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IMPACT OF ORGANIC AND INORGANIC FERTILIZATION ON YIELD, TUBER CONTENTS AND SOME HEAVY METALS CONCENTRATION IN POTATO TUBERS

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ABSTRACT

Two field trials were established during winter seasons of 2002/2003 and 2003/2004 at El-Zahraa village, Mansoura, Dakahlia Governorate. Certified seed potato var. Spunta was cultivated to study the effect of organic manure and minerals fertilization on yield, tuber contents and concentration of some heavy metals in potato tubers. Applying of ammonium nitrate (33.5%N) with or without micronutrients in addition to P and K at the recommended rates (180 kg N + 75 kg P_2O_5 + 96 kg K_2O fed^{-1}) increased the vegetative growth expressed as plant height, number of main stems/plant and foliage fresh weight /plant. The results indicated that the mineral fertilizer application at the recommended rate gave higher weight of tuber and total tubers yield fed^{-1} in compared with the other treatments. Tuber dry matter content and total carbohydrates (%) increased due to the application of organic manure; on the other hand, using of mineral fertilization led to increasing of crude protein (%), total lipids (%) and ash (%) in the dry matter of tubers. The concentrations of some heavy metals i.e cadmium, nickel and lead (ppm) were increased in the dry matter of tubers by using the mineral fertilizers and the lower concentrations of heavy metals in the dry matter of tuber by using of 50% from organic manure with foliar nutrients spraying from (NPK). Thus, the proper fertilization can prevent or greatly reduce the potential contamination from heavy metals of plants and soil. Generally the results indicated that the concentration of heavy metals in potato tubers with using organic or inorganic fertilizers are still at or below accepted food safety standards.

INTRODUCTION

Potato (*Solanum tuberosum*, L.) is one of the most important food crops all over the world including Egypt. Potato tubers are an important source of digestible carbohydrates, dietary fiber, v.c. and some necessary minerals.

Rabie (1996), Arisha & Bardisi (1999) and El-Banna *et al.* (2001) found that NPK application resulted in significant increase in stems length, main stems number/plant and fresh weight of foliage/plant. The tubers yield was increased, whereas the dry matter percentage of tuber was decreased with increasing of nitrogen fertilizer levels compared with farmyard manure application, Grzeskiew & Sock (1989) and Sharma & Arora (1995); Anadousi *et al.* (1998); Arnout (2001) and Rodriguez *et al.* (2001).

Makaraviciute (2003) found that organic fertilizers application slightly increased the dry matter and starch contents in the tuber, while the mineral fertilization gave the highest tubers yield. Striban *et al.* (1984) and Abou-Hussein (2002) suggested that tubers carbohydrates content was increased with organic fertilizers application.

Talley (1983) and Sirkumar & Ockerman (1990) reported that the higher application of mineral fertilization improved the protein content of tuber, whereas organic manure application influenced positively on the fat content in the tuber. In recent years, there have been reports of heavy metals contamination from fertilizers manufactured.

Ocker *et al.* (1984) found that, generally, the tuber contains very low amounts from heavy metals. Heavy metals such as lead (Pb) causes neurological damage in infants and children, while Cadmium (Cd) causes kidney damage in the elderly, usually (FAO, 2004). Raven & Loeppert (1997) found that Pb and Cd were high concentrations relatively in N, P & K fertilizers in compared with organic manure. Stevens (2001) reported that Cd and Pb concentrations in potato tubers were generally at or below accepted food safety standard, even with the application of up 8* maximum rates of triple superphosphate (TSP) and rock phosphate (RSP). Rupert et al (2004) showed that Cd and Ni content in the edible parts of food crops (potato, tomato, radish) were satisfactory, whereas the Pb uptake models were less robust.

MATERIAL AND METHODS

Two field experiments were conducted during two successive winter seasons of 2002/2003 & 2003/2004 at El – Zahraa village (20 km north Mansoura City), Dakahlia Governorate. Certified seed potato tuber of cultivar Spunta. The whole seed tubers were planted on 15th and 10th of October in the two previous seasons, respectively. The physical and chemical properties of the experimental soil were determined according to the method of Jackson (1973) and presented in Table 1 as follow:

Table 1: Some chemical, physical and available nutrients of the experimental soil.

pH	E.C dS.m^{-1}	Soluble Cations and Anions (meq l^{-1})							
		Cations				Anions			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}
7.9	1.1	1.2	2.5	5.6	1.7	-	2.7	5.4	2.9
Partical size distribution					Texture class	Available (ppm)			
Coarse sand %		Fine sand %	Silt %	Clay %		N	P	K	O.M%
1.78		30.72	27.25	34.9	Loam	18	12.6	405	1.79

Average of contents of some heavy metals (Ni, Pb & Cd) in the mineral fertilizers and organic manure used in this experiments are shown in Table 2 as follow:

Table 2: Ni, Pb. and Cd content in mineral and organic fertilizers.

Fertilizers	Ni (ppm)	Pb (ppm)	Cd (ppm)
A. nitrate with micronutrient (33.5% N)	22.31	23.70	2.60
A. nitrate (33.5% N)	22.49	23.26	3.35
P. sulphate (48% K_2O)	19.62	15.73	2.24
S.S.P (15.5% P_2O_5)	19.33	14.25	2.34
Organic manure	6.26	6.35	1.64

The treatments: The experiment included eight treatments as follows:

T_1: Ammonium nitrate (33.5% N) + micronutrients. (Ca 1%, Mg 2%, S 0.4%, Fe 3000 mg/kg, Zn 100 mg/kg and Mn 100 mg/kg).

T_2: Ammonium nitrate (33.5% N) without micronutrients.

T_3: 50% T_2 + 50% organic manure (1.26, 0.55 & 1.32) for N, P & K.

T_4: 25% T_2 + 75% organic manure.

T_5: organic manure fertilizing at rate of 14.285 ton fed^{-1} in both seasons, (equal 180 kg N) according to N content in organic manure.

T_6: 50% T_5 + foliar nutrition with NPK (0.5: 1: 2)

T_7: 75% T_5 + foliar nutrition with NPK (0.5: 1: 2)

T_8: 100% T_5 + foliar nutrition with NPK (0.5: 1: 2).

Fertilizers rates and applications:

Organic manure (14.285 ton fed^{-1}) and single superphosphate (75 kg P_2O_5 fed^{-1}) were added once to the soil before planting.

Ammonium nitrate (180 kg N fed^{-1}) was added on three equal portions at 4, 6 & 8 weeks from planting date, while potassium sulphate (96 kg K_2O fed^{-1}) was added one after 8 weeks from planting date.

Each experimental plot contained 4 rows, 5 m long/row and 0.75 m wide (plot area of 15 m^2). Single superphosphate and potassium sulphate fertilizers were added to all plots according to the recommended doses. The cultural practices, diseases and pests control programs were applied according to the recommendation of Egyptian Ministry of Agriculture.

Data recorded:

1. Growth characters:

A random sample of 5 plants was taken at 90 days after planting (DAP) from every treatment for measuring some of vegetative growth characters. i.e.; plant height (cm), number of main stems/plant and fresh weight of foliage/plant (gm).

2. Yield and quality of tubers at harvest:

Each experimental plot was harvested individually after 105 days from planting, then average of tuber weight (gm), tuber dry matter % (A.O.A.C.,1990) and total yield (ton fed^{-1}) were determined.

3. Chemical measurements:

A random sample of eight rubbers was selected from every treatments at harvest to determine some characteristics in the dry matter of tubers i.e.; total carbohydrates, ash contents and total nitrogen were determined by the methods recorded in A.O.A.C. (1990) and the last was calculated by multiplying nitrogen percentage by the factor 5.75 (Robinson, 1973). Total lipids were estimated by solvent extraction according to the method outlined in IUPAC (1987). Heavy metals i.e.; (Ni), (Pb) and (Cd) were determined in the dry matter of tuber using atomic absorption spectrophotometer.

4. Statistical analysis:

The statistical analysis was calculated according to Gommez and Gommez (1984).

RESULTS AND DISCUSSION

Data presented in Table 3 indicate that application of ammonium nitrate with or without micronutrients in addition to P & K at the recommended rates (T1 or T_2) gave a significant increase in the vegetative growth parameters i.e. plant height, number of main stem/plant and foliage fresh weight. This result can be explained on the basic that mineral fertilization is faster and easier than the organic manure which , in turn, led to stimulation plant roots, absorption nutrients and photosynthesis process and finally gave vigorous plants. Similar results were reported by Rabie (1996); Arisha & Bardisi (1999) and El-Banna *et al.* (2001).

Table 3: Effect of organic and inorganic fertilization on vegetative growth.

Characters / Treatments	Plant height (cm)		No. of main stems/plant		Foliage fresh weight (g/plant)	
	2002/2003	2003/2004	2002/2003	2003/2004	2002/2003	2003/2004
T1	38.67	41.67	2.56	2.78	225.00	244.67
T2	39.00	41.33	2.67	2.67	215.67	247.00
T3	36.67	38.00	2.00	2.11	200.33	212.00
T4	33.00	34.00	2.22	2.22	196.00	201.33
T5	24.33	26.00	1.89	2.00	185.33	194.67
T6	25.67	28.33	1.78	1.89	196.33	199.00
T7	27.67	29.67	2.11	2.22	198.33220	199.67
T8	28.67	30.33	2.22	2.22	2.00	209.00
F-test	**	**	**	**	**	**
N-LSD at 5%	2.55	2.19	0.41	0.38	7.46	13.07
N-LSD at 1%	3.53	3.03	0.57	0.54	10.18	17.83

As shown in Table 4, applying organic manure in addition to the spraying with (NPK) foliar nutrients (T_8) caused a significant increase in the percentage of tuber dry matter in both seasons. On the other hand, data in the same Table 4 also, reveal that the tuber weight average and total tuber yield were increased significantly by using the mineral fertilization in both seasons, these results are good indicators on reflection of vigorous of vegetative growth. These results are in agreement with those obtained by Grzeskiew & Sock (1989); Sharma & Arora (1995); Anadousi *et al.* (1998); Arnout (2001), Rodriguez *et al.* (2001) and Makaraviciute (2003). Results illustrated in Table 5 indicated that the percentage of total carbohydrates in the dry matter of tubers was significantly increased with applying of organic manure (T_8), this result show the positive correlation between dry matter and total carbohydrates of potato tubers. In the same trend, Striban *et al.* (1984), Abou-Hussein (2002) and Makaraviciute (2003), suggested that the tuber carbohydrates content was increased with organic manure application.

Table 4: Effect of organic and inorganic fertilization on tuber dry matter, average of tuber weight and total yield.

Characters	Tuber dry matter %		Average of tuber weight (g)		Total yield (ton/fad)	
Treatments	2002/2003	2003/2004	2002/2003	2003/2004	2002/2003	2003/2004
T1	16.43	16.35	135.67	140.67	12.610	13.797
T2	16.38	16.32	135.33	136.33	12.294	12.993
T3	16.36	16.41	113.33	126.33	9.450	10.077
T4	16.64	16.77	103.00	102.00	6.771	6.793
T5	17.17	17.02	102.67	107.00	4.457	4.750
T6	17.07	16.95	94.67	99.67	4.740	4.910
T7	17.14	17.02	100.00	102.00	4.593	4.820
T8	17.35	17.14	108.67	113.33	5.532	5.975
F-test	**	**	**	**	**	**
N-LSD at 5%	0.53	0.27	10.05	6.52	0.470	0.620
N-LSD at 1%	0.76	0.37	13.71	9.04	0.651	0.851

In the same Table 5, data indicate that the percentage of total protein, total lipids and ash in the tuber dry matter were significantly increased with mineral fertilizer (T_1). Similar conclusion was obtained by Talley (1983) and Sirkumar & Ockerman (1990).

Table 5: Effect of organic and inorganic fertilization on total carbohydrates, crude protein, total lipids and ash in tuber (dry weight).

Characters	Carbohydrates %		Crude protein %		Total lipids %		Ash %	
Treatments	2002/2003	2003/2004	2002/2003	2003/2004	2002/2003	2003/2004	2002/2003	2003/2004
T1	80.94	80.54	8.79	9.04	0.317	0.340	4.95	5.08
T2	81.19	81.21	8.86	8.84	0.353	0.370	4.78	4.80
T3	82.27	82.49	8.29	8.10	0.310	0.303	4.13	4.11
T4	82.37	82.97	7.80	7.32	0.297	0.300	4.63	4.41
T5	83.25	83.19	6.75	6.83	0.303	0.303	4.71	4.67
T6	82.66	83.25	6.78	6.80	0.283	0.287	3.77	3.72
T7	82.95	82.80	7.67	7.73	0.290	0.297	4.62	4.24
T8	84.25	84.11	7.13	7.49	0.303	0.303	3.69	3.80
F-test	**	**	**	**	**	**	**	**
N-LSD at 5%	5.20	4.86	0.30	0.29	0.022	0.018	0.23	0.37
N-LSD at 1%	5.34	5.19	0.41	0.40	0.031	0.024	0.33	0.52

Concerning with the effect of organic or/and inorganic fertilizers on the content of some heavy metals in the dry matter of tubers, data presented in Table 6 indicate that using mineral fertilizer (T_1) was significantly increased the tuber content of some heavy metals i.e. Pb, Ni and Ca, this result might be due to that the mineral fertilizers contained higher concentrations of heavy metals (Table 2) than the organic manure, so that applying mineral fertilizers to the soil increase heavy metals cations exchange capacity of soils, and allowing increase the availability and consequently this metals uptake of plants. These results are in harmony with those obtained by Ocker *et al.* (1984), Raven and Loeppert (1997), Stevens (2001) and Rupert *et al.* (2004).

Table 6: Effect of organic and inorganic fertilization on some heavy metal contents in tuber (dry weight).

Characters / Treatments	Lead (ppm)		Nickel (ppm)		Cadmium (ppm)	
	2002/2003	2003/2004	2002/2003	2003/2004	2002/2003	2003/2004
T1	5.46	5.67	10.57	10.78	1.72	1.75
T2	4.32	4.47	10.25	10.23	1.70	1.67
T3	4.26	4.31	9.47	9.66	1.61	1.74
T4	3.80	3.82	9.38	9.40	1.17	1.23
T5	3.25	3.30	7.28	7.33	1.51	1.51
T6	3.08	2.90	8.04	8.03	0.55	0.51
T7	3.62	3.52	8.20	8.12	0.74	0.69
T8	3.91	3.84	8.73	8.94	1.08	1.08
F-test	**	**	**	**	**	**
N-LSD at 5%	0.38	0.32	0.29	0.43	0.13	0.11
N-LSD at 1%	0.52	0.45	0.40	0.59	0.18	0.15

Generally, heavy metals concentration in potato tuber by using inorganic or/and organic fertilizers are still at or below accepted food safety standards. (120 mg kg^{-1} dm Pb, 75 mg kg^{-1} dm Ni and 1 mg kg^{-1} dm Cd, according to WHO, 2001).

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تأثير التسميد العضوي و المعدني على المحصول و محتويات و تركيز بعض العناصر الثقيلة في درنات البطاطس

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أجريت هذه الدراسة خلال موسمي شتاء ٢٠٠٢/٢٠٠٣، ٢٠٠٣/٢٠٠٤ في قرية الزهراء – المنصورة – محافظة الدقهلية. وقد استخدمت تقاوي بطاطس معتمدة صنف اسيونتا لدراسة تأثير استخدام التسميد العضوي والمعدني على المحصول و محتويات الدرنة و تركيز بعض العناصر الثقيلة في درنات البطاطس.

أظهرت النتائج أن استخدام نترات الأمونيوم ٣٣,٥% نيتروجين مع أو بدون عناصر صغرى بالإضافة إلى الفوسفور و البوتاسيوم بالمعدلات الموصي بها (١٨٠ كجم ن + ٧٥ كجم فو + ٩٦ كجم بو /فدان) أدى إلى زيادة النمو الخضري متمثلا في ارتفاع النبات و عدد الأفرع الرئيسية للنبات و الوزن الأخضر الطازج للنبات. كما أن استخدام التسميد المعدني عند المعدل الموصى به أعطى أعلى وزن للدرنة و أعلى محصول درنات للفدان مقارنة بباقي المعاملات . أدى استخدام التسميد العضوي إلى زيادة محتوى الدرنة من المادة الجافة والكربوهيدرات الكلية (%)، علي الجانب الآخر فإن استخدام التسميد المعدني قد أدى إلى زيادة نسبة البروتين الخام (%)، الدهون الكلية (%) و الرماد (%) في المادة الجافة للدرنات . بينما أدى استخدام الأسمدة المعدنية إلى زيادة تركيز الكادميوم و النيكل و الرصاص (ppm) في المادة الجافة للدرنات . وكانت أقل تركيزات للمعادن الثقيلة في المادة الجافة للدرنات عند استخدام المعاملة التسميد العضوي بمعدل (٥٠% من الموصي به) مع الرش بمغذيات ورقية تحتوي على NPK .

لذلك فإن استخدام التسميد الملائم قد يمنع أو يقلل بشدة التلوث المحتمل للنباتات و التربة بصفة عامة فإن تركيز المعادن الثقيلة في درنات البطاطس مع استخدام الأسمدة العضوية أو المعدنية تظل دون معايير الأمان المقبولة للأغذية .