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Improvement in nutrient uptake and yield of wheat by combined use of urea and compost

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Abstract

Organic city wastes are recycled to prepare composts with improved physical properties and enriched with nutrients for their better utilization. Combined application of composts along with inorganic fertilizers may sustain crop productivity and soil fertility. Present study was conducted to assess the impact of 3 city waste composts (2 non-enriched and 1 enriched with 25% N requirement of crop) on the economical utilization of urea in wheat. Generally, fertilizer application along with compost increased the yield, N and P uptake by wheat compared to the fertilizer alone. Performance of the treatments was found in the order: NEC (nitrogen enriched compost) + fertilizer > non-enriched compost + fertilizer > fertilizer. The NEC along with lower fertilizer-N rate (75 mg kg^{-1} soil) was found at par with that of the highest fertilizer rate (175 mg N kg^{-1} soil) alone. The results showed that the use of NEC (200 mg kg^{-1} soil) for wheat production could be a useful tool to improve the efficiency of commercial N-fertilizer.

Key words: nutrient uptake, improved yield, integrated use, compost, urea

Introduction

Wise application of ogranic and inorganic sources of nutrients is important to decrease the sole dependence of crop production on chemical fertilizers and to promote sustainable agriculture (Swift and Woomer 1993; Millner *et al.*, 1998; Korsaeth *et al.,* 2002). The combined application of the nutrient sources is considered to decrease the losses of fertilizers to the environment and to enhance efficiency of the either source (Bauer and Black, 1994). The fertilizers are attractive due to their huge response, easy availability, transportation and application (Graham and Vance, 2000). Sole application of organic sources can not maintain and synchronize the required nutrient supply to the growing plant due to lesser quantity of mineral nutrients or time needed for their mineralization to release nutrients for plant uptake.

Combined use of the organic plus inorganic inputs could be a way to ensure soil productivity at a higher level than the expected additive effects of either input by itself. Addition of organic matter to soil not only provide plant available nutrients on its decomposition but also offer an energy (carbon) source to the soil ecosystem and build soil fertility and structure in the long run (Harmsen *et al.*, 1994). Their use may increase soil microbial activity and nutrient cycling and may reduce nutrient loss either from the soil (N leaching and denitrification) or within the soil (P sorption) (Stevenson, 1994; Zahir *et al.*, 2007). The beneficial effects of the organic source thus compel to be combined along with fertilizer to improve the efficiency of the later one and recycle certain natural nutrient pools to promote sustainable soil fertility and crop production (Ahmed *et al.*, 2006, 2008). Organic inputs have already been introduced recently as compost manufactured from the municipal wastes (Zahir *et al.*, 2007). The research is, however, needed to optimize fertilizer and compost application to synchronize plant nutrient demand. The present studies focused to economize inorganic N application to wheat by evaluating the effect of combined use of composts along with different rates of nitrogen on nutrients uptake and growth of wheat.

Materials and Methods

Experimental site

The experiment was conducted in the greenhouse of Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad. Soil was collected from the experimental area of the institute.

Soil analysis

The soil was air dried, ground and passed through a 2 mm sieve to fill in pots and to determine the physical and chemical properties (Table 1). The soil saturated paste was prepared to determine the water holding capacity of the soil (Rhoades, 1982). It was analyzed for texture by hydrometer

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method (Moodie *et al.*, 1959) and organic matter by Walkley and Black method (Walkley and Black, 1934). Soil chemical properties like pH_s and electrical conductivity (EC_e) were determined using saturated paste and extract of soil, respectively, (U.S. Salinity Lab. Staff, 1954). Phosphorus was extracted by 0.5*M* $NaHCO_3$ and determined using spectrophotometer (Watanabe and Olsen, 1965) while total mineral N was determined using 2 *N* KCl extract (Keeney and Nelson, 1982).

Table 1: Physical and chemical properties of the soil used

Soil property	Unit	Value
pH_s	-	8.3
EC_e	dS m^{-1}	2.5
Water holding capacity	%	33.2
Total mineral N	mg kg^{-1}	8.0
Organic matter	%	0.58
Olsen's P	mg kg^{-1}	5.1
Clay	%	22.5 %
Silt	%	18.0 %
Sand	%	59.5 %
Textural class	-	Sandy clay loam

Compost analysis

The composts were analyzed for C (Nelson and Sommers, 1996), N, P and K (Van Schouwenberg and Walinge, 1973) and their ratios i.e. C/N, C/P and C/K were also calculated. The nitrogen enriched composts contained lower C/N ratio compared to other composts (Table 2).

Table 2: Chemical analysis of composts used in the experiment

Compost	C	N	P	K	C/N	C/P	C/K
	%						
C1	23.2	2.5	0.5	1.5	9.3	51.6	15.4
C2	27.0	1.1	0.3	1.0	24.1	90.0	27.6
C3	29.0	0.8	0.2	1.1	38.7	138.1	26.1

C1, C_2 and C_3, are N enriched compost, commercial compost-1 & commercial compost-2, respectively

Experiment

The greenhouse experiment was carried out in pots containing 5 kg soil each, placed in completely randomized design with each treatment replicated three times. The treatments contained N @ 0 (control), 75, 125 and 175 mg N as urea kg^{-1} soil applied alone and along with composts i.e. C_1 (NEC: compost enriched with 25% N requirement of crop) C_2 and C_3 (Non enriched compost available in the market). The compost was applied @ 200 mg kg^{-1} soil in all the composted treatments. All the fertilizer and compost were mixed with soil before sowing. In N-enriched compost and fertilizer treatments, N application rates were calculated including the N contents of compost. The recommended basal doses of P (60 mg P_2O_5 kg^{-1} soil) as TSP and Zn (5 mg kg^{-1}) as $ZnSO_4$ were also applied. Wheat cv. Seher was sown in pots at field capacity and thinned to 4 seedlings per pot after one week of germination. The crop was irrigated on daily basis to replenish water content to 100 % field capacity and harvested at physiological maturity. The grain and straw yields were recorded and plant samples were oven dried at 70 ^oC and subsample was digested in H_2SO_4 and H_2O_2 to determine N and P uptake (Van Schouwenberg and Walinge, 1973). Significance of treatments was evaluated employing ANOVA technique (Steel and Torrie, 1993).

Results and Discussion

Results regarding the effect of N-enrichment of different composts on grain and straw yields, 1000 grain weight, grain N and P contents and their uptake are presented in Tables 3-6.

Generally combined application of compost with urea improved yield of wheat compared to urea alone (Table 3). However, compost prepared by University of Agriculture, Faisalabad (C_1) was found better in terms of grain yield production. The compost-C_1 applied with lower N rate N (75 mg N kg^{-1}) was found more effective in improving grain yield (85.8% increase over control) while the increases were smaller at higher N rates. The increases in grain yield corresponding to combined application of N and other composts (C_2 or C_3) were significantly lower than that produced by N plus C_1 application The maximum straw yield was recorded with the combined application of compost C_1 and highest N rate which was statistically equal to that with the highest rate of N application alone (Table 3). Overall, at all the levels of N application, higher straw yields were recorded with C_1 compared to C_2 and C_3. The results revealed that the combined application of N-enriched compost (C_1) and fertilizer-N was better than non N-enriched compost either applied alone or along with fertilizer and fertilizer alone. The previous studies also found the increases in yield of wheat (Zahir *et al.*, 2007; Ahmad *et al.*, 2008) and rice (Zahir *et al.*, 2007) by combined application of N-enriched compost and fertilizer-N. The utilization of N from N-enriched compost is enhanced due to better availability of nitrogen to crop from organic sources that resulted in increased biomass yield (Amor, 2007).

Interactive effect of composts and fertilizer was found non-significant on 1000 grain weight (Table 4). However, the mean value of the grain weight was higher with combined application of compost together with fertilizer than that with the fertilizer alone. The maximum 1000 grain weight was recorded with C_1 (along with the highest N

Table 3: Effect of various composts and N rates on grain and straw yield (g pot^{-1}) of wheat

Compost	0	75	125	175	Mean
	mg N kg^{-1} soil				
	Grain				
C0	5.36e	7.85d	9.25bc	9.67abc	8.03B
C1	8.06d	9.96ab	10.49a	10.56a	9.77A
C2	5.60e	8.65cd	9.21bc	10.04ab	8.38B
C3	5.10e	7.94d	8.78cd	9.73abc	7.86B
Mean	6.03C	8.60B	9.43A	10.00A	
	Straw				
C0	9.20f	12.0e	14.4d	16.0a	12.89B
C1	12.58e	14.95bcd	15.71bc	17.18a	15.11A
C2	8.09f	12.10e	14.00d	14.40d	12.15BC
C3	8.69f	12.26e	12.07e	14.60cd	11.91C
Mean	9.63D	12.83C	14.04B	15.55A	

Table 4: Effect of various composts and N rates on 1000 grain weight

Compost	1000 grain weight (g)				Mean
	0	75	125	175	
	mg N kg^{-1} soil				
C0	35.90f	37.00cde	39.00bc	43.30a	38.80B
C1	37.10cde	38.9bcd	40.10b	45.50a	40.4A
C2	36.20de	37.30cde	39.30bc	43.60a	39.1AB
C3	36.10e	37.20cde	38.90bcd	43.20a	38.9B
Mean	36.3C	37.6C	39.4B	43.9A	

Table 5: Effect of various composts and N rates on N and P content (%) of wheat

Compost	0	75	125	175	Mean
	mg N kg^{-1} soil				
	Grain P content				
C0	0.395c	0.394c	0.360d	0.362d	0.378B
C1	0.411abc	0.424abc	0.433a	0.424abc	0.423A
C2	0.406abc	0.433a	0.421abc	0.406abc	0.416A
C3	0.397c	0.399c	0.431ab	0.418abc	0.411A
Mean	0.402A	0.413A	0.411A	0.402A	
	Grain N content				
C0	1.34d	1.35cd	1.56ab	1.60a	1.46A
C1	1.54ab	1.51abc	1.56ab	1.64a	1.56A
C2	1.37cd	1.44bcd	1.56ab	1.60a	1.49A
C3	1.37cd	1.51abc	1.54ab	1.56ab	1.49A
Mean	1.40C	1.45BC	1.55AB	1.60A	

Values in a row or column followed by different letter (*lower case*) are significantly different by LSD test (p<0.05)
Values for treatment means (compost or urea) followed by different letter (*upper case*) are significantly different by LSD test (p<0.05)
C_0, C_1, C_2, & C_3, are No compost, N enriched compost, commercial compost-1 & commercial compost-2, respectively

rate). Zahir *et al.* (2007) and Ahmad *et al.* (2008) also found an increase in 1000 grain weight of wheat by the application of N-enriched compost + fertilizer-N.

The mean P content of grain showed significant improvement in P concentration in composted treatments compared to fertilizer-N alone (Table 5). While, the interactive effect of composts X fertilizer-N was found variable in accumulating P content in grain. Generally, treatments producing more biomass yield decreased in P concentration due to dilution of the nutrient and vice versa. Generally, the N content of grains was increased with increase in N rates. The combined application of compost and fertilizer improved N content of grain compared to

fertilizer alone, however, the increases were non-significant. The N-enriched compost (C_1) treatment contained maximum N content (1.64%) when combined with the highest N rate. The dilution effect was less dominant on N content of grain due to the increasing N rates. While, N and P uptake by grain increased with increasing fertilizer-N rates either because of the increase in nutrient concentration or the yield (Table 6). Generally, P uptake by grain was improved by compost application compared to fertilizer N alone. The maximum P uptake was recorded when compost-C_1 was applied along with highest N-rate. Application of N beyond 75 mg kg^{-1} had non-significant effect on P uptake. Similar to P uptake, N uptake was enhanced by increase in N-rates and compost treatment further improved the accumulation of N over that with the fertilizer-N alone. The compost-C_1 application along with 75 mg N kg^{-1} caused significant increase in N uptake over the application of C_1 alone and other composts. The studies of other scientists (Zahir *et al.*, 2007; Ahmed *et al.*, 2006; Ahmad *et al.,* 2008) also found the increase in grain N and P uptake by the combined application of compost and inorganic fertilizer. Organic material enhanced the efficiency of inorganic fertilizer due to decrease in losses of inorganic N on their mixing with organic material. While the P uptake and yield of the crop are improved by organic compound induced mobilization of native and applied nutrients.

Table 6: Effect of various composts and N rates on N and P uptake (mg pot^{-1}) by wheat

Compost	0	75	125	175	Mean
	mg N kg^{-1} soil				
	P uptake by grain				
C0	21.2g	30.9f	33.3def	35.2cdef	30.2C
C1	33.1def	42.2ab	45.5a	44.8ab	41.4A
C2	22.7g	37.5bcde	38.7bcd	40.7abc	34.9B
C3	20.3g	31.7ef	37.8bcd	40.4abc	32.5BC
Mean	24.3C	35.6B	38.8AB	40.3A	
	N uptake by grain				
C0	71.8g	106.3f	144.0bcd	155.3abc	119.3B
C1	123.8def	150.3abc	163.3ab	172.9a	152.6A
C2	76.8g	124.0def	143.7bcd	160.3ab	126.2B
C3	69.9g	120.2ef	134.9cde	150.5abc	118.9B
Mean	85.6C	125.2B	146.5A	159.8A	

Values in a row or column followed by different letter (*lower case*) are significantly different by LSD test (p<0.05)
Values for treatment means (compost or urea) followed by different letter (*upper case*) are significantly different by LSD test (p<0.05)
C_0, C_1, C_2, & C_3, are No compost, N enriched compost, commercial compost-1 & commercial compost-2, respectively

Conclusions

Fertilizer-N application along with compost improved yield and nutrient (N and P) uptake by wheat compared to the fertilizer alone. However, nitrogen-enriched compost performed better than non N-enriched composts and the former was more effective at lower N rates compared to the higher ones.

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