Poultry Litter Induces Tillering in Rice
Helen Belefant-Miller

ABSTRACT. Poultry litter (PL) is used as a soil amendment for numerous crops including rice (Oryza sativa L.). Although it is known that overall rice growth and yield are improved by the addition of PL to the soil, tiller number is here identified as a specific parameter that is increased by PL. Since the addition of PL can have highly variable results in field studies, a relatively quick, small-scale, and controlled system was developed for examining the effects of PL on young rice plants grown in pots in the greenhouse. This system has several advantages over field experiments. Since the effects of PL can be observed early in rice growth by measuring early tiller production, tests can be done in a shorter time period. Greenhouse tests can also be carried out throughout the year. The application of either PL or inorganic fertilizer to the soil increases tiller number, but the combination of PL and fertilizer results in a synergistic increase in early tillers. Tiller induction by PL occurred in a number of rice cultivars which included high- and low-tillering varieties. Tiller induction occurred with multiple commercial PL sources from different areas of North America and thus from different varieties of chickens, bedding material, and feeds. Since each of the diverse commercial PLs induced tillering, it must be considered that the tiller induction factor(s) are derived from the chickens. The molecular mechanisms for tillering are not understood and PL then could be valuable as a triggering mechanism for studying this phenomenon. doi:10.1300/J064v31n01_12

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INTRODUCTION

Poultry litter (PL) is chicken or turkey manure mixed with bedding, feathers, and waste feed (Sumner et al. 2002). PL is used as a soil amendment to add nutrients and organic matter, thereby increasing soil fertility. PL is considered a relatively inexpensive source of macro- and micronutrients and its application rates are usually determined in terms of the N, P, and/or K provided (Sistani et al. 2004).

Rice tillers are culms or stems that develop from another stem. Tillers become morphologically indistinguishable from the main stem and terminate in the panicle that, upon maturity, carries the harvestable rice kernels (Moldenhauer and Gibbons 2003). Tiller number and the resulting panicle number are one of the main components of rice yield (Vergara 1980), so an increase in tiller number generally corresponds to an increase in yield.

Investigations of the effects of PL on rice have focused almost completely on the macronutrients contained in PL and on the total biomass and grain yield of the rice plants. The final yield of a crop is, of course, one of the most important agronomic measures of the benefits of a field treatment. However, yield relays very little information about the physiological or biochemical mechanisms of the improvement. Once the mechanisms affected are known, the specific processes involved in those mechanisms can be studied directly with the objective of further improvement.

The effects of PL are highly variable in field studies and responses can be affected by numerous parameters such as the crop, condition of the PL, fertilizer level, etc. A small-scale, greenhouse system was developed to study effects of PL to reduce the variability encountered in field studies and to isolate specific factors involved in changes in rice growth.

To date, no definitive study has been done to specifically investigate the tillering response of rice to PL. By identifying a distinct plant response, tillering, future studies can focus on the physiological and biochemical aspects of the growth induction. Four rice cultivars with different basal levels of tillering were compared in their response with PL. PL sources were obtained from different locations around North America to ensure the same tillering response was obtained across a range of litter components. The contribution of inorganic fertilizer to the tillering response was also ascertained.
MATERIALS AND METHODS

Plant and Soil Material and Growth Conditions

Rice (*Oryza sativa* L.) plants were grown in a greenhouse in non-draining 20.4 cm-diameter (8") pots filled with local field soil. Seeds were planted into pots in which 10 g of commercial, pelletized PL had been added into the top 3 cm of soil. Plants were kept under flood after the fourth leaf had emerged, equivalent to developmental stage V3 (Counce et al. 2000). To ensure that no nutrients were at limiting levels, fertilized plants, for all tests except the fertilizer test, were watered twice a week with Pro Select (Scotts Miracle-Gro, Marysville, OH) complete (containing 20% nitrogen, 20% phosphate, 20% potassium, 0.02% boron, 0.05% copper, 0.1% iron, 0.05% manganese, 0.0005% molybdenum, 0.05% zinc) fertilizer two times at the recommended daily rate of 5 mL/3.8 L/week (equivalent to 1 teaspoon/gallon/week) for houseplants. Oakley pelletized chicken litter (Oakley, Beebe, AR, USA) was used, unless otherwise noted, in all experiments.

Field soil (Crowley silt loam) from one site was used for all tests. Soil was mixed for each test. The soil contained an average of 19 mg/kg P and 80 mg/kg K, and 0.95% organic matter.

Unless otherwise specified, Wells cultivar was planted. Tiller counts, unless otherwise specified, were made approximately 60 days after planting. Tiller numbers include the main culm. Only tillers with emerging leaves (productive tillers) were counted.

Fertilizer Test

Two replicate pots of six to seven rice plants were used for each test point. Pro Select was dissolved at 1X and 2X the recommended amount. The standard fertilizer application was 225 mL of 2X fertilizer applied once a week. So a 3X fertilizer treatment, for example, was 225 mL of the 1X solution one day a week and 225 mL of the 2X another day of the week.

Cultivar Test, Panicle Weights, and Time Course

To compare different cultivars, cultivars with a range of tillering levels were selected. Jefferson and Wells are low tillering, Bengal is intermediate, and PI 312777 is high tillering. Tillers were counted as the plants developed during the time course. The last time point of the time course is
the number of panicles. Each treatment had four replicates with five plants in each replicate. The five main panicles from each pot were bulked at maturity and dried in a 37°C oven for 3 days before weighing.

**PL Sources**

All PL sources were pelletized and non-composted. PL sources were Cock-a-Doodle-Doo (Pure Barnyard, Raymond, NH, USA, NPK = 5-3-2), Harmony 5-4-3 (Kreher Enterprises, Clarence, NY, USA, NPK = 5-4-3), Greenhouse Gold (Envirem, Fredericton, New Brunswick, Canada, NPK = 4-1-2), and Oakley (NPK = 3-3-3) pelletized chicken litter. Each treatment had 10 g of each PL source in each pot, with three replicate pots of six plants per pot.

**RESULTS AND DISCUSSION**

The improvement in rice growth in soil to which PL has been added is visually apparent (Figure 1). The improvement by PL alone often appears

FIGURE 1. Effects of different poultry litter (PL) and fertilizer (Fert.) treatments on rice plant (cv. 'Wells') growth. The treatments are, left to right, PL and fertilizer, fertilizer alone, PL alone, and no amendments (Cont.).
similar to that made by the addition of fertilizer alone. But when PL and fertilizer are added together, an even greater growth improvement can be observed, particularly in the number of tillers for each plant (Figure 1).

Adding fertilizer at $1 \times$ and $2 \times$ the recommended rate resulted in more tillers than not adding any fertilizer. But tillering did not further increase with more fertilizer, even when 10 times the fertilizer recommended rate was added (Figure 2). Therefore, the $2 \times$ rate (0.07 g each of NPK is added each week to a pot) of fertilizer was used for the rest of the tests.

Improvements in rice tillering and growth have previously been noted with the combination of manure and fertilizer. PL (Eneji et al. 2001) and unidentified farmyard manure (Satyanarayana et al. 2002) each significantly increased tillering in rice when added with fertilizer. Rice yield was highest and best maintained for years when farmyard manure was added with a small amount of fertilizer (Maeda 2001). In this study, an increase in the number of tillers occurred at low fertilizer levels and further increases in the amount of fertilizer did not further increase tillering (Figure 2). Only with PL combined with inorganic fertilizer was a further increase in tiller number achieved (Figures 3 and 4).

FIGURE 2. The effect of increasing levels of complete commercial fertilizer on tillering in rice (cv. ‘Wells’). The recommended level is $1 \times$. Fertilizer in all of the other tests in this study were applied at $2 \times$ the recommended level. Each data point represents the mean of 10 to 13 plants. Error bars represent the standard deviation of the measurements.
FIGURE 3. The number of tillers present during rice plant development under different poultry litter (PL) and fertilizer (F) treatments. No amendment is indicated by “0.” The final value at 115 days represents the number of panicles. Each data point is the mean of 20 plants. Error bars represent the standard deviation of the measurements.

As observed by Matsushima (1966), early tiller numbers were comparable with the number of panicles produced later on (Figure 3). Tiller number is increased by PL early in rice growth and is maintained through growth. The effect of PL on early tillering thus provides a short-term yield indicator of yield component with measurements possible in about one-quarter of the time needed for full maturity. The relatively short time period needed to observe the effect is valuable for allowing more tests to be done in a year and eliminating concerns for late season insects, fungal infection, temperature extremes, etc.

Tiller induction by PL occurred in low, medium, and high tillering varieties of rice (Figure 4). To ensure that the situation was not one where there were more panicles but each panicle was more poorly filled, mature panicles were weighed from each treatment. There was no detrimental effect of PL on panicle weights; in fact, weights at harvest generally increased with PL (Figure 5).

A variety of commercial pelletized PL sources from around North America (Figure 6) were tested for their ability to induce rice tillers. As
FIGURE 4. Rice cultivars with different basal levels of tillering were compared in their induction of tillering by poultry litter in the presence of complete fertilizer (see Figure 3 for treatments). Each data point represents the mean of 20 plants. Error bars represent the standard deviation of the measurements.

![Graph showing tillers per plant for different rice cultivars with treatments: O, PL, F, PL+F.](image)

FIGURE 5. Effects of poultry litter and optimal levels of complete fertilizer on mature panicle weights of four rice cultivars (see Figure 3 for treatments). Each data point represents the mean of four replicate tests. Error bars represent the standard deviation of the measurements.

![Graph showing panicle weight for different rice cultivars with treatments: O, PL, F, PL+F.](image)
FIGURE 6. Effect of different sources of commercial poultry litter (PL), in the presence of complete fertilizer (Fert or F), on induction of tillering in rice plants. Bars with no or narrow stripes have no poultry litter added. Each data point represents the mean of 18 plants. Error bars represent the standard deviation of the measurements.

PL comprises the manure plus any other materials (such as bedding) that are discarded along with the manure, PL from different sources are different in make-up. Poultry bedding material varies with locale (e.g., rice hulls are frequently used in Arkansas while pine shavings or peanut hulls are more likely to be used in Georgia). Litter components vary, too, with more bedding contained in broiler litter than in breeding and laying hen litter (Sumner et al. 2002). Nonetheless, plants grown in each of the different PL sources produced more tillers than plants grown without any amendment. More particularly, plants grown in PL in combination with fertilizer always generated more tillers than plants grown in either PL or fertilizer alone.

Atiyeh et al. (2001) observed increased growth of tomato seedlings in pig manure vermicompost combined with a complete commercial fertilizer and speculated that the manure contained growth enhancing factors, while Satyanarayana et al. (2002) attributed the interaction of farmyard manure with fertilizer to increased nutrient availability and
uptake. The use of PL and other animal manures as a substitute for inorganic fertilizer has been studied in numerous plants (for reviews, see Edmeades 2003; Wiatrak et al. 2004). But few cereal grain studies have considered the aspect that manure is a complex animal product and so may contain non-nutritive components that could promote the growth of plants itself or in combination with inorganic fertilizers. Since tiller induction occurred with each PL source, from different varieties of chickens, bedding material, and feeds, it seems that each of the diverse commercial PLs contained the tillering component. And so it must be considered that the tiller induction factor(s) are derived from the chickens. Chickens as the source of the manure may also be important. PL was shown to be more effective than swine, cattle, or mixed manures in increasing the biomass of rice (Eneji et al. 2001).

PL has a positive effect on tillering. Tillering is an important trait for grain production and is thereby an important aspect of rice growth improvement. Evidently additional, non-nutritive components are present in the PL and are the cause of the increased tillering seen when PL and fertilizer are combined. The molecular mechanisms for tillering are not understood and PL may be able to provide a triggering mechanism for studying this phenomenon.

REFERENCES


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