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Effect of organic manures and chemical fertilizers on grain yield of maize in rainfed area

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Abstract

A field experiment was conducted to study the effects of different rates of farm yard manure (FYM), poultry manure (PM), sewage sludge (SS) and chemical fertilizers on grain yield and NPK uptake of maize plants. The chemical fertilizers and different organic manures were incorporated in soil individually and in combination, before sowing the maize crop variety Agaiti 85. The experiment was carried out under Randomised Complete Block Design (RCBD) with 3 repeats. The results revealed that PM significantly enhanced grain yield of maize when applied alone or in combination with half of recommended chemical fertilizer as compared to FYM, SS and NP fertilizers. However, organic manures (FYM, SS) performed significantly well when applied in combination with chemical fertilizers. The maximum increase in NP uptake was observed with the application of chemical fertilizer (NP) @ 90- 60 kg ha^{-1} and K uptake with PM alone.

Key Words: Chemical fertilizers, poultry manure, FYM, sewage sludge, maize

Introduction

To meet the food requirements of ever increasing human population, there is a great need of high crop productivity rate, which is only possible when soil is fertile. To keep the soil fertile and to get maximum yield, farmers exercise many practices. Commonly used practice is application of chemical fertilizers, but rising cost of chemical fertilizers and their timely availability, is a constraint in their adequate use. Therefore, use of organic manures to supplement chemical fertilizers is essential to maintain a good soil fertility level (Jama *et al*., 1997).

In recent years, organic materials like poultry manure (PM) and sewage sludge (SS), at some places, are coming into use of the farmers. Studies have shown that soil application of organic material, such as SS compost etc. increased plant growth mainly because they contain considerable quantities of plant nutrients, including micronutrients, and help in improvement of physical properties of soil (Epstein *et al*., 1976; Pagliai *et al*., 1981; Korentajer, 1991; Bolan *et al*., 2004). Farm yard manure (FYM), poultry manure (PM) and sewage sludge (SS) are the waste products of livestock, commercial poultry farm and sewage treatment plants, respectively. These organic manures provide almost all the essential plant nutrients including trace elements. Application of FYM was found useful in increasing the yield of maize and wheat by 27 and 20%, respectively (Mahajan, 1996).

At present, the sewage treatment plants are working at Islamadad and Karachi in Pakistan. In these plants, sewage (waste water) is treated to remove suspended solids and subjected to a digestion process that stabilizes the waste. With the introduction of more sewage treatment plants, in future, more sewage sludge will be available for disposal. Disposal of sewage sludge in itself is a problem. Different disposal alternatives available are incineration, ocean disposal, land fills and land utilization but these are costly. Since SS is a source of organic matter and essential plant nutrients, therefore, its disposal on agricultural land is being considered more feasible. Rao and Shantaram (1996) observed increase in maize yield, due to application of sewage sludge (SS). The PM and SS are recent introduction and needs their comparative evaluation with the traditionally used FYM and chemical fertilizers so that it could be used more efficiently either alone or in combination with chemical fertilizers. A study was therefore, carried out to evaluate the yield performance of maize at different rates of FYM, PM, SS and chemical fertilizers and compare effects of these amendments applied individually and in combination on total N, available-P and extractable- K in plants, grain and soil.

Materials and Methods

A field experiment was conducted at the research farm of University of Arid Agriculture Rawalpindi, during the year 2005-06. Before the application of treatments, the experimental sites were sampled, air dried, ground, passed through 2mm sieve and analysed for physical and chemical characteristics (Table 1). The soil textural class was computed as per method described by Bouycous (1962). The soil samples were subjected to analysis for pH, ECe and organic matter (Page *et al*., 1982), total nitrogen (Hussain

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and Jabbar, 1985) and soil available P and K (Soltanpour and Workman, 1979).

The sewage sludge (SS), poultry manure (PM) and farm yard manure (FYM) were collected from sewage treatment plant Islamabad, Poultry Research Institute, Rawalpindi and Rawat village, Rawalpindi, respectively, and analysed for total nitrogen, phosphorus and potassium (Table 2). The experiment was conducted under RCBD with the following treatments repeated 3 times.

1 Control
2 NP @ 90- 60 kg ha^{-1}
3 Farm Yard Manure (FYM) @ 20 t ha^{-1}
4 Poultry Manure (PM) @ 20 t ha^{-1}
5 Sewage Sludge (SS) @ 20 t ha^{-1}
6 ½ NP + ½ FYM
7 ½ NP + ½ PM
8 ½ NP + ½ SS

The field was prepared by one ploughing followed by planking and two ploughings by cultivator. All the treatments of NP, FYM, PM and SS were applied before sowing. Urea and DAP were used as sources for N and P, respectively. The net plot size was 4.5 x 5 m for all the treatments. Maize variety Agaiti- 85 was sown and weeds were manually removed during crop growth. The data collected for various variables was subjected to statistical analysis using the analysis of variance technique (Steel *et al*., 1997).

Results and Discussion

The data regarding the effects of various treatments on grain yield of maize are presented in Table 3. The results revealed that significant increase in grain yield over control was obtained with the application of PM @ 20 t ha^{-1}, ½ NP + ½ PM, ½ NP + ½ FYM and ½ NP + ½ SS. Application of NP fertilizers, SS and FYM did not increase the maize yield alone, however, SS, PM and FYM were equally effective in

Table 1. Presowing soil analysis

Sr. No.	Particulars	Units	Values
1	pH		7.6
2	ECe	dS m^{-1}	0.26
3	Organic matter	%	0.61
4	Total Nitrogen	%	0.023
5	Avaialable Phosphorus	mg kg^{-1}	2.02
6	Avaialable Potassium	mg kg^{-1}	100
7	Sand	%	43
8	Silt	%	37
9	Clay	%	20
10	Textural Class	Loamy	

Table 2. Nitrogen, phosphorus and potassium contents in sewage sludge (SS), farm yard manure (FYM) and poultry manure (PM)

Sr. No.	Nutrients (mg kg^{-1})	Sewage Sludge (SS)	Farm Yard Manure (FYM)	Poultry Manure (PM)
1	Total nitrogen	7.92	6.2	28.3
2	Available P	6.98	2.4	16.82
3	Available- K	0.01	5.3	22.6

Table 3. Effects of NP and organic manures on grain yield of maize

(Average of 3 repeats)

Sr. No.	Treatments	Maize grain yield (kg ha^{-1})	Percent increase over control
1	Control	1219 b*	-
2	NP @ 90-60 kg ha^{-1}	1476 b	21.08
3	Farm Yard Manure (FYM) @ 20 t ha^{-1}	1302 b	6.81
4	Poultry Manure (PM) @ 20 t ha^{-1}	2338 a	91.80
5	Sewage Sludge (SS) @ 20 t ha^{-1}	1276 b	4.68
6	½ NP +½ FYM	2303 a	88.93
7	½ NP +½ PM	2493 a	104.51
8	½ NP +½ SS	2287 a	87.62

*Means followed by same letters are statistically alike at 5% level of probability.

Table 4. Effects of NP and organic manures on NPK concentration in maize leave

(Average of 3 repeats)

Sr. No.	Treatments	N, P and K concentration (%)		
		Nitrogen	**Phosphorus**	**Potassium**
1	Control	0.65 d*	0.024 b	0.36 b
2	NP @ 90-60 kg ha^{-1}	1.46 a	0.050 a	0.40 ab
3	Farm Yard Manure (FYM) @ 20 t ha^{-1}	1.04 b	0.035 ab	0.50 ab
4	Poultry Manure (PM) @ 20 t ha^{-1}	0.79 cd	0.029 b	0.60 a
5	Sewage Sludge (SS) @ 20 t ha^{-1}	0.63 d	0.027 b	0.38 b
6	½ NP +½ FYM	1.08 b	0.031 b	0.40 ab
7	½ NP +½ PM	1.00 bc	0.034 ab	0.40 ab
8	½ NP +½ SS	0.87 bc	0.030 b	0.39 b

*Means followed by same letters are statistically alike at 5% level of probability.

Table 5. Effects of NP and organic manures on NPK concentration in maize grains

(Average of 3 repeats)

Sr. No.	Treatments	N, P and K concentration (%)		
		Nitrogen	**Phosphorus**	**Potassium**
1	Control	0.45 e*	0.002 c	0.25 a
2	NP @ 90-60 kg ha^{-1}	1.07 a	0.040 a	0.30c
3	Farm Yard Manure (FYM) @ 20 t ha^{-1}	0.96 ab	0.015 bc	0.33 c
4	Poultry Manure (PM) @ 20 t ha^{-1}	0.74 d	0.013 bc	0.52 a
5	Sewage Sludge (SS) @ 20 t ha^{-1}	0.59 e	0.007 bc	0.31 c
6	½ NP +½ FYM	0.92 bc	0.090 bc	0.41 b
7	½ NP +½ PM	0.84 bcd	0.020 b	0.39 b
8	½ NP +½ SS	0.77 cd	0.018 bc	0.39 b

*Means followed by same letters are statistically alike at 5% level of probability.

increasing maize yield when half of their doses (10 t ha^{-1}) was applied in combination with half of the recommended dose of NP fertilizer (45-30 kg ha^{-1}). Our results are in conformation with Mucheru-Muna *et al*. (2007) who reported similar trends, when different soil-incorporated organics were applied along with half of recommended rate of mineral fertilizer on yield of maize crops and recorded the highest net benefit with this combination.

Maximum increase (104% over untreated control) in grain yield was observed with the application of 10 t ha^{-1} of PM + ½ NP followed by with PM @ 20 t ha^{-1} that was 92% more than untreated control. From these results, it seems that PM can be applied to the maize crop either alone @ 20 t ha^{-1} or at half rate i.e. 10 t ha^{-1} in combination with half the dose of NP fertilizer (45-30 kg ha^{-1}). However, in case of FYM and SS, it seems that their dose (20 t ha^{-1}) could not meet nutrition requirements of NP in maize crop. Both these manures performed well when supplemented with reduced rates of NP. Nitrogen and phosphorus contents of PM had higher NP contents (4-5 times) than FYM and SS (Table 2) therefore, it could meat NP requirements when applied alone. On the other hand, FYM and SS had less NP contents, so they require supplemental NP for giving yield equivalent to PM. Although, yield from application of NP fertilizers was not significantly different from control, yet increasing trend was observed due to these fertilizers. It is speculated that availability of NP from fertilizers was not optimum probably due to lack of soil moisture during the growing season. The results are in agreement with Madhavi *et al*. (1996), Sharma and Singh (1996), Rao and Shantaram (1996).

It is evident from the data that NPK contents in maize leaves (Table 4) and maize grain (Table 5) were increased significantly by all the treatment over untreated control. The maximum contents of N (1.46%) and P (0.05%) in maize leaves were observed with NP fertilizer applied @ 90- 60 kg ha^{-1}, followed by 1.08% with ½ NP + ½ FYM whereas 0.035 and 0.034% P with the treatments containing FYM @ 20 t ha^{-1} and ½ NP + ½ PM, respectively. The highest K contents (0.60%) in maize leaves were observed with PM followed by 0.50% with FYM applied @ 20 t ha^{-1}. The results are in accordance with those of Mahajan, 1996; Tujvavalagi and Silva, 1996; who reported increased uptake of P and K by maize plants with the application of PM.

The NP and K contents of maize plants ranged from 0.45 to 1.07, 0.002 to 0.04 and 0.25 to 0.52%, respectively. The highest values of N and P contents in maize grain was observed with the application of NP @ 90- 60 kg ha^{-1},

whereas the maximum K contents of 0.52% were recorded with the application of PM @ 20 t ha^{-1} over untreated control. The performance of PM in increasing the K uptake might be due to high K contents in PM than FYM and SS (Table 2) to meet the K requirement of maize crop when applied alone.

From the above discussion, it can be suggested that PM significantly enhanced the grain yield of maize when applied individually or in combination with chemical fertilizer. The FYM, SS and NP fertilizer did not significantly increase the maize grain yield when applied individually. However, they performed well when applied in combination of chemical fertilizer. The maximum increase in NP was observed with the application of NP @ 90- 60 kg ha^{-1} and K uptake with PM alone. Thus it is imperative to apply PM along with half of the recommended rate of chemical fertilizer (NP) to enhance maize crop yield and sustainability of soil fertility particularly in rainfed areas.

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