Research Article

Integrated effect of organic waste and NPK fertilizers on nutrients uptake in potato crop and soil fertility

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Abstract

The present research was carried out at Nuclear Institute of Food and Agriculture (NIFA), Peshawar Pakistan, to evaluate the integrated response of organic waste and N-P-K fertilizers to nutrients concentration in potato tuber and soil fertility. Fifteen treatment combinations with three replications were used in RCB design. Potato tubers and soil samples (0-15 and 15-30 cm depth) was collected before and after the experiment were analyzed. Data indicated that combined use of organic waste and N-P-K fertilizers significantly improved soil fertility and nutrients concentration in potato tuber. Higher nitrogen (N) ($2.10\text{g } 100\text{g}^{-1}$), phosphorus (P) ($0.30\text{g } 100\text{g}^{-1}$) and potassium (K) ($3.16\text{g } 100\text{g}^{-1}$) concentration were recorded with treatments (municipal solid waste (MSW)+ half NPK) and (Filter cake +full NPK) as compared to control. Maximum total soil N, AB-DTPA extractable P, K and micronutrients were recorded with (MSW+ half NPK) and (Filter cake +full NPK) at both depths. Investigation revealed that the combined use of organic waste and chemical fertilizers beneficial to soil and plant. Moreover, treatments (MSW +full NPK) and (Filter cake + full NPK) seemed to be an adequate dose, for sustainable nutrients concentration in potato tuber and soil fertility.

Key words: Potato; Organic waste; NPK fertilizer; Organic matter; Micronutrients

Introduction

Pakistan is an agriculture country and most of the people are related to agriculture sector. According to an estimate, less than 1% organic matter is present and 100% of soil is deficient of some nutrients. Application of organic manure not only improving soil fertility but also enhance crop productivity

when available to crop at appropriate level [1]. Organic matter play a multi role in soil, such as increasing of organic matter and to release the nutrients throughout in growing plant; also increase the mobility of moisture, in-term of water holding capacity (AWHC) and buffering capacity of soil [2]. Crops residue, municipal waste enhance physico-chemical

properties and fertility status of soil, resulting better productivity [3]. Composts are also indispensable to maximize organic matter in those area where organic matter contents are very low. The main causes of low production in Pakistan are nutrients deficiencies, improper use of chemical fertilizers, low organic matter and poor physical condition of soil [4]. Balance use of synthetic fertilizers are essential to get economical produce, while imbalance and improper time application, significantly loss most of essential nutrients from the soil through leaching and volatilization [5].

Potato is an important crop of world, including Pakistan, ranked on 4th in the world and 7th in Pakistan. It is mostly cultivated in hilly area of North West Khyber Pakhtunkhwa and plain of Punjab. Potato crop can be cultivated in a year three times such as spring and in the plain area it is grown in autumn while in the hilly area in summer. In Pakistan it is cultivated on area of 0.14 million hectares, with total production of 2.55 million tons, while in Khyber Pakhtunkhwa (KPK) it is cultivated on 9.20 thousand hectares and with total production is 0.12 million tons. In Pakistan average yield per hectare is 22.7 tons, while in KPK the average yield per hectare is 13.1 tons [6].

Due to low soil fertility and nutrients deficiency fertilizer use is very important to increase crop production. Potato yield and quality increases through application of NPK fertilizers. Application of potassium fertilizers increases quality of potato tuber and production [7]. The efficiency of N-P-K fertilizers can be increased with the combine use of organic manure [8]. The main objective of present work was to study

response of different doses of fertilizers to nutritional composition of local variety of potato (Core), observed soil fertility and quality of potato through best combination of organic waste and mineral fertilizers.

Materials and methods

Location

Experiment was carried out at research field of NIFA Tarnab, situated at longitude 71°50 and latitude 34°01, Peshawar, Pakistan during autumn season 2012. The experimental site was located on 400 m altitude near Peshawar having cooled in winter and warm to hot in summer. Soil samples were collected from 0-15 and 15-30 cm depths to analysis the Physico-chemical properties of site are presented in Table 1.

Field procedure and treatment

The experiment consisted of fifteen treatments combination, using appropriate RCB design, replicated thrice. Ridges was made and potato were sown on 30 cm high and ridges distance was kept 80 cm. Different treatments combinations including control, farm yard manure, municipal solid waste, NPK full, tomato residue + half NPK, filter cake + half NPK, tomato residue + full NPK, filter cake + full NPK, recommended PK, tomato residue alone, filter cake alone, (farm yard manure) FYM + half NPK, MSW + half NPK, FYM + full NPK and MSW + full NPK. All P and K were applied at the time of sowing while N was applied in split, half at sowing and half at the time of earthing off.

Statistical analysis

Means were separated using Duncan's Multiple Range Tests at 0.05 level of probability as F – ratio was significant.

Table 1. Physico-chemical properties of the research 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(1:5)	—	8.2	8.2
Electrical Conductivity	dS m ⁻¹	2.73	2.4
organic matter	mg kg ⁻¹	0.94	0.9
Total nitrogen	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

Organic matter and NPK concentration in soil

Data showed that treatment combinations significantly ($P \leq 0.05$) affect the total N, AB-DTPA extractable P and K as compared to control (Table 2). At depth of 0-15cm maximum total N concentration (0.083g 100g⁻¹) was recorded in those treatments which were treated with (Filter cake+ full NPK) and statistically similar to those treatments which were received Tomato remains+ full NPK, MSW+ full NPK and similar trend was found for 15-30cm depth. The AB-DTPA extractable P (11.2 mg Kg⁻¹) was observed higher in treatment (half NPK +Filter cake) at depths of 0-15cm and 15-30cm. High AB-DTPA extractable K (176.8 and 113.3 mg Kg⁻¹) was recorded in the treatment (full NPK+ Filter cake) at two soil depths at 0-15 and 15-30cm respectively. The highest organic matter in the soil was observed (1.64 and 1.07 g 100g⁻¹) in the treatment (full NPK +Filter cake) at soil depths at 0-15 and 15-30 cm simultaneously. At the depths of 0-15 cm and 15-30 cm the

minimum concentrations of total N, AB-DTPA extractable P and K and soil organic matter were observed. The balance supply of the major three nutrients required for plant growth and development, there might be a significant increase in total N concentration [9].

Influence of organic waste and NPK fertilizer on NPK concentration in potato tuber

N-P-K fertilizers and organic waste significantly ($P \leq 0.05$) increases NPK application in potato tuber as compared to control treatment. Statistically higher N concentration was perceived (2.10 g 100g⁻¹) in treatment which received half NPK+ MSW and was different from rest of the treatments and lowest in control as shown in Table 3. The maximum P concentration (0.30 g100g⁻¹) was recorded in treatment combination which was applied Filter cake +full NPK dose and lowest was recorded in control (0.19 g 100g⁻¹). The K concentration was highest (3.16 g 100g⁻¹) in treatment (half NPK +MSW) and lowest in control (2.0g100g⁻¹).

Table 2. Effect of organic waste and NPK fertilizers on soil organic matter and NPK concentration in soil

Treatments	N (g 100g ⁻¹)		P (mg Kg ⁻¹)		K (mg Kg ⁻¹)		SOM (g 100g ⁻¹)	
	0-15cm	15-30cm	0-15	15-30	0-15	15-30	0-15	15-30
Control	0.049i	0.043e	5.1i	4.16e	100f	50.0f	0.63j	0.40g
P-K Recommended	0.056gh	0.055d	6.1h	4.8d	120.0e	66.6ef	0.77h	0.63de
FYM alone	0.060fg	0.056d	9.8cd	6.0c	143.3cd	73.3de	0.84g	0.77c
Tomato residue	0.053h	0.058d	7.2g	4.8d	110.0ef	60.0ef	0.64j	0.54f
Munciple solid waste	0.064e	0.056	11.2a	5.1d	120.0e	86.6cd	1.06de	0.80c
Filter Cake	0.064e	0.060cd	9.8cd	6.2c	113.3ef	86.6cd	0.97f	0.64d
NPK recommend	0.066de	0.058cd	8.1f	6.3c	153.3bcd	93.3bc	1.04e	0.56ef
FYM+ half NPK	0.063ef	0.059cd	9.5de	5.1d	150.0bcd	106.6ab	0.72i	0.59def
Tomato residue + half NPK	0.062ef	0.059cd	9.1e	5.0d	110.0ef	86.6cd	0.87g	0.47g
MSW + half NPK	0.069cd	0.063bc	10.4b	6.0c	146.6bcd	93.3bc	1.30c	0.63de
filter Cake + half NPK	0.071c	0.066b	11.2a	7.2b	146.6bcd	100.0bc	1.10d	0.59def
FYM + full NPK	0.076b	0.072a	10.1bc	8.1a	156.6bc	106.6ab	1.65a	0.80c
Tomato residue + full NPK	0.081a	0.074a	9.6cd	6.1c	140.0d	93.3bc	1.64a	0.97b
MSW + full NPK	0.080a	0.072a	11.4b	5.0d	160.0b	106.6ab	1.50b	1.07a
Filter cake +NPK full	0.083a	0.067a	8.1f	8.1a	176.8a	113.3a	1.64a	1.07a
LSD 0.05	0.003	0.005	0.48	0.48	13.5	17.6	0.047	0.075

The NPK application was considerably enriched in potato tuber by the accumulation of organic waste and NPK fertilizers. The results are in general agreement with the findings of [10], who reported that farm yard

manure when subjected to the soil, results in boosting of carbon mineralization from the soil due to available carbon for microbial respiration, providing of nitrogen and phosphorus.

Table 3. Effect of organic waste and NPK fertilizer on NPK concentration in potato tuber

Treatments	N (g 100g ⁻¹)	P (g 100g ⁻¹)	K (g 100g ⁻¹)
Control	1.50f	0.19d	2.00cd
P-K recommended	1.53ef	0.26b	2.16bcd
FYM	1.68d	0.240bc	2.16bcd
Tomato residue	1.42g	0.240bc	2.33bcd
Municipal solid waste	1.55ef	0.21cd	2.50abcd
Filter Cake	1.59e	0.21cd	1.83d
NPK recommended	1.57ef	0.240bc	2.50abcd
FYM + half NPK	1.88c	0.20cd	2.66abc
Tomato residue + half NPK	1.73d	0.25bc	2.16bcd
MSW + half NPK	2.10a	0.24bc	2.50abcd
Filter Cake + half NPK	1.59e	0.25bc	2.50abcd
FYM + full NPK	1.87c	0.24bc	2.33bcd
Tomato residue + full NPK	1.57e	0.26b	2.83ab
MSW + full NPK	2.01b	0.25b	3.16a
Filter cake + NPK full	2.04ab	0.30a	2.66abc
LSD 0.05	0.071	0.038	0.72

Effect of NPK fertilizers and organic waste on micronutrients concentration in potato tuber.

Data showed that the concentration of micronutrient (Cu, Zn, Fe and Mn) in potato tuber was significantly ($P \leq 0.05$) increased with NPK fertilizer and organic waste compared to control treatment (table 4). The Maximum concentration of zinc (23.50 mg Kg⁻¹) was observed in the treatment where only Tomato residue was applied and minimum (2.73 mg Kg⁻¹) was recorded in control. The treatment in which PK of the recommended dose was applied showed highest Cu concentration (4.13 mg Kg⁻¹) while lower concentration (0.16 mg Kg⁻¹) was observed in control. The treatment in which Filter cake + full was used showed higher concentration of Fe (1147.3 mg Kg⁻¹)

and lowest concentration of iron (1095.3 mg Kg⁻¹) was noted in control. The Mn concentration was in the range of 0.050-0.088 mg Kg⁻¹, the highest Mn concentration was recorded in treatment where MSW + full NPK were applied and lowest in control. The extractable concentrations of (Zn, Fe, Cu, and Mn) in the potato tuber were considerably enhanced with combined use of NPK organic and waste as compare to control and other treatments. The micronutrients concentration is increases with addition of organic waste the same results were reported by [11] who reported that addition of organic material increased micronutrient concentration in soil and enhanced their uptake positively. The results are also in line with finding of [12].

Table 4. Effect of organic waste and NPK fertilizers on Zn, Cu, Fe and Mn concentration in potato tuber

	Zn (mg Kg ⁻¹)	Cu (mg Kg ⁻¹)	Fe (mg Kg ⁻¹)	Mn (mg Kg ⁻¹)
Control	2.73j	0.16e	1095.3bcd	0.050b
P-K recommended	10.96h	4.13a	1119.7abcd	0.068ab
FYM	22.00ab	2.23b	1075.3d	0.085a
Tomato residue	23.50a	2.70b	1139.3ab	0.070ab
Municipal solid waste	7.03i	0.50de	1108.0abcd	0.077ab
Filter Cake	19.00bcdef	0.73d	1086.7cd	0.070ab
NPK recommended	16.56defg	0.43de	1085.7cd	0.072ab
FYM + half NPK	6.067ij	1.46c	1137.7ab	0.072ab
Tomato residue + half NPK	21.00abc	1.73c	1115.7abcd	0.078ab
MSW + half NPK	17.33cdef	0.56de	1121.7abcd	0.067ab
Filter Cake + half NPK	15.33fg	0.40de	1096.0bcd	0.067ab
FYM +full NPK	13.00gh	1.40c	1102.0abcd	0.0703ab
Tomato residue + full NPK	16.33efg	4.00a	1131.0abc	0.072ab
MSW+ full NPK	20.00abcd	1.33c	1130.0abc	0.088a
Filter cake +NPK full	20.33abcd	0.63de	1147.3a	0.077ab
LSD 0.05	3.92	0.46	50.79	0.03

Conclusions

It is concluded from the above result that use of organic waste significantly improved soil organic matter, nitrogen, Phosphorous and Potassium ingredients in soil and tuber were significantly improved with the application of Filter cake + Full NPK and Full NPK + MSW in treatments respectively. Hence the long term use of organic and inorganic fertilizers will be beneficial in achieving sustainable yield.

Authors' contribution

Conceived and designed the experiments: M Zahoor, Performed the experiments: M Zahoor & N Khan, Analyzed the data: M Ali & M Adnan, Contributed reagents/ materials/ analysis tools: M Saeed, Z Ullah & B Ahmad, Wrote the paper: M Ali & M Saeed.

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