predictable short period of time, when the soil no longer contains available N for plant uptake, causing a deficiency in N.

Nitrogen, the most limiting ingredient for plant productivity, is a major determining factor in choosing organic N sources. Organic Fertilizer products perform better when the

METHODS
A 12-week laboratory incubation study was conducted at a Minnesota university in a large environmental room at 70º F. Four replicates in 1L beakers with 250 grams of wetted field-moist Dodge silt loam top soil and organic fertilizer treatments were the subjects of a statistical analysis. The organic fertilizer/soil mixes were incubated and tested weekly for ammonium and nitrate concentration by extracting subsamples with 2 M KCl.
The performance of an organic fertilizer can be influenced by the manufacturing process. The methods used to produce homogenous fertilizer composites may vary from typical pelleting to more specialized practices such as wet extrusion, which produces more favorable characteristics in the prill structure and could affect nutrient availability. Pelleting is a manufacturing process often used for animal feed where ingredients are gelatinized into a mash by applying heat and pressure to break down the molecular bonds of the nutrients to make them more available. Pellets are made by adding a binder, heating the mash to 180°F and applying 80-90 psi and low moisture via steam, then pressing the mixture through die holes. Wet extrusion evenly disperses all the fertilizer ingredients into a fine homogenous particulate and is conditioned using large amounts of steam and water. Moisture levels are higher in the wet extrusion method. Moisture levels as high as 35% are extruded under 100-120 Amps of pressure. The uniform wet agglomeration is heated to 280°F and cooked. The extrusion manufacturing process may enable greater nutrient release from the end fertilizer product because lengthy chains of non-starch polysaccharide or highly resistant disulfide bonds break down under the increased heat, pressure, moisture and steam.

RESULTS

The following data illustrates weekly measurements taken during the 12-week laboratory study from extractable soil ammonia and nitrate to determine the rate of net mineralization in each sample. In chart 1, a comparison is shown in the amount of ammonia (NH₄) released in the four groups of pellet products; a pelleted 5-6-6 mixture, 100 SGN and 255 SGN, and the wet extruded, Natural Origins 5-4-4 product, 100 SGN and 200 SGN. In chart 2, a comparison is shown in the amount of ammonia (NH₄) released in the four groups of pelleted products; a pelleted 13-0-0 mixture, 100 SGN and 300 SGN; and a wet extruded Natural Origins 13-0-0, 250 SGN, 100 SGN and 250 SGN. In charts 3 and 4, a comparison is made in the amount of nitrate (NO₃⁻) present in the same aforementioned soil groups. A negative control of soil with no fertilizer treatment and a positive control of soil treated with inorganic urea fertilizer were also tested.

As shown in Charts 1 and 2, it was found that both methods to produce organic fertilizers exhibited a statistically slower rate in converting N to ammonia, as compared to inorganic urea, which contains all N in the ammonium form, immediately releasing high levels of NH₄, then rapidly converting to NO₃. The smaller, 100 SGN prill size had a greater rate of converting N to ammonia than the larger 250 SGN prill size in both types of manufacturing processes. The extruded, Natural Origins organic fertilizers had a statistically greater rate of converting N to ammonia and an increased production of ammonia to nitrate than the pelleted organic fertilizers. A statistically greater portion of N was released from the extruded organic products.

In Charts 3 and 4, the rate of nitrification is shown as statistically slower and remains linear for organic products, as compared to urea, and were statistically higher than the control with no fertilizer. A distinction was made in the extruded, Natural Origins organic products where there was a statistically higher production of available N, released as NO₃ within ten weeks. After 10 weeks a quick decline occurs from microbial immobiliza-
tion in all organic fertilizer product samples to nearly the same level of NO3. If the products were to remain linear, it would indicate more N is still being released.

CONCLUSION

The net mineralization cycle through the release of ammonium and nitrate determines the amount and consistency of controlled nitrogen release available in the soil to the plant. Consider also, that the study contains only soil and no plant, thus the percent of nitrate for all products, including inorganic urea, remains high as nitrate (NO3) since it is not absorbed by the plant. It is important to note that the plant would absorb the nutrients as soon as they became available in nitrate form and more than 90% of N is absorbed by plants in NO3 form, only a portion of NH4 may be used by the plant.

Also noteworthy: all characteristics of the two products other than the manufacturing process were fundamentally invariable – from ingredients, consisting of similar protein based meals and nutrients, to the nitrogen levels and the standard guide sizes (SGN) of the prill.

A beneficial quality indicative of slow-release fertilizer products is a release rate of NH4 that is greater than NO3 and a steady release rate of NO3 over time, at a linear increase. For best results, the organic fertilizer will have an extended release rate greater or equal to 7-8 weeks and completes within 14-16 weeks, or a typical growing season. Many organic fertilzer products have release rates that surpass a growing season and continue beyond 16 weeks, where a good portion of the N would not be available to the plant until N is in an available form.

The Natural Origins organic fertilizer products showed a parallel rate of nitrification that was steady and linear, but produced a greater amount of available NO3 throughout ten weeks when nitrification declined from both pelleted products and became statistically equal at 12 weeks. These results indicate the wet extruded, Natural Origins products have a greater dispersal and availability of N.

A statistical comparison signifies a greater occurrence of available N from wet extruded products within ten weeks, as opposed to pelleted products, which consistently display less NO3 as available N than Natural Origins. Also, the products with smaller prill size at 100 SGN had a greater rate of ammonia production than larger particles, most likely from the additional surface area allowing more microorganisms to attach and breakdown the organic material.

In the 12-week study, in measurements of soil mineralization from protein rich products, the extruded Natural Origins products, when compared to pelleted products, influenced better dispersion and available nitrogen as nitrate.

REFERENCES


