Research Article

Growth of wheat as affected by fresh and composted poultry manure, urea and beneficial microbes

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Abstract

Organic manures can be used to increase crop growth, productivity and sustainability. Organic manures applications without processing have low potential to supply nutrients in short time. In this experiment different treatments were applied as source of nitrogen and 120 kg N ha⁻¹ was desired from each single treatment or combination of treatments. The different treatments were comprised of poultry manure composted (PMC) for various durations i.e. 5, 10, 15 and 20 days. Two composting conditions were used i.e. one sole composted poultry manure and the other was integrated with half nitrogen from urea. Beneficial microbes (BM) were applied in two levels i.e. no BM and 50 L ha⁻¹. Sole treatment of poultry manure only, machine compost, urea only, a combination of urea and poultry manure in 50:50 ratio and a control treatment for mean comparisons were also used. The results of the experiment indicated that different composting duration significantly affected days to anthesis, leaf area tiller⁻¹, leaf area index, days to maturity and plant height. Higher values were recorded with compost duration of 15 days except days to anthesis and plant height which were higher with compost duration of 20 days. Moreover addition of compost along with urea in 50:50 ratio increased days to anthesis, leaf area, leaf area index, days to maturity and plant height. Application of beneficial microorganisms at the rate of 50 L ha⁻¹ increased crop growth. The fertilized treatment in comparison with control treatment was found superior in terms of growth. The pit compost in comparison with machine compost performs better and increased growth and yield. It is concluded that compost duration of 15 days when applied in 50:50 ratio with urea increased crop growth and yield and thus recommended for general cultivation of wheat crop.

Keywords: Beneficial microbes; Composted poultry manure; Fresh poultry manure; Growth; Wheat and Urea

Introduction

Wheat (*Triticum aestivum* L.) is most important crop amongst the cereals in terms of production and consumption. Wheat was cultivated on about 9.25 million ha with total production of 25.5 million ton, having an average yield of 2873 kg ha⁻¹ while in Khyber Pakhtunkhwa province area under cultivation was 0.75 million ha having production of about 1.4 million ton with the

average yield of 2359 kg ha⁻¹ [1]. In Asia Pakistan is the third-largest producer of wheat where annual consumption of wheat is around 23 million ton that will leave the country with a surplus of a few ton that can be exported [2]. With rapidly increasing population rate generally in world and specifically in Pakistan food and feed shortages are being faced. But the resources

available for wheat production are likely to be significantly lower [3].

The use of chemical fertilizer was at its top after that period which resulted in soil depletion and contamination of environment and increasing production cost [4]. Soil depletion is a major factor in low crop productivity and continuous use of chemical fertilizer is not only hazardous for health but also cause nutrient depletion in soil. The applied chemical fertilizer mostly leach down and contaminate the ground water which is the main source of drinking water and lead to cause certain disorders in human [5].

Different waste materials generated on different types of farms including farmyard manure, poultry manure, animal excreta, green manure and crop residues which are best option to substitute chemical fertilizer when utilize in an efficient way [6]. Several researchers had reported the beneficial effects of these organic materials when used as fertilizer. It not only improves crop productivity but also improves soil health and properties [7].

Since soil fertility is the main factor in boosting crop production, therefore it is a prerequisite to improve soil health and fertility in order to achieve sustainability in crop production on long term basis. This is neither possible with applying chemical fertilizer only nor with application of organic manures only [8]. Therefore integrated approaches should be practiced by combine use of organic and inorganic fertilizers which not only increase crop yield on sustainable basis but also will improve soil properties and nutrient status [9]. Application of synthetic fertilizer along with composted organic material increased yield as well as nutrient uptake by wheat as compared to inorganic fertilizer alone [10].

Organic farming is a practice to achieve sustainability in crop production without endangering soil properties, rather improving it. In this type of farming normally different composts, organic manures and their extracts are used in order to enhance soil fertility and opposing various

kind of diseases and pests [11]. These sources had a significant effects on crop quality and production potential [12]. Use combine application of fertilizers and manures is a traditional method to improve soil fertility and enhance crop yield [13]. Compost application increase soil microbial activities and enhance nutrient and carbon concentration in soils [14]. Organic manure acts as sponge in soil and thus improves soil water and nutrient holding capacity by improving soil physical properties, in accompanied with increasing soil fertility, organic manures also improve crop growth rate and water use efficiency [15]. Compost application improves germination of seeds and dry matter yield of crop as compared to no compost application [16].

Keeping in view the importance of composts, poultry manure, urea and beneficial microorganisms the current research was conducted to evaluate the efficacy of these factors for higher wheat productivity.

Materials and methods

To evaluate the “effect of fresh and composted poultry manure, urea and beneficial microbes on growth of wheat” an experiment was conducted at Agronomy Research Farm, The University of Agriculture Peshawar Pakistan, during fall 2016-2017. The experiment was laid out in randomize complete block design (RCBD) having three replications. The organic sources were analyzed for N and P content. Fully composted and partially composted poultry manure were applied at the rate of 5.21 t ha⁻¹ and poultry manure sole was applied at the rate of 5.71 t ha⁻¹ to meet the required nitrogen amount 120 kg ha⁻¹. Layout was established with the plot size of 3 m x 2.4 m having 8 rows 30 cm apart from each other. Wheat variety ‘Pirsabak 2013’ was sown at the rate of 120 kg seed ha⁻¹ at proper moisture condition on November 25, 2016. All other cultural practices like irrigation, hoeing were practiced uniformly in each plot.

Preparation of compost

Pits were dug out, each pit was 1.8m long, 1.5m wide and 1m deep. The pits were

filled with poultry manure in moist condition and covered with plastic sheet. The pits were closed and poultry manure was buried for 5, 10, 15 and 20 days. The compost materials were turned over after 5 days interval in order to speed up composting process and aeration. Beneficial microbes were applied at the rate of 50 L ha⁻¹ to four pits and four pits were without beneficial microbes.

The following factors were kept in consideration:

Factor A: Compost duration (days)

5, 10, 15 and 20 days

Factor B: Composting conditions

$$\text{Emergence m}^{-2} = \frac{\text{No. of seedling counted}}{\text{Row - row distance (0.3m) x Row length (3m) x No. of rows (3)}}$$

2. Number of leaves tiller⁻¹

Number of leaves tiller⁻¹ were obtained at anthesis stage by counting the number of leaves at post anthesis stage in randomly selected 10 tillers and average was calculated.

3. Leaf area tiller⁻¹

Leaf area tiller⁻¹ was measured by collecting leaves from randomly selected

$$\text{Leaf areatiller}^{-1} = \frac{\text{No. of leaves x avg. leaf length (cm) x avg. leaf width (cm) x 0.65}}{\text{Number of tiller}}$$

4. Leaf area index

Leaf area index was calculated as the product of leaf area tiller⁻¹ and tillers m⁻² divided by 10,000. Leaf area tiller⁻¹ was calculated by multiplying the average length and width of five randomly

$$\text{Leaf area index} = \frac{\text{leaf area tiller}^{-1} \times \text{no. of tillers m}^{-2}}{10000 \text{ cm}^2}$$

5. Days to anthesis

Data on days to anthesis were recorded by counting the number of days from sowing till 80% plants reached anthesis.

6. Plant height (cm)

At physiological maturity, ten tillers were randomly measured from ground level to tip of the plant including spikes and excluding awns. Average was calculated.

7. Days to maturity

Days to maturity data were collected by counting the number of days from sowing

Compost only, 50% Compost and 50% urea

Factor C: Beneficial microorganisms

Control, 50 L ha⁻¹ (Applied at the time of composting)

The treatments also contain a sole treatment of poultry manure, sole urea, mix treatment (50% urea + 50% poultry manure), machine compost and a control treatment with no N fertilizer and BM for comparison.

Procedure for recording data

1. Emergence m⁻²

Emergence data was recorded by counting number of plants emerged in one meter long row at three random places in each plot and were converted using the given formula:

five tillers in each plot in four central rows at anthesis stage. Their leaf area was calculated by multiplying the product of average leaf length (excluding leaf sheath) and average leaf width with correction factor [17] and total number of leaves which was then divided by the number of tillers to get the leaf area tiller⁻¹.

selected tillers with correction factor (0.65). Tiller m⁻² were calculated by counting the number of tillers in two central rows in each plot and was converted into m⁻².

till 80% plants reached to physiological maturity indicated by turning yellow the color of spikes [18].

Statistical analysis

The recorded data were subjected to statistical analysis using Microsoft Excel package according to randomized complete block design and means were compared using least significant difference test (LSD) at 5% level of probability upon obtaining significant F-value.

Results

Emergence m^{-2}

Emergence m^{-2} of wheat was non-significantly affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), machine vs pit compost, control vs fertilized, poultry manure (PM) vs urea, PM vs mixed, urea vs mixed and interaction between BM and fertilizer (F) treatments (Table 1).

Number of leaves tiller $^{-1}$

Number of leaves tiller $^{-1}$ of wheat were non significantly affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), machine vs pit compost, control vs fertilized, PM vs urea, PM vs mixed, urea vs mixed and interaction between BM and fertilizer (F) treatments (Table 2).

Leaf area tiller $^{-1}(cm^2)$

Compost duration (D), compost condition (C), beneficial microorganisms (BM), machine vs pit compost and control vs fertilized significantly affected leaf area tiller $^{-1}$ of wheat, while PM vs urea, PM vs

mixed, urea vs mixed and the interactions between D x C and BM x F were non-significant (Table 3). Mean values of compost duration indicated that minimum leaf area tiller $^{-1}$ (108 cm^2) was recorded at compost duration of 5 days. Leaf area was decreased with increasing compost duration and greater leaf area tiller $^{-1}$ (125 cm^2) was recorded with compost duration of 15 days. Thereafter no significant increase was observed. In case of compost condition, addition of compost only produced lower leaf area (115 cm^2) compared to addition of compost along with urea in 50:50 ratio (124 cm^2).

The BM applied plots produced greater leaf area (124 cm^2) compared with no BM application (115 cm^2). The planned mean comparison revealed that greater leaf area tiller $^{-1}$ was recorded in fertilized plots (118 cm^2) compared to control plots (93 cm^2). Pit compost produced greater leaf area (119 cm^2) compared to machine compost (109 cm^2).

Table 1. Emergence m^{-2} of wheat as affected by different PM,compost duration, compost conditions and beneficial microbes

Compost duration (days)	Beneficial Microbes (BM) ($L\text{ ha}^{-1}$)		Mean
	50	0	
5	147	141	144
10	134	136	135
15	150	150	150
20	157	151	154
LSD(0.05)			ns
Compost condition			
Compost only	157	149	153
1/2 compost+1/2Urea	136	139	138
Significance			ns
Mean	147	144	ns
Planned Mean Comparisons			
Contrast	Mean 1	Mean 2	Significance
Control vs fertilized	146	145	ns
Machine vs pit compost	145	145	ns
PM vs mixed	148	137	ns
PM vs Urea	148	150	ns
Urea vs mixed	150	137	ns
Interactions			
D x C	ns		
BM x F	ns		

Table 2. Number of leaves tiller⁻¹ of wheat as affected by different PM, compost duration, compost conditions and beneficial microbes

Compost duration (days)	Beneficial Microbes (BM) (L ha ⁻¹)		Mean
	50	0	
5	6	6	6
10	7	7	7
15	6	7	6
20	6	7	6
LSD(0.05)			ns
Compost condition			
Compost only	6	6	6
1/2 compost+1/2Urea	6	7	7
Significance			ns
Mean	6	6	ns
Planned Mean Comparisons			
Contrast	Mean 1	Mean 2	Significance
Control vs fertilized	6	6	ns
Machine vs pit compost	6	6	ns
PM vs mixed	7	6	ns
PM vs Urea	7	6	ns
Urea vs mixed	6	6	ns
Interactions			
D x C	ns		
BM x F	ns		

Table 3. Leaf area tiller⁻¹ of wheat as affected by different PM,compost duration, compost conditions and beneficial microbes

Compost duration (days)	Beneficial Microbes (BM) (L ha ⁻¹)		Mean
	50	0	
5	109	106	108 c
10	122	115	119 b
15	130	120	125 a
20	136	117	126 a
LSD(0.05)			6
Compost condition			
Compost only	121	109	115 b
1/2 compost+1/2Urea	128	120	124 a
Significance			**
Mean	124 a	115 b	**
Planned Mean Comparisons			
Contrast	Mean 1	Mean 2	Significance
Control vs fertilized	93	118	**
Machine vs pit compost	109	119	**
PM vs mixed	116	117	ns
PM vs Urea	116	114	ns
Urea vs mixed	114	117	ns
Interactions			
D x C	ns		
BM x F	ns		

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test

Leaf area index (LAI)

Leaf area index (LAI) of wheat was significantly affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), control vs fertilized and interaction between D x C, while machine vs pit compost, PM vs urea, PM vs mixed, urea vs mixed and the interaction between BM and F were non-significant (Table 4). Minimum LAI (3.3) was recorded at compost duration of 5 days. LAI was decreased with increasing compost duration and greater LAI (4.0) was recorded with compost duration of 15 days. Thereafter no significant increase was observed. In case of compost condition, LAI was lower (3.4) with addition of compost only compared to addition of compost along with urea in 50:50 ratio (4.1).

The BM applied plots had greater LAI (4.0) compared with no BM application (3.5). The planned mean comparison revealed that higher LAI was recorded in fertilized plots (3.7) compared to control plots (1.9). The interaction between compost duration and condition revealed that LAI increased with increasing compost duration up to 10 days when only compost was applied and thereafter no increase was observed, however increasing compost

duration increased LAI when compost was applied along with urea (Figure 1).

Days to anthesis

Days to anthesis of wheat was significantly affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), control vs fertilized, PM vs urea and urea vs mixed, while machine vs pit compost, PM vs mix and the interactions between D x C and BM x F were found non-significant (Table 5). Mean values of the compost duration revealed that minimum days to anthesis (128) were recorded at compost duration of 5 days. Anthesis was delayed with increasing compost duration and maximum days to anthesis (130) were recorded with compost duration of 20 days. Regarding compost condition, addition of compost only took minimum days to anthesis (128) compared to addition of compost along with urea in 50:50 ratio (130).

The BM applied plots took more days to anthesis (129) compared with no BM application (128). The planned mean comparison revealed that more days to anthesis were taken by fertilized plots (129) compared to control plots (125). Urea took more days to anthesis (130) compared to PM (127) and mix (128).

Table 4. Leaf area index of wheat as affected by different PM, compost duration, compost conditions and beneficial microbes

Compost duration (days)	Beneficial Microbes (BM) (L ha ⁻¹)		Mean
	50	0	
5	3.4	3.1	3.3 c
10	3.8	3.4	3.6 b
15	4.2	3.7	4.0a
20	4.5	3.6	4.1 a
LSD(0.05)			0.2
Compost condition			
Compost only	3.6	3.1	3.4 b
1/2 compost+1/2Urea	4.4	3.8	4.1 a
Significance			**
Mean	4.0	3.5	**
Planned Mean Comparisons			
Contrast	Mean 1	Mean 2	Significance
Control vs fertilized	1.9	3.6	**
Machine vs pit compost	3.5	3.7	*
PM vs mixed	3.5	3.5	ns
PM vs Urea	3.5	3.3	ns
Urea vs mixed	3.3	3.5	ns
Interactions			
D x C	*		
BM x F	ns		

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test

Figure 1. Interaction between compost duration and compost condition for LAI of wheat

Table 5. Days to anthesis of wheat as affected by different PM,compost duration, compost conditions and beneficial microbes

Compost duration (days)	Beneficial Microbes (BM) (L ha ⁻¹)		Mean
	50	0	
5	128	128	128 c
10	129	128	129 b
15	130	129	129 b
20	130	129	130 a
LSD(0.05)			1
Compost condition			
Compost only	128	127	128
1/2 compost+1/2Urea	131	130	130
Significance			**
Mean	129	128	**
Planned Mean Comparisons			
Contrast	Mean 1	Mean 2	Significance
Control vs fertilized	125	129	**
Machine vs pit compost	128	129	ns
PM vs mixed	127	128	ns
PM vs Urea	127	130	**
Urea vs mixed	130	128	**
Interactions			
D x C	ns		
BM x F	ns		

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test

Plant height (cm)

Different compost duration (D), compost condition (C), beneficial microorganisms

(BM), control vs fertilized, machine vs pit compost, PM vs urea and urea vs mix, while PM vs mix and the interactions between D

x C and BM x F were found nonSignificantly affected plant height of wheat (Table 6). Mean values of the data regarding compost duration revealed that short stature plants (91.3 cm) were produced with compost duration of 5 days. Plant height of wheat was increased with increasing compost duration and taller plants (98.6 cm) were produced with compost duration of 20 days. In case of compost conditions, taller plants (96.4 cm) were produced with application of compost and urea in 50:50 ratio compared to addition of compost only (93.7 cm).

The BM applied plots produced taller plants (97.8 cm) compared with no BM application (92.2 cm). The planned mean comparison revealed that taller plants were

produced by fertilized plots (94.1 cm) compared to control plots (85.3 cm). Pit compost produced taller plants (95.0 cm) compared to machine compost (90.5 cm). Urea application produced taller plants (96.5 cm) compared to PM (89.4 cm) and mix (92.7 cm).

The BM applied plots produced taller plants (97.8 cm) compared with no BM application (92.2 cm). The planned mean comparison revealed that taller plants were produced by fertilized plots (94.1 cm) compared to control plots (85.3 cm). Pit compost produced taller plants (95.0 cm) compared to machine compost (90.5 cm). Urea application produced taller plants (96.5 cm) compared to PM (89.4 cm) and mix (92.7 cm).

Table 6. Plant height (cm) of wheat as affected by different PM,compost duration, compost conditions and beneficial microbes

Compost duration (days)	Beneficial Microbes (BM) (L ha ⁻¹)		Mean
	50	0	
5	94.0	88.5	91.3 c
10	96.0	92.2	94.1 b
15	99.5	92.7	96.1 b
20	101.8	95.5	98.6 a
LSD(0.05)			2.4
Compost condition			
Compost only	95.7	91.7	93.7 b
1/2 compost+1/2Urea	99.9	92.8	96.4 a
Significance			**
Mean	97.8 a	92.2 b	**
Planned Mean Comparisons			
Contrast	Mean 1	Mean 2	Significance
Control vs fertilized	85.3	94.1	**
Machine vs pit compost	90.5	95.0	**
PM vs mixed	89.4	92.7	Ns
PM vs Urea	89.4	96.5	**
Urea vs mixed	96.5	92.7	*
Interactions			
D x C	ns		
BM x F	ns		

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test

Days to maturity

Days to maturity of wheat was significantly affected by different compost duration (D), compost condition (C), beneficial

microorganisms (BM), control vs fertilized and PM vs urea, while machine vs pit compost, PM vs mix, urea vs mix and interactions between D x C and BM x F

were found non-significant (Table 7). Mean values of the compost duration revealed that minimum days to maturity (182) were recorded at compost duration of 5 days. Maturity was delayed with increasing compost duration and maximum days to maturity (184) were recorded with compost duration of 15 days. There after no significant increase was observed. Regarding compost condition, addition of compost only took minimum days to

maturity (182) compared to addition of compost along with urea in 50:50 ratio (185).

The BM applied plots took more days to maturity (184) compared with no BM application (183). The planned mean comparison revealed that more days to maturity were taken by fertilized plots (183) compared to control plots (179). Urea took more days to maturity (184) compared to PM (181).

Table 7. Days to maturity of wheat as affected by different PM,compost duration, compost conditions and beneficial microbes

Compost duration (days)	Beneficial Microbes (BM) (L ha ⁻¹)		Mean
	50	0	
5	182	182	182 c
10	184	182	183 b
15	185	184	184 a
20	184	183	184 a
LSD(0.05)			1
Compost condition			
Compost only	182	181	182 b
1/2 compost+1/2Urea	185	184	185 a
Significance			**
Mean	184	183	*
Planned Mean Comparisons			
Contrast	Mean 1	Mean 2	Significance
Control vs fertilized	179	183	**
Machine vs pit compost	183	183	ns
PM vs mixed	181	182	ns
PM vs Urea	181	184	**
Urea vs mixed	184	182	ns
Interactions			
D x C	ns		
BM x F	ns		

Means within the same category followed by different letters are significantly different at $P \leq 0.05$ using LSD test

Discussion

Emergence m⁻² of wheat was non-significantly affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), machine vs pit compost, control vs fertilized, poultry manure (PM) vs urea, PM vs mixed, urea vs mixed and interaction between BM and fertilizer (F) treatments. Its might be due to emergence depends on endosperm of seeds,

however, nutrients had little or no effect on seed emergences [19]. Our results are in line with [20-23] who stated that emergence was not affected by fresh, compost manures as well as synthetic fertilizers.

Days to anthesis and maturity of wheat was significantly affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), control vs fertilized, PM vs urea and urea vs mixed. It

might be due to repaid decomposition of organic fertilizers by beneficial microbes which may be enhanced delayed anthesis and maturity. Our results are in line with the results of [23] who reported that nitrogen is responsible for delayed anthesis and maturity when applied from organic or synthetic sources. Beneficial microbes increase decomposition rates which might have delayed anthesis and maturity of crops [24]. Organic or synthetic fertilized plots significantly delayed phenology as compared to controls plots [25].

Number of leaves tiller⁻¹ of wheat was non-significantly affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), machine vs pit compost, control vs fertilized, PM vs urea, PM vs mixed, urea vs mixed and interaction between BM and fertilizer (F) treatments. It might be due to the fact that leaves tiller⁻¹ usually influenced by genotype, nutrient provision and planting density of crop. Our results agree with [26] who reported that fertilizer had no or little effect on number of leaves tiller⁻¹.

Leaf area tiller⁻¹ and leaf area index of wheat was considerably affected by different compost duration (D), compost condition (C), beneficial microorganisms (BM), machine vs pit compost and control vs fertilized. This might be due to the fact that BM enhances organic matter decomposition in the soil which might have increased nutrient availability and thus increased leaf area and LAI of the plants. Similar results were earlier presented by [27] who stated that application of beneficial microbes increased leaf area per plant when applied with organic manures. [28] also reported that greater leaf area can be achieved with application of abundant nitrogen regardless of sources, they also stated that crop growth is mainly associated with availability of nitrogen in soils. Similarly [29] reported a significant increase in leaf area with application of fertilizers as compared to control treatment. Plant height of wheat was significantly affected by different compost duration (D),

compost condition (C), beneficial microorganisms (BM), control vs fertilized, machine vs pit compost, PM vs urea and urea vs mix. Plant height is primarily influenced by genetic variations in the genotypes but it is also influenced by nutrients supply and nutrient management practices as well as phenotypic variations [30]. The increase in plant height with addition of BM might be due to accelerated decomposition of organic matter in soil which enhanced nutrients availability to plants. Similar findings were earlier stated by [31, 27] who observed taller plants with the addition of BM. The probable reason for increase in plant height with addition of complete compost in comparison with partial compost might be the variation in C:N ratio of the feed stock which is associated with nutrients availability [32]. Likewise [33] reported taller plants with addition of urea and compost in combine form. Pit compost was proved superior to machine compost which might be due to the complete decomposition of organic material in pit as compared to machine compost [34].

Conclusion

It was concluded that compost duration of 15 days along with urea in 50:50 ratio and addition of beneficial microorganisms at the rate of 50 L ha⁻¹ increase crop growth while the pit compost was found superior as compared to machine compost. So application of 15 days older compost along with urea in 50:50 ratio with beneficial microorganisms is recommended for higher wheat productivity.

Authors' contributions

Conceived and designed the experiments: A Liaqat & F Nawaz, Performed the experiments: A Liaqat, Analyzed the data: A Liaqat, S Ullah & Z Hussain, Contributed materials/ analysis/ tools: A Liaqat, AR Khan, Wrote the paper: N Khan.

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