Research Article

Effect of organic waste and NPK fertilizer on potato yield and soil fertility

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Abstract

A field experiment was conducted to examine the effect of organic waste and NPK fertilizers on macro and micronutrients concentration in potato straw and on yield at Nuclear Institute of food and Agriculture Peshawar, Pakistan during 2012. Fifteen treatments of various organic and inorganic fertilizers were applied to potato crop each replicated three times. After harvesting of the crop, potato yield was recorded. For soil fertility analysis 90 soil samples from two depths (0-15 and 15-30 cm) and 45 straw samples were also collected and analyzed. Fertilizer doses showed significant effect on potato yield and soil fertility parameter. The treatments (Filter cake + full NPK) and (Municipal solid waste + full NPK) showed high yield and significant effect on NPK and micronutrients concentrations in potato straw. The lowest concentrations of micronutrients in soil and potato straw were observed mainly in treatment (PK recommended dose) and control. It can be concluded from this experiment that the conjunctive use of inorganic fertilizers with organic waste further accelerated the beneficial effect of inorganic fertilizers on soil and plants. The treatments (Filter cake + full NPK) and (MSW + full NPK) seemed to be the appropriate dose for sustainable production of potato.

Key words: Potato; Fertilizer; Manure; Municipal solid waste; F cake; Yield

Introduction

Pakistan is basically an agricultural country. The soils are 100% deficient in organic matter (O.M less than 1%) and in major plant nutrients including nitrogen and phosphorus. Soil organic matter plays a major role in maintaining soil quality and also effect the production of the crop [1]. The beneficial effects of organic manures are manifested through increase in soil organic

matter and humus over the period. Soil organic matter and humus acts in several ways; it serves as slow release source of plant nutrients to the crops and increases water holding capacity to maintain the water regime of the soil and acts as a buffer against change in soil pH [2]. Using the residues of agricultural activities, municipal waste, improve soil physical and chemical properties and also the fertility and

production capacity [3]. Composts are important source to maintain and restore soil fertility particularly in those countries where the organic matter content of the soil is low. Nutritional stress including widespread nutrient deficiencies, low organic matter content, unbalanced use of fertilizers, poor physical condition and soil fertility are the major limiting factors causing low crop production in Pakistan [4]. The balance application of chemical fertilizer is very necessary for valuable production. However, their imbalance use, high rates, availability time is not properly managed and some nutrient has losses from the soil is the serious problem for the farmers [5].

Potato (*Solanum tuberosum* L.) belongs to family solanaceae is the fourth most important food crop in the world on the basis of production. Its cultivation is quite intensive in northern west Punjab and north west Khyber Pakhtunkhwa. Three crops of potato can be grown in a year, a spring and an autumn crop in the plains and a summer crop in the hilly area at higher altitudes. The area under potato is 137.7 thousand hectares with production of 2554.2 thousand tonnes with average yield is 22.7 t ha⁻¹. In Khyber Pakhtunkhwa it is grown on the area of 9.2 thousand hectares and yield is 123.1 thousand tonnes with average yield of 13.1 t ha⁻¹ [6]. The potato crop is high nitrogen (N) feeder. Organic matter slowly releases plant nutrients and thus contributing to efficient crop production and sustainable soil fertility. Fertilizer application is the best way of increasing yield per unit area. It is believed that NPK fertilizers improve both yield and quality of potato tubers. The quality of potato tuber optimum growth and production require high amount of potassium fertilizer [7], but its recovery of K is often quite low. The efficiency of NPK fertilizers can be further increased by the use of micronutrients [8]. The aim of present study was to determine the effect of different doses of

fertilizers on nutritional composition of prominent local variety of potato i.e. Core. Results of this study would be to improve the nutritional quality of potato by the use of suitable combination of NPK fertilizers and organic waste.

Materials and methods

Location: A field experiment was conducted during autumn season 2012. The experiment was conducted at the Research Farm of Nuclear Institute for Food and Agriculture (NIFA), Tarnab (longitude 71°50', latitude 34°01'), Peshawar, Pakistan. The site is located at the altitude of 400 m above sea level in the Peshawar valley of Khyber Pakhtunkhwa and has cool climate in winter and warm to hot in the summer. Soil of the experimental site was clay loam [Order: Inceptisols, Sub order: Ustepts, Soil great group: Haplustepts, Soil Sub group: Udic Haplustepts,

Experimental design

The experiment was conducted according to randomized complete block (RCBD) with fifteen treatments and each treatment was replicated three times. Potato was sown on ridges made 30 cm high and 80 cm apart. Different treatments i.e. N, P₂O₅, K₂O, FYM, MSW and filter cake were applied alone or in various combinations including control, farm yard manure, municipal solid waste, NPK full (250- 120-120 kg ha⁻¹), tomato residue + half NPK, filter cake + half NPK, tomato residue + full NPK, filter cake + full NPK, recommended PK, tomato residue alone, filter cake alone, FYM + half NPK, MSW + half NPK, FYM + full NPK and MSW + full NPK. The fertilizers were applied at the time of sowing; half of the nitrogen was applied at time of sowing and half at the time of earthing off.

Laboratory procedure

Total nitrogen in Potato straw samples was determined by Kjeldhal method suggested by Bremner [9] while total Phosphorous, Potassium and micronutrients was

determined by the standard procedure described by [10].

Statistical Analysis

The data were recorded and statistically analyzed by using analysis of variance

techniques. Treatment means were tested by using least significant differences (LSD) at 5% level of probability [11].

Table 1. Physico-chemical properties of experimental site

Properties	Units	Experimental Sites	
		0-15cm	15-30cm
Sand	%	20	20
Silt	%	46	40
Clay	%	34	40
Texture Class		Clay loam	Clay loam
pH		8.2	8.2
Electrical Conductivity	dS m ⁻¹	2.73	2.4
organic matter	mg kg ⁻¹	0.94	0.9
Total N	mg kg ⁻¹	0.84	0.74
Phosphorous	mg kg ⁻¹	8.75	6.9
Potassium	mg kg ⁻¹	80	60
Zinc	mg kg ⁻¹	1.71	1.45
Copper	mg kg ⁻¹	8.52	7.3
Iron	mg kg ⁻¹	5.45	5.01
Manganese	mg kg ⁻¹	14.37	10.5

Results and discussions

Effect of organic waste and NPK fertilizer on micronutrients concentration in soil

Organic waste and NPK fertilizer significantly ($P \leq 0.05$) affected the micronutrient concentration in soil. The result showed that maximum Zn concentration were found (176.8 and 113.3 mg Kg⁻¹) in the treatment where MSW+ half NPK, Filter cake + full NPK were applied at two soil depth 0-15 cm and 15-30 cm respectively. The maximum Cu concentration was observed (5.4 mg Kg⁻¹) in the treatments (Filter cake + half NPK and F.Y.M + half NPK) at soil depths of (0-15 cm) and (15-30 cm) respectively. The highest concentration of Fe (448.6 and 402.6 mg Kg⁻¹) was observed in the treatment (FYM + half NPK) at soil depths of (0-15 cm) and (15-30

cm) respectively. High Mn concentrations (14.1 and 12.4 mg Kg⁻¹) were observed in the treatment (Filter cake+ full NPK and FYM + half NPK) at soil depth (0-15 cm) and (15-30 cm) respectively. The lowest concentrations of Zn, Cu, Fe and Mn were observed in control presented in table.2 at 0-15 and 15-30 cm soil depth. The results was in line with those of Diacono *et al.*, [12] who also reported that Zn, Cu, Fe and Mn concentration increase with applications of organic manure. Asiegbu *et al.* [13] Found that N, P and K fertilizers were more efficient than the organic manures in supplying N, P and K to the growing plant at least in the short run, further supported by Banin *et al.* [14] that FYM increase the uptake of N, Fe and Zn and also enhanced P uptake.

Table2. Effect of organic waste and NPK fertilizer on micro nutrients concentration in soil

Treatments	Zn (mg Kg ⁻¹)		Cu(mg Kg ⁻¹)		Fe (mg Kg ⁻¹)		Mn (mg kg ⁻¹)	
	0-15cm	15-30cm	0-15	15-30	0-15	15-30	0-15	15-30
Control	0.6f	0.3j	2.8e	2.5h	41.0h	23.0j	4.1h	2.6g
PK only Recommended	1.8e	2.0ef	5.1ab	4.2de	47.6h	31.0ij	7.5f	7.3e
FYM alone	3.3ab	2.2ef	4.9ab	4.1ef	120.0f	87.3g	8.1e	10.6b
Tomato residue	2.7d	1.9fg	4.6bcd	4.9bc	56.2gh	38.6hi	6.1g	8.4d
Munciple solid waste	3.5ab	2.8bc	4.0d	5.4ab	162.6de	115.3f	7.6f	7.6e
Filter Cake	2.6d	2.3de	3.9d	5.4ab	70.0g	43.0h	10.2c	9.5c
NPK recommended	3.4ab	2.2ef	4.7abc	5.4ab	215.3c	196.0c	12.0b	10.1b
FYM+ half NPK	2.9cd	2.2ef	4.2cd	5.5a	448.6a	402.6a	14.5a	12.4a
Tomato residue + half NPK	3.6a	1.2i	5.1ab	5.2ab	445.3a	394.3a	7.3f	6.4f
MSW +half NPK	3.6a	3.1b	4.9abc	4.6cd	170.7d	156.6d	10.2c	8.6d
filter Cake + half NPK	3.3ab	2.6cd	5.4a	4.5cde	54.7gh	42.6h	8.1e	7.3e
FYM + full NPK	3.5ab	1.3hi	5.2ab	4.4de	151.0e	139.3e	12.3b	10.7b
Tomato residue + full NPK	3.6a	2.9bc	4.7abc	3.3g	311.3b	283.6b	10.2c	8.5d
MSW + full NPK	3.2bc	1.6gh	4.9ab	3.6fg	223.3c	202.3c	9.5d	8.2d
Filter cake +full NPK	3.4ab	3.7a	5.1ab	3.5g	223.0c	201.3c	14.1a	10.4b
LSD _{0.05}	0.36	0.34	0.68	0.51	16.5	9.95	0.38	0.54

Effect of organic waste and NPK fertilizer on micro nutrients concentration in potato straw

The micronutrient concentration (Zn, Cu, Fe and Mn) in potato straw were significantly ($P \leq 0.05$) increased with the organic waste and NPK fertilizers as compared to control and presented in Table.3. Highest zinc concentration (27.00 mg Kg⁻¹) was observed in the treatment where only Tomato residue was treated which was significantly higher from rest of treatment and lowest zinc concentration was recorded (5.53 mg Kg⁻¹) in control. Similarly maximum Cu concentration was noted (29.26 mg Kg⁻¹) in

the treatment where only Tomato residue was applied and the minimum concentration (11.46 mg Kg⁻¹) was in control. The Fe concentration was in range (1314.0-1376.4 mg Kg⁻¹) and highest in treatment (Filter cake + full NPK) and lowest in control. The significant ($P \leq 0.05$) highest concentration of Mn (3.16 mg Kg⁻¹) was recorded on municipal solid waste treatment and lowest concentration was observed in control. Micronutrients concentrations of plants is directly associated with their concentrations in soils, their levels significantly differ with plant species, and even can also affected by genotypes within the same species [15].

Table 3. Effect of organic waste and NPK fertilizer on micro nutrients concentration in potato straw

Treatments	Zn (mg Kg ⁻¹)	Cu (mg Kg ⁻¹)	Fe (mg Kg ⁻¹)	Mn (mg Kg ⁻¹)
Control	5.53f	11.46g	1314bcd	1.36e
P-K recommended	13.66d	16.13cd	1343.7abcd	2.18bc
FYM	20.66bc	17.50c	1290.3d	1.63de
Tomato residue	27.00a	29.26a	1367.3ab	2.26bc
Muncipal solid waste	14.66d	27.63a	1329.7abcd	3.16a
Filter Cake NPK	21.00bc	13.83ef	1304cd	1.29e

recommended	23.00b	17.56c	1302.7cd	1.90cd
FYM + half NPK	10.00e	16.10cd	1365.3ab	2.18bc
Tomato residue + half NPK	21.33bc	20.03b	1339abcd	2.19bc
MSW + half NPK	21.33bc	20.10b	1346abcd	2.11bc
Filter Cake + half NPK	19.66c	15.13de	1315.3bcd	1.44e
FYM + full NPK	11.66de	12.20fg	1322.7abcd	2.13bc
Tomato residue + full NPK	18.66c	14.10def	1357.3abc	2.08bc
MSW + full NPK	21.00c	12.26fg	1355.7abc	2.35b
Filter cake + full NF	23.00b	18.30bc	1376.7a	2.10bc
LSD _{0.05}	3.23	2.26	60.84	0.39

Effect of organic waste and NPK fertilizer on NPK concentration in potato straw.

Combine application of organic waste and NPK fertilizers significantly ($P \leq 0.05$) increased NPK concentrations in potato straw over control. The significantly ($P \leq 0.05$) higher N concentration was observed (2.25 g 100 g⁻¹) in treatment where MSW + full NPK was applied and statistically different from rest of the treatments. Lowest N concentration was recorded in control (Table 4). The highest P concentration was observed (0.27 g 100 g⁻¹) in treatment where only Farm yard manure was applied and statistically similar to treatment where MSW + full NPK was treated and lowest Phosphorous concentration was noted in control (0.27 g 100 g⁻¹). The K concentration was maximum (3.66 g 100 g⁻¹) in treatment where FYM was applied and lowest in control (2.66 g 100 g⁻¹). Nitrogen, Phosphorus and Potassium uptake by plants increase with increase in FYM application [16]. Phosphorus and FYM application had significant ($P \leq 0.05$) effect on both tuber and shoot weight showing that there was positive interaction between

Phosphorous and FYM on tuber and shoot weight.

Effect of organic waste and NPK fertilizer on Yield and plant height of potato.

The data regarding potato tuber yield is presented in table.5, the results indicated that the combined used of organic and inorganic fertilizer increased potato yield significantly ($P \leq 0.05$) over control. Treatment where MSW + half NPK showed maximum yield (20.66 kg plot⁻¹) and yield was decreased up to (10.16 kg plot⁻¹) in control. Potato plant height was in range 33.80-54.46 cm. The result was agreed with findings of Baishya [17] who observed that the highest tuber yield was obtained with the application of 50 %NPK of the recommended dose through inorganic fertilizers and remaining 50% from PM. Similar result were founded by Moshileh *et al.* [7] who revealed that the significant increased were noted in plant height and chlorophyll concentration with the increase of potash levels. Tikhonov *et al.* [18] found that NPK application increased yield and enhanced starch content when compared with NP and NK.

Table 4. Effect of organic waste and NPK fertilizer on NPK concentration in potato straw

Treatments	N (g 100g ⁻¹)	P (g 100g ⁻¹)	K (g 100g ⁻¹)
Control	1.616e	0.17d	2.66c
P-K recommended	1.676de	0.21c	2.83bc
FYM	1.79bcde	0.27a	3.66a
Tomato residue	1.58e	0.24abc	3.50ab
Munciple solid waste	1.76cde	0.21c	3.50ab

Filter Cake	1.85bcde	0.25ab	3.16abc
NPK recommended	2.02abc	0.24abc	3.66a
FYM + half NPK	2.05abc	0.25ab	3.33abc
Tomato residue + half NPK	2.06abc	0.22bc	3.50ab
MSW + half NPK	2.08ab	0.24abc	3.50ab
Filter Cake + half NPK	1.96abcd	0.22bc	3.50ab
FYM +full NPK	2.05abc	0.27a	2.8bc
Tomato residue + full NPK	2.04abc	0.23bc	3.50ab
MSW+ full NPK	2.25a	0.26a	3.50ab
Filter Cake + full NPK	2.19a	0.25ab	3.50ab
LSD _{0.05}	0.3	0.33	0.81

Table 5. Effect of organic waste and NPK fertilizer on yield and plant height of potato

Treatments	Yield (kg plot ⁻¹)	Plant Height (cm)
Control	10.16ef	33.80h
P-K recommended	12.83de	44.26de
FYM	17.66abc	46.33cd
Tomato residue	8.167f	33.80h
Municipal solid waste	14.00cde	41.26fg
Filter Cake	19.16ab	50.26b
NPK recommended	15.66bcd	44.40de
FYM + half NPK	14.83bcd	47.46c
Tomato residue + half NPK	17.83abc	50.13b
MSW + half NPK	20.66a	51.13b
Filter Cake + half NPK	18.83ab	45.66cd
FYM +full NPK	17.83abc	54.46a
Tomato residue + full NPK	12.66de	33.60h
MSW+ full NPK	15.00bcd	39.60g
Filter Cake + full NPK	18.16abc	43.13ef
LSD _{0.05}	4.47	2.29

Conclusions

From the present research work it is concluded that combine application of organic waste and inorganic fertilizers could significantly improve soil fertility and nutrients concentration in potato straw. Application of Filter cake + Full NPK and Municipal solid waste + Full NPK could be recommended. The long term use of organic and inorganic fertilizers will be beneficial in achieving sustainable yields.

Authors' contributions

Conceived and designed the experiments: M Afzal, Performed the experiments: M Zahoor, M Ali & W Mohammad, Analyzed the data: N Khan & M Adnan, Contributed reagents /materials/ analysis tools: W Mohammad & A Ali, Wrote the paper: M Ali & M Saeed.

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