Middle East Journal of Applied Sciences
ISSN 2077-4613
Volume : 08 | Issue :02 |April-June| 2018
Pages: 474-482

Response of peanut plants to different foliar applications of nano- iron, manganese and zinc under sandy soil conditions

[1]El-Metwally I. M., Doaa M. R. Abo-Basha[2] and M. E. Abd El-Aziz[3]

[1]*Botany Dept., National Research Centre, 33 El-Bohooth St., Dokki, Cairo, Egypt, P.O. Box, 1262.*
[2]*Plant Nutrition Department, National Research Centre, Dokki, Cairo, Egypt. P.O. Box, 1262.*
[3]*Polymers and Pigments Dept., National Research Centre, 33 El-Bohooth St., Dokki, Cairo, Egypt, P.O. Box, 1262.*

Received: 06 Mar. 2018 / Accepted: 30 April 2018/ Publication date: 14 May 2018

ABSTRACT

Increasing productivity of peanuts and improve seed quality using Fe, Mn and Zn considered an important factor especially in poorly nutritive sandy soil. Therefore, two field experiments were lay out in newly cultivated sandy soil during the two summer seasons of 2016 and 2017 at the Experimental Farm of the National Research Center to examine the result of nano- fertilizer foliar application on peanut yield amount and seeds quality. Results indicate that use of nano-fertilizers at 30 ppm gave the greatest of plant height, number of branches/plant, number of pods /plant, pods weight /plant, number of seed /plant, seed weight /plant, fresh weight of straw /plant , dry weight of straw /plant and 100-green seed weight of peanut as compared with untreated plant. Also, using nano-fertilizer with concentration 30 ppm give the highest value of N, P, Fe, Mn and Zn contents in both seeds and straw as well as chemical constituent such as Chlorophyll, carotenoids, total carbohydrate, total soluble sugars, total proteins and oil percentages content in seeds compared with other treatments.

Key words: Foliar application Nano-fertilizer, Peanut, Seed quality, Yield.

Introduction

Peanut is one of mainly essential trade and industry oilseeds in many countries around the warld. It is generally grown for its oil, protein and carbohydrate resource (Panhwar, 2005). Peanut seed contain 43-55% oil and 25-28% protein. Peanut is one of the important summer crops in the new reclaimed soil in Egypt. The peanut is considered an important export crop where it consumes about 65-70%.Trac elements which play a critical position on the plants growth and enhancement as well as have a main payment due to their requirement to enhance the yield of the crop (Forozany 1993).

Peanuts are a sensitive crop of zinc, iron and manganese deficiency, especially in alkaline soils (Zuo and Zhang 2011). In the calcareous soil we find that the ratio of iron available to plants is less than 10%, so we find that lack of iron leads to lower yield and poor quality.

The foliar application of Fe fertilizer is still the mostly effective way to get better Fe nutrition in plants. Most types of fertilizers are spread over the commercial level either to be organic or inorganic in Chelated-Fe form. Soluble inorganic-Fe fertilizer does little to develop the available Fe content in alkaline calcareous soils. Organic-Fe fertilizer is easy adsorbed onto soil particles, which are able to reduce the fertilizer effect. Iron oxide nanoparticles (Fe_2O_3-NPs) are one of the mainly vital oxides in the field of nano material's (NMs). At present, Fe_2O_3-NPs has been used in many medical and agricultural fields (Cheng *et al*. 2015 and 2016).

Nanotechnology in the field of agriculture focuses at present on aim farming that involves applies of NPs with unique properties to increase crop and farm animals' productivity (Zuo and Zhang 2011). The addition of nanotechnology in agriculture also consists of fertilizers to enhance plant development and yield, sensors for monitor soil quality and pesticides for pest and disease management. The aim of apply of NMs in the field of agriculture is to improve the efficiency and sustainability of agricultural practices by putting fewer input and generating less misuse than conventional products and approaches.

The fertilizers are very important for plant growth and improvement; mainly of the applied fertilizers stay unavailable to plants due to numerous factors such as leaching and degradation by hydrolysis, insolubility and decomposition, also, addition of conventional fertilizers at a high rate and

Corresponding Author: El-Metwally I. M., Botany Dept. National Research Centre, 33 El-Bohooth St., Dokki, Cairo, Egypt, P.O. Box, 1262.

for a long time in the agriculture field have caused main environmental issues worldwide. Addition of heavy use of nitrogen (N) and phosphorus (P) fertilizers has become the major anthropogenic factors ensuing in world-wide eutrophication problems in freshwater bodies and coastal ecosystems (Conley *et al*. 2009). Thus, very important research wants to develop to minimize nutrient losses in fertilization and to enhance the crop yield through the utilization of new applications with the assist of NMs and nanotechnology.

The use of nanotechnology is the goal of sustainable agricultural workers and can replace traditional agriculture in the coming years, where it plays a major role in crop improvement, especially with the successive environmental changes (Zuo and Zhang 2011).

The micro elements that the plant needs in small amounts play an important role in the metabolic processes that take place inside the plant. The addition of the iron element by using nanotechnology has resulted in the increase of pigment in optical construction at a rate of 10 % in the yield of the seed and the increase on blacked eyed pea and soybean yield Delfani *et al*. (2014). The use of Mn-NPs on *Vigna radiata* fields improved the growth, yield and its components compared with manganese sulphate (Ghafariyan *et al*. 2013).

Zinc is the vital trace-elements and regulates. Nano-fertilizers is able to simply penetrate into the seed and enhance availability of nutrient to rise seedling which cause fit and more shoot and root length but if concentration is more than the best it may show inhibitory effects on the germination and seedling growth of the plant. Nano-fertilizers increase the seed germination, vigor, growth characters and dry material production, pigments content, rate of the photosynthesis which effect extra production and translocation of photosynthesis to unlike parts of the plant.

The aim of this study was to determine the effects of nanotechnology liquid fertilizers on the plant growth, yield and seed chemical composition of peanut.

Materials and Methods

Materials

Sodium hydroxide, zinc acetate, and manganese nitrate were purchased from S.D. Fine-Chem. While polyvinyl pyrrolidone, iron nitrate, and ethanol were supplied from El-Naser company.

Preparation of ZnO nanoparticles (ZnO-NPs) (Chen et al., 2008).

ZnO nanoparticles prepared by the dissolving of zinc acetate in a basic alcohol medium where, 3.942g zinc acetate and 1.44g NaOH were dissolved in 1L ethanol and refluxed at 70°C for 2 h. clear and transparent solution were obtained since, ZnO-NPs can be separated and purified by adding DI-water and then centrifugated at 5000 rpm for 10 min then dry in oven at 60 °C for 24 h to get ZnO-NPs.

Preparation of $MnFe_2O_4$ nanoparticles ($MnFe_2O_4$ –NPs) (Naseri et al., 2011).

An aqueous solution of polyvinyl pyrrolidone 1% which was prepared at 70 ºC. After that, 0.2 mmol of iron nitrate $Fe(NO_3)_3.9H_2O$ and 0.1 mmol of manganese nitrate $Mn(NO_3)_2.6H_2O$ were dissolved in the above solution, and stirred for 2h until a colorless and transparent solution was obtained. The pH of the solution was adjusted to be in the range 1-2. Then it poured into a glass Petridish and heated in an oven at 80 ºC for 24 h to evaporate the water. The dried, orange, solid manganese ferrite that remained was crushed and ground in a mortar to form powder. The calcinations of the powder were conducted at 600 ºC for 3h to decompose the organic compounds and crystallize the nanocrystals.

Characterization

X-ray diffraction (XRD)

The XRD patterns were carried out on a Diano X-ray diffractometer using CoK_α radiation source energized at 45 kV and a Philips X-ray diffractometer (PW 1930 generator, PW 1820 goniometer) with

CuK radiation source (λ= 0.15418 nm). The basal spacing (dL) was calculated from the (001) reflection via the Bragg's equation.

Transmission Electron Microscope (TEM)

The morphological and particles size of nanomaterials were demonstrated by using TEM model JEM-1230, Japan, operated at 120 kV, with maximum magnification of $600X10^3$ and a resolution until 0.2 nm. A drop of an aqueous dispersion of the nanomaterials was placed on a carbon-coated copper grid and allowed to dry in air before characterization.

Preparation of foliar nano-fertilizer

A solution of ZnO -NPs and MnFe2O4 –NPs were prepared by dispersion 1g of each NPs in 1L of water.

Experiment layout

Two field experiments were conducted during the 2016 and 2017 seasons at the experimental farm of National Research Centre, Nubaria region, Egypt. The experimental area was classified as arid region with cool winters and hot dry summers. The soil of the experiments was sandy loam, the physical and chemical analysis (Cottenie *et al*., 1982) of the soil were carried out before sowing and presented in Table (1).

Soil analysis:-

Particle size distribution and soil texture of the representative soil samples collected from research and production station, National Research Centere, Nubaria site were determined according to Blackmore *et al* (1972). Contents of $CaCO_3$ as well as Ec and pH along with soluble cations and anions and anions were determined according to Black *et al* (1982).Total N and available P,K,Fe,Mn,Zn and Cu were also determined according to Jackson(1973).

Table 1: The physical and chemical properties of the used soil.

Sand (%)	Silt (%)	Clay (%)	Texture			O.M (%)		CaCo3
68.7	24.5	6.8	Sandy loam			0.16		7.00
pH (1:2:5)	EC (ds/m)	Cations and Anions (meq/1)						
		Ca^{++}	Mg^{++}	Na^{++}	K^{+}	$HCO3^{-}$	Cl^{-}	$SO4^{--}$
7.8	0.20	3.00	2.00	2.09	0.23	1.41	0.70	5.21
Macronutrients (mg/100 g soil)			Micronutrients (mg/kg)					
N	P	K	Fe		Mn		Zn	Cu
14.5	9.20	16.0	7.36		3.19		1.66	3.0

Irrigation water was obtained from an irrigation channel passing through the experimental area with pH 7.35, and electrical conductivity (EC) of 0.41 dS/m. The experimental design was randomized complete block design with four replications and the plot area was 10.5 m2 consisting of five rows (3.5m length and 60 cm between rows). The experiment included 4 rates (10 ppm, 20 ppm, 30 ppm and 40 ppm) of nano-fertilizers and control (untreated).

The experimental field was deep ploughed before planting. A combined driller that facilitated concurrent application of fertilizer and seeds was used. Groundnut (*Arachis hypogaea* L.) variety Gize 6 cv was inoculated just before sowing with the specific rhizobiumbacteria inoculants. Seeds of peanut were sown in the first week of May in the two seasons. The driller setting was such that it applied 45 kg of seed per fed, at 5-cm soil depth with 60 cm row spacing and sown in hill15 cm apart. Fertilizers application was based on soil analysis. All treatment plots received the same amount of total fertilizer. A compound fertilizer was applied as follow: 60 kg N/fed as ammonium nitrate, 30 kg P_2O_5/fed as single superphosphate and 50 kg K_2O/fed as potassium sulphate. Groundnut was manually harvested on September 10th and 14th in the first and second season, respectively.

Measurements

Growth yield and yield attributes: At harvesting, the following data were recorded:
Plant height (cm), No. of branches/plant, Number of pods /plant, Pods weight (g) /plant, No. of seed /plant, Seed weight (g) /plant, Fresh weight of straw gm/plant, Dry weight of straw g/plant, 100-green seed weight (g), Pod yield (ton/fed) for the last traits the two central ridges of each experimental unit were devoted the determination.

The chlorophyll and carotenoids contentsin Peanut leaves were determined according to Witham *et al.* (1971).

Measurement of Nutritional status: Macronutrients (N, P and K) and micronutrients (Fe, Mn and Zn) of peanut seeds and straw were determined according to Cottenie *et al*. (1982).

Measurement of Chemical Constituents: The percentages of (oil, total proteins, total carbohydrate and total soluble sugars) in peanut seeds were determined according to A.O.A.C., 1990.

Statistical analysis:

The data obtained were subjected to analysis of variance (ANOVA) according to Gomez and Gomez (1984).

Results and Discussion

Transmission electron microscope (TEM)

Fig. (1) illustrated the morphological structure of the prepared (a) ZnO -NPs and (b) $MnFe_2O_4$ -NPs. It can be demonstrated that the prepared nanomaterials with particles size less than 50 nm.

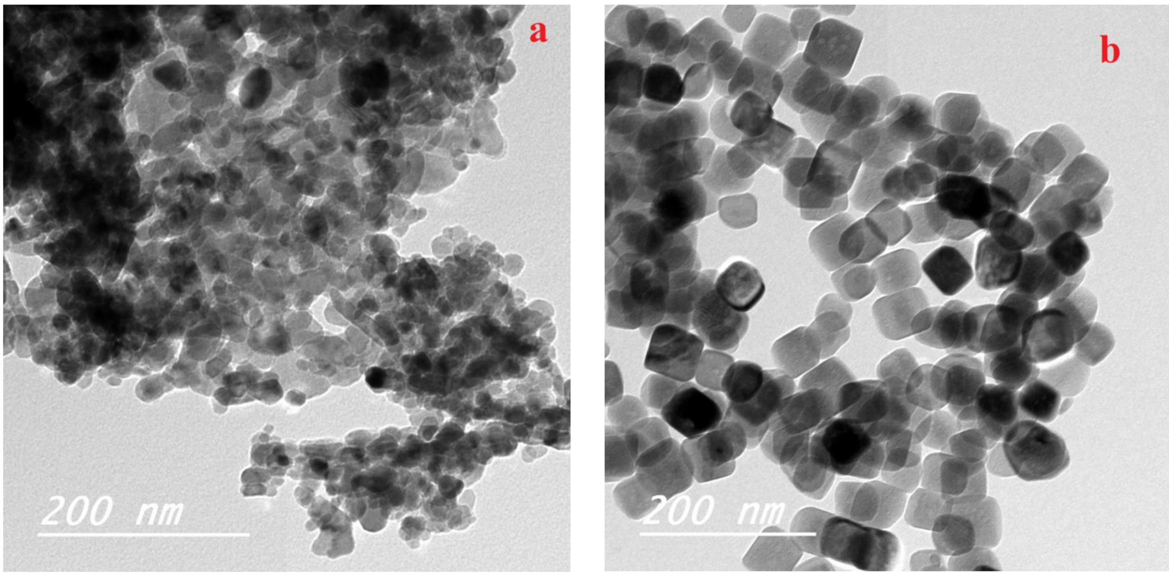

Fig. 1: TEM image of ZnO -NPs (a) and $MnFe_2O_4$ -NPs (b)

Structural analysis X-Ray diffraction

Fig. (2) shows the XRD diffractogram of zinc oxide and manganese ferrite nanoparticles.
zinc oxide nanoparticles has possess main peaks at 2θ =32°, 34.4°, 36.4°, 47.7° and 56.7° equivalent to (100), (002), (101), (102) and (110) planes, correspondingly. All peaks could be assigned to ZnO structure. (Sue, 2003).

The XRD diffraction pattern of the manganese ferrite nanoparticles show the reflection planes (111), (220), (311), (400), (422), (511), and (440), which confirm the presence of single- stage $MnFe_2O_4$ with a face-centered cubic structure. (Chen 2013 and Zhen *et al.* 2008)

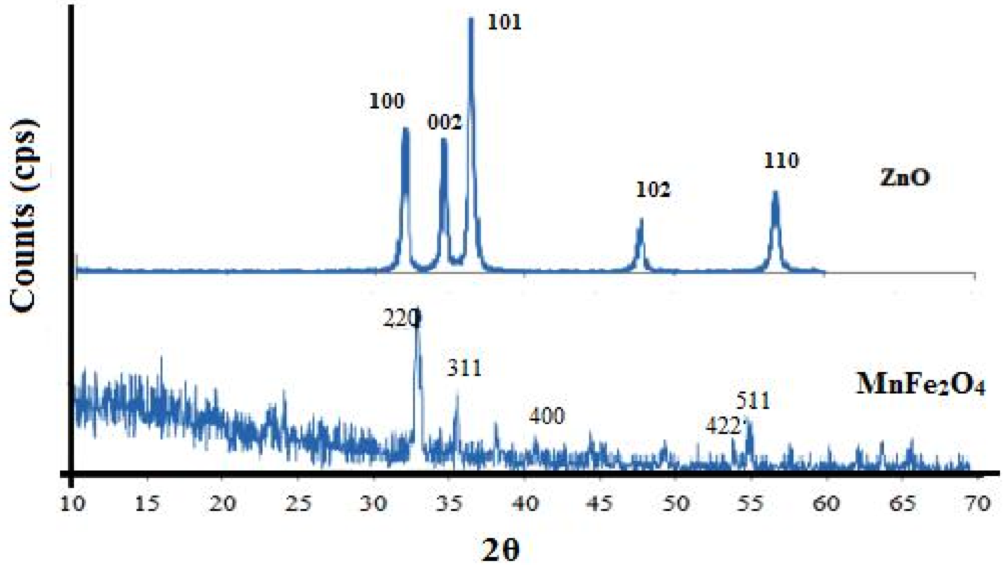

Fig. 2: XRD pattern for manganese ferrite ($MnFe_2O_4$)and zinc oxide (ZnO) nanoparticles

Growth yield and yield attributes:

Nanomaterials had a significant effect on plant height, number. of branches, number of pods /plant, pods weight /plant, no. of seed /plant, seed weight /plant, fresh weight of straw /plant and dry weight of straw /plant and 100-green seed weight of peanut (Table 2). Application of 30 ppm nano fertilizers led to significantly produced maximum values of aforementioned characters. Data also, reveal that application of 10, 20 and 30 ppm nano fertilizers gave higher values of seed yield ton/fed (Fig.3).

Values of seed yield ton/fed significantly increased over the untreated plants by19.4, 40.6, 52.7 and 51.7%, respectively. These results may be due to nano-fertilizers enhance ease of use of nutrient to the plants which enhance pigments formation, photosynthesis rate, dry material production and result get better in general growth of the plant (Hediat, 2012). Zheng *et al.* (2005) indicate that nano-fertilizers significantly get better seed germination and overall development of the plant. Kobraee *et al.* (2011) reported that Fe foliar application increased grain yield by influencing amount of seeds per plant and seed weight of soybean. This is in agreement with our results that showed Fe, Zn and Mn lead to increasing in plant biomass and consequently increasing in seed yield when compared to the control.

It is obvious from his study that foliar application of zinc, iron and manganese manipulates the growth of chickpea, resulting in useful changes in seed yield and yield attributes. The possible cause for such positive role is enhance in the activity of bio-substances or activity of photosynthetic system (Quary *et al.* 2006) or might be due to the active role of these trace-elements in metabolic processes of plants and photosynthesis and thus, reflected to increase the yield attributes. The present results are in agreement with those of Alireza *et al*. (2015) and Mekkdad (2017).

Table 2: Effect of nano- fertilizers on growth, yield and yield attributes (combined analysis of two seasons).

Treatments (ppm)	Plant height (cm)	No. of branche s /plant	No. of pods/ plant	Weight of pods /plant	No. of seeds /plant	Seed weight /plant (g)	Fresh weight of straw/ plant(g)	Dry weight of straw/ plant(g)	100-seed weight (g)	Seed yield (ton/ fed)
Control	25.17	6.33	11.00	22.43	20.00	12.46	34.86	5.77	53.46	1.800
10	28.25	8.33	16.67	28.95	27.67	16.11	51.76	7.26	55.99	2.150
20	32.69	13.00	25.00	48.05	49.33	23.9	66.00	11.14	61.33	2.530
30	38.29	15.00	32.33	51.53	60.00	28.27	71.09	12.60	66.78	2.750
40	37.00	13.00	30.00	62.86	52.12	26.98	68.29	11.38	62.35	2.730
LSD 0.05	2.67	1.86	1.11	5.12	4.32	1.15	3.13	1.03	3.22	0.211

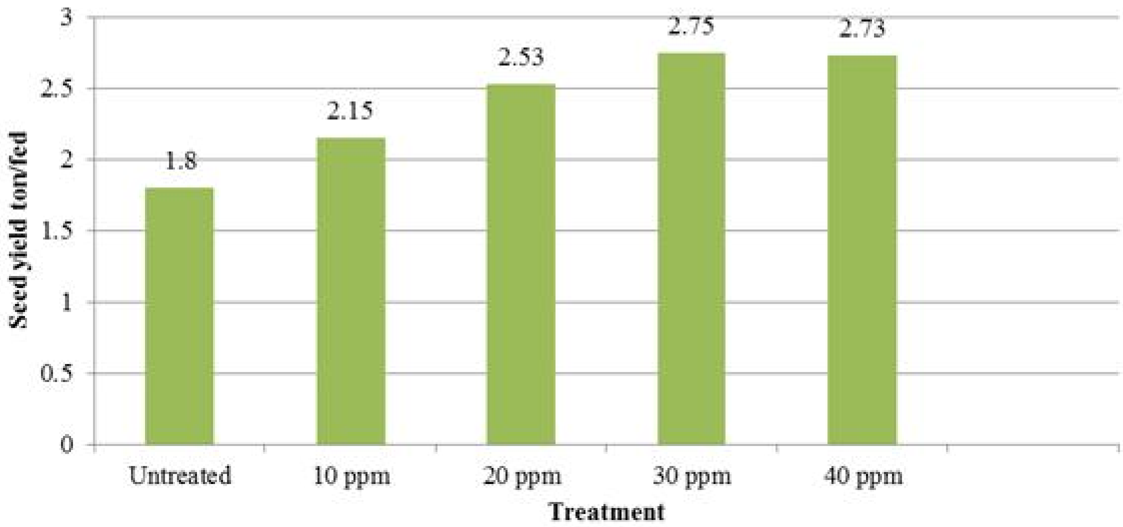

Fig. 3: Effect of nano-fertilizer on yield of peanut (combined analysis of two seasons)

Chlorophyll, carotenoids and chemical composition of seeds:

Chlorophyll, carotenoids in peanut leaves total carbohydrate, total soluble sugars, protein and oil percentages in seeds were appreciably influenced by nano fertilizers (Table 3). Nano fertilizers levels, produced progressive increases in all aforementioned plant traits. Application of nano fertilizers at the rate of 30 ppm led to the highest values of previous characters. On contrast, the minimum values were recorded with foliar of water treatment (untreated plants).

The micro elements that the plant needs in small amounts play an important role in the metabolic processes that take place inside the plant. Therefore, it is important not only to improve plant growth but also to improve human health. Zinc plays an important role in increasing plant roots to exchange cations, which helps plants absorb important nutrients, especially nitrogen responsible for protein synthesis. It also plays an important role in the metabolism of carbohydrate and protein. Zinc is involved in the work of plant hormones especially IAA and helps in the formation of starch and seed maturity (Fageria *et al*., 2002).

Table 3: Effect of nano- fertilizers on Chemical constituents of peanut seeds (combined analysis of two seasons).

Treatments (ppm)	Chlorophyll (a+b) mg/g dwt	Carotenoids mg/g dwt	Total carbohydrate mg/g	Soluble sugars mg/ g	Seed oil %	Protein %
Control	3.17	0.82	215.30	19.48	38.00	14.77
10	4.59	1.33	301.40	23.61	42.00	18.35
20	5.17	1.58	312.37	26.68	43.00	19.73
30	6.07	1.89	326.93	31.66	45.00	20.62
40	5.86	1.73	322.63	30.68	42.33	19.51
LSD 0.05	0.54	0.14	23.15	2.18	1.25	0.61

Prasad *et al.* (2012) found that the application of fertilizer in nanoform is completely controlled, which has led to an increase in grain yield in wheat, improved protein content and reduced soluble sugar level.

In this connection, iron has a great role in increasing growth characters, being a component of ferrodoxin, an electron move protein and is related with chloroplast. It helps in photosynthesis and hence, it have increased the growth. Kumar *et al.* (2009) showed that application of iron fertilizer increased the grain yield of chickpea by 17.3% over the control. Jin *et al*. (2008) reported that iron has an important role in the synthesis of chlorophyll, photosynthesis improvement and plant growth regulation. Safyan *et al*. (2012) reported that nano iron has the highest concentration of chlorophyll in comparison to the other treatments. In protein content zinc element had an additive role for protein formation that showed an important role in the protein content of plants; Potarzycki and Grzebisz (2009) concluded that among micronutrients, iron and zinc are the most important nutrient and its essential has been demonstrated for corn production, so deficiency of iron can reduce seed protein content because of the direct positive effect of iron on protein synthesis (Cakmak 2008). These results are in coinciding with those detected by Jin *et al*. (2008); Safyan *et al*. (2012) and Saedpanah *et al*. (2017).

Nutrients Status in seeds and straw:

It is clear from the data in Tables (4) and (5) which reveal that nano fertilizers treatments significant affect macronutrients (N, K and P) and micronutrients (Fe, Mn and Zn) in seeds and shoot of peanut plants at harvest. The highest content values of aforementioned characters in shoot were obtained at the treatment of 30 ppm nano fertilizers followed by 20 and 40 ppm treatments. Application of 30 ppm nano fertilizers gave the highest values of macronutrients (N, P and K) while, 40 ppm nano gave the greatest values of micronutrients (Fe, Mn and Zn) in seeds of peanut. These results may be due to the high number of nodules, and roots weight resulted in high rate of nitrogen fixation and improved root enlargement can enable plants to take up more nutrients and water for growth .In this connection, the percent increase in N content with nano-fertilizer application varied from 42.9 to 55.8 % in grain and 59.0 to 76.4% in straw respectively over NPK alone in peanut plant (Sudha and Staline, 2015). These results support the findings of (Potarzycki and Grzebisz, 2009) and (Keram *et al*., 2012) who stated that such increase could be attributed to the synergistic effect between N and Zn which might be due to increase enzymatic activity by Zn application.

Table 4: Effect of nano- fertilizers on macronutrients and micronutrients content in peanut seeds (combined analysis of two seasons).

Treatments	Macronutrients (%)			Micronutrients (mg/g)		
(ppm)	N	P	K	Fe	Mn	Zn
Control	2.36	0.35	2.21	87.33	58.33	21.00
10	2.94	0.50	2.35	96.33	65.33	33.33
20	3.16	0.58	2.41	112.0	68.00	36.00
30	3.30	0.64	2.45	123. 7	74.67	42.00
40	3.12	0.54	2.45	130.0	78.67	44.00
LSD 0.05	0.11	0.05	NS	5.12	2.17	1.11

Table 5: Effect of nano-fertilizers on macronutrients and micronutrients content in peanut straw (combined analysis of two seasons).

Treatments	Macronutrients (%)			Micronutrients (mg/g)		
(ppm)	N	P	K	Fe	Mn	Zn
Untreated	2.15	0.23	1.82	85.33	65.00	31.00
10	2.25	0.29	1.99	94.00	76.33	36.67
20	2.32	0.35	2.03	101.0	83.00	41.00
30	2.38	0.39	2.04	108.0	87.33	48.00
40	2.33	0.37	2.01	102. 7	79.00	39.00
LSD 0.05	0.04	0.03	NS	4.15	2.13	2.22

Results also revealed that application of nano fertilizers gave the highest values of potassium concentration. These results are in accordance with the findings of Keram, (2012). This might be due to the synergistic interaction between zinc and potassium, many zinc dependent enzymes are involved in carbohydrate metabolism in general and leaves in particular, impartment of K in stomata regulation, phloem export of assimilation from the source i.e., the leaves into the sink organs, maintained water balance in the soil-plant-atmosphere continuum. Zinc sufficiency is also associated with the marked increase in potassium efflux from roots, shoots into growth medium. Zinc also facilitates the movement of potassium in guard cells of stomata. Further it is also interesting to note that K content was higher in straw than grain of peanut as compared to N and P in the present study, which indicates that peanut straw is useful as a source of potassium .The massive increase in potassium content due to the interaction of K and Zn by the improvement of enzymatic activity and metabolic processes of plant which might have ultimately facilitated the removal of potassium and consequently enhanced the yield.

In this regard, the increase in zinc content in grain and straw at harvest might be due to foliar application of zinc absorption by leaf epidermis and remobilization in to the grain through phloem and several membranes of zinc regulated transporters which might have regulated this process (Bashier *et al*. 2012).The same conclusion was mentioned by El- Habbasha (2015) and Mekdad (2017).

Conclusion

Eventually, it could be concluded that application of nano fertilizer at 30 ppm gave the maximum values of growth parameters and yield, its attributes and quality of peanut seeds under sandy soil conditions.

References

A.O.A.C., 1990. Official Methods of Analysis of the Association of Official Edition, Washington, D.C.

Alireza, J., A. L. Moghadam and Elham Danaee, 2015. Response of Growth and Yield of Cucumber Plants (*Cucumis sativus* L.) to Different Foliar Applications of Nano- Iron and Zinc. International Research Journal of Applied and Basic Sciences, 9 (9): 1477-1478.

Bashier, K., Y. Ishimaru and N. K. Nishizawa, 2012. Molecular mechanism of zinc uptake and translocation in rice. Plant and Soil, 361:189-201.

Blackmore, L.C., 1972. Methods for Chemical analysis of soil. Newzea land Soil Durean, p.A21, Rep. No.10.

Cakmak, I., 2008. Enrichment of cereal grains with zinc: agronomic or genetic biofortification? Plant Soil, 302(1-2):1–17.

Chen, J., C.Y. Cheng, W.Y. Chiu, C.F. and Lee and N.Y. Liang, 2008. Synthesis of ZnO/polystyrene composites particles by Pickering emulsion polymerization. European Polymer J., 44: 3271–3279.

Chen, D., Y. Zhang and Z. Kan, 2013. A low temperature synthesis of Mn Fe_2O_4 nanocrystals by microwave-assisted ball-milling, Chemical Eng. J., 215: 235-239.

Cheng, W., J. Xu, Y.J. Wang, F. Wu, X X. Xu and J.J. Li, 2015. Dispersion-precipitation synthesis of nanosized magnetic iron oxide for efficient removal of arsenite in water. Colloid Interface Sci., 445: 93-101.

Cheng, W., J. Xu, F. Wu and J.J. Li, 2016. Synthesis of cavity-containing iron oxide nanoparticles by hydrothermal treatment of colloidal dispersion. Mater. Lett., 164: 210–212.

Conley, D. J., H. W. Paer, R. W. Howarth, D. F. Boesch and S. P. Seitzinger, 2009. Ecology controlling eutrophication: nitrogen and phosphorus, Science, 323 : 1014–1015.

Cottenie, A., M. Verloo, L. Kiekens, G. Velgh and R. Camerlynck, 1982. Chemical Analysis of Plant and Soil. Lab. Anal. Agrochem. State Univ. Gthent, Belgium, 63.

Delfani, M, M. B. Firouzabadi, N. Farrokhi and H. Makarian, 2014. Some physiological responses of black-eyed pea to iron and magnesium nanofertilizers. Commun Soil Sci. Plant Anal., 45:11.

El-Habbasha, S. F., 2015. Impact of nitrogen fertilizer and zinc folia application on growth, yield, yield attributes and some chemical constituents of groundnut. Inter. J. of plant and soil Sci., 4(3):259-264.

Fageria, N. K., V.C. Baligar and R.B. Clark, 2002. Micronutrients in crop production. Advances in Agronomy, 77: 189-272.

Forozany, M., 1993. Nutrition Basics. Tehran, press four, 213-240.

Ghafari, H. and J. Razmjoo, 2013. Effect of foliar application of nano-iron oxidase, iron chelate and iron sulphate rates on yield and quality of wheat. International Journal of Agronomy and Plant Production, 4 (11): 2997-3003.

Ghafariyan, M. H., M. J. Malakouti, M. R. Dadpour,P. Stroeve and M. Mahmoudi, 2013. Effects of magnetite nanoparticles on soybean chlorophyll. Environ. Sci. Technol., 47:10645-10652.

Gomez, K.N. and A.A. Gomez, 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York, 2nd Ed., 68p.

Hediat, M.H. Salama, 2012. Effects of silver nanoparticles in some crop plants, Common bean (*Phaseolus vulgaris* L.) and corn (*Zea mays* L.). International Research Journal of Biotechnology, 3:190-197.

Jin, Z., M. Wang, L. Wu, J. Wu and S. Chunhai, 2008. Impacts of combination of foliar iron and boron application on iron bio fortification and nutritional quality of rice grain. Journal of Plant Nutrition, 31(9):1599-1611.

Keram, K.S., B. L. Sharma and S. D. Sawarkar, 2012. Impact of Zn application on yield, Quality, Nutrients uptake and Soil fertility in a medium deep black soil (Vertisol). International Journal of Science, Environment and Technology. 1(5):563 – 571.

Kobraee, S., K. Shamsi and B. Rasekhi, 2011. Effect of micronutrients application on yield and yield components of soybean. Annals of Biological Research, 2(2):476 - 482.

Kumar, V., V. N. Dwivedi and D. D. Tiwari, 2009. Effect of phosphorus and iron on yield and mineral nutrition inchickpea. Annals of Plant Soil Research, 11:16 -18.

Mekkdad, A.A.A., 2017. Response of peanut nitrogen fertilizer levels and foliar zinc spraying rates in newly reclaimed sandy soils. J. plant production Mansoura Univ., 8(2):153-159.

Naseri, M., E. Saion, H. Ahangar, M. Hashim, A. Shaari, 2011. Synthesis and characterization of manganese ferrite nanoparticles by thermal treatment method, J. of Magnetism & Magnetic Materials, 323: 1745-1749.

Panhwar, F., 2005. Oilseed crops future in sindh Pakistan. Digitalvelarg Gmbh, Germany, 38. 64.

Potarzycki, J. and W. Grzebisz, 2009. Effect of zinc foliar application on grain yield of maize and its yielding components. Plant Soil Environ, 55 (12):519-527.

Prasad, T., P. Sudhakar, Y. Sreenivasulu, P. Latha, V. Munaswamy, K. R. Reddy, T. S. Sreeprasad, P. R. Sajanlal and T. Pradeep, 2012. Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut. J. Plant Nutr., 35(6):905–92

Quary, F. X., F. Leenhardt and C. Remesy, 2006. Genetic variability and stability of grain Mg, Zn and Feconcentration in bread wheat. European Journal of Agronomy, 25(2):177 - 185.

Saedpanah, S., K. Mohammadi and M. Javaheri, 2017. Agronomic traits of forage maize (*Zea mays* L.) as influenced by zeolite application and spraying of nano-fertilizers. Journal of Research in Ecology, 5(2):785-791.

Safyan, N., M. Reza, N. Darbaghshahi and B. Bahari, 2012. The effect of microelements spraying on growth, qualitative and quantitative grain corn in Iran. International Research Journal of Applied and Basic Sciences, 8:34-57.

Sue, K., K. Murata, K. Kimura and K. Arai, 2003. Continuous synthesis of zinc oxide nanoparticles in supercritical water, Green Chemistry, 5: 659-662.

Sudha, S. and P. Staline, 2015. Effect of zinc on yield, quality and grain zinc content of rice genotypes S International Journal of Farm Sciences, 5(3) : 17-27

Witham, F.H., D.F. Blaydes and P.M. Devin, 1971. Experiments in plant physiology. Van Nosland Reihold. Co. New York, 55-58.

Zhen, L., K. He, C. Xu and W. Shao, 2008. Synthesis and characterization of single-crystalline $MnFe_2O_4$ nanorods via a surfactant free hydro-thermal route, J. of Magnetism and Magnetic Materials, 320: 2672–2675.

Zheng L., F. Hong, S. Lu and C. Liu, 2005. Effect of nano-TiO_2 on strength of naturally aged seeds and growth of spinach. Biol. Trace Elem. Res., 104: 83-91.

Zuo, Y. and F. S. Zhang, 2011. Soil and crop management strategies to prevent iron deficiency in crops. Plant Soil, 339:83–95.