Organic Fertilization for Improving Potato Production with Application of ^{15}N- Isotope Dilution Technique

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Abstract: Compost and compost tea used in this study have revealed to increase the production of tuber potato. Tuber yield significantly increased by application 50%compost treatment with 50% chemical fertilizer as compared all treatment. Application of compost soiled under all treatment compost with combination chemical fertilizer none significantly increased compared other application to method, compost tea foliar or compost tea soil application alone or combination chemical fertilizer, this true with all rate N chemical alone or combination with organic. In most of compost tea application soil, the addition 50% compost + 50%chemical fertilizer had increased N uptake by tuber over those recorded with 100% compost tea,treatment 50% compost combination 50%chemical fertilizer accumulated 1215 g N plot $^{-1}$ seems to be the best ones. The Nitrogen derived from fertilizer %Ndff values were higher in the tuber potato than shoots for all treatments, it was decreased rate 75% compost with combination 25%chemical fertilizer and 25% compost + 75%chemical fertilizer under compost soiled application or compost tea foliar as compared to application compost tea soil. Nitrogen derived from compost as affected by application method was highest for compost tea soil application as compared to both tow methods application. The percentage fertilizer use efficiency (%FUE) with tuber of potato was higher than those recorded with shoots under all rate and methods. Compost tea can also improve nutrient utilization and lower the environmental pollution through reducing the amounts of fertilizers added to the soil.

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Key words: Compost/ Compost tea/ Drip irrigation/ ^{15}N technique / Potato

1. Introduction

Solanum tuberosum represents the fourth world crop production after barley, rice and maize. It is cultivated in almost twenty millions hectares, with a production of three hundred millions tones **(Mahmoud et al., 2003).** The world production in Africa, Asia and Latin America has progressed from 11% between 1961 and 1963 to 81% between 1991 and 1993 **(Storey and Davis, 1992).** In temperate region, the productivity can attain 40t/ha, but remains low in the tropics, varying from 5 to 11t/ha in low lands, and from 20 to25 t/ha in highlands **(Caburet et al., 2002).**

Potato (*Solanum tuberosum* L.) is cultivated in Egypt in a wide area and ranks the first vegetable crop for export and local market. In 1936, the Central Potato Cooperative, later known as the Potato Growers' Cooperative was established to promote production and marketing of potatoes Commercial production of potatoes is concentrated in the Nile Delta, Middle Egypt and the newly reclaimed land such as Nubaryia **(Gad-Elrab, 2003).** Hence, chemical fertilizers have been used as one of the main solutions recognized to equilibrate nutrients balance, and allow plants to express their potentialities **(Barbier and Cattin, 1994)**. Unfortunately, this practice leads to serious nutritional and environmental risks **(Lachance and Rouleau 2004)**. In addition to their high costs **(Gonlaina, 2002),** the inadequate utilization of chemical fertilizers may cause water and soil pollution or increase the sensibility of plants to several diseases (Hartzler, 1990). To overcome these difficulties, biological fertilizers and organic amendments have been recommended **(Landais et al., 1990; Ngakou, 2007)**. The use of organic fertilizers such as chicken manures **(Mabong, 2004)** or compost **(Ngakou et al., 2008),** have been reported to improve the quality of soil and crop yields in the region. More over, an extract derived from compost, the so called (compost tea) represents not only a mean of completing the role of compost in the fertilization process, but also, a strategy of cultivation of useful micro flora to prevent stem and floral diseases **(Deschêne, 2007).** Hence, there is growing interest in the potential for using composts tea to stimulate root and vegetative growth, prevent and control diseases in field crops, increase crop yields and quality, and information concerning their use and effectiveness is slowly increasing **(Litterick et al., 2004; Hibar et al., 2006; Haggag and Saber, 2007).**

2. Materials and Methods

A field experiment was carried out at the Plant Nutrition and Fertilization Unit, Soils and Water Research Department, Nuclear Research Center, Atomic Energy Authority, Inshas, Egypt, on potato as an indicator plant using the materials described below. Tubers of potato cultivar (*Solanum tuberosum*

L) (Spunta), supplied by the Agriculture Research Centre (ARC), Giza, Egypt were used in the experiments carried out through the study. Tubers seeds from each spunta were sown on 21Th of January in seasons and spaced at 25cm apart. physical and chemical properties of used sandy soil were 88.5% sand, Silt 2.7%, and 8.8% clay, pH(1: 2.5) 7.97, EC(dSm-)0.27,O.C%0.017, O.M%0.03, T.N%0.007, C/N Ratio2.43, Ca CO3 %1.0.The compost was prepared from 50 % organic manure (cattle manure + poultry manure + goat manure + rabite manure) 50 % plant residues (Rice straw + wheat straw + barley straw + Chic straw + Lupine straw) + 2 kg sulphur agriculture + 2 kg $(NH_4\ So_4)^2$ + 2 kg Super phosphate + Fungi (100 ml spirigellus). Compost tea was obtained by extraction from compost treatment on 1day up 60 day. The extraction compost tea from mixture of compost and water hold capacity. The chemical properties of compost the used investigated were PH (1:5) 6.40, EC ds/m20.80, C/N ratio10.15, O.M%57.02, N %3.13, P%0.84, K %0.692 and compost tea were PH (1:5) 6.70, EC ds/m12.70, C/N ratio12.62, O.M%56.89, N %2.83, P%0.51, K %1.617. A field experiment was carried out where the experimental design was complete randomized block with three replicates. The drip irrigation occupied the main plots. The experiment included (13 treatments of each variety of potato Spunta) each 13 treatments of 3 replicate (1 treatment100 % Mineral fertilizer (control), 1 treatments 100 % organic manure (OM) and 1 treatments 75% organic manure (OM) + 25% Mineral fertilizer (MF), 1 treatments 50% organic manure (OM) + 50% Mineral fertilizer (MF) and 1 treatments 25% organic manure (OM) + 75% Mineral fertilizer (MF)and three methods 1compost soiled application, 1 compost tea soil application, 1 compost tea foliar application. A basic supplemental of N, P and K fertilizers were applied to each plots (2 x 5 m^2) at the rate of 180 kg/ fed as organic manure **or** Mineral fertilizer (ammonium sulphate), 75 kg fed^{-1} as phosphoric acid and 96 kg fed^{-1} as potassium sulfate, respectively. ^{15}N-Labeled ammonium sulfate (2% ^{15}N atom excess) was applied as a source of mineral nitrogen (ammonium sulfate) was applied as solution one time after 15 days from planting. The dry weights of whole plants and plant parts, total nitrogen, Nitrogen derived from fertilizer (%Ndff), Nitrogen derived from soil (%Ndfs), Nitrogen derived from organic compost (% Ndf comp) and Fertilizer use efficiency (% FUE) were calculated. After 120 days, plants were harvested and shoots were dried at 70ºC, weighed and digested.

Chemical and physical analyses of tested soil samples were determined according to Black (1965).

Statistical analysis:

Analysis of variance was determined an obtained data.

3. Results and Discussion

Data in table (1) show that all treatment of yield as affected by addition organic sources and chemical fertilizer. Tuber yield significantly increased by application 50%compost treatment with 50% chemical fertilizer as compared all treatment. The rate of increase due to organic sources combination chemical fertilizer was 45.0,41.0 32.3, 27.0 and 26.0 kg plot $^{-1}$ at the treatment 50% compost + 50% chemical fertilizer,100% chemical fertilizer, 25% compost + 75% chemical fertilizer, 75% compost + 25% chemical fertilizer and 100% compost respectively. Application of compost soiled under all treatment compost with combination chemical fertilizer none significantly increased compared other application to method, compost tea foliar or compost tea soil application alone or combination chemical fertilizer, this true with all rate N chemical alone or combination with organic.

Compost tea is a readily available form of compost that will impact the plant more than compost mixed into the soil. The postulated direct mechanisms that account for the positive impact of compost tea on plant vigor and growth include plant response to nutrients or growth promoting chemicals in the compost tea, On the other hand, postulated indirect mechanisms include altering composition and/or populations of plant associated microorganisms that cause a direct effect, or over time, moderation of the chemical, physical or biological properties of the rhizosphere/phyllosphere, such as soil structure, pH, or reducing the effect of In this research, compost and compost tea were also assessed for their ability to control the disease and tuber of potato. In general, these biological amendments can effectively deliver micro-organisms to natural soils, resulting in a wide variety of effects on soil microbial communities. Results revealed that the use of compost tea differs significantly from the use of solid compost to suppress potato production. Compost and compost tea used in this study have revealed to increase the production of tuber potato, which are growth parameters. Non-aerated compost tea may favor the extraction of antibiotic compounds that play an important role in suppression of plant nutrition**.** The difference between the use of soil applied compost and compost tea has been reported to be the immediate control of surface spreading pathogens, while soil compost acts more slowly over a longer period of time. Furthermore, the quantities required to effect control are significantly less for compost tea than compost **((Hardy and Sivasithamparam, 1991, Brinton, 1995).** These results are similar to those of **Mohammed et al. (2010),** who observed higher yield

in compost tea than in organic applied treatments on Le-Conte pear trees. But, the fact that there was no significant difference between the weights of different treatments is obvious, since spoilage usually reduce the weight of tubers. Shoots potato plant was significantly increased with application of compost and /or chemical fertilizer and method application table(1) The mean average increase was 4.50,4.200, 4.00, 3.60, and 2.00 when nitrogen chemical with combination organic add at the rate 25% compost +75% chemical fertilizer, 75% compost +25% chemical fertilizer,100% chemical fertilizer, 50% compost +50% chemical fertilizer and 100% compost. Shoots potato as affect by application method, compost and compost tea. Shoots potato was enhanced by application foliar compost tea and application compost tea soil as compared to application compost with all rates organic or combination chemical.

Table (1) Effect of compost and compost tea and inorganic fertilizer on tuber and shoot dry matter kg plot^{-1} of potato.

Source of applied nitrogen (S)	Methods of organic material (M)											
	Tuber				shoot				total			
	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean
(S1)	26.0	28.0	39.0	31.0	2.0	2.6	5.5	3.4	28.0	30.6	44.5	34.4
(S2)	27.5	36.2	36.0	33.2	4.2	5.2	4.7	4.5	31.7	41.4	40.7	37.9
(S3)	45.0	46.5	45.0	45.5	3.6	4.7	4.0	4.1	48.6	51.2	49.0	49.6
(S4)	32.3	35.0	46.0	37.8	4.5	4.0	4.2	4.3	36.8	39.0	50.2	42.1
Mean	32.7	36.4	41.5	-	3.6	4.13	4.6	-	36.3	40.6	46.1	41.0
100% CF	37.0				4.0				41.0			
L.S.D. (0.05): M: 1.81, S: 1.81, M×S: 2.71												

Methods of organic material (M): Soil – applied Compost (M1), Soil – applied compost tea (M2), foliar– applied compost tea(M3)

Source of applied nitrogen (S): 100% compost (S1), 75% compost+ 25% chemical fertilizer(S2), 50% compost + 50% chemical fertilizer(S3), 25% compost +75% chemical fertilizer(S4), 100 % chemical fertilizer (100% CF)

Values of N uptake by tuber potato plant grown in sandy soil was greatly improved by the compost or compost tea and chemical fertilizer table (2) The main improving effect on nitrogen uptake by tuber potato of applied rate 50% compost + 50%chemical fertilizer with three application methods as comparing to other rate. Under application foliar compost tea, treatment 25% compost + 75%chemical fertilizer and 50% compost + 50%chemical fertilizer seems to be the best ones. The lowest value of N uptake by tuber was recorded with 75% compost + 25%chemical fertilizer followed 100% compost tea. In most of compost tea application soil, the addition 50% compost + 50% chemical fertilizer had increased N uptake by tuber over those recorded with 100% compost tea, treatment 50% compost combination 50% chemical fertilizer accumulated 1215 g N plot $^{-1}$ seems to be the best ones. Wile the lowest value of N uptake by tuber was recorded with 100% compost. Under application method, compost tea foliar induced higher N uptake by tuber than tow method, compost and compost tea soil application. N uptake by shoots potato plant grown in sandy soil was greatly improved by the compost or compost tea and chemical fertilizer table (2) Data show it was clear that application of treatment compost tea foliar, enhanced N uptake by shoots as compared to two other method. Under compost treatment of 75% compost + 25%chemical fertilizer is the best N uptake by shoots could be arranged as fallowing 75% compost + 25%chemical fertilizer > 25% compost + 75% chemical fertilizer > 50% compost + 50% chemical fertilizer > 100% chemical fertilizer > 100 compost, N uptake by shoots was significantly affected by fertilizer or compost with methods compost tea soil application. Under most rate the application of 75% compost tea with combination 25% chemical fertilizer induced high N uptake by shoots as compared to be totally fertilized with organic or chemical fertilizer while the lowest value was recorded with 100% compost tea.

Values for nitrogen derived from fertilizer (%Ndff) similar were tuber and shoots, respectively, for mean of rate of 50% nitrogen fertilizer combination 50% compost or compost tea greater than those for all treatment table (3) In the compost tea soil application, %Ndff was much higher for compost tea soil application (58.37 g plot^{-1}) than for compost tea foliar application (41.40 g plot^{-1}) and compost solid application (33.5 gplot^{-1}). The %Ndff values were higher in the tuber potato than shoots for all treatments, it was decreased rate 75% compost with combination 25%chemical fertilizer and 25% compost + 75%chemical fertilizer under compost soiled application or compost tea foliar as compared to application compost tea soil.

Table (2) Effect of compost and compost tea and inorganic fertilizer on N uptake gplot^{-1} of potato varieties.

Source of	Methods of organic material (M)											
	Tuber				shoot				Total			
	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean
(S1)	780.0	868.0	1248.0	965.3	52.0	70.2	154.0	92.1	832.0	938.2	1402.0	1057.4
(S2)	798.0	1086.0	1116.0	1000.0	113.4	145.6	126.9	128.65	911.4	1231.6	1242.9	1128.7
(S3)	1215.0	1302.0	1215.0	1244.0	100.8	112.0	112.0	108.3	1315.8	1414.0	1327.0	1352.3
(S4)	838.5	945.0	1196.0	993.2	112.5	104.0	105.0	107.2	951.0	1049.0	1301.0	1100.4
Mean	907.9	1050.3	1193.8	-	94.7	108.0	124.5	-	1002.6	1158.2	1318.2	-
100% CF	1260.0				108.0				1268.0			
L.S.D. (0.05): S: 10.41,R: 10.81,, S ×R : 20.51												

Table (3) Effect of compost treatments and inorganic fertilizer on N dff g plot^{-1} of potato varieties.

Source of	Methods of organic material (M)											
	Tuber				shoot				Total			
	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean
(S2)	7.18	68.40	17.86	31.1	7.60	2.62	2.02	4.1	14.78	71.02	19.90	35.23
(S3)	30.38	57.29	49.82	45.8	3.33	4.48	3.25	3.7	33.71	61.77	53.07	49.5
(S4)	15.93	38.27	49.04	34.4	6.41	4.05	2.21	4.2	22.07	42.32	51.25	38.6
Mean	17.65	54.70	38.90	-	5.78	3.71	2.94	-	33.50	58.37	41.40	
100% CF	38.27				2.18				40.45			
L.S.D. (0.05): *S: 1.11, R: 1.31,, S ×R: 3.71*												

The nitrogen derived from compost in treatment 75% compost +25% chemical was higher as compared to treatment25% compost +75% chemical, 50% compost +50% chemical and 100% compost,whereas the converse was obtained with treatment 50% compost + 50% chemical under compost soiled application which gave the highest values as compared than other tow in this studied table (4) Nitrogen derived from compost as affected by application method were highest for compost tea soil application as compared to both tow methods application.

Table (4) Effect of compost treatments and inorganic fertilizer on Ndf compost g plot $^{-1}$of potato varieties.

Source of applied	Methods of organic material (M)											
	Tuber				shoot				Total			
	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean
(S2)	128.57	839.84	531.58	500.0	68.11	69.67	82.15	73.3	196.98	909.51	613.73	573.41
(S3)	275.93	561.65	516.54	451.4	42.81	31.54	48.47	40.9	318.74	593.19	565.01	492.31
(S4)	185.71	509.02	554.14	416.3	31.21	63.60	58.41	51.1	216.92	572.62	612.55	467.36
Mean	196.73	636.83	534.08	-	47.38	54.93	63.00		244.21	691.8	597.10	
L.S.D. (0.05): *S: 12.81, R: 12.61,, S× R: 23.71*												

Values for %Ndf compost were 691.71, 597.09 and 171.80 compost tea applications, compost tea foliar and compost soiled application respectively. The mean values of rate for %Ndf compost were 573.30,492.31and 457.37 for75% compost +25% chemical, 50% compost + 50% chemical and 25% compost +75% chemical respectively. Data show that tuber was higher nitrogen derived from compost than shoots with all treatments. Similar to other results obtained by **Ketterer, 1990; Tränkner, (1991),** compost tea may act directly in varying degrees to suppress both the growth and plant production. The primary source of effects observed with compost tea has been reported to be apparently of living micro-organisms. In other words, active biological control is apparently responsible for the positive effects observed for compost tea. Not only this, the compost must be of high quality as reported by **Brinton (1995)** in order to expect the awaited positive effects. On the other hands, organic fertilizers such as compost may improve the physical, chemical and biological properties of nearly all types of soils, adjusting the pH, increasing nutrient solubility and production of crops **(Zhou et al., 2001). (Ngakou etal., 2012)** found that The benefits of compost tea in agriculture include enhanced disease suppression or resistance towards diseases, promotion of crop health; provision of available nutrients for plants, decreased fertilizer requirements and associated costs, increased soil micro-organism populations and diversity to improve soil structure, water retention, rooting depth and plant growth. Based on results obtained from this study, compost/compost tea could be recommended to organic and conventional growers because of the above gains in yield and/or production efficiency it induces. Our understanding

of the science behind this complex product will continue to grow and help us to validate some of its possibilities and limitations. However, research is still needed to valuate the control of plant diseases in relation to specific cultivar and specific pathogen.

The percentage fertilizer use efficiency(%FUE) in table(5) data showed that %FuE was enhanced by application of mean rate 50% compost plus 50% chemical fertilizer treated as compared to plant totally fertilizer. On the other hand, the lowest present of %FuE was noticed with application of rate 25%compost +75%chemical fertilizer. In general, the%FuE under application compost soiled was lower than those recorded with tuber and shoots when application treatment compost tea soil and compost tea foliar were considered. %FuE with tuber of potato was higher than those recorded with shoots under all rate and methods. Compost tea can also improve nutrient utilization and lower the environmental pollution through reducing the amounts of fertilizers added to the soil **(Abdou El-nour, 2002).** These similarities in their effects may account for the positive response in their suppressive activities over the control treatment. Furthermore, foliar feeding of nutrients may actually promote root absorption of the same nutrient or other nutrients uptake **(El-Fouly and El-Sayed, 1997).**

Table (5) Effect of compost treatments and inorganic fertilizer on %FuE of potato varieties.

Source of	Methods of organic material (M)											
	Tuber				shoot				Total			
	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean	(M1)	(M2)	(M3)	Mean
(S2)	5.98	57.0	43.68	35.6	6.30	2.18	1.67	3.38	12.28	59.18	45.35	38.93
(S3)	25.32	47.74	41.52	38.2	2.78	3.73	2.71	3.1	28.1	51.47	44.23	41.27
(S4)	13.28	32.27	40.87	28.8	5.34	1.82	1.84	3.0	18.62	34.09	42.71	31.81
Mean	14.86	45.67	42.02	-	4.81	2.58	1.87		19.67	48.25	43.89	
100% CF	32.27				1.82				34.09			
L.S.D. (0.05): S: 0.71, R: 0.91, S× R: 2.71												

Conclusion

The data obtained in the present study support the following conclusions: Compost tea is an aerated solution derived from compost containing a high concentration of beneficial microorganisms that can be sprayed directly onto plants as a liquid feed or onto soil as a drench. Compost tea is being used in conventional and organic agricultural production. As costs have increased there has been considerable interest in using compost tea to reduce fertilizer and agrochemical use in full scale potato Production. Compost tea to sustainable and low-cost and Improves soil and plant health,Helps achieve better looking plants,Users experience less disease,aids nutrient recycling,improves root growth and 100% safe and natural and cannot be over-applied.

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