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Relative efficacy of organic manures in spring barley (*Hordeum vulgare* L.) production

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Abstract

The effect of organic sources of nutrients on the growth of spring barley (*Hordeum vulgare* L.) was studied in a pot experiment in a heated glasshouse at the University of Wales, Aberyswyth from November 2006 to March 2007. Spring barley seeds were sown in 120 pots containing a mixture of peat and 180g dry weight of poultry manure, cowdung, chicken manure pellet, sheep manure and horse manure. Chicken manure pellet was applied at 3.0 g pot^{-1} as top dressing. Mineralization pattern of the organic manures was monitored in a parallel experiment with 24 pots containing only the growth media. In this study, organic manures significantly increased plant height and chlorophyll content of leaves over the control plants. The application of inorganic fertilizer increased plant height over chicken manure and compost. In addition chlorophyll content was higher with inorganic fertilizer than cowdung at six weeks after germination. N mineralization significantly varied among organic manure sources with compost having the highest mineralized N and sheep manure the least. Plant tissue analysis revealed significant differences in plant tissue nutrient composition under organic manure treatment. Growing plants in organic manure resulted in 1.2 to1.6-folds, 1.1 to 4-fold and 1.1 to 4.1-fold increases in total N content of plant tissue at four weeks, eight weeks and twelve weeks after germination, respectively. Dry matter production by plants was also significantly increased under organic manure treatments. Organic manure application had the potential of increasing spring barley yield by 1.5 to 4-fold. Cowdung appeared to be the best source of organic manure for spring barley production.

Key words: Barley, organic manures, mineralization, nutrient uptake

Introduction

The efficient use of nutrients within crop production systems has been in focus for several decades. The application of manures to soil provides potential benefits including improving the fertility, structure, water holding capacity of soil, increasing soil organic matter and reducing the amount of synthetic fertilizer needed for crop production (Phan et al; 2002; Blay et al., 2002). Manures are the main sources of nitrogen (N) supply in organic crop production. Nitrogen availability from applied manure includes the inorganic N (NO_3-N and NH_4-N) in manure plus the amount of organic N mineralized following application. Nitrogen mineralization differs for different manure types since the inorganic/organic fraction and quality of organic N varies (Eghball et. al., 2002: Jae-Hoon et al., 2006). Poultry manure which has rapid N release is used for crops with high N demands (Ekbladh et al., 1993). Large amounts of organic substances are needed which usually leads to over-supply of nutrients with respect to crop requirement and thus leaching of nutrients (Kingery et al., 1993; Sharpley et al., 1998). In the absence of other constraints, nutrient uptake and yield are closely related (Hedge, 1997) though the difficulties of matching manure N availability to crop demands are well recognized (Brinton, 1985). Nutrients are often released from organic sources at a time when there is little crop uptake and consequently more opportunity for leaching which constitutes a pollution hazard for underground waters and aquifers (Bouman et al., 2002; Sharpley et al., 1998). The amount of N mineralised from organic sources in the cropping season provides a major portion of the plants N needs. Appropriate timing of nutrient release from

Table 1. Major nutrient composition of organic manure (g/kg DM)

Organic Manure	N	P	K
Compost (6X)	40.00	11.73	29.10
Chicken Manure	22.61	15.21	28.97
Cowdung	32.55	6.05	56.06
Horse Manure	13.66	4.15	24.68
Sheep Manure	19.26	5.70	22.51
Chicken Manure Pellet	40.00	25.00	23.00

the soil/manure system to meet crop demand will therefore ensure sufficient nutrient supply and avoid loss of nutrients to the environment. The objectives of this study were to determine the response of barley to different sources of organic manure.

Materials and methods

The experiment was conducted in pots in a heated glasshouse in the University of Wales, Aberystwyth. Spring barley (*Hordeum vulgare* L.) variety Charlice, was used for the study. The types of organic manure were: poultry manure, sheep manure, horse manure, cowdung, compost, and chicken manure pellets. One hundred and twenty pots were filled with a mixture of peat and 180g of each organic manure/pot (based on field application rate of 60 tonnes/ha). Seeds of spring barley were sown on the 16th of November, 2006 and pots arranged in a randomized complete block design (RCBD) with five replications. Chicken manure pellet and inorganic fertilizer were applied as top dressing at a rate of 3.0g and 2.1g pot^{-1}, respectively when designated treated plants were two weeks old. All organic fertilizer sources were analyzed for the major nutrients composition. To determine the mineralization of the organic manures, a parallel experiment with only manures in 24 pots, without plants, was set up in three replicates with the same experimental design and subjected to similar conditions as those in pots with plants. Media in pots without plants were sampled at two weeks interval and analyzed for NH_4-N and NO_3-N. Plant height was measured at two weeks interval. Chlorophyll content of 20 youngest fully expanded leave/pot was measured using a chlorophyll meter (Model SPAD 502, Minolta, Japan) at six weeks after germination when differences in leaf colour were obvious. Treatment plants were sampled at four weeks interval and at each sampling number of tillers plant^{-1}, stem dry weight, leaf dry weight, root dry weight, leaf area were determined. Bulked plant parts were ground after drying at 70^0 C for 48 hours. Total N in plant tissues was determined after Kjeldahl digestion and dilution with an Autoanalyzer (Bran+Luebbe, Norderstedt, Germany). Nitrate-N and NH_4-N in growth media were extracted in 2M KCL and analyzed on the Autoanalyzer.

Data collected on plant height, leaf area plant^{-1}, number of tillers plant^{-1}, chlorophyll content of leaves, leaf dry weight plant^{-1}, stem dry weight plant^{-1}, root dry weight plant^{-1}, total N mineralized and plant tissue nutrient content were statistically analyzed using the GENSTAT v.9.

Results and discussion

The content of NPK of the organic manures varied (Table 1) and N and P content was highest for chicken manure pellet. Plant height increased with organic manure application (Table 2) though at two weeks after germination, plants growing in compost chicken manure and cowdung were the shortest (data not shown). This observation could be attributed to the delayed seed germination (2-3 days) observed in these media and possibly the slower decomposition and release of nutrients to support growth. By the twelve week after germination plants growing in any source of nutrients were similar in height and taller than control plants (data not presented). At this stage, plants growing in chicken manure, cowdung, horse manure and sheep manure were taller than plants treated with inorganic fertilizer. Ghosh and Sharma (1990) reported that the application of organic manures increased the height of rice plants.

Four weeks after germination only inorganic fertilizer, horse manure and sheep manure were observed to have significantly increased tillering (Table 3). Plants growing in chicken manure medium had most tillers (7) at twelve weeks after germination. Though number of tillers per plants in the other organic manure media, except compost, was more than the control, the difference was not significant. At eight weeks after germination, significantly higher number of tillers was observed in plants growing in chicken manure (5.5) and cowdung (3.8). At this stage, with the exception of plants growing in chicken manure pellet and compost, plants growing in any source of nutrient had higher number of tillers than the control. Ofori et al (2005) and Satyanarayana et al (2002) reported an increase in the number of tillers in rice with organic manure application. An increase in number of tillers per plant is important since it may contribute to the number of grains and hence yield of barley (Grupo et al 1995). Application of organic

Table 2. Effect of organic manure on plant height of spring barley (cm)

Treatment	Weeks after germination				
	Week 2	Week 4	Week 6	Week 8	Week 10
Control	11.5 ab	19.2	43.5	58.8	58.9
Inorganic Fertilizer	11.2 b	24.2	46.1	65.3	65.4
Chicken Manure	7.5 c	16.1	34.3	63.7	69.2
Chicken Manure Pellet	11.6 ab	22.2	42.6	61.6	61.6
Cowdung	7.8 c	17.7	41.1	65.6	69.7
Compost	4.2 c	10.4	19.6	28.9	54.7
Horse Manure	12.3 a	24.9	50.7	69.5	69.7
Sheep Manure	12.3 a	24.9	52.1	67.2	69.5
LSD (5%)	0.90	1.88	5.78	5.43	4.36

Table 3. Effect of organic manure on the number of tillers plant^{-1} of spring barley

Treatment	Four weeks after germination	Eight weeks after germination	Twelve weeks after germination
Control	1.5c	2.7c	1.6e
Inorganic Fertilizer	2.9a	3.4b	3.4d
Chicken manure	2.1c	5.5a	7.1a
Chicken Manure Pellet	2.2c	2.6c	2.4d
Cowdung	2.4ab	3.8b	4.7c
Compost	1.6c	2.2c	6.0b
Horse manure	3.1a	3.3b	3.0d
Sheep Manure	2.8a	3.1b	3.0d
LSD (5%)	0.62	1.03	0.93

manure, especially sheep manure, resulted in a significant increase in chlorophyll content of barley leaves (Table 4). Except chicken manure pellet, cowdung and compost, the application of organic manure resulted in higher leaf chlorophyll content than inorganic fertilizer. The chlorophyll content can potentially provide an estimate of the N status of crops (Matsuzaki et al., 1980). The significantly higher chlorophyll content of barley leaves observed in the pots with organic manures could be due to differences in nitrogen content of the organics manures and its uptake (Fig 2). The greater chlorophyll values in leaves on plots treated with organic manure are of importance because photosynthetic activity and crop yield may increase with increased chlorophyll content of leaves (William et al*.,* 1990; Ramesh et al., 2002).

Spring barley plants grown with organic manure, except cowdung, compost and chicken manure, produced significantly greater leaf area at four weeks after germination than the control (Table 5). A number of researchers have reported an increase in leaf area of plants with the application of organic manure (Rao and Shaktawat, 2001, van Delden, 2001). Horse manure fertilized plants produced the highest leaf area plant^{-1}. Plants growing in chicken manure, cowdung and especially in compost had few leaves (data not shown) and subsequently the lowest leaf area per plant with the least recorded for compost plants. Plants growing in horse manure had the highest leaf area per plant at this stage. It is noteworthy that plants growing in any fertilizer treatment, except cowdung, chicken manure and compost, at this stage also had higher leaf area per plant than control plants.

Table 4. Effect of organic manure on leaf chlorophyll content

Treatment	Chlorophyll content (SPAD)
Control	28.10c
Inorganic Fertilizer	33.86b
Chicken Manure	34.10b
Chicken Manure Pellet	33.56b
Cowdung	32.24b
Compost	33.62b
Horse Manure	37.80a
Sheep Manure	39.36a
LSD (5%)	3.25

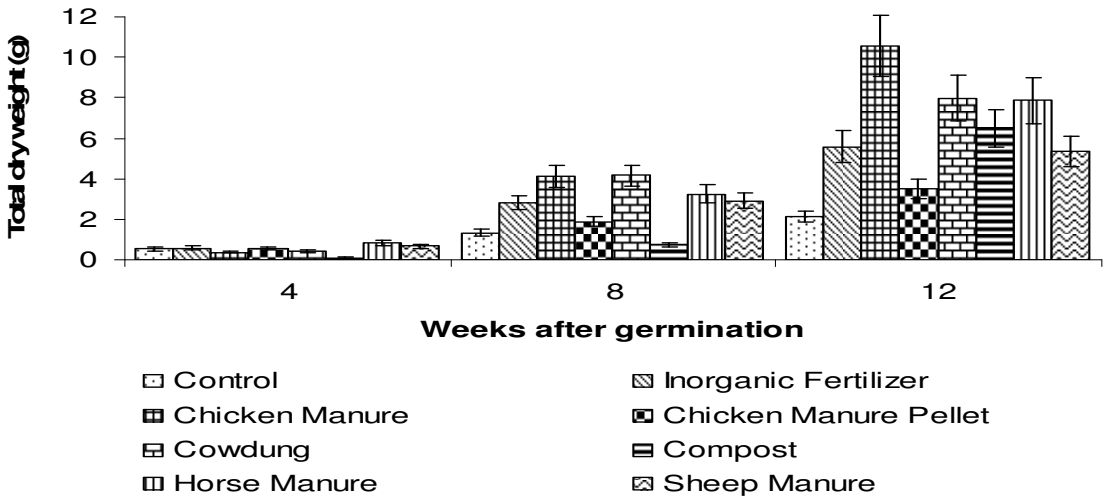

Fig 1. The effect of organic manure on total dry matter production in barley

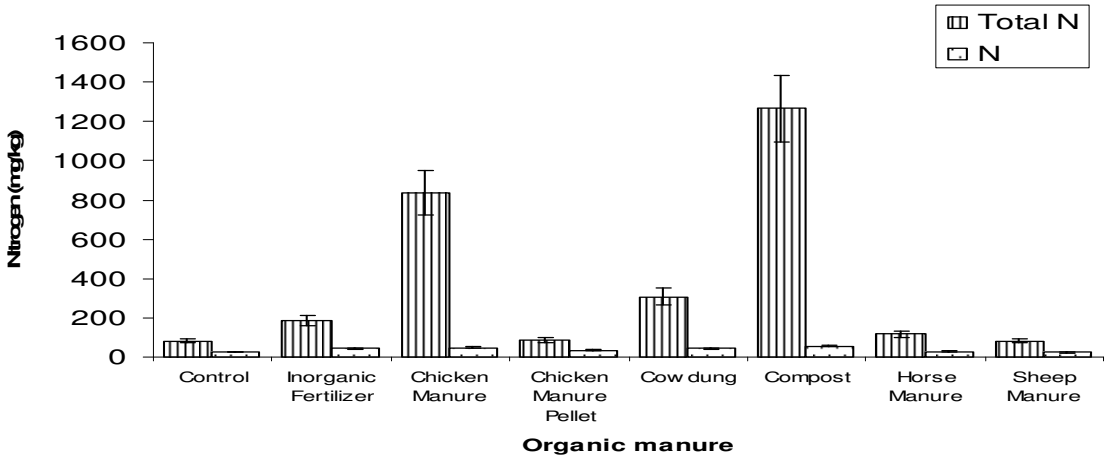

Fig 2. Total N mineralized from organic manure and N uptake by barley plants

At eight weeks after germination, plants growing in cowdung were observed to have the highest leaf area per plant with the least recorded for control plants. Increased leaf area has implications for light interception and dry matter production to support plant growth and yield (Vargas, 2002; Board, 2004).

The various nutrient sources applied resulted in increased total dry matter accumulation in plant (Fig 1). Generally, dry matter accumulation in plants growing under chicken manure was the highest at twelve weeks. Total plant dry weight was increased by 1.6 to 5-fold under organic manure (Table 6). Except for compost, organic manure treatments increased head dry weight by 1.5 to 4-fold and had the potential of increasing grain yield of spring barley. Among the organic sources, cowdung had the greatest effect on the reproductive development of the crop with plants growing in this source of nutrient producing head weight of 3.77 g plant^{-1} (Table 6). The superiority of cowdung to the other sources of organic manure and inorganic fertilizer may be attributed to balanced and gradual release of plant nutrients and increased nutrient

Table 5. Effect organic manure on leaf area plant^{-1} of spring barley (cm^2)

Treatment	Four weeks after germination	Eight weeks after germination
Control	116.5bc	21.3bc
Inorganic Fertilizer	150.6b	90.7b
Chicken Manure	88.8c	373.9a
Chicken Manure Pellet	137.1b	26.5bc
Cowdung	88.7c	395.5a
Compost	15.8d	69.4b
Horse Manure	191.9a	72.2b
Sheep Manure	148.1b	93.3b
LSD (5%)	31.19	59.88

Table 6. Effect of organic manure of plant dry weight of spring barley (g)

Treatment	Twelve weeks after germination				
	Leaf	Stem	Root	Head	Total dry weight
Control	0.56c	0.52e	0.12d	0.93cd	2.12d
Inorganic Fertilizer	1.22b	1.43d	0.36c	2.66b	5.57c
Chicken Manure	2.41a	5.14a	0.74a	2.37b	10.56a
Chicken Manure Pellet	0.83bc	1.01d	0.19cd	1.46c	3.50d
Cowdung	1.33b	3.30b	0.34c	3.77a	7.97b
Compost	2.11a	3.19c	0.52b	0.56cd	6.51b
Horse Manure	0.92bc	1.80d	0.36c	2.79b	7.87b
Sheep Manure	0.61bc	1.65d	0.24cd	2.82b	5.32c
LSD (5%)	0.39	0.78	0.15	0.76	1.80

uptake to support growth(Fig 2). Tamal and Sinha (2006) reported an increase in grain yield of rice by applying organic manure.

Mineralization of organic manure

Indeed, one of the most important considerations in efforts to reduce N leaching from agricultural soils

is to supply the crop with N when it is needed and to avoid large amount of N in soil when no crop is growing. Eghball (2000) reported differences in N mineralized from organic manure sources. In this study the N mineralized from all the organic manures was higher than N taken up by plants and presents possible leaching of excess N into the environment. In general, the amount of NH_4-N was highest earlier during incubation and may be due to the decomposition of very labile organic N (Sierra, 1990). This observation can be attributed to the conversion of NH_4-N to NO_3-N and possibly losses through volatilization. After twelve weeks of incubation the media amended with compost had the highest total N among the organic manures with the least in sheep manure. The cumulative inorganic N mineralized (NH_4-N +NO_3^-N) varied with the type of organic manure (Fig 2). Among the amended media, N mineralization potential was highest in medium amended with compost and lowest in that amended with sheep manure. The decrease in mineralization later on during incubation may be ascribed to the disappearance of more labile N and the dominance of the more recalcitrant organic N (Sierra, 1990).

Plant Tissue Analysis

During the experimental period, the manure-amended pots produced barley plants with different N content than the control. Plant tissue N content related positively to the amount of mineralized N in the growing media. Manure application resulted in 1.2 to 1.6-fold, 1.1 to 4-fold and 1.1 to 4.1-fold increases in tissue N content at four weeks, eight weeks and twelve weeks after germination, respectively (Fig 2).

Conclusion

The study showed that organic manure application in spring barley production resulted in increased plant height, chlorophyll content of leaves, dry matter accumulation and nutrient uptake by plants. Mineralization of organic manures and nutrient uptake by plants indicate that the rate of application of organic manures used in the study may present a risk to leaching. Knowledge of mineralization obtained in this study should serve as a guide to the best time to apply the organic manures for better utilization by barley. Cowdung was observed to be the best source of organic manure for spring barley production since plants produced the highest head weight when supplied with cowdung.

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