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EFFECT OF ORGANIC AND MINERAL NITROGEN FERTILIZERS ON POTATO CROP

El-Ghamry, A. M.*; R. A. El-Dissoky and A. M. AbdEl-Hameed*****

* Soil Dept., Faculty Agric., Mansoura Univ., Egypt.

** Soil Improvement Preservation and Dept., Soil Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt.

*** Plant Nutrition Dept., Soil Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt.

ABSTRACT

A field experiment was conducted on alluvial soil at Dakahlia Governorate, Egypt during the growing season of 2007/2008 to study the effect of organic-N as rice straw compost (three levels 0, 6 and 12 t fed^{-1}), inorganic-N as ammonium nitrate (three rates 60, 120 and 180 kg N fed^{-1}) and their interaction on potato (*Solanum tuberosum*, L) cultivar Spunta. Organic-N and mineral-N application significantly increased leaves No./plant, plant height and leaf area. While, the interaction effect between organic and mineral N was insignificantly on leaves No./plant and plant height and significantly on leaf area. Fresh tuber yield and dry shoot yield significantly increased with compost and mineral-N application and their interaction. The highest value of fresh tuber yield was 19, 28 t fed^{-1} with interaction of 180 kg N + 12 t fed^{-1} compost. Dry matter % in tubers was significantly affected by mineral-N, compost application and their interaction after 70, 90 and 110 days from planting. Protein percent and specific gravity were significantly affected with mineral-N fertilization, but insignificantly affected by compost application. N, P and K % in shoots and tubers dry matter were increased with mineral nitrogen and compost addition and their interaction as compared with control at different periods.

INTRODUCTION

Soil fertility, one of the important determinants of agricultural productivity is generally thought to be supplemented through the application of nutrients mainly through inorganic fertilizers, (Rasool and *et al.*, 2007). Potato (*Solanum tuberasum L.*) as a number of the family solanaceae is one of the most important food crops all over the world including Egypt. It ranks the first export and the second vegetable crop in acreage. Potato has a high N requirement, but its recovery of fertilizer N is often quite low. Nitrogen is an indispensable elementary constituent of numerous organic compounds of general importance (amino acids, protein, and nucleic acids) and the formation of protoplasm and new cells.

The effect of organic manure on plant behavior is not just a matter of nutrients supply, organic materials but also influences the physical, chemical and biological characteristics of soil which in turn influences development of plants. Because of the high fertilizer prices and transport costs in the hills, there is a need to supplement a part of N needs of potato with organic fertilizer.

The rice straw residue is about 6.5 million tons/year in Egypt. The large quantity of it is disposal by burning the straw in the field and this way for removal straw causes air pollution, this is the actual reasons for the problem of black cloud which appeared and that pollution is dangerous and harmful for

human health which causes a lot of diseases, so this problem should be faced.

Therefore, the main objectives of the present study are to evaluate the effect of compost "rice straw" levels, mineral-N levels application and their interaction on potato growth, yield, quality and the concentration of N, P and K in potato plant.

MATERIALS AND METHODS

A field experiment was conducted at Batra village, Talkha district, Dakahlia Governorate, Egypt, during growing season of summer 2007/2008 on potato (*Solanum tuberosum*, L.) cultivar Spunta. The experimental soil is considered a clay loam in texture. (36.50 % sand, 29.59 % silt and 34 % clay). This clay loam texture reflects the physical characteristics of soil where, saturation percentage was 64 %, bulk density 1.27 g cm^{-3} and real density 2.65 g cm^{-3}. The analysis also illustrate that soil pH was 7.8. The soil is non-saline where EC was 3 dSm^{-1} (less than 4 dSm^{-1}). Soil organic matter content was 3.20 % and $CaCO_3$ % was 3.2 %. Soil was medium in available nitrogen (35ppm), available phosphorus (15 ppm), and available potassium (380 ppm). The previous soil analysis were carried out according to (Jackson, 1967) and (Hesse, 1971).

Compost of rice straw was prepared before the cultivation season. It was composted at this location according to method described by (Abou El-Fadl, 1960). Some chemical properties of the compost sample were determined. pH value was 6.40 and EC was 2.26 dSm^{-1}. The total carbon percentage was 27.4 %, and total nitrogen was 1.44 %. Therefore the C/N ratio was 19:1. pH and EC values were determined in 1:10 suspension and water extracts for compost, respectively. Total carbon and total nitrogen % were determined as described by (Jackson, 1967).

The experimental design was a split plot design with 3 replicates. The three levels of compost (C) were the main plots, and the three rates of nitrogen (N) were the sub-plots. Treatments were applied as follow:

- The three levels of rice straw compost were applied as follows: C0: (control), C6 (6 ton compost fed^{-1}) and C12 (12 ton compost fed^{-1}).
- The three rates of N (as ammonium nitrate) were applied as follows: N60 (60 kg N fed^{-1}), N120 (120 kg N fed^{-1}) and N180 (180 kg N fed^{-1}).

Application of Compost, Fertilizers and Irrigation: The levels of compost were applied before the last tillage. The rates of nitrogen fertilizers were divided into 2 doses; the 1st dose was added with the 1st irrigation and the 2nd dose with the 2nd after planting. Calcium super-phosphate (15.5 % P_2O_5) was applied before planting irrigation at the rate of recommended does of 75 kg P_2O_5 fed^{-1} for all treatments. Potassium sulfate (50 % K_2O) was applied at rate of 96 kg K_2O fed^{-1} (recommended does) for all treatments, as a one dose with the third irrigation. Potato plants were irrigated after planting 6 irrigations.

Plant Measurements and Analysis:

Number of leaves per plant and plant height (cm) were measured; leaf area (m^2/plant) was calculated using the following equation according to (Koller, 1972):

$$\text{Leaf area} = \frac{\text{Dry weight of leaves x disk area x No. of disks}}{\text{Dry weight of disks}}$$

Potato was harvested after 110 days from planting date and the following parameters were recorded: dry shoot yield (t fed^{-1}) and Fresh tuber yield (t fed^{-1}).

Tuber quality: Dry matter % was determined in tuber after 70, 90 and 110 days from planting, where specific gravity and protein % were determined for tuber potato at harvest (110 days).

$$\text{Specific gravity (S.g.)} = \frac{\text{Weight in air}}{\text{Weight in air - Weight in water}}$$ (Smith, 1975)

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$ (Ranganna, 1977)

Chemical composition: N, P and K % were determined in shoot and tuber dry matter after 70, 90 and 110 days from planting according to the methods described by (Jackson 1967).

The statistical analysis of the obtained data was done according to the methods described by (Gomez and Gomez, 1984) using LSD to compare the means of treatments values.

RESULTS AND DISCUSSION

1- Plant Growth Parameters:

A- Effect of compost:

Data concerning the effect of the various compost applications on plant growth parameters of potato are presented in Table 1. The results indicated that the leaves No./plant, Plant height, Leaf area, dry shoot yield and fresh tuber yield were significantly increased with increasing compost application. This effect of compost application on plant growth parameters (leaves No./plant, Plant height and leaf area) may be related to compost content of nutrients which increase with increasing application rates, in addition, may be related to positive effect of compost in improving soil properties and availability of nutrients which reflected on increasing plant growth. These results confirmed with the work of Abdel-Kader, (2002).

B- Effect of nitrogen fertilizer rates:

Data presented in Table 1, showed that the leaves No./plant, Plant height, Leaf area, dry shoot yield and fresh tuber yield were significantly increased with increasing nitrogen fertilizer rates. The increase in plant growth may be due to fact that N is an essential element for all plants, which is a constituent of the chlorophyll and protein molecules. In this concern El-Sirafy, *et al.*, (2006) found that plant height and leaf area of potato plants were significantly increased with application of N-levels 100 and 150 kg N fed^{-1}.

C- Effect of the interaction between compost application and nitrogen fertilizer rates:

The effect of their interaction on plant growth parameters of potato are shown in Table 1. It had a insignificant effect on leaves No./plant and plant height, but had a significant effect on leaf area, dry shoot yield and fresh tuber yield. The application of compost at the rate 12 t. fed^{-1} with nitrogen fertilizer rates 180 kg N fed^{-1} in combination resulted in the maximum mean values of the above-mentioned growth parameters.

Table 1: Effect of organic and mineral nitrogen fertilizers on potato plant growth.

Treatments		Leaves No. plant^{-1}	Plant height (cm)	Leaf area (m^2 plant^{-1})	Dry shoot Yield (t fed^{-1})	Fresh tuber yield (t fed^{-1})
Compost effect						
C0		14.89	21.00	0.234	0.60	12.01
C6		17.00	21.89	0.277	0.64	15.18
C12		18.00	23.00	0.337	0.74	16.65
LSD 5%		**0.73**	**0.80**	**0.024**	**0.039**	**0.584**
Nitrogen effect						
N60		12.11	17.11	0.207	0.47	10.01
N120		18.22	24.11	0.310	0.71	16.59
N180		19.56	24.67	0.331	0.80	17.23
LSD 5%		**0.58**	**0.46**	**0.019**	**0.036**	**0.487**
Interaction effect						
C0	N60	10.00	15.67	0.137	0.39	7.08
	N120	16.33	23.33	0.273	0.68	14.18
	N180	18.33	24.00	0.293	0.72	14.78
C6	N60	13.00	17.33	0.240	0.49	10.55
	N120	18.67	24.00	0.290	0.70	17.33
	N180	19.33	24.33	0.300	0.76	17.64
C12	N60	13.33	18.33	0.243	0.56	12.40
	N120	19.67	25.00	0.367	0.75	18.26
	N180	21.00	25.67	0.400	0.80	19.28
LSD 5%		--	--	**0.033**	**0.045**	**0.844**

2- Tubers Yield Quality.

A- Effect of compost:

Data in Table 2 revealed that addition of compost levels significantly decreased dry matter % in tubers at 70 and 90 days. On the other hand, at 110 days dry matter % was increased significantly as compared with control (without addition of compost). However, the effect of compost on tuber specific gravity and protein percentage in tuber were insignificantly. These results confirmed with those obtained by El-Dissoky (2005) who showed that protein % of potato tubers were significantly increased with compost and mineral-N fertilization.

B- Effect of nitrogen fertilizer rates:

Data in Table 2 show that the addition of nitrogen fertilizer rates significantly decreased dry matte % in tuber as compared with control (without N) at 70 days. At 90 days, it increased significantly. As for specific gravity, it is obvious from the results that its values significantly decreased with N fertilization. Data in the same previous table reveal that protein % significantly increased with N-rates addition.

C- Effect of the interaction between compost application and nitrogen fertilizer rates:

The effect of interaction between the compost application and nitrogen fertilizers rates on dry matter % was significantly at 70, 90 and 110 days. While, the effect of interaction C x N on specific gravity of tubers was insignificant. As well as, the effect of interaction on protein % was significant. Protein % was increased with interaction, where the highest value of protein % was obtained with interaction between C6 and N180.

Table 2: Effect of organic and mineral nitrogen fertilizers on tuber quality of potato

Treatments		Dry matter percentage after			Specific gravity	Protein percentage
		70 days	90 days	110 days		
Compost effect						
C0		14.36	20.03	21.95	1.071	8.20
C6		13.09	18.90	23.63	1.073	8.35
C12		14.08	18.76	23.43	1.072	8.19
LSD 5%		0.402	0.741	0.670	--	--
Nitrogen effect						
N60		14.48	19.30	20.89	1.076	6.94
N120		13.48	18.89	24.00	1.071	8.86
N180		13.57	19.50	24.12	1.069	8.93
LSD 5%		0.318	0.293	0.582	0.003	0.234
Interaction effect						
C0	N60	15.43	19.62	20.05	1.078	6.53
	N120	13.97	19.45	23.50	1.067	9.24
	N180	13.67	21.02	22.31	1.068	8.83
C6	N60	13.02	19.05	21.40	1.077	6.85
	N120	13.09	19.08	24.27	1.072	8.85
	N180	13.16	18.59	25.23	1.069	9.35
C12	N60	14.99	19.24	21.23	1.074	7.45
	N120	13.37	18.14	24.23	1.074	8.49
	N180	13.86	18.91	24.83	1.068	8.62
LSD 5%		0.551	0.508	1.009	--	0.406

3- Chemical Composition of Potato.

A- Effect of compost:

Data in Table 3 show the effect of compost application on N, P and K contents in shoot and tubers. N % in shoot increased with compost addition as compared with control, these increase was significantly at 70 days and 110 days and insignificant at 90 days. Although, nitrogen concentration in shoot of potato was decreased with mature. N % in tubers was insignificantly affected by compost addition at 70 and 110 days, but significantly at 90 days. This effect confirmed with that obtained by El-Ghamry, *et al.*, (2005). Also, data reveal that P % in shoot significantly increased with compost applied. However, compost application significantly increased P % in tubers at 70 days and insignificantly at 90 and 110 days. These results could be attributed to effect of compost in increase soil organic matter, soil nutrients and decrease soil pH, which reflected on availability of P and then its uptake. These results confirmed with El-Sirafy, *et al.*, (2006). As well as data reveal that compost application significantly increased K % in shoot and tubers at 70, 90 and 110 days. It is noticed that K concentration increased with increasing compost application.

B- Effect of nitrogen fertilizer rates:

Data in Table 3 reveal that application of N-rates significantly increased N % in shoot and tubers of potato plants at 70, 90 and 110 days. The rate of N180 recorded the highest N % at 70, 90 and 110 days. This trend may be due to the dry matter accumulation at this rate. These results are in accordance with those reported by Abdel-Kader, (2002).

Table 3: Effect of organic and mineral nitrogen fertilizers on N %, P % and K % in potato shoots and tubers in different stages.

Treatments		N %						P %						K %					
		in shoot			in tuber			in shoot			P % in tuber			in shoot			K % in tuber		
		70 days	90 days	110 days	70 days	90 days	110 days	70 days	90 days	110 days	70 days	90 days	110 days	70 days	90 days	110 days	70 days	90 days	110 days
Compost effect																			
C0		3.65	3.03	1.99	1.48	1.47	1.30	0.21	0.20	0.18	0.19	0.19	0.18	4.21	3.81	2.99	1.85	2.00	1.94
C6		3.86	3.02	2.20	1.62	1.50	1.32	0.23	0.21	0.19	0.22	0.20	0.18	4.46	4.51	3.52	1.94	2.07	1.77
C12		3.96	2.99	2.36	1.61	1.47	1.30	0.24	0.22	0.20	0.23	0.28	0.19	4.78	4.18	3.83	2.00	2.26	1.86
LSD 5 %		**0.225**	--	**0.090**	--	--	--	**0.006**	**0.006**	**0.010**	**0.005**	--	--	**0.108**	**0.326**	**0.544**	**0.089**	**0.083**	**0.058**
Nitrogen effect																			
N60		3.13	2.52	1.97	1.34	1.30	1.10	0.20	0.18	0.16	0.19	0.18	0.17	4.31	4.21	3.07	1.91	2.11	1.77
N120		3.98	3.22	2.23	1.66	1.58	1.41	0.22	0.21	0.20	0.22	0.27	0.19	4.47	4.09	3.51	2.01	2.20	1.86
N180		4.36	3.30	2.34	1.70	1.56	1.42	0.26	0.24	0.21	0.23	0.21	0.19	4.68	4.20	3.75	1.87	2.01	1.95
LSD 5 %		**0.222**	**0.137**	**0.096**	**0.141**	**0.008**	**0.044**	**0.011**	**0.009**	**0.007**	**0.004**	--	--	**0.118**	--	**0.308**	**0.045**	**0.065**	**0.024**
Interaction effect																			
C0	N60	2.93	2.54	1.81	1.28	1.26	1.03	0.17	0.16	0.16	0.16	0.16	0.15	3.96	3.51	2.66	1.81	2.16	1.88
	N120	3.80	3.16	2.00	1.61	1.58	1.47	0.21	0.20	0.19	0.20	0.20	0.19	4.22	4.16	2.87	2.00	1.93	1.94
	N180	4.22	3.40	2.16	1.50	1.53	1.40	0.25	0.23	0.20	0.22	0.21	0.20	4.46	3.76	3.43	1.73	1.91	2.01
C6	N60	3.29	2.50	2.04	1.43	1.38	1.08	0.21	0.18	0.16	0.20	0.19	0.17	4.56	4.95	2.94	1.88	1.84	1.63
	N120	4.23	3.35	2.24	1.69	1.55	1.40	0.22	0.21	0.20	0.22	0.20	0.19	4.46	4.17	3.82	1.99	2.39	1.75
	N180	4.40	3.22	2.32	1.75	1.58	1.48	0.27	0.24	0.20	0.23	0.21	0.19	4.36	4.40	3.78	1.96	1.98	1.94
C12	N60	3.51	2.54	2.06	1.32	1.26	1.18	0.22	0.20	0.17	0.21	0.19	0.18	4.42	4.16	3.61	2.04	2.35	1.78
	N120	3.92	3.16	2.47	1.70	1.60	1.34	0.24	0.22	0.21	0.23	0.41	0.20	4.72	3.95	3.85	2.04	2.27	1.88
	N180	4.45	3.27	2.54	1.80	1.55	1.37	0.27	0.24	0.22	0.24	0.22	0.19	5.20	4.44	4.03	1.92	2.16	1.90
LSD 5 %		**0.348**	**0.102**	--	--	**0.015**	**0.076**	**0.007**	**0.011**	--	**0.008**	--	--	**0.206**	**0.336**	**0.092**	**0.078**	**0.114**	**0.042**

As well as data in the same table indicate that the percentage of P in shoot was significantly increased with N-rates addition, but P % in tuber was significantly increased at 70 days and insignificantly at 90 and 110 days. The positive effect of nitrogen application on P uptake by plants could be attributed to increasing of growth, increasing of root growth, altered metabolism, and increased solubility of soil P. Also, data show that N-rates application significantly increased potassium concentration in shoots at 70 and 110 days, but insignificantly at 90 days. Whereas the effect of N-fertilization on K % in tuber was significantly after 70, 90 and 110 days. The positive effect of nitrogen fertilization on K % in shoots may be related to the role of N in increasing the root and vegetative growth and consequently the uptake of nutrients. This effect confirmed with obtained effect by El-Metwally, (2003), who observed that percentages of total K in dry matter tubers were increased with N application.

C- Effect of the interaction between compost application and nitrogen fertilizer rates:

As show in Table 3, the effect of interaction between compost-levels and N-rates was significantly on N % in shoot at 70 and 90, but insignificantly at 110 days. However, this effect of interaction on N % at tuber was insignificantly at 70 days, but was significantly at 90 and 110 days. These results are in accordance with those reported by Alromian and El-Fakharani, (2002). As well as the effect of interaction on P % in shoot was significant at 70 and 90, but insignificantly at 110 days. As for the effect of interaction on K % in shoot and tubers, it is obvious that was significantly at 70, 90 and 110 days. These results are in accordance with those reported by El-Dissoky, (2005).

Conclusion

The present study recommends that the application of 180 kg N fed^{-1} as ammonium nitrate + 12 ton compost fed^{-1} of rice straw with the constant background of recommended doses of phosphorus 75 kg P_2O_5 fed^{-1} as super-phosphate and potassium 96 kg K_2O fed^{-1} as potassium sulfate is used to obtain high fresh tuber yield of potato.

REFERENCES

Abdel-Kader, A. E. (2002). Effect of some organic and mineral fertilizers on some potato cultivars. M. Sc. Thesis, Fac. of Agric. Mans. Univ., Egypt.

Abou El-Fadl, M. (1960). Organic fertilizer and the production of plant and animal wastes, Arabic Statement Committee Press, Cairo, (In Arabic).

Alromian, F. M. and Y. M. El-Fakharani (2002). Effect of sulfur on the utilization efficiency of nitrogen by wheat on sandy soils of Saudi Arabia. J. Agric. Sci. Mans. Univ., 27 (9): 6477-6490.

El-Dissoky, R. A. (2005). Effect of nitrogen fertilization and sulfur under compost application on potatoes. M. Sc. Thesis, Fac. Agric., Mans. Univ., Egypt.

El-Ghamry A. M.; Z. M. El-Sirafy and R. A. El-Dissoky (2005). Response of potato grown on clay loam soil to sulfur and compost application. J. Agric. Sci. Mans. Univ., 30 (7): 4337 - 4353.

El-Metwally, E. M. (2003). Fertigaiton of drip irrigated potato (Solanum tuberosum, L.). Ph. D. Thesis, Fac. Agric., Mans. Univ., Egypt.

El-Sirafy, Z. M.; A. M. El-Ghamry and R. A. El-Dissoky (2006). Effect of some soil amendments and nitrogen fertilization on potatoes. J. Biol. Chem. Environ. Sci., 1(4):843-880.

Gomez, K. A. and A. A. Gomez (1984). "Statistical Procedures for Agricultural Research". 2nd Ed. John Wiely and Sons, pp. 680.

Hesse, P. R. (1971). "A Text Book of Soil Chemical Analysis". John Murry (publishers) Ltd, 50 Albermarle Street, London.

Jackson, M. L. (1967). "Soil Chemical Analysis". Printic Hall of India, New Delhi. pp 144-197.

Koller, H. R. (1972). Leaf area, leaf weight relationship in soybean canopy. Crop Sci., (12): 180-183.

Ranganna, S. (1977). "Manual of Analysis of Fruit and Vegetable Products". Central Food Technological Research Institute Mysore.

Rasool, R. ; S. S. Kukal and G. S. Hira (2007). Soil physical fertility and crop performance as affected by long term application of FYM and inorganic fertilizers in rice – wheat system. Soil and Tillage Res., 96, 64-72.

Smith, N. R. (1975). "Specific Gravity, Potato Processing". The AVI Publishing Comp. Inc., 43-66.

تأثير الأسمدة النتروجينية المعدنية و العضوية على محصول البطاطس

أيمن محمد الغمرى *، رمضان عوض الدسوقى و عادل عبد الحميد*****

* قسم الأراضي- كلية الزراعة – جامعة المنصورة – مصر

** قسم تحسين وصيانة الأراضي – معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية – جيزة – مصر.

*** قسم تغذية النبات – معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية – جيزة – مصر.

أجريت تجربة حقلية فى أرض رسوبية بمحافظة الدقهلية, مصر. خلال موسم الزراعة لعام ٢٠٠٧/٢٠٠٨ لدراسة تأثير النتروجين العضوى فى صورة كمبوست قش الأرز (ثلاث مستويات صفر, ٦, ١٢طن للفدان) والنتروجين المعدني فى صورة نترات الامونيوم (ثلاث معدلات صفر و ١٢٠, ١٨٠كجم ن للفدان) وتفاعلاتهم على البطاطس صنف اسبونتا.

وكانت النتائج كما يلى:-

- زاد عدد الأوراق وارتفاع النبات والمساحة الورقية معنويا بالتسميد النتروجينى العضوى والمعدنى. بينما اثر التفاعل بينهما غير معنويا على عدد الأوراق وارتفاع النبات ومعنويا على المساحة الورقية.
- زاد معنويا كلا من محصول الدرنات الطازج و محصول العرش الجاف بالتسميد النتروجينى العضوى فى صورة كمبوست والمعدنى والتفاعل بينهما. كان أعلى محصول درنات طازج ١٩,٢٨ طن/فدان عند التفاعل بين ١٨٠ كجم ن فى صورة نترات امونيوم + ١٢ طن كمبوست/فدان.
- تأثرت النسبة المئوية للمادة الجافة فى الدرنة معنويا بإضافة النتروجين المعدنى والكمبوست والتفاعل بينهما بعد ٧٠ و ٩٠ و ١٢٠ يوم من الزراعة، تأثرت النسبة المئوية للبروتين والوزن النوعي للدرنة أيضا معنويا بإضافة النتروجين المعدنى وغير معنويا بإضافة الكمبوست.
- زادت النسب المئوية لكلا من النتروجين والفوسفور والبوتاسيوم فى العرش والدرنات مع إضافة النتروجين المعدنى والكمبوست والتفاعل بينهما بالمقارنة بالكنترول عند الفترات المختلفة للتقدير.