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Dehydrated Broiler Litter: Agronomic Valorization by Application to Horticultural Crops



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Introduction

One of the main concerns of modern society is the growing production and accumulation of waste, which poses major hazards to human health and environmental equilibrium. The European Union member countries produced more than 2.500 million tons of waste in 2014 [1]. Also, the European agricultural, forest and fishing sectors alone accounted for 197 million tons [2]. Breeding of broiler chickens (*Gallus gallus domesticus*) in Europe has increased in response to an increasing household consumption, with Spain as the fourth producer at present [3]. A total of 2.462.825.000 laying hens and broiler chickens were bred in 2016 [4]. If each 1000 birds are assumed to produce 0.7-1.4 tons of manure [5], then the overall production of litter in Europe last year was 1.6-3.4 million tons. The European Union's waste management policy aims at minimizing production and discharge while maximizing valorization. One way of valorizing poultry manure is by using it as organic fertilizer, thereby turning waste into a resource.

Fresh Broiler Manure: Environmental and Health Problems

Broiler litter consists largely of faeces, breeding material (e.g., sawdust, woodshavings, rice hulls, peanut hulls), feathers and feed remains. Its high contents in nutrients such as N, P and K, and in organic matter, in addition to its low moisture, make it a highly valued product that is used mainly as a fertilizer for economically significant crops such as maize [6], cotton [7], soybean [8], forage [9] and horticultural plants [10]. Although poultry farms produce manure throughout the year, crops only need fertilization on a seasonal basis. As a result, manure often ends in waste stacks or is applied in excessive amounts or at wrong times, both of which raise environmental problems such as nitrogen emissions to the atmosphere, chemical and

microbial contamination of aquifers, off-odours or spreading of bioactive pollutants such as antibiotics [11]. A number of studies conducted all over the world have shown that inappropriate management of fresh broiler manure poses environmental and health problems. Recent food safety crises such as those derived from the use of hormones for animal production, and contamination with dioxins or veterinary drug residues, has raised increasing concerns about food quality among consumers. The increasing social demand for stricter control and greater transparency in agricultural and animal breeding practices has led to major policy changes in the European Union in the form of stringent animal feeding control standards consistent with the guidelines set in the Food Safety white paper of 2000 [12].

Processing Fresh Manure to Obtain Quality Organic Fertilizers

A number of procedures such as composting [13], dehydration [14] and pyrolysis [15] have been developed over the last few decades to avoid the environmental and health problems caused by fresh manure. The resulting products can be certified for use as organic fertilizers with a low moisture content, metal contents meeting legal requirements, stabilized organic matter, hygienic conditions, and ease of transport and management. In addition to these economic advantages, procedures such as composting and dehydration have been found to degrade drug residues [16]. Few studies, however, have assessed the agronomic efficiency of processed manure against fresh manure.

Agronomic Valorization of a Commercial Dehydrated Broiler Litter Granulate

Several previous studies have investigated the benefits of drying broiler litter as regards handling and N contamination

risks [17,18]. None, however, has examined the effects of drying and pelletizing on fertilizer value. Below are presented the main results obtained in greenhouse trials on horticultural crops to which pelletized dehydrated broiler litter (BL) obtained on a farm in northwestern Spain was applied for several years.

Fertilizer value of pelletized dehydrated broiler litter

Thermally treated broiler litter (BL) obtained over four production cycles was compared in terms of fertilizer value with fresh manure. Based on the results, dehydrated litter was more stable in composition than was the fresh product. Also, the former contained no faecal bacteria or antibiotic residues, and released no off-odours. In addition, pelletization facilitated transport, storage and application in the field [14].

Effects of pelletized dehydrated broiler litter on horticultural crops

Intensive greenhouse crops and organic crops require quality organic fertilizers, namely: fertilizers supplying the nutrients needed by the crop in a gradual manner, introducing no pathogens and raising the levels of no potential toxins such as metals or salts. This led us to set up greenhouse experiments involving various horticultural crops to assess the performance of BL as a fertilizer. Based on the results for four growth cycles of Trocadero lettuce (two under the more unfavourable weather conditions of autumn and summer and the other two under the more favourable conditions of spring and summer), a BL rate of 500-600g m⁻², which supplied ca. 120kg N ha⁻¹, sufficed to increase production relative to conventional mineral fertilizer for greenhouse lettuce with figures similar to those for controlled release mineral fertilizers. Also, BL had a residual effect in both winter and summer that increased with increasing rate and allowed growing two consecutive lettuce crops with a single application [19].

Using BL, at rates as low as 60kg N ha⁻¹, in pepper crop type 'Lamuyo' was observed similar production, quality (class I) and size (class G) than that obtained with a slow-release mineral fertilizer applied at 100kg N ha⁻¹ [19].

Although BL is effective for agricultural purposes, its high salt content can raise secondary salinization problems if used at high rates (especially in arid and semi-arid regions [20] or in greenhouse soils). A field trial involving four cropping cycles revealed that applying BL to lettuce increased EC_e in the soil in proportion to the rate used and to levels exceeding the acceptable salinity threshold for this crop (1.3dSm⁻¹) with a rate of 1064g m⁻² (equivalent to 235kg N ha⁻¹). Although the organic fertilizer raised salt concentrations, this had no adverse impact on crop yield, so it was concluded that potential salinization in the long term could be avoided by using rates not exceeding 532g m⁻² at any time of year when repeated applications were done [21].

One other caution is that broiler manure is especially rich in N and can thus raise the levels of this element in soil, thereby

leading to excessive accumulation of nitrates in leafy crops such as lettuce. The nitrate concentration in these crops is a quality factor to be controlled for safety reasons [22]. This variable was examined by growing lettuce in a greenhouse at times of high and low irradiation for two years. The increase in lettuce nitrate levels caused by BL was not different from that resulting from the use of mineral fertilizers at similar equivalent rates (120kg N ha⁻¹). In any case, the BL rate used under low irradiation should not exceed 1064g m⁻² (235kg N ha⁻¹) if nitrate concentrations in the outer leaves of lettuces are not to approach the maximum tolerated levels in European regulations [19].

Conclusion

Dehydrated broiler litter provides quality organic fertilizer that can compete with the usual mineral fertilizers for intensive horticultural crops; also, if applied at appropriate rates, it should cause no damage by effect of excess nutrients or salinity. In addition, BL improves the content in organic matter and biological activity of the soil. Therefore, it can be safely used on greenhouse crops or even in organic agriculture as it complies with its stringent restrictions.

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