RESPONSE OF MAIZE TO INTEGRATED USE OF COMPOST AND UREA FERTILIZERS

Zahir Shah, Zahid Shah, Muhammad Tariq and Muhammad Afzal

ABSTRACT

The effect of integrated use of compost and urea on yield of and N uptake by maize was assessed in a field experiment in Peshawar valley of North West Frontier Province, Pakistan during summer 2005. Urea and compost were combined in various ratios in such a way that the total N supply from both sources was 120 kg ha^{-1}. The contributions of N from the two sources were in 0:0, 100:0, 75:25, 50:50, 25:75 and 0:100 ratios. The treatments were arranged in a RCB design with four replications. Maize (variety: Jalal) was planted in rows. Data on biological, grain and stover yields of maize were recorded. Samples of grain and stover were analyzed for total N to determine its uptake by the crop. The results indicated that maximum biological (12410 kg ha^{-1}), stover (8200 kg ha^{-1}), and grain (4210 kg ha^{-1}) yields of maize were obtained in treatment receiving N from urea and compost in 75:25 ratio. The next higher yield was obtained in treatment receiving 50 % N from urea and 50 % from compost. Comparing with other fertilizer treatments, the yields were significantly lower in treatments where N from urea source was below 50 %. Similarly, the N uptake in grain (64.84 kg ha^{-1}) and stover (34.44 kg ha^{-1}) was also significantly ($P<0.05$) greater in treatments receiving 75 % N from urea and 25 % from compost. The data on crop yields and N uptake of maize in response to integrated use of urea and compost supported each other. The residual soil organic fertility after maize harvest was proportional to the level of compost used. Our data thus suggest that integrated use of urea and compost at 75:25 or 50:50 ratios (N basis) has produced maximum yields and is therefore recommended for profitable maize yield and sustainable soil fertility.

INTRODUCTION

Depletion of soil fertility is a major constraint for higher crop production in Pakistan. Most of the cultivated soils have organic matter of below 1.5 % and on the other hand, addition of organic matter is very low. Almost all farmers are relying on chemical fertilizers to remove nutrient deficiency for profitable yields. Consequently little or no accumulation of organic matter occurs in soil. A suitable combination of organic and inorganic sources of nutrients is necessary for sustainable crop yields. Nambiar (1997) reported that integrated use of organic manure and chemical fertilizers would be promising not only in providing greater stability in production, but also maintaining better soil fertility status. A long-term research revealed that the application of dung manure at 5 t ha^{-1} y^{-1} improved soil resources from degradation (Bhuiyan *et al*. 1994). In another study, Goyal *et al*. (1992) reported that the yields of pearl millet (*Pennisetum glaucum*), N uptake, and N recovery after 4 years of the experiment were greater with the combination of FYM, or sesbania green manure and urea compared with urea alone but less when wheat straw was combined with urea. The decrease in yields with wheat straw even after 4 years was related to net N immobilization that would be expected from a material with a C/N ratio of 102 (Shah and Khan, 2003). Mittal et al. (1992) found that maize yields obtained from the 100 % leucaena (*Leucaena leucocephala*) and 100 % urea treatments were similar the first 2 years but were slightly higher in the leucaena plots the third year. Yields from the 25 % Leucaena-25 % urea combinations were higher than the 100 % leucaena treatment during all 3 years suggesting the superiority of the combined application of the organic and inorganic nutrient sources. In another study, Jones et al. (1997) reported that maize yields and N use were higher for gliricidia (*Gliricidia sepium*) residues than for leucaena residues. Although having similar amounts of N, gliricidia residues resulted in a large and rapid net N mineralization while Leucaena exhibited initial net immobilization followed by net mineralization probably of higher polyphenol content in the later. Additions of inorganic N with the residues produced an increase in yields and N use efficiency with leucaena but not with gliricidia. The higher yields obtained from gliricidia was attributed mainly to better synchrony of nutrient availability to crop demand. Addition of inorganic N to leucaena improves synchrony by increasing the N supply at the initial stages of net immobilization resulting from applications of leucaena.

It is generally believed that combining organics with inorganic fertilizer will increase synchrony and reduce losses by converting inorganic N into organic forms. Studies have shown that it is not always true. For example, Janzen and Schaalje (1992) found that fertilizer N losses were twice as large as when green manure plus fertilizer was applied to barley. The interpretation was that green manure promoted high levels of nitrate and available C in the soil, enhancing denitrification. However, losses were reduced with smaller repeated applications of green manure, implying that the use of high quality green manure as partial substitution for inorganic fertilizer rather than addition to inorganic fertilizer may increase nutrient use efficiency. Xu *et al*. (1993) found large losses of

Department of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar – Pakistan

25 to 41 % of N added from leucaena prunings. They attributed this to denitrification. It was also found that losses were greater when materials were incorporated rather than surface applied (Xu *et al*., 1993; Jones *et al*., 1997). Ganry *et al*. (1978) also concluded that large applications of low quality straw can result in large losses of fertilizer N through denitrification. (Shah *et al*. 2002). These results thus indicate that N losses can be quite high from both organic and inorganic sources, contrary to the popular belief that application of organic resources will result in fewer losses.

Application of organic materials alone or in combination with inorganic fertilizer helped in proper nutrition and maintenance of soil fertility (Salim *et al*., 1988; Talashiker and Rinal, 1986). Hussain *et al.* (1988) reported that organic manures increased the efficiency of chemical fertilizers. Beneficial effects of farm yard manure on crop production through improved fertility and physical properties of soil is an established fact (Singh and Sarivastore, 1971). Shah and Ahmad (2006) recently established that combined application of urea and FYM in such a way that former contributing 75 % and later 25 % N produced the highest crop and N yields of wheat in a field experiment in Peshawar Valley.

This paper reports the influence of urea and compost in various combinations on crop and N yields of maize in Peshawar valley of North West Frontier Province, Pakistan.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of NWFP Agricultural University, Peshawar during summer 2005 to assess the influence of integrated use of urea and compost on crop and N yield of maize. Urea and compost were combined to supply total N of 120 kg ha^{-1} in different ratios i.e., 0:0 (T1), 100:0 (T2), 25:75 (T3), 50:50 (T4), 75:25 (T5), and 0:100 (T6) ratios.

The treatments were arranged in a randomized complete block design with four replications. Compost was obtained from cattle manure and municipal solid wastes. The characteristics of compost are presented in Table I. A field low in soil fertility was selected at the Research Farm of NWFP Agricultural University, Peshawar. Composite soil sample at 0-30 cm was collected from the experimental field and analyzed for soil characteristics (Table II).

The field was thoroughly prepared. Lay-out was carried out according to the experimental plan, with treatment plot size of 10 × 4 m. Urea and compost at appropriate ratios were uniformly distributed in relevant treatment plots and thoroughly mixed into the soil. Treatments (T5 and T6) requiring N from urea below 60 N ha^{-1} received all the urea N at sowing time while those (T2 and T3) requiring N from urea above 60 kg N ha^{-1}, received 60 kg N at sowing time and the remaining urea N at knee high stage. A basal dose of P at 90 kg P_2O_5 and K at 60 kg K_2O ha^{-1} was also applied to each treatment plot uniformly at the time of sowing.

After thorough seed-bed preparation and fertilizer application, maize (variety: Jalal) was planted in rows 60 cm apart on June 25, 2005. The crop was irrigated from canal when needed and weeds were removed. Furadan was applied to control stem borer. The crop was harvested at maturity and data on biological, stover and grain yields were recorded. Grain and stover samples were analyzed for total N to determine N uptake by the crop.

Soil and Plant Analysis

Total N in soil, grain and stover samples was determined by the Kjeldhal method of Bremner (1996). The mineral N (NH_4-N and NO_3-N) in soil was determined by the steam distillation method of Mulvaney (1996). Organic C in soil was determined by the Walkley-Black procedure using dichromate as oxidizing agent described in Nelson and Sommers (1996). Soil texture was determined by the Bouyocous hydrometer method (Moodie et al., 1954). Soil pH and EC were determined in soil-water suspension (1:5) with the help of pH meter (Thomas, 1996) and Electrical Conductivity Meter (Rhoades, 1996), respectively.

Statistical Analysis

The procedures of Steel *et al.* (1997) were followed for statistical analysis of the data.

RESULTS AND DISCUSSION

The results obtained on the effect of integrated use of urea and compost on yield and N uptake of maize are presented and discussed below:

Biological, Stover and Grain Yield of Maize

Biological Yield

The results showed that all fertilizer treatments significantly ($P<0.05$) increased the biological yield of maize compared with the control treatment (Table III). The maximum biological yield of 12410 kg ha^{-1} was obtained in treatment receiving N from urea and compost in 75:25 ratio followed by those receiving the same in 50:50, 100:0, and 0:100 ratio. The biological yield was minimum (3810 kg ha^{-1}) in the control receiving no urea or compost. The treatment receiving 100 % N from urea had significantly lower yield compared to those receiving N from urea and FYM in 75:25 or 50:50 ratio. The biological yield was further reduced significantly when N from urea and compost were added in 25:75 ratio. The treatment receiving 100 % N from compost and 0 % N from urea showed significantly lower yield compared with other fertilizer treatments. These results indicated that the yield of biological mass was more in response to combined application of urea and compost contributing N in 75:25 or 50:50 ratio. Reducing the level of N from urea to 25 % with 75 % that from compost was not supporting higher biological yield and resulted in significantly lower yield compared with that receiving 100 % N from urea alone. These findings are in agreement with Negi and Mahajan (2000) and Mishra (2000) who reported significant increases in wheat grain and straw yields with addition of FYM to inorganic fertilizers as compared to no FYM. Shah and Ahmad (2006) also reported profitable increase in crop and N yields of wheat with integrated use of FYM and urea fertilizers in Peshawar valley.

Stover Yield

Like biological yield, the stover yield of maize was also significantly greater in treatment receiving N from urea and compost in 75:25 ratio followed by that receiving the same in 50:50, 100:0 and 25:75 ratios (Table III). Treatment receiving 100 % N from compost without any urea was better only than the control with respect to stover yield. These results indicated that under the given experimental conditions, combined application of compost and urea significantly improved stover yield of maize only when the N contribution from urea was 50 % or greater. Compost alone did not prove as effective as urea alone. Reducing the level of N from urea source to 25 % with the remaining from compost did not produce higher stover yield than treatment receiving 100 % N urea source. Urea was indicated as a quick and more potent source of N for increasing the vegetative growth as compared to compost but the combination of the two sources in 50:50 or 75:25 ratio was found more effective. Similar results were reported by Shah and Ahmad (2006) for wheat.

Grain Yield

The grain yield of maize was significantly ($P<0.05$) greater in N fertilized (from either source) than in the control treatment (Table III). Like biological or stover yields, the maximum grain yield of 4210 kg ha^{-1} was obtained in treatment receiving N from urea and compost in 75:25 ratio followed by 4090 kg in treatment receiving N from the two sources in 50:50 ratio, and values for these two treatments were not significant. Treatments receiving N solely from urea or 25 % from urea and 75 % from compost produced comparable yields but were significantly lower than in treatments 3 and 4 (T3 and T4). Treatment receiving N solely from compost produced significantly lowest grain yield compared with other fertilizer treatments. Rathore et al. (1995), Dudhat et al. (1996), Kumar and Singh (1997) and Vyas et al. (1997) reported similar observations of getting higher yields of wheat grain with combined application of FYM and inorganic fertilizers.

Nitrogen Concentration in Grain and Stover of Maize - Nitrogen Concentration in Grain

Data on N concentration in maize grain showed variable response to different fertilizer treatments (Table IV). The N concentration in grain was significantly ($P < 0.05$) greater for fertilized than for the control treatment. It was noted that maximum N concentration of 1.54 % was found in T3 receiving 75 % N from urea and 25 % from compost. The next highest N concentration of 1.50 % was found in T2 receiving 100 % N from urea and in T4 receiving 50 % N from urea and 50 % from compost. The N concentrations in maize grain for T5 and T6 were at par with that for T1. Our results are in agreement with the findings of Vyas *et al*. (1997) who reported that application of FYM significantly increased N uptake and grain and straw yields of wheat. Also the application of N and P fertilizers significantly improved the grain and straw yields of wheat and protein content in its grain.

Nitrogen Concentration in Stover

The N concentration in maize stover was not affected significantly by any of the fertilizer treatments (Table IV). Although N concentration in stover was somehow greater in fertilized compared with the control treatment, differences between the corresponding treatments were statistically non-significant. The maximum N concentration of 0.47 % in stover was observed in T4 followed by 0.45 % in T2, 0.44 % in T5, 0.42 % in T3, 0.40 % in T6 and 0.35 % in T1. The N concentration in stover showed little variability among treatments probably most of the N from stover has been translocated to grains by the time of crop maturity.

Nitrogen Uptake in Grain and Straw of Maize
Nitrogen Uptake in Grain

Nitrogen uptake in maize grain and stover (total crop uptake) followed similar pattern of response to various combinations of fertilizer treatments (Table V). The results showed that N uptake by maize crop were significantly greater in N fertilized than in the control treatment. The maximum N uptake of 99.28 kg ha^{-1} by maize crop was obtained in treatment (T3) receiving 75 % N from urea and 25 % from compost. The treatment (T4) receiving 50 % N each from urea and compost produced comparable results with T3. The next highest N uptake was obtained in T2 and T5. Significantly lowest N uptake was obtained in treatment (T6) receiving 100 % N from compost comparing with other fertilizer treatments.

These observations are in accordance with those of Metwally and Khamis (1998) who reported that combination of organic and inorganic N resulted in greater values of apparent net N release than those obtained when each was applied singly. They also reported that N requirements of wheat could not be met by solely from FYM. Their observation that the best mixture ratio between organic and inorganic N sources was 1:1, partially agreed with our findings.

These results suggested that integrated use of urea and compost performed better than the use of urea or compost alone in terms of improving crop and N yields of maize despite the fact that the level of applied N was same i.e. 120 kg N ha^{-1} either alone from urea, compost or combinations of both. The combined application of urea and compost at 75:25 or 50:50 ratio based on net N contribution produced better results.

Soil Organic Fertility at Harvest Stage

The soil analysis after maize harvest showed that mineral N content of soil was significantly greater in the N fertilized than in the control treatment (Table VI). The maximum mineral N content of 25.42 mg kg^{-1} soil was obtained in treatment receiving 100 % N from compost followed by 22.52 mg in treatment receiving 75 % N from compost and 25 % from urea, and in both cases the values were significantly greater than that in other N fertilized treatments.

Total N content of soil was also highest in treatment receiving 100 % N from compost or 75 % from compost and 25 % from urea. The next highest value for total N was obtained for treatment receiving 50 % N each from compost and urea. Total N content of soil in other N fertilized treatments was at par with the control treatment.

Like N, the organic matter content of soil was also highest in treatments receiving 100 % N from compost or 75 % N from compost and 25 % from urea. Organic matter contents in the remaining fertilizer treatments were at par with that in the control treatment.

CONCLUSIONS AND RECOMMENDATIONS

Our results suggested that the integrated use of urea and compost performed better than the use of urea or compost alone in terms of improving crop and N yields of maize despite the fact that the level of applied N was same i.e. 120 kg N ha^{-1} either alone from urea, compost or combinations of both. The combination of urea and compost at 75:25 or 50:50 ratio based on net N contribution produced better results and is therefore recommended for optimum maize production.

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Table I. ***Some chemical characteristics of compost (dry weight basis) used in the study***

Analysis	Unit	Value
Total N	g kg^{-1}	17.3
NH_4-N	mg kg^{-1}	14.0
NO_3-N	mg kg^{-1}	84.0
Total P	g kg^{-1}	5.8
Total K	g kg^{-1}	9.3
Total Zn	mg kg^{-1}	70.4
Total Cu	mg kg^{-1}	16.6
pH	-	7.3
EC	dS m^{-1}	0.8

Table II. Some *characteristics of soil of the experimental site*

Characteristic	Unit	Value
Clay	%	33.60
Silt	%	54.10
Sand	%	12.30
Textural class	-	Silty Clay Loam
pH (1:5)	-	8.20
E.C (1:5)	dSm^{-1}	0.12
Organic matter	%	0.76
Total N	%	0.06
Total mineral N	mg kg^{-1} soil	12.60

Table III. ***Biological, grain and stover yield of maize as affected by integrated use of urea and compost***

No	Treatment		Biological	Stover	Grain
	%N from urea	%N from compost	Yield kg ha^{-1}		
T1	0	0	3810 f	2830 e	980 d
T2	100	0	11000 c	7430 c	3570 b
T3	75	25	12410 a	8200 a	4210 a
T4	50	50	11935 b	7845 b	4090 a
T5	25	75	10550 d	7210 c	3340 b
T6	0	100	9350 e	6500 d	2850 c
	LSD		386.0	270.5	350.8

Means with different alphabets in the same column indicate significant difference (α=0.05)

Table IV. ***Nitrogen concentration in grain and stover of maize as affected by integrated use of urea and compost***

No	Treatment		Grain	Stover
	%N from urea	%N from compost	% N	
T1	0	0	1.35 b	0.38^{ns}
T2	100	0	1.50 a	0.45
T3	75	25	1.54 a	0.42
T4	50	50	1.50 a	0.47
T5	25	75	1.45 a	0.44
T6	0	100	1.42 ab	0.4 0
	LSD		0.15	0.08

Means with different alphabets in the same column indicate significant difference (α=0.05)

Table V. ***Total N uptake in grain and stover of maize as affected by integrated use of urea and compost***

No	Treatment		Grain	Stover	Total uptake
	%N from urea	%N from compost	kg N ha^{-1}		
T1	0	0	13.23 d	10.75 c	23.98 d
T2	100	0	53.55 b	33.44 a	86.99 b
T3	75	25	64.84 a	34.44 a	99.28 a
T4	50	50	61.35 a	36.87 a	98.22 a
T5	25	75	48.43 b	31.72 a	80.15 b
T6	0	100	40.47 c	26.00 b	66.47 c
LSD			8.50	5.24	10.44

Means with different alphabets in the same column indicate significant difference (α=0.05)

Table VI. ***Soil organic fertility (0-10 cm) at harvest stage of maize***

No	Treatment		Mineral N (mg kg^{-1} soil)	Total N (%)	Organic matter (%)
	%N from urea	%N from compost			
T1	0	0	4.80 e	0.061 d	0.854 c
T2	100	0	10.50 d	0.063 d	0.882 c
T3	75	25	14.30 c	0.072 cd	1.008 c
T4	50	50	18.48 b	0.078 be	1.092 bc
T5	25	75	22.52 a	0.080 ab	1.080 ab
T6	0	100	25.42 a	0.085 a	1.120 a
LSD			3.50	0.022	0.053

Means with different alphabets in the same column indicate significant difference (α=0.05)

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