Terminal Narrative: CRIS Report 2004. Using Paper Mill Residuals in Intensive, Irrigated Vegetable Production in Wisconsin's Central Sands.

The objectives of our research were to evaluate effects of annual additions of raw paper mill residuals (PMR), PMR composted alone (PMR-C), PMR composted with bark (PMR-B) on soil chemical and physical properties, plant health and crop yield in a sandy soil under irrigated vegetable production over a five year period. Each spring, from 1998 to 2002, we applied PMR and PMR composts at two rates to a three-year vegetable rotation of potato, snap bean, and cucumber. The experimental design was a randomized complete block with amendment type/rate as the main effect. Treatments were replicated five times in plots 15 ft. X 25ft. Total soil C and N (TC, TN), particulate organic matter (POM) C and N, plant available N, and plant available water (PAW) were determined three to four times per amendment year. After four years, all PMR amendments significantly increased TC, TN, POM C, and POM N. After the second amendment year, all high-rate PMR treatments maintained higher TC and POM C levels relative to the control. Both composts produced similar TC levels, while PMR and PMR-C produced similar POM C levels.

We also evaluated PMR and compost effects on aggregate stability. Dry sieving of air-dried soil samples was used to determine the aggregate size distribution using a nest of sieves with openings of 8mm, 4mm, 1 mm, 500 um, and 250 um. The predominant aggregate size class was 250 um regardless of treatment; representing 42 percent of the soil weight. Only the 4 mm size class showed significant differences among treatments. Within this size class PMR and PMR-B soils had the highest proportional weight, while PMR-C and the control treatment had the smallest proportional weight. Aggregate size distribution was expressed as geometrical mean diameter (GMD); PMR-B and PMR-C amended soils had similar size distributions weighted toward the larger size classes, while PMR and control soils had similar distributions weighted toward smaller size classes. We also performed a slake test using the 4 mm air-dry aggregates to determine stability in water. Aggregates from amended soils were more stable in water than the control. We found that the stability in water moderately increased (r2=38 percent) with increasing TC and TN, and with POM-C and POM-N. Size distribution was positively correlated with TC and TN and with POM-C and POM-N.

Paper mill residual amendments had modest effects on crop yield and quality among all three crops in the rotation. In the first and third years, there were no statistical differences among potato yields. All amendments increased bean yields relative to the no-amendment control in the second and fifth years. For cucumber, there were no statistically significant differences among treatments on both the number of harvestable fruits per plant and the fruit weight per plant. We demonstrated suppression of two foliar diseases in the second and third year of the experiment: brown spot in snap bean and angular leaf spot in cucumber. In the fifth year, re-application of PMR amendments significantly reduced common root rot severity by 60-70 percent compared to the non-amended control treatment.

Impact

Five years of research suggests that annual additions of moderate to high amounts of paper mill residuals or their composts can build and maintain soil organic matter levels in sandy soils. The quantity of organic matter is important for soil functions like nutrient and water retention, but quality of organic matter may be more important for suppressing specific plant diseases. For example, annual additions of PMR amendments might be needed to maintain increased water availability, yet large amounts of very active organic matter might enhance susceptibility to certain diseases. Improvements in soil physical properties such as water holding capacity should reduce irrigation requirements and frequency, increase nutrient use efficiency, and potentially reduce N leaching to ground water. Improving aggregate stability should reduce potential for wind erosion. Reducing the negative environmental impacts like nutrient leaching should also sustain economic viability of irrigated sand vegetable production in Wisconsin.

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