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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 °C 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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