International Journal of Environment Volume : 04 | Issue : 03 | July-Sept. | 2015
ISSN: 2077-4508 Pages: 181-185

Response of Spinach Plants to Nanoparticles Fertilizer and Foliar Application of Iron

EL-Aila, H.I., S.A.A EL-Sayed and A. A. Yassen

Plant Nutrition Dept., National Research Centre, 33 El-Bohouth St., (former El- Tahrir St.,) Dokki, Giza, Egypt. Postal Code: 12622.

ABSTRACT

The use of slow release fertilizer has become a new trend to save fertilizer consumption and to minimize environmental pollution. Therefore, in this paper we describe a strategy for sustained release of nitrogen into the soil. A greenhouse experiment was conducted at the Plant Nutrition Dept., National Research Centre, was conducted to study the growth response of spinach plant. The incorporation of NPK fertilizers in polymerization of methacrylic acid was obtained by dissolving different amounts of NPK to produce a component (10/10/10) and (15/15/15). The slow release fertilizers were applied prior to sowing by mixing it with soil, whereas urea was applied at rates of (1.5, 3.0 & 6.0 g/pot). Ferrous sulphate was applied at a rate of 100 ppm as foliar spray after 20 & 30 days. Obtained results proved that the addition of urea at different doses with or without iron increased the fresh & dry weight and decreased the nitrate in leaves and stem of spinach plants as compared to the addition of urea. Nitrogen, Phosphorus, potassium and iron content recorded highest significant values in Spanish plants.

Key words: Incorporation - Iron-Nanoparticles- NPK-Spinach (Spinacia oleracea),

Introduction

Fertilizers are chemical compounds applied to promote plant and fruit growth (Behera and Panada, 2009). Knowing to overuse of fertilizers and pesticides is one of the causes for the degradation of environment and soil. Slow release fertilizers are the newest and most technically advanced way of supplying mineral nutrients to crops. Compared to conventional fertilizers, their gradual pattern of nutrient release meets plant needs, minimizes leaching, and therefore improves fertilizer use efficiency. Slow release can be achieved by providing coatings. Subbarao *et al.,* (2004). Add fertilizer is usually either through the soil (for uptake by plant roots) or by foliar feeding (for uptake through leaves). Fertilizers can also be applied to aquatic environments, not apply ocean fertilization. Artificial fertilizers are inorganic fertilizers formulated in appropriate concentrations and combinations supply three main nutrients: nitrogen, phosphorous, and potassium (N, P and K) for various crops and growing conditions. Nitrogen promotes leaf growth and forms proteins and chlorophyll. Phosphorus contributes to root, flower and fruit development. Potassium contributes to stem and root growth and the synthesis of proteins Mandal *et al*., (2009); Gu *et al.,* (2009).

However, about 40-70% of nitrogen, 80-90 of phosphorus and 50-70% of potassium of the applied normal fertilizers is lost to environment and cannot be absorbed by plants, causing not only substantial economic and resource losses but also very serious environment pollution Trenkel, (1997); Saigusa, (2000). Recently, the use of slow release fertilizers has become a new trend to save fertilizer consumption and to minimize environmental pollution (Wu & Liu 2008); Guo *et al.,* (2005).

Some apparatus and processes are described by El-Aila, *et al*., (2001) for more efficient coating materials as well as controlled release. The primary object is to provide random motion of the particles with respect to each other thereby production a truly homogeneous moving mass of particles in a simple conventional horizontal rotary drum to ensure that all particles are equally exposed to a liquor or molten spray material as they pass through the drum regardless of range of size or shape. Also granulation, predominantly by a true coating, or layering action can be accomplished by spraying the hot solution or melt of a fertilizers compound into a fluidized bed of undersized compound nuclei.

Spinach (*Spinacia oleracea L.*) is one popular leafy vegetable grown in Egypt. spinach has a high nutritional value of vitamin A, vitamin C, vitamin K magnesium, manganese, folate and iron and good source of the B vitamins riboflavin and vitamin B6, vitamin E, calcium, potassium and dietary fiber Toledo *et al*., (2003). The main purpose of in the present investigation is to study was to produce a nanoparticles NPK fertilizer sources on the nutrient use efficiency in spinach plant.

Corresponding Author: EL-Aila, H.I., Plant Nutrition Dept., National Research Centre, 33 El-Bohouth St., (former El-Tahrir St.,) Dokki, Giza, Egypt. Postal Code: 12622.
E-mail: elailahesham@hotmail.com

Materials and Methods

Preparation of slow NPK fertilizers

There are many types of commercial fertilizers that consist of mixing the substances containing nitrogen (N), phosphorus (P) and potassium (K) in different proportions. In this study, the sources of N, P and K used urea, mono ammonium phosphate and potassium sulphate, respectively. These substances were used separately. The incorporation of NPK fertilizers in polymerization of methacrylic acid was obtained by dissolving different amounts of NPK to produce to component (10/10/10) and (15/15/15) under magnetic stirring for 4 h at 25^{o} C. The resulting fertilizers produced by incorporate NPK into the nanoparticles presents put with an apparatus described previously by EL-Aila *et al*. (2001) to produce slow release fertilizers with nanoparticles.

Pot experiment

A greenhouse experiment was conducted at the Plant Nutrition Dept. of the National Research Centre. Two Kg of air dried soil were packed in plastic pots 15cm height, 10 cm diameter. The characterization of the investigated soil was 89.7, 5.25 and 5.05% for sand, silt and clay respectively, pH 8.01, E.C. 0.46dsm^{-1} , organic matter 0.11,$CaCO_3$ 2.2% total nitrogen 0.012%. The treatments were used of study as shown in (Table 1).

Table 1: The experiments include ten treatments and arranged as follow:

Treatments	Foliar application of Iron	
	Without Fe^{++}	with Fe^{++}
Control No fertilizers	---	100 ppm
Urea 1.5 g /pot	----	100 ppm
Urea 3.0 g /pot	----	100 ppm
Urea 6.0 g /pot	----	100 ppm
(10/10/10) 1.5 g /pot	----	100 ppm
(10/10/10) 3.0 g /pot	----	100 ppm
(10/10/10) 6.0 g /pot	----	100 ppm
(15/15/15) 1.5 g /pot	----	100 ppm
(15/15/15) 3.0 g /pot	----	100 ppm
(15/15/15) 6.0 g /pot	----	100 ppm

The slow release fertilizers were applied prior to sowing by mixing it with soil, whereas urea was applied at rates of (1.5, 3.0 & 6.0 g/pot) calcium super phosphate were applied at a rate of 50 mg P_2O_5/kg soil. Potassium sulphate was applied at a rate of 40 mg K_2O/kg soil for treatments without slow release fertilizers as control. Spinach plant was used as a test plants. Ferrous sulphate was applied at a rate of 100 ppm as foliar spray after 20 & 30 days. The experiment was laid out in a completely randomized block design with three replicates. Samples of plants were taken after 50 days of planting. Fresh weights were recorded, dried at 70^{o}C weight and ground to pass through a 1-mm sieve. Nitrogen, phosphorous, potassium, nitrate, chlorophyll a, b and iron were determined according to the methods described by Black (1982).

All data were statistical analyzed according to the technique of analysis of variance (ANOVA) for the completely Randomized design (CRD) using MSTATC software package according to Gomez and Gomez (1984). Least Significant Difference (LSD) was used to compare the differences between treatments means at the level 0.05%.

Results and Discussion

Fresh and Dry weight

Slow release fertilizers were applied to spinach plant in different application rate i.e.1.5, 3.0 &6.0 g /pot with or without iron as foliar spray. Table (2) shows that the addition of urea at different doses with or without iron increased the fresh and dry weight of spinach plant as compared to control. The addition of 6.0 g urea /pot with iron was a remarkable effect on fresh and dry weight of spinach plant as compared to 1.5 &3.0 g/pot with or without iron as foliar application. It was observed that the addition of iron as foliar spray gave the highest value of fresh and dry weight of spinach plant as compared to without iron as foliar spray. These results may be related to the structure of the ionic compound and the ability of urea to form stable complexes with Fe and urea through a ligand-exchange reaction Siam, Hanan *et al.,* (2006); Cajuste *et al.*, (1996).

Data also show that the application of slow release fertilizers as (15/15/15) as 1.5g/pot with or without iron gave the lowest value of fresh and dry weight of spinach plant as compared to 3.0 &6.0 g/pot. The application of 6.0g /pot of (15/15/15) were more pronounced effect on fresh and dry weight of spinach plant. Data also show that increasing the level of nitrogen from 1.5 to 6.0 g/pot with iron spray increased the fresh and dry weight of spinach plant. It was noticed that the addition of (15/15/15) with iron spray was more effective on fresh and dry weight of spinach plant especially at a level of 6.0 g/pot. This phenomenon could be explained by the irregularity of the coating process, creates many pinholes that affect the dissolution rate EL-Aila *et al.* (2001).

Nitrate content (ppm)

The effect of slow release fertilizers with or without iron spray on nitrate of stem and leaves of spinach plants are show in Table (2). It was observed that the application of slow release fertilizers decreased the nitrate in leaves and stem of spinach plants as compared to the addition of urea. Increasing the levels of nitrogen from 1.5g/pot to 6.0g/pot increased the nitrate in leaves and stem of spinach plants.

Table 2: Effect of nitrogen and slow release fertilizers with the foliar iron on fresh, dry weight and nitrate accumulation of spinach plant.

Treatments	Fresh weight. gm/plant		Dry weight. gm/plant		NO_3 (ppm)			
					Stem		Leaves	
	without Fe^{++}	with Fe^{++}	without Fe^{++}	with Fe^{++}	without Fe^{++}	with Fe^{++}	without Fe^{++}	with Fe^{++}
Control No fertilizers	2.47	2.99	0.13	0.19	306.7	404.0	68.0	178.8
Urea 1.5 g /pot	3.39	4.05	0.23	0.30	858.5	1127.2	758.8	1038.7
Urea 3.0 g /pot	5.51	6.50	0.35	0.33	1080.0	1356.5	1140.5	1397.1
Urea 6.0 g /pot	7.31	8.59	0.41	0.38	1626.8	1993.3	1309.7	1698.7
(15/15/15) 1.5 g /pot	4.52	5.72	0.26	0.32	429.0	635.6	156.4	316.1
(15/15/15) 3.0 g /pot	6.82	7.48	0.42	0.56	945.5	1040.7	220.2	519.0
(15/15/15) 6.0 g /pot	9.51	10.64	0.71	0.96	1127.3	1321.5	349.4	834.8
(10/10/10) 1.5 g /pot	4.08	5.41	0.24	0.29	661.9	937.0	564.0	740.6
(10/10/10) 3.0 g /pot	6.05	7.18	0.43	0.52	1017.9	1331.3	628.3	840.4
(10/10/10) 6.0 g /pot	8.48	9.59	0.55	0.87	1226.1	1521.4	713.4	997.8
LSD 0.05 %	0.150	0.088	0.031	0.031	5.84	14.25	10.70	12.48

It was noticed that the application of slow release fertilizers as (10/10/10) increased the nitrate in stem and leaves in spinach plants. These results may be due to the penetration of water vapor into urea granule and condenses the soluble fertilizer salt. Leading to development pressure within the particle Christianson, (1998); Sharon *et al.,* 1990). Also the beneficial effect of thickness coating delay the diffusion of water vapor into the granules, furthermore the diffusion of urea take place El-Aila, (1998).

Data also show that the addition of iron as foliar spray with slow release fertilizers decrease the level of nitrate concentration in stems and leaves. The addition of fertilizer (15/15/15) was more effective on the level of nitrate of stem and leaves. These results can be explained by the interactions of nitrogen with iron through changes in pH. When ammonium nitrogen is absorbed, plants release protons causing the growth medium to be more acid and iron availability is increased Marchner, (1995).

Macronutrient concentration

Effect of type and rate of slow release fertilizers with or without iron as foliar application on N, P & K concentration by spinach plants are shown in Table (3). The application of slow release fertilizer (10/10/10) with iron as foliar application had slightly increased N concentration in plant tissues, While N concentration was progressively increased by increasing the rate of nitrogen. This result could be explained on the basis of dissolution rate. Low dissolution rate may enhance the N-efficiency through minimizing N-losses (EL-Aila and Abouseeda, 1996 I; 1996 II). The magnitude variation of N concentration with respect to application of (10/10/10) and (15/15/15) were very clear application of (15/15/15) with iron as foliar application with 6.0 g/pot gave the highest value of N (5.16%) followed by (10/10/10) 3.97%, relative to other investigated treatments.

Table 3: Effect of nitrogen and slow release fertilizers with the foliar iron on macronutrient content in spinach plant.

Treatments	Nitrogen %		Phosphorus %		Potassium %	
	without Fe^{++}	with Fe^{++}	without Fe^{++}	with Fe^{++}	without Fe^{++}	with Fe^{++}
Control No fertilizers	1.18	1.75	0.055	0.126	2.920	3.72
Urea 1.5 g /pot	2.15	2.52	0.157	0.219	4.380	6.82
Urea 3.0 g /pot	2.63	3.10	0.244	0.329	5.603	7.80
Urea 6.0 g /pot	3.92	4.40	0.295	0.349	6.481	8.14
(15/15/15) 1.5 g /pot	2.48	3.29	0.180	0.228	5.833	7.29
(15/15/15) 3.0 g /pot	3.00	3.78	0.318	0.379	6.123	8.31
(15/15/15) 6.0 g /pot	4.04	5.16	0.395	0.515	7.505	9.69
(10/10/10) 1.5 g /pot	2.29	2.93	0.140	0.218	3.677	6.40
(10/10/10) 3.0 g /pot	2.77	3.18	0.288	0.325	5.613	7.10
(10/10/10) 6.0 g /pot	3.97	4.33	0.318	0.428	6.504	8.26
LSD 0.05 %	0.074	0.075	0.0066	0.0091	0.31	0.044

With regard to the P and K concentration by plant, data in Table (3) show that increasing rates of nitrogen with iron application increased the concentration of phosphorous and potassium by spinach plant. Data also show that the addition of 6.0 g/pot with iron as foliar application gave the highest value of P and K concentration as compared with other treatments. Increasing in NPK concentration by spinach plants could be explained by positive effect of slow release fertilizer for improving the nutritional status of soil. Many investigators have shown an increase in absorption of NPK by plant with slow release fertilizer EL Diwani *et al.,* (2007); Hassanein *et al.,* (2013); Shadia *et al*., (2013).

Photosynthetic pigments and Iron content

Data in table (4) indicated that the effect of slow release fertilizers with or without iron as foliar application on chlorophyll a, b and iron at spinach plant. It was observed that the foliar spray of iron increase the content of chlorophyll a, b and iron at spinach plants as than the plants without iron as foliar spray. Data also show that the application of iron spray with addition of slow release as (15/15/15) was more pronounced effect on chlorophyll a, b and iron at spinach plants. It was noticed that the highest of chlorophyll a, b and iron at spinach plants were recorded when spinach plants received slow release fertilizers as (10/10/10) with Iron as foliar application as compared to urea application at any levels.

The same trend was also found by El-Ashry *et al.,* (2006). Applying 1.5 g/pot with or without iron as foliar application did not effect on iron and chlorophyll a, b in spinach plants than the addition of 3.0 g/pot. The highest iron and chlorophyll a, b in spinach plants was recorded by the addition of 6.0 g fertilizers/pot with iron as foliar spray. Since iron hypothesized that plasma lemma ATP as activity and regulation may provide favorable apoplastic pH level and improve Fe^{3+} reductase activity (Tagliavini and Rombola, 2001). Nitrogen could potentially affect Fe uptake via is general role in cation/anion balance and facilitating movement of organic acids such as citrate. Marschner, (1995).

Table 4: Effect of nitrogen and slow release fertilizers with the foliar iron on Chlorophyll and Iron content in spinach plant.

Treatments	Chlorophyll a (mg\g fw.)		Chlorophyll b (mg\g fw)		Iron (ppm)	
	without Fe^{++}	with Fe^{++}	without Fe^{++}	with Fe^{++}	without Fe^{++}	with Fe^{++}
Control No fertilizers	0.056	0.113	0.092	0.112	805.2	975.0
Urea 1.5 g /pot	0.395	0.588	0.403	0.133	996.2	1181.8
Urea 3.0 g /pot	0.512	0.642	0.119	0.152	1217.5	1665.5
Urea 6.0 g /pot	0.632	0.717	0.151	0.172	1275.2	1773.2
(15/15/15) 1.5 g /pot	0.483	0.530	0.157	0.168	1500.8	1683.2
(15/15/15) 3.0 g /pot	0.630	0.697	0.176	0.197	1883.0	2383.8
(15/15/15) 6.0 g /pot	0.848	1.015	0.229	0.253	2163.8	3262.2
(10/10/10) 1.5 g /pot	0.425	0.491	0.122	0.149	1183.0	1390.2
(10/10/10) 3.0 g /pot	0.533	0.614	0.147	0.169	1507.7	2022.5
(10/10/10) 6.0 g /pot	0.636	0.871	0.179	0.197	1996.5	3152.2
LSD 0.05 %	0.006	0.022	0.27	0.0023	8.18	9.04

References

Behera, S. K., R.K. Panada, 2009. Integrated management of irrigation water and fertilizers for wheat crop using filed experiments and simulation modeling. Agricultural Water Management,96,1532-1540.

Black, C. A., 1982. Official Method of Analysis of the Association of Washington D.C.,U.S.A.

Cajuste, L. J., R. J. Laire, L. Cajuste B Jr. and B. G. Cuevas, 1996. Citrate and oxalate influence on phosphate, aluminum, and iron in tropical soils. Commun. Soil sci. Plant Anal., 27: 1377-1386.

Christianson, C. B., 1998. Factors affecting N-release of urea from reactive layer coated urea. Fert. Res. 16: 273-284.

El Diwani G., S. El Rafie, N. N. El Ibiari, H. I. El-Aila, 2007. Recovery of ammonia nitrogen from industrial wastewater treatment as struvite slow releasing fertilizer. Desalination 214 (1), 200-214.

EL-Aila, H. I., M. Abouseeda, 1996. Studies on slow release fertilizer: I. The utilization of controlled release and traditional nitrogen fertilizers by wheat. J. Agric. Sci. Mansoura Unvi., 21(11)4161-4178.

EL-Aila, H. I., M. Abouseeda (1996). Studies on slow release fertilizer: II. Utility studies on controlled release nitrogenous fertilizers and urease inhibitor in spinach plant. J. Agric. Sci. Mansoura Unvi., 21(12) 4634-4654.

EL-Aila, H. I., M. Abouseeda and M. A. Ziada, 2001.New approach for controlling the release of nitrogenous fertilizers and their effects on sorghum plants. Egypt.J.AppL.sci,16(6)324-346.

EL-Aila, H.I., 1998.Studies on slow release fertilizer :V. Effectiveness of some slow release nitrogenous fertilizers and potassium fertilizers on the growth of sudan grass. J. Agric. Sci. Mansoura Univ. 23(6):2879-2886.

EL-Ashry, S., Kh. S. Morsy and H.I.EL-Aila, 2006. Effect of Iron spray and potassium fertilizer on yield of grapevines grown under sandy soil conditions. Egypt. J. of Appl.Sci.,21(9),281-289.

Gomez, K.A. and A.A. Gomez, 1984. Statistical procedures for agricultural research. 2nd Edition, john Willy and sons Inc. New York. pp: 680.

Gu Y.F., Zhang Z. P., Tu S. H., K. Lindstrom, 2009.Soil microbial biomass, crop yields, and bacterial community structure as affected by long term fertilizer treatments under wheat-rice cropping. European Journal of Soil Biology,45, 239-246

Guo M. Y., M. Z. liu, F. L. Zhan, L.Wu, 2005. Preparation and properties of a slow release membrane encapsulated urea fertilizer with superabsorbent and moisture preservation. Industrial and Engineering Chemistry Research, 44, 4206-4511.

Hassanein, M.S., Amal, G. Ahmed, Nabila, M. Zaki, H.I.EL-Aila and M. M. Tawfik, 2013. Response of two wheat cultivars grown in newly cultivated lands to iron and slow release N fertilizers. 7(1): 498-505.

Mandal, K.G., K.M. Hati, A. K. Misra, 2009. Biomass yield and energy analysis of soybean production in relation to fertilizer-NPK and organic manure. Biomass and Bioenergy, 33, 1670-1679.

Marschner, H., 1995. Mineral Nutrition of Higher Plants, 2nd Ed., Academic Press, New York.

Saigusa, M., 2000. Broadcast application versus band application of polyolefin coated fertilizer on green peppers grown on andisol. Journal of Plant Nutri., 23, 1485-1493.

Shadia EL Rafie, EmanTora, Marwa S. Shalaby, Hesam EL-Aila, S. Hawash, 2013. Chemical and solar energetic treatment for human urine to produce natueal fertilizer. Journal of Social Sciences & Humanities., 1(17):120-138.

Sharon, G., K. Malka and A. Yorom, 1990. Studies on slow-release fertilizers II. A method for evaluation of nutrient release rate from slow-releasing fertilizers. Soil Science, 150(1):446-450.

Siam, Hanan S., Kh. S. Moursy and H.I. El-Aila, 2006. Effect of different sources and methods of application of iron on the improvement of growth and nutrient uptake by Sudan grass. Egypt. J. Appl. Sci., 21(IIB): 772-789.

Subbarao, Ch. V., P. V. Gopal Singh and Ch. Harikrishna, 2004. Delayed release of fertilizer through a coating of plaster of paris. Nature, Environment and Pollution Technology. 3, 401-404.

Tagliavini, M. and A.D. Rombola, 2001. Iron Deficiency and chlorosis in orchard and vineyard ecosystems. Eur.J.Agron.,15, 71-92.

Toledo, M.E.A., Y. Ueda, Y. Imahori and M. Ayaki, 2003. L-ascorbic acid metabolism in spinach (Spinacia oleracea L.) during postharvest storage in light and dark. Postharvest Biol. Terminol., 28: 47-57.

Trankel M. E., 1997.Controlled release and stabilized fertilizers in agriculture. International fertilizer industry Association, Paris.

Wu l., Liu M., 2008. Preparation and properties of chitosan coated NPK compound fertilizer with controlled release and water-retention. Carbohydrate Polymers, 72, 240-247.