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Environmental Hazards and Agronomic Benefits of Organic and Inorganic Nitrogen Fertilization to Sandy Soils Monocropped with Radish.

Tantawy, I. A. A. [1]; M. H. Hashem [2] and M. M. Abd El-Azeim[3]

[1]Department of Horticulture Department, Faculty of Agriculture, Minia University, El-Minia, Egypt.

[2]Central Laboratory of Organic Agriculture, Agriculture Research Center, Giza, Egypt.

[3]Department of Soil and Water, Faculty of Agriculture, Minia University, El-Minia, 61517, Egypt

Corresponding author: E-mail: mohyeldeen.elatar@mu.edu.eg, Tel +02 086 2362333, Fax: +020862362182

ABSTRACT

Application of organic in combinations with inorganic N fertilizers can supply plants with all necessary nutrients in slowly available forms without environmental pollution. Vegetable field trials were conducted under controlled greenhouse conditions for two successive seasons using radish as a catch crop in order to evaluate environmental hazards and agronomic benefits of applying different combinations of organic and inorganic N fertilizers to sandy soil. Over both seasons of this study, improvements in growth quality parameters of radish plants were in most cases not significantly different at the higher fertilizer application rates of 120 and 180 kg ha^{-1}. This finding indicates that radish response as a catch crop owing to the increasing of fertilizer application rate is subjected to diminishing returns, beyond which further additions will not improve the yield but pollute soil environment.Results of this research showed that, major considerations in applying of inorganic N fertilizers alone on sandy soils monocropped with catch crops are the increase in residual nitrate in soils, the increase in groundwater contamination potentials by nitrate, and the threat of nitrates build-up in plant tissues. Under conditions of this study, high application rates of inorganic nitrogen fertilizer (180 kg ha^{-1}) caused high levels of nitrate accumulation in radish, and on being consumed by human beings, pose serious health hazards. In general, at the rate of 120 kg ha^{-1} equal combined organic and inorganic fertilizers, no health problems could be foreseen to humans or animals from food chain movement of nitrates. From this research it could be concluded that incorporation of combined organic and inorganic fertilizers into sandy soil monocropped with catch crops at the rate of 120 kg ha^{-1} nitrogen using drip irrigation system was the best management strategy practice to reach optimum agronomic benefits while minimizing environmental and health hazards.

Keywords: *Catch crops, Nitrate pollution, Environmental hazards.*

INTRODUCTION

Inexpedient agricultural intensification practices in greenhouse vegetable systems coupled with irresponsible use of organic and inorganic fertilizers and high inputs of water has deteriorated soil health and the aquatic environments (Verma *et al.*, 2017; Haddad *et al.*, 2019; Zhang *et al.*, 2019). Monocropping is a management practice of farming where fields are often replanted season after season with one type of cropping, such as catch crops. In monocropping farms, soils become depleted of certain nutrients used by the same crop. As a result, farmers have to add large quantities and different types of fertilizers to replenish lost nutrients which might result in deterioration of soil health and aquatic environment. Monocropping of catch crops in Egypt is a common phenomenon in most governorates of the country being monocropped in fertile soils and endued with intensive fertilization. Consequently, soil health could have been deteriorated since crop productivity has been declining despite high rates of fertilizers applied and high yielding cultivars (Hammam and Mohammed, 2019).

Egypt is undergoing rapid economic growth and scrimmages of natural water and arable land resources. This is happened under an incredible population growth pressure that will continue without levelling off in a foreseeable future. Such growth in population requires more food production that has been accomplished by the increased use of organic and inorganic N fertilizers. Egypt's population (104 million in 2018) is concentrated in the Nile Valley and Delta, which constitute less than 5% of the total area of the country (Haddad *et al.*, 2019). The other 95% has sandy and calcareous soils, with coarse texture, low fertility, high infiltration rate and low organic matter (less than 0.5%). Reclamation of these soils making them more productive and habitable in order to solve the problems of food and housing for the continuously increasing population, is crucial for Egypt's future (Abd El-Azeim *et al.*, 2016).

Furthermore, Egypt's population growth and growing income have resulted in the production of large amounts of agricultural, animal and human organic wastes. In Egypt, 18% of the agricultural residuals are used directly as fertilizers. Another 30% is used as an animal food. The remainder of these wastes is burnt directly on the fields or it is used for heating in the small villages (El-Mashad, *et al.,* 2003). These various organic wastes represent an important source of valuable macro and micro-nutrients that can be used more efficiently as a source of organic fertilizers. Also, organic wastes can be applied to agricultural land to help improve soil physical properties, as well as the inorganic characteristics of soils and the biological properties (EL-Mancy, *et al.*, 2008).

The utilization of organic and inorganic N fertilizers has become a public interest in the last 5 decades after building Aswan High dam (Craig, 1993). In Egypt, Excessive amounts of organic and inorganic N fertilizers are applied to crops. Farmers considering that it is a favorable action against yield shortage and their economic consequences. However, when input of nitrogen exceeds the demand, plants are no longer able to absorb it, and nitrogen then builds up in the soil, mostly as nitrates (Abo-Bakr and El-Iraqi 1986; Vogeler *et al.*, 2019; Zhang *et al.*, 2019). This causes imbalance of nutrients in the soil and increases the nitrate level in groundwater supplies (NAAS, 2005) which influences the nitrate content of plants (Dapoigny *et al.*, 2000), especially the leafy and tuber vegetables like radish, watercress and lettuce (Imthiyas and Seran, 2017; Verma *et al.,* 2017). Nitrate has long been one of the highly problematic issues, always being talked about, whether with pride or with horror (Vogeler *et al.*, 2019; Zhang *et al.*, 2019). There are conflicting evidences regarding the potential long-term health risks associated with nitrate levels encountered in the human diet. That reduction in dietary nitrate is a desirable preventive measure (Santamaria, 2006), stands undisputed. Tuber and Leafy vegetables occupy a very important place in the everyday human diet, but unfortunately, constitute a group of foods which contributes maximally to nitrate consumption by living beings (Slupski, *et al.*, 2004). Under excessive application of inorganic and organic nitrogen fertilizers, these vegetables can accumulate high levels of nitrate and, on being consumed by living beings, pose serious health hazards.

Radish (*Raphanus sativus*) is an edible tuberous root vegetable belong to Brassicaceae family, easy to grow, fast maturing, has many nutritional values and it was grown 2700 B.C. (Becker, 1962). In Egypt, radish is considered one of the most important vegetables as it can be grown all over the year due to variety of weather conditions and continued evolution of new cultivars tolerant to different seasons. Vegetable production in Egypt requires minimizing the use of inorganic fertilizers to avoid environmental pollution and assure fewer chemical residuals in the soils. By means of organic and inorganic fertilizers combinations we possibly will assist dropping the quantities of inorganic fertilizers added to soils and improve radish production under sandy soil conditions (Zeid *et al.*, 2015; Kaluram Khede *et al.*, 2019). Further investigation is therefore required for a better understanding of compost behavior when applied to soil alone or combined with inorganic N fertilizers. Soil application of organic and inorganic N fertilizers for the beneficial use must take into account strategies to meet the nutrient agronomic levels and to minimize the environmental hazards. Thus, the aim of this research is to study effects of different combinations of organic and inorganic N fertilizers on tuber yield of radish (*Raphanus sativus* L.) and to examine the fate of nitrogen in terms of nitrate uptake, accumulation and soil residuals as well as total N recovery from organic and inorganic N fertilization by radish grown on a sandy soil under greenhouse-controlled conditions.

MATERIALS AND METHODS

Materials and methods that trigger newly reclaimed sandy soils productivity must be in harmony with the environment on a long-term base and also economically viable. Field trials were conducted and maintained under controlled greenhouse conditions at Shosha Research Centre facilities, Faculty of Agriculture, Minia University in the period from 10 September 2018 to 30 December 2018. The experiment was performed with different combinations of organic and inorganic nitrogen fertilizers to evaluate its suitability for amending sandy soil used in the monocropping of radish without nitrogenous environmental pollution.

Experimental materials and procedures.

Prior to initiation of greenhouse experiments, pre-planting collected composite soil sample was air dried, sieved to < 2.0 mm, and were used to determine soil properties using standard methods derived from Avery and Bascomb, (1982) and Page *et al.*, (1982). Investigated soil physicochemical characteristics detailed in Table 1 was used for radish cultivation under greenhouse conditions in the faculty farm at Agricultural Researches Centre, Shosha, Minia University, El-Minia governorate, Egypt.

Two kinds of composts detailed in Table 2 were obtained from the Nile Company for compost, industrial city, El-Minia governorate in June 2018. Sub-samples of dried, ground, and sieved two composts were used to determine some physicochemical properties such as moisture, heavy metals and total nutrients. Most of the methods employed are of standard methods derived from methods of soil analysis Avery and Bascomb, (1982); and Page *et al.*, (1982). These two composts were made from plant agricultural residuals (Organic Nile compost) and organic plant and animal residuals mixtures (Aloboor organic compost) using aerobic fermentation-composting method. The compost in its loose condition was air dried, then ground, mixed and screened to < 5.0 mm to remove undecomposed materials, which can cause nitrogen deficiency if not removed, and then stored in unsealed plastic bags at 4 ^{o}C before adding to the experimental soil.

Table 1. Physicochemical properties of the investigated sandy soil.

Particle-Size Distribution %	**Coarse sand 56.30%**	**Fine sand 33.45%**	**Silt 7.60%**	**Clay 2.65%**
Texture grade		**Sand**		
F.C %		17.63		
PWP %		4.97		
WHC %		19.66		
A.V(F.C – PWP) %		12.66		
A.V(WHC – PWP) %		14.69		
Bulk Density g/cm^3		1.64		
Particle Density g/cm^3		2.51		
pH (1-2.5)		7.76		
CEC cmol$_c$ kg^{-1} soil		3.2		
O.M (g kg^{-1}*)		6.6		
EC dS m^{-1} at 25 ^{0}C		0.70		
Total N g kg^{-1}		0.58		
Total P g kg^{-1}		0.19		
Total K g kg^{-1}		3.2		
CaCo$_3$ g kg^{-1}		105		

*** Loss on ignition method.**

The procedure of this research was to conduct field trials in two successive seasons cultivating radish as a catch crop, with the aim of evaluating the overall harmful environmental impacts and beneficial influences of applying different combinations of organic and inorganic fertilizers to sandy soil. Ammonium nitrate (33.5%) as inorganic fertilizer and compost as organic fertilizers were then added to sandy soil alone at rates of 0.0, 60, 120, 180 kg ha^{-1}., and in equivalent combinations with each other on a dry weight basis at same rates by two methods of application (Broadcasting and Incorporating).

Table 2. Some physicochemical properties of the studied dewatered composts.

Compost properties	Organic Nile compost	Aloboor Organic compost
Moisture weight %	36.60 %	31.20%
pH (1 - 10)	7.90	8.10
EC dS m^{-1} at 25 ^{0}C	5.20	3.60
CEC $cmol_c$ kg^{-1} compost	45.66	42.76
Dry solids %	63.40	68.8
Ash %	29.90	31.10
Total organic carbon % (D.M)	26.50	26.23
Total N % (D.M)	1.00	1.50
C/N Ratio	26.50	17.48
Total P % (D.M)	0.50	0.40
N/P Ratio	2.00	3.75
Total K % (D.M)	0.90	0.80
Total Ca % (D.M)	2.63	2.28
Total Mg % (D.M)	0.66	0.57
Fe (mg kg^{-1})	1700	1400
Mn (mg kg^{-1})	120	90
Cu (mg kg^{-1})	200	130
Zn (mg kg^{-1})	65	42

The experimental treatments included were as following:

1- (T_1) = 100% of inorganic N fertilizer of ammonium nitrate (33.5%) at the rates of 0.0, 60, 120, 180 kg ha^{-1}.
2- (T_2) = 100% of organic Aloboor compost at the same rates.
3- (T_3) = 100% of organic Nile compost at the same rates.
4- (T_4) = 50% of inorganic N fertilizer of ammonium nitrate + 50% of organic Aloboor compost.
5- (T_5) = 50% of inorganic N fertilizer of ammonium nitrate + 50% of organic Nile compost.

Vegetable trials were made up of 120 plots; each plot size was 2 × 1m and detached by folded plywood frame inside the greenhouse, and fertilized with weights of air dried-compost alone and in different combinations with ammonium nitrate corresponding to the equivalent application rates. Fertilizers were added as broadcasting or incorporated by hand into the soil plots to a depth of 10 cm directly before sowing radish. Recommended levels of Phosphorus as single superphosphate (15% P_2O_5, 6.5% P) and potassium dosages as potassium sulphate (46% K_2O, 38% K) were applied once to all treatments in a single dosage during each season. Radish plants were not fertilised other than treatments application and P and K during the growth cycle (35 days). Local cultivar of radish was grown (space 30 ×10, 60 plants per plot) in each plot after watering to 70% of soil field capacity, then each plot was watered every third day using drip irrigation system to compensate for losses of water which maintained moisture content at field capacity during the whole period of the experiment. Standard agricultural practices and plant protection procedures were adapted for assuring healthy radish plants. Weed control was maintained weekly by hand.

At harvesting for determining various growth and yield parameters, five whole radish plants (leaves and tubers) were randomly chosen from each treatment, pulled off, washed with distilled water, weighed fresh, oven dried at 65 ^{o}C for 96 h, and weighed again to determine dry weight. After first season of radish experiment, plots were left for 20 days covered with black polyethylene and watered once a week for residuals to decompose before the second season. Radish plants and soil samples were collected at the time of first and second harvest for nitrogen analyses. The experimental design was a randomised complete block design with three replicates and the experimental data was computed using the procedures available in the (9.3, SAS Institute, 2003) package. Data presented are mean values and statistically were subjected to variance analysis. Significance of the differences was estimated and compared using Duncan test at 5% level of probability ($p < 0.05$).

Sampling and analyses methods.

Nutrition state.

Radish growth parameters were recorded after the entire growth cycle included fresh and dry weights of plants. Dry matter contents of the samples were determined by oven-drying at 65°C until a constant weight was obtained. Nutrition state of radish plants was checked by determining content of nutritional element of nitrogen in radish roots taken from all experimental plots at harvesting (35 days after seeding). Plant roots were dried and ground in a stainless-steel mill, digested using H_2SO_4 and H_2O_2 and analysed for N according to the procedures described by Page *et al.* (1982) and Avery and Bascomb, (1982). Total N was determined according to Rowell, (1994). Soil samples were also air-dried, sieved to pass a 2-mm sieve and 5 grams of soil was oven-dried at 105 ^{0}C for 24 hours prior to total N analysis on the apparatus. Nitrogen recovery (NR%) was calculated as the percentage of N applied for each treatment where: NR% = [(Plant N uptake for each treatment (g/plot) – Plant N uptake for control (g/plot)] / Total N applied for each treatment (g/plot) × 100.

Nitrate analyses.

Soil samples were taken from each plot to determine the amounts of residual NO_3-N in soil plots (0 – 20 cm depth) before and after second season fertilizers application. The amounts of NO_3-N in 20 cm soil depth were calculated by multiplying their concentrations by bulk density and soil depth. Nitrate in fresh radish was determined spectrophotometrically according to the method of MAFF (1998) and ISO (1984). All samples of soil nitrate analyses were carried out using standard methods derived from (Rowell 1994, and MAFF, 1998). All estimations were carried out in replicates and the limit of detection was 1 mg kg^{-1} for nitrate (MAF, 1998; Petersen and Stoltze, 1999).

RESULTS AND DISCUSSION

Nutritional state and growth parameters of radish.

Effects of all fertilizer N treatments on fresh weight (g/plant), dry weight (g/plant), plant uptake (g/plant), N concentration % and N recovery % of radish plants for two seasons are presented in Table (3). Data perusal of Table 3 revealed that application of different combinations of organic and inorganic N fertilizers high significantly affected growth and yield parameters and nutritional status of radish crop. Results revealed that growth parameters of radish plants were highly increased significantly due to fertilizer N addition compared to control, regardless of the fertilizers type, method of applications and/or application rates. Overall, results showed that equivalent combination of inorganic fertilizer with Aloboor compost (T_4) or Nile compost (T_5) resulted in a high significant promotion on all growth parameters rather than application of 100% inorganic (T_1) or organic fertilizers alone (Aloboor compost T_2 and Nile compost (T_3) in both seasons. The favorable effect of integrating organic and inorganic N fertilizers is, the former improving soil structure which encouraged plant to have an efficient root flourishment and the latter effect was to help the living organisms in organic fertilizers to multiply. These results are in harmony with those obtained by Ali *et al.* (2007), Shaheen *et al*, (2007); Hassan *et al.* (2009); Jat *et al.*, (2017) and Hammam and Mohammed, (2019). These results are in agreement with Hassan *et al.*, (2009), they stated that using N via three sources of organic, inorganic and bio-fertilizers was preferable and proved beneficial for obtaining an economical yield and improving physicochemical characteristics of onion bulb and available nutrients in sandy soil. On contrast, using 100% of organic or inorganic N fertilizers alone had adverse effects on all onion investigated parameters.

The statistical analyses demonstrated that significant differences do existed for the increase in nutritional and growth parameters of radish plants depending on fertilizer type, methods of application and application rates ($P \leq 0.05$; Table 3). But this increase was not proportional to the increase in both organic or inorganic fertilizer N application rates and its combinations reflecting diminishing returns. Ottman and Pope (2000) indicated that addition of more than the recommended N level had a negligible effect on crop yield. These results are in good agreement with those obtained by Saleh and Abd El-Fattah (1997); and Abd El-Aal, *et al.,* (2013) and Hammam and Mohammed, (2019). Among fertilizer N application methods in both seasons, nutritional status and growth parameters of radish plants grown on fertilizer N-incorporated plots was significantly higher compared to fertilizer N-mulched. In synopsis, different effects observed regarding methods of application can be explained on the basis of variation in C/N ratio created by each application method (Vogeler *et al.*, 2019; Zhang *et al.*, 2019). Further, results revealed that nutritional and growth parameters of radish plants had almost no significant differences between seasons.

Total N uptake of radish plants as affected by organic and inorganic N fertilizers during two seasons are shown in Table 3. The total N uptake increase at the application rate of 180 kg ha^{-1} was slightly significant and only 10% more than that achieved at 120 kg ha^{-1}. However, in most cases there was no significant increase in the total N uptake at the application rate of 180 kg ha^{-1} over that achieved at 120 kg ha^{-1}. This indicated that diminishing returns of nitrogen uptake are being measured for increases in application rates over 120 kg ha^{-1}. This finding suggests that radish plants may have reached maximum N uptake and excess N will be likely to accumulate in the sandy soil and leach into ground water from incorporated fertilizers or volatilise from the fertilizer N broadcasting layer under radish cultivation. These results are in good agreement with those obtained by Abd El-Aal, *et al.* (2013). They specified that, under the conditions of their study, interaction data between both variables cleared that a nitrogen rate of 120 kg ha^{-1} is quite sufficient to cover nitrogen needed by most of the tested sugar beet varieties which maximized sugar yield and quality parameters.

In order to maximize use efficiency of a fertilizer at a given yield level, it will be necessary to minimize residual soil NO_3-N. In general, growth parameters (fresh and dry weights) and total N uptake of radish plants closely paralleled at the fertilizer N application rates of 120 and 180 kg ha^{-1}, especially in the case of incorporated organic and inorganic N fertilizer with slight significant differences, indicating that the highest quality plants were produced in plots receiving 120 or 180 kg ha^{-1}. Mekael *et al.* (2006) stated that application of nitrogen fertilizer at the rate of 120 kg/fed combined with poultry manure at the rate of 3.0 ton/feddan to the newly reclaimed sandy soils cultivated with wheat proved to be the most viable economical treatment of all the studied treatments. Also, Wang *et al.*, (1999) and Vogeler *et al.*, (2019) pointed out that excessive nitrogen fertilizer rate decreased the nitrogen use efficiency through leaching of nitrogen in sandy soil.

Radish plants N % concentrations.

Nitrogen concentrations in radish plants (leaves and tubers) taken from plants grown on both organic and inorganic fertilized-plots were about twofold higher in the case of the lowest fertilizer application rate (60 kg ha^{-1}) than from the plants grown on control plots. In general, using combined organic and inorganic fertilizer N (T_4 and T_5), N concentrations of radish plants increased significantly with the increase of the application rates in both seasons compared to using organic or inorganic fertilizer N alone (T_1, T_2 and T_3) except in the case of $(T_1)_{120}$ where the highest N concentration (3.98%) was obtained by radish plants grown on inorganic fertilizer N incorporated-applied plots. The increase in either organic or inorganic fertilizer N broadcasted or incorporated applied plots was not proportional to fertilizer N application rate, especially in the case of 120 and 180 kg ha^{-1}.

Table 3. Radish growth and nutrition parameters as affected by organic and inorganic fertilizer treatments.

Treatment (kg ha^{-1})			**Fresh weight (g/plant)**		**Dry weight (g/plant)**		**Nitrogen uptake (g/plant)**		**N concentration %**		**N recovery (NR %)**	
Method and Rate			**Season 1**	**Season 2**	**Season 1**	**Season 2**	**Season 1**	**Season 2**	**Season 1**	**Season 2**	**Season 1**	**Season 2**
Broadcasting	T1	$(T1)_{0}$	54.71	55.12	5.72	5.84	0.058	0.066	1.01	1.12	1.66	1.88
		$(T1)_{60}$	211.40	210.80	22.83	22.16	0.498	0.476	2.18	2.15	11.45	10.70
		$(T1)_{120}$	216.15	215.28	23.59	23.14	0.722	0.659	3.06	2.85	15.81	14.14
		$(T1)_{180}$	215.15	216.33	23.42	23.75	0.674	0.739	2.88	3.11	13.52	14.76
	T2	$(T2)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T2)_{60}$	164.37	165.46	18.19	18.44	0.411	0.367	2.26	1.99	9.20	7.85
		$(T2)_{120}$	167.05	168.22	19.35	19.03	0.476	0.402	2.46	2.11	9.96	8.00
		$(T2)_{180}$	168.22	167.65	18.99	18.64	0.524	0.531	2.76	2.85	10.22	10.21
	T3	$(T3)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T3)_{60}$	163.77	164.65	17.87	18.12	0.336	0.357	1.88	1.97	7.24	7.59
		$(T3)_{120}$	166.12	165.85	18.88	18.54	0.457	0.380	2.42	2.05	9.50	7.49
		$(T3)_{180}$	169.46	168.57	19.18	19.22	0.529	0.473	2.76	2.46	10.34	8.93
	T4	$(T4)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T4)_{60}$	265.44	266.25	28.25	28.09	0.667	0.604	2.36	2.15	15.85	14.02
		$(T4)_{120}$	268.45	269.07	29.18	29.87	0.890	0.890	3.05	2.98	19.81	19.63
		$(T4)_{180}$	271.22	268.06	30.95	29.22	0.978	0.880	3.16	3.01	20.18	17.85
	T5	$(T5)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T5)_{60}$	264.86	264.27	28.05	28.12	0.592	0.638	2.11	2.27	13.91	14.92
		$(T5)_{120}$	265.47	262.88	27.24	27.05	0.725	0.663	2.66	2.45	15.87	14.22
		$(T5)_{180}$	267.68	268.09	29.78	29.16	0.703	0.644	2.36	2.21	14.14	12.70
Incorporating	T1	$(T1)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T1)_{60}$	282.85	281.45	29.95	29.75	0.913	0.940	3.05	3.16	22.28	22.78
		$(T1)_{120}$	287.12	286.15	30.65	30.55	1.220	0.965	3.98	3.16	27.67	21.43
		$(T1)_{180}$	286.84	286.59	30.14	30.09	0.871	0.767	2.89	2.55	17.83	15.39
	T2	$(T2)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T2)_{60}$	236.58	237.32	25.19	25.87	0.821	0.789	3.26	3.05	19.88	18.84
		$(T2)_{120}$	238.67	239.04	26.55	26.15	0.658	0.617	2.48	2.36	14.30	13.13
		$(T2)_{180}$	239.88	241.07	27.01	27.22	0.870	0.996	3.22	3.66	17.80	20.41
	T3	$(T3)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T3)_{60}$	225.15	226.12	24.11	24.87	0.596	0.637	2.47	2.56	14.00	14.87
		$(T3)_{120}$	228.25	226.54	25.12	24.66	0.781	0.792	3.11	3.21	17.22	17.29
		$(T3)_{180}$	231.25	229.48	26.33	25.87	0.911	0.911	3.46	3.52	18.71	18.53
	T4	$(T4)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T4)_{60}$	277.40	278.17	29.66	30.01	0.937	1.032	3.16	3.44	22.90	25.18
		$(T4)_{120}$	280.05	281.08	31.02	31.18	1.135	0.988	3.66	3.17	25.65	21.97
		$(T4)_{180}$	291.09	287.57	32.88	31.68	1.263	1.115	3.84	3.52	26.42	23.02
	T5	$(T5)_{0}$	54.72	55.11	5.73	5.85	0.058	0.066	1.01	1.12	1.66	1.88
		$(T5)_{60}$	276.45	277.09	29.75	30.54	1.029	1.072	3.46	3.51	25.30	26.21
		$(T5)_{120}$	278.75	277.94	30.08	30.13	0.893	0.946	2.97	3.14	19.89	20.97
		$(T5)_{180}$	281.11	279.88	31.54	30.84	1.035	0.971	3.28	3.15	21.42	19.87
LSD$_{0.05}$		Method	1.33	1.45	0.65	0.71	0.114	0.111	0.014	0.021	0.96	1.01
		Rate	0.92	0.98	0.47	0.55	0.133	0.115	0.022	0.016	1.15	1.22

*** Means of three samples.**

Data indicated that high significant improvement in radish N-concentration occurred due to application of inorganic fertilizer alone or in combinations with organic fertilizer compared to organic fertilizer alone. In general, the results presented in (Table 3) clearly indicated that the increase in N concentrations of radish treated with the organic N fertilizer of Aloboor compost alone (T_2) or combined with inorganic fertilizer (T_4) at all application rates were more pronounced and highly significant than those of radish treated with organic N fertilizer of Nile compost alone (T_3) or combined with the inorganic N fertilizer (T_5) in both seasons, illustrating that the N availability and release pattern were not very similar. The reason for high significant increase is maybe the differences in C/N ratio between two investigated composts.

The average percentage of N concentrations were all within the optimum range (2.0-5.0) (Hochmuth, *et al.*, 1991) in all fertilizer N treatments except the lowest rate of radish plants grown on broadcasted plots with organic fertilizer N of Nile compost $(T_3)_{60}$, which were slightly below this range. In general, N concentrations of radish leaves from control plots were far below this optimum range and reported at deficiency level. In both seasons, control radish plants were yellow showing severe nutritional deficiency symptoms (corresponding to a depletion of nutrients from control plots) in comparison to organic or inorganic fertilizer N-amended plots. In addition, plants of second season in control plots were severely stunted and dead plants were recorded. Thus, almost no yield was recorded indicating severe nutrient deficiency and depletion.

Radish percentage of N recovery.

Organic and inorganic nitrogenous fertilizers application significantly *($p \leq 0.05$)* influenced radish N recovery (%) from all fertilizer N-treated plots compared to control (Table 3). The statistical analyses show that significant differences do exist in N recovery by radish plants due to fertilizer N type, application rate and application method. Results of N recovery by radish plants grown on fertilizer N-incorporated plots were significantly higher than for fertilizer N-broadcasted in both seasons. Two reasonable reasons are present to explain why N uptake or recovered by radish plants from fertilizer N-incorporated plots was significantly greater than from the fertilizer N-broadcasted. First, incorporating application of united organic and inorganic fertilizer N, caused significant mineralization of organic N. Once mineralized, this N can probably be taken up by the plants, immobilized, denitrified and volatilized or leached. This leads to increased levels of available nitrogen within the soil crop system so causing greater increases in N uptake and recovery or loss (Kaluram Khede *et al*., 2019). Second, there was greater water availability and more constant soil structure that might have resulted in more optimum soil workability and more conducive soil environment to microbial decomposition, N release and balanced utilization of nitrate by crops. There is also a possibility that some of N might have been lost through NH_3 volatilization. Nitrogen recovered by radish crop exceeded 25% of the total applied N after one and two fertilizer N applications. This value was higher than the 10% value reported for organic fertilizers N in the literature (Tester *et al*, 1977).

Residual nitrate in the investigated soil.

After one fertilizer application, residual nitrate at the end of first season increased as the application rate of fertilizer increased regardless of the application method (Table 4). After two fertilizer applications with different rates, residual nitrate followed a similar pattern and had insignificant differences between seasons. Nitrate-N residual ranged from 0.32% of the total applied N with no fertilizer added to 2.76% and 2.87% with 180 kg ha^{-1} of fertilizer as broadcasted and incorporated-applied, respectively. Residual nitrate-N was significantly greater with fertilizer-incorporated plots than with fertilizer-broadcasted at all application rates. These observations suggest that greater and a faster rate of N mineralization occurred with fertilizer-incorporated plots than with fertilizer-broadcasted. The fertilizer intimately incorporated with sandy soil would decompose more rapidly than the surface applied fertilizer. As a result, greater amounts of nitrate will be likely to accumulate in this sandy soil and leach into the groundwater with incorporated applied than broadcasting fertilizers.

Table 4. Effect of different organic and inorganic N fertilizers treatments on soil residual nitrate (mg/kg).

Treatment (kg ha^{-1})		**Soil Residual Nitrate (mg/kg)**			
		Broadcasting		**Incorporation**	
		(mg/kg)	**%**	**(mg/kg)**	**%**
T1	$(T1)_0$	11.15	0.32	11.15	0.32
	$(T1)_{60}$	71.15	1.85	82.35	2.14
	$(T1)_{120}$	96.12	2.29	99.11	2.36
	$(T1)_{180}$	135.64	2.76	131.01	2.87
T2	$(T2)_0$	11.15	0.32	11.15	0.32
	$(T2)_{60}$	55.93	1.46	75.19	1.96
	$(T2)_{120}$	65.03	1.55	86.65	2.06
	$(T2)_{180}$	51.26	1.12	95.87	2.10
T3	$(T3)_0$	11.15	0.32	11.15	0.32
	$(T3)_{60}$	59.14	1.54	69.67	1.81
	$(T3)_{120}$	70.13	1.67	91.35	2.18
	$(T3)_{180}$	72.05	1.58	113.01	2.48
T4	$(T4)_0$	11.15	0.32	11.15	0.32
	$(T4)_{60}$	68.63	1.79	79.88	2.08
	$(T4)_{120}$	81.12	1.93	96.34	2.29
	$(T4)_{180}$	96.03	2.11	126.11	2.77
T5	$(T5)_0$	11.15	0.32	11.15	0.32
	$(T5)_{60}$	74.22	1.93	80.94	2.11
	$(T5)_{120}$	79.11	1.88	93.33	2.22
	$(T5)_{180}$	84.38	1.85	111.69	2.45
LSD $_{0.05}$	Methods	2.06			
	Rates	1.64			

It was speculated that the greater residual N in the incorporated plots at the highest rate of 180 kg ha^{-1} after two fertilizer applications was due increasing organic matter which caused greater water availability and more constant soil structure that might have resulted in more optimum soil workability and more conducive soil environment to microbial decomposition, N release and balanced utilization of nitrate by crops. Overuse of nitrogenous fertilizers were mainly reported in vegetables production systems where nitrogen input in a vegetable field is about seven times more than in a crop rotation fields (Ju *et al*., 2007; Sun *et al*., 2013). Consequently, excessive nitrogenous fertilizers have led to lower nutrient use efficiency due to shallow root of vegetables and cumulation of large amounts of nitrogen in soils which exposed to loss into the environment (Zhang *et al*., 2019).

Nitrate pollution of radish plants.

Vegetables are the chief cause of nitrate contamination in food chain as more than 80% of nitrates are consumed by individuals through vegetables. The scientific objective of this research was to investigate the content of nitrate in radish mostly consumed by Egyptian people and to evaluate the overall safety of natural nitrates in radish. Organic or inorganic fertilizer N addition significantly *($p \leq 0.05$)* influenced radish nitrate concentrations (mg/kg fresh weight) from all fertilizer N-treated plots compared to control (Table 5). Also, results of nitrate concentrations by radish plants grown on fertilizer N-incorporated plots were significantly higher than for the fertilizer N-broadcasted in both seasons. In most cases, radish nitrate concentrations from fertilizer N-incorporated plots was very high and similar regardless of the application rate. The statistical analyses show that significant differences do exist in nitrate concentrations in radish plants arising from type of fertilizers, the fertilizer N application rates and methods.

In general, in all treatments, nitrate concentrations of radish plants determined were under levels that established by the European Commission for leafy and tuber vegetables (max 2500 mg nitrate kg/fresh weight) (Petersen and Stoltze, 1999). Nitrate concentrations of radish plants did respond significantly to increasing fertilizer N rate beyond 120 kg/fed in both seasons, regardless of application method or fertilizer type. In both seasons, highest content of nitrate was found in radish plants grown on incorporated plots with inorganic fertilizers alone at the rate of 180 kg/fed (2265 and 2101 mg kg). The Acceptable Daily Intake (ADI) for nitrate of 3.7 mg nitrate kg body weight was established by EU Scientific Committee for Food in 1995 and European Food Safety Authority (EFSA), (2008). Under this study conditions, high application rates of inorganic nitrogen fertilizer (180 kg ha^{-1}) caused high levels of nitrate accumulation in radish plants, and on being consumed by living beings, pose serious health hazards.

Table 5. Effects of different organic and inorganic N fertilizer treatments on radish nitrate contents mg kg^{-1} fresh weight.

Treatment (kg ha^{-1})		Nitrate Concentration (mg kg^{-1} fresh weight)			
		Season 1		Season 2	
		Broadcasting	Incorporation	Broadcasting	Incorporation
T1	$(T1)_0$	86	88	86	88
	$(T1)_{60}$	1406	1501	1718	1856
	$(T1)_{120}$	1637	1718	1811	1727
	$(T1)_{180}$	1815	1921	2101	2265
T2	$(T2)_0$	86	88	86	88
	$(T2)_{60}$	875	915	942	966
	$(T2)_{120}$	766	1011	1015	1126
	$(T2)_{180}$	911	984	993	1088
T3	$(T3)_0$	86	88	86	88
	$(T3)_{60}$	546	641	615	628
	$(T3)_{120}$	712	816	676	718
	$(T3)_{180}$	788	815	655	818
T4	$(T4)_0$	86	88	86	88
	$(T4)_{60}$	1062	1111	1115	1211
	$(T4)_{120}$	1115	1311	1212	1311
	$(T4)_{180}$	1226	1370	1295	1401
T5	$(T5)_0$	86	88	86	88
	$(T5)_{60}$	825	921	854	964
	$(T5)_{120}$	945	943	1215	1217
	$(T5)_{180}$	1106	1296	1222	1286
LSD $_{0.05}$	Methods	54.22	48.35	74.32	55.63
	Rates	60.19	57.23	65.78	71.36

Vegetables nitrate content may range from 1 to 10,000 mg kg (Ximenes, Rath, & Reyes, 2000; and Parks *et al.* 2012). This research results revealed that all radish samples, had a nitrate concentration below 2,000 mg kg^{-1} and only two samples exceeded 2000 mg kg^{-1} in the second season at the highest application rates of 180 kg ha^{-1} of inorganic fertilizer (T_1). However, almost all plant samples, had a mean nitrate concentration just below 1500 mg kg^{-1} and was well below the maximum level allowed. Nitrate contamination in catch crops occurs when crops absorb more than they require for their sustainable growth. On the one hand, vegetables such as spinach, lettuce, broccoli, cabbage, celery, watercress, beetroot, radish possess the tendency to accumulate nitrates. On the other hand, vegetables such as cauliflower, French beans, peas and carrots rarely accumulate nitrates. These results confirm that catch crops such as radish could absorb residual nitrogen in soils and control N losses and leaching through fallow seasons (Zhang *et al.*, 2019). Radish is not only a popular vegetable for local farmers but also a high price vegetable so that planting radish as a catch crop may be the most economic and effective procedures to reduce nitrate loss into the environment.

According to current results, ingestion of only 150 g of fresh high polluted radish with the highest nitrate concentration of 2000 mg/kg fresh weight will already lead to an intake of 300 mg NO_3^- . Consuming this item alone, for a person of 80 kg, would exceed the ADI for nitrate (3.7 mg kg^{-1} bw) by 4 mg. Calculating in the partial conversion of nitrate to nitrite (5%) after such consumption, the current SCF ADI for nitrite (0.06 mg kg^{-1} bw) would be exceeded by 10.2. Ysart *et al.* (1999) estimated for the adult human population a total nitrate intake of 93 mg/day, normally through potatoes (33%), green vegetables (21%), other vegetables (15%), beverages (8.5%), meat products (4.2%), fresh fruit (3.5%), dairy (3.1%), milk (2.9%), miscellaneous cereals (2.1%), bread (1.6%) and others (5.1%). Nitrate accumulation differences may be attributed to amounts and kind of nutrients present in soil, amount and composition of the fertilizers applied, temperature and light factors from the ecological environment (Zhou *et al,* 2000; Wortman, 2016; Guo *et al.,* 2018, Kaluram Khede *et al.,* 2019). Therefore, efforts are warranted to minimize the accumulation of nitrate in catch crops and its ingestion by human beings. Results are in agreement with those reported by other investigators who stated that the nitrate concentrations in fresh vegetables were usually under levels established by the European Commission (Petersen and Stoltze, 1999; Chung *et al,* 2003; Zhou *et al.,* 2016; Zhang *et al.,* 2019). These results also are in complete agreement with Luo *et al.,* (1993), they stated that nitrogenous fertilizers, mainly of nitrate variety, are used widely in vegetable agriculture, resulting in accumulation of nitrate in plants, if the rate of its uptake exceeds the rate of its reduction to ammonium.

Finally, the aim of this research was to provide a fertilization strategy that maximises the agronomic benefits and minimises the environmental impacts of applying different combinations of organic and inorganic fertilizers to cultivable sandy soil cultivated with radish under arid conditions. The influence of different combinations of organic and inorganic fertilizers applied under such conditions is dependent on, fertilizers type, soil characteristics, the methods of application, and the application rate (Kaluram Khede *et al.,* 2019). In addition, this research revealed that high rates of nitrogen fertilizers application increased plant nitrate content without increasing yield. This indicated that radish plants may uptake available nitrate luxuriously without maximum nutrients uptake and assimilation. Consequently, farmers who apply undue fertilizers to ensure that nitrogen is not a limiting factor for plant growth are unlikely to achieve any yield gain but increase nitrate contents of a crop to levels potentially toxic to humans.

CONCLUSION

This research results showed that all growth and nutritional characteristics of radish plants were highly increased significantly due to different fertilizer organic or inorganic N treatments compared to control, regardless of the fertilizers type, method of applications and/or application rates. In both seasons, among fertilizer N application methods, all measured parameters of radish plants grown on fertilizer N-incorporated plots was significantly higher compared to fertilizer N-broadcasted. In summary, integrated fertilization of organic and inorganic N systems led to a high significant promotion on all nutritional characteristics and a marked decrease in nitrate contents of radish plants at the same rates where the lowest levels were recorded in radish plants received equal organic and inorganic fertilizers. Organic fertilizers application to sandy soils could reduce overall catch crops production costs by reducing consumption of inorganic fertilizers as well as decreasing nitrate pollution in radish as an everyday ordinary salad vegetable in Egypt. Therefore, these results confirm the importance of partial replacement of inorganic by organic N fertilizers for producing catch crops under coarse-textured sandy soils and arid conditions.

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المخاطر البيئية والفوائد الزراعية للتسميد النيتروجيني العضوي وغير العضوي للأراضي الرملية المزروعه بالفجل.

إسماعيل أبوبكر عبدالوهاب طنطاوي[١] ، مصطفي حسين هاشم[٢] و محي الدين محمد عبدالعظيم[٣]
[١]قسم البساتين – كلية الزراعة – جامعة المنيا
[٢]المعمل المركزي للزراعة العضوية- مركز البحوث الزراعية-الجيزة- مصر
[٣]قسم الأراضي والمياه – كلية الزراعة – جامعة المنيا

أستخدام مخاليط من الأسمدة العضوية وغير العضوية في التسميد الزراعي يؤدي الي أمداد النبات بجميع العناصر الغذائية حسب احتياجاته دون تلوث البيئة المحيطة. أجريت تجارب خضر حقلية تحت ظروف الصوبة لمدة موسمين متتاليين بزراعة الفجل كمحصول خضر قصير الأجل من أجل تقييم المخاطر البيئية والفوائد الزراعية لأستخدام مخاليط مختلفة من الأسمدة العضوية وغير العضوية في تسميد التربة الرملية. خلال كلا الموسمين من هذه الدراسة ، لم تكن التحسينات في معايير جودة النمو لنباتات الفجل مختلفة في معظم الحالات اختلافًا كبيرًا بين معدلات استخدام الأسمدة الأعلى البالغة ١٢٠ و ١٨٠ كجم هكتار. ولذا تشير هذه الدراسة إلى أن استجابة الفجل كمحصول قصير الأجل لزيادة معدل الاستخدام من الأسمدة النيتروجينية قد يؤدي الي نقص في العائد ، مما يعني أن الزيادة من هذه الأسمدة لن تؤدي إلى تحسين الغلة بل تلوث بيئة التربة. أظهرت نتائج هذا البحث أن الاعتبارات الرئيسية التي يجب أن تؤخذ في الأعتبار عند أستخدام الأسمدة غير العضوية وحدها في تسميد التربة الرملية المزروعة بمحصول واحد هي الزيادة في النترات المتبقية في التربة ، وزيادة إمكانات تلوث المياه الجوفية بواسطة النترات ، وكذلك خطر تراكم النترات في الأنسجة النباتية. في ظل ظروف هذه الدراسة ، تسبب ارتفاع معدلات الاستخدام من الأسمدة النيتروجينية غير العضوية (١٨٠ كيلوجرام هكتار) في ارتفاع مستويات تراكم النترات في الفجل ، وعلى كون البشر يستخدمونها باستمرار قد يشكلون مخاطر صحية خطيرة علي الأنسان. بشكل عام ، التسميد بمعدل ١٢٠ كجم هكتار بخليط متساوي من الأسمدة النيتروجينية العضوية وغير العضوية مجتمعة ، يضمن بذلك عدم توقع أي مشاكل صحية للإنسان أو الحيوانات من حركة النترات في السلسلة الغذائية. من نتائج هذا البحث ، يمكن أن نستنتج أن دمج الأسمدة العضوية وغير العضوية مجتمعة عند تسميد التربة الرملية المزروعة بالمحاصيل الأحادية بمعدل ١٢٠ كيلوجرام هكتار نيتروجين وباستخدام نظام الري بالتنقيط كان أفضل ممارسة استراتيجية في أدارة المزرعة للوصول إلى الفوائد الزراعية المثلى مع التقليل من الأضرار البيئية والمخاطر الصحية.

الكلمات الدالة: محاصيل قصيرة الأجل, التلوث بالنترات, المخاطر البيئية.