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Effect of foliar application of different sources of nano-fertilizers on growth and yield of wheat

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A field experiment was carried out at the extension farm in Al-Shafeieyah to study the effect of foliar application of different sources of nano-fertilizers on growth and yield of wheat. The experiment included di spray application of N, P and K Nano-fertilizer (N+P), (N+K), (P+K) and tri (N+P+K), Super Micro Plus SMP nano-fertilizer, Traditional fertilizer (NPK+TE) (AGRIMEL) and without application as control for comparison with three replicates in a simple one-way experience using RCBD design. A number of growth criteria in plant and yield (quality and quantity) parameters were recorded. Results indicated that significant response was spraying of SMP nano-fertilizer followed by the spraying combined of tri (N+P+K), di (N+P), (N+K) and (P+K) nano-fertilizer compared to control and traditional (NPK+TE) fertilizer treatments respectively in all growth and yield parameters of wheat with an increment of the spray foliar (SMP) of 87.77cm, 12.22cm, 58.22 spad, 3.17%, 0.66% and 2.88% for plant height, length of spike, total chlorophyll, concentration of N, P and K respectively compared to control treatment. The same treatment had grain yield and protein % of 5.996 Mg ha^{-1} and 13.69 % compared to the treatment of control and traditional fertilizer, which amounted to (4.060 Mg ha^{-1} and 11.94%) and (5.198 Mg ha^{-1} and 11.94 %) respectively. Harvest index were in the range (from 35.27 to 44.96 %) for control and nano SMP fertilizer treatment respectively. The highest fertilizer productivity was achieved when spraying treatments of nano SMP and tri nano mixture of (N+P+K) fertilizers (1936.0 and 1581.0 kg kg^{-1}) compared to traditional fertilizer (569.0 kg kg^{-1}).

Keywords: Wheat, Foliar application, Nano nitrogen, Nanophosphors, Nano potassium.

INTRODUCTION

World agricultural cropping systems intensively using large amount of fertilizers, to achieve more production per unit area but using more doses than optimum of fertilizers leads to several problems like environment pollution (soil, water, air pollution), low input use efficiency, decrease quality of food material, less income from the production, soil degradation, deficiency of micro nutrient in soil, toxicity to different beneficial living organism present above and below the soil surface. (Tan et al., 2005; Brunnert et al.,2006; Laghari *et al.,*2010). On the other hand, crop growth and productivity is affected by many biotic and abiotic factors (Al-Rifaee et al 2004; Musallam et al ,2004; Tawaha and Turk , 2004; Turk et al.,2004; Al-Tawaha and Odat, 2010; Abu Obaid et al. 2018; Al-Tawaha et al. 2018a; AL-Taey et al.,2018). Fertilizer such as phosphorus and nitrogen are the most important macro nutrient that plays significant role in physiological and biochemical reactions such as photosynthesis and transfer characteristics (Turk and Tawaha 2002; Tawaha et al., 2003; Turk et al, 2003; Nikus et al., 2004, Al-Tawaha et al., 2018b). Therefore, in the future, there is need to produce nutritive agricultural produce rich in protein and other essential nutrient required to the human and animal consumption that is why emphasis should be laid on production of high quality food with the required level of nutrients and proteins (Abera et al., 2005; Lee et al.,2005; Supanjani, et al., 2005; Sulpanjani et al.,2006; Assaf et al.,2006; Abu-Darwish et al., 2009; Al-Tawaha et al.,2010; Jyothi and Hebsur,2017; Qureshi et al., 2018).

For solving these problems in crop, production nano-fertilizers may effective tools in agriculture for better pest and nutrient management because these nano-materials having more penetration capacity, surface area and use efficiency which avoid residues in environment. Size below 100 nm nano-particles can use as fertilizer for efficient nutrient management which are more eco-friendly and reduce environment pollution. Hence, these agricultural useable nano-particle develop with the help of nanotechnology can be exploited in the value chain of entire agriculture production system (Morales-Díaz et al., 2017; Al-Juthery and Saadoun, 2018).

At the nano-scale the matter presents altered properties which are novel and very different from those observed at macroscopic level. The change in properties is due to the reduced molecular size and also because of changed interactions between molecules. The properties and possibilities of nanotechnology, which have great interest in agricultural revolution, are high reactivity, enhanced bioavailability and bioactivity, adherence effects and surface effects of nanoparticles (Gutierrez *et al.,* 2011). Customized manufactured products are made from atoms; their properties depend on how those atoms are arranged. Nano fertilizers enhance growth parameters (plant height, leaf area, number of leaves per plant) dry matter production, chlorophyll production, rate of the photosynthesis which result more production and translocation of photosynthesis to different parts of the plant compare with traditional fertilizers (Ali and Al-Juthery, 2017 ; Singh et al., 2017).

Foliar applications is the technique of feeding plants by spraying liquid fertilizers or other chemical or natural product directly to the leaves of macro and micronutrients are more effective in term of getting maximum yield and reduce losses (Rahman et al., 2014). Optimum N management to wheat is important for maximum yield, optimum water utilization and minimum contamination to environment (Corbeels et al., 1999; Al-Taey, et al, 2018).

Phosphorus is essential for enhancing seed maturity and seed development (Ziadi et al., 2008). Both P and K application favored tillering of wheat and reduced lodging in wheat (Liakas et al., 2001), improved photosynthetic activity and transport to the ripening grains (Hadis et al.,2018). This resulted heavier grains (Crista et al., 2012; Rietra et al., 2017). With adequate application of phosphorus, 20% more grain yield of wheat can be obtained (Abdel-Aziz et al., 2016). N and P uptake could be enhanced with increased P applications (Abdel-Aziz et al., 2018). Different researchers recommended different P application rates. Potassium is a one of special significance because of its active role in bio-chemical functions of plant e.g. activating various enzymes, protein formation, carbohydrates and fat concentration, tolerance to drought and resistance to frost, lodging, pests and disease attack (Gosavi et al., 2017). Thus, K deficiency in soil may results in yield losses (Saifullah et al., 2002). In the present day, intensive and high yield oriented agriculture, there is a negative K balance and soils are being mined for this essential element (Laghari et al., 2010). Increased use of N without adding required K in soil has further aggravated K deficiency (Havlin et al., 2014) because K play important role in improvement of the growth indices. Increasing K amount in wheat grain increased dry matter, 1000-grain weight, tillers, K contents in plant plant height, protein contents and grain yield (Bahmanyar and Ranjbar, 2008). Potassium application also significantly helped uptake of N and P in straw as well as wheat grain (Saifullah et al*.,* 2002; Laghari et al., 2010). The interaction between N and K had positive significant effects on grain yield and quality (Wu et al,. 2006).

Therefore, our aim was to determine the extent effect foliar feeding of Nano-fertilizers SMP and tri, di combination of N, P, and K ano-fertilizer compare with control and traditional fertilizer in some parameters of wheat growth and yield.

MATERIALS AND METHODS

A field experiment of wheat cultivar Ebaa 99 was carried out at Extension farm in Al-Shafeieyah in Silt clay Loam soil (Table 1).

The study included the maximize growth and yield of wheat by foliar application of Nanofertilizers Super Micro Plus (NSMP) chelates contain as a complex of 11 essential elements (N 5%, P 4%, K 2%, Mg 1%, Ca 1.5%, Fe 4%, Cu 1%, Zn 5% , Mn 2%, Mo 0.04 % and B 0.06%), Traditional foliage fertilizer(AGRIMEL) (20-20-20+TE) its content of(N 20%, $P_2O_5$20%, K_2O20%, Fe 260, Cu75, Mn320, Zn230, B100 and Mo10 ppm), Nano Nitrogen Fertilizer 25%N (N), Nano phosphorus Fertilizer 25%P (P) and Nano Potassium Fertilizer 35%K (K) applied in di and tri Combinations (N+P), (N+K), (P+K), (N+P+K) and control. on some growth parameters with three replicates in a simple one-way experience using RCBD. The process of foliar application was conducted at the start of the flag leaf stage according to spraying schedules and concentrations tabe.2 The foliar application was conducted early in the morning through applying 400 liters ha^{-1} of mixture in 14 days between applications. Di ammonium phosphate (DAP 18-45-0) was applied at 200 kg ha^{-1} to all treatments as a starter and source for some N and P. Nitrogen at 150 kg N ha^{-1} using urea (46%N) and potassium at 100 kg K ha^{-1} using potassium sulfate (41.5K) were applied in split for better management . All management practices for soil (e.g. land ,soil preparation "tillage " and irrigation) and for plants (e.g. pesticides) were done as required. Size of experiment units was 9 m^2(3x3m) and a distant of 1.5 m was left between units and replicates to increase the precision of the trial. Each experimental unit consisted of 15 lines with a length of 3 m at a distance of 20 cm between lines and a depth of 5 cm and seeds were sawn at 15th of Nov. 2017 with rate of 120 kg ha^{-1} using an Iraqi wheat variety called Ebaa 99 .

At the stage of grain maturity some parameters of growth and yield were estimated. Nutrient concentrations in plants after wet digestion were measured according to Hayens (1980).Total chlorophyll was measured using (SPAD). Biological yield ton ha^{-1} was estimated for all plants in 3 lines with a length of 50 cm from each experimental unit weighing the entire plants (grains + straw), weight of 1000 grain were measured too after isolation and removing of straw at 12% humidity (AOAC, 2000), Protein content in grain was calculated from (N%× 5.7). Fertilizer productivity kg yield of grains/ kg amount of fertilizer was calculated using the following equation= yield of Fertilizer treatment - yield of Comparative / Amount of added fertilizer (Ali, 2011).

Analysis of variance were analyzed using a simple one-way experiment and a less significant difference (LSD) at (0.05) using Genstate program.

Table 1. Some soil properties

property	value	Reference
Particle size distribution (gm kg^{-1} soil)		
Clay	120	Salim and Ali,2017 Landon,1984
Silt	580	
Sand	300	
Texture	Silt clay Loam	
CEC Cmolc kg^{-1}Soil	23.1	
OM gm kg^{-1}Soil	11.2	
Total carbonates gm kg^{-1}Soil	201	
pH	7.7	
EC(1:1) (dS m^{-1})	2.4	
Available macronutrients (mg kg^{-1}soil)		
N	17	
P	11	
K	199	
Available micronutrients (mg kg^{-1}soil)		
Cu	0.19	
Zn	0.17	
Fe	0.30	
Mn	0.30	
Bulk density Mg m^{-3}	1.31	

Table 2. Treatments used in the study

Tr. N^{O}	Treatments of Spraying	Dates and rates of foliar applied treatment combinations	
		120 DAP	134DAP
T_1	**Control**	0	0
T_2	**Nano(N+P)**	50+50	75+75
T_3	**Nano (N+K)**	50+50	75+75
T_4	**Nano (P+K)**	50+50	75+75
T_5	**Nano (N+P+K)**	33.3+33.3+33.3	50+50+50
T_6	**Nano SMP**	100	150
T_7	**Traditional AGRIMEL**	200	300

Concentrations were : 100(50+50) and 150 (75+75) ml of Nano Fertilizer(N+P),(N+K) and (p+k); 100(33.3+33.3+33.3) and 150(50+50+50) ml of Nano (N+P+k); 100 and 150 of NPK+TE Nano fertilizer and 200 and 300 ml of Traditional NPK+TE in 100 L^{-1} water

RESULTS

Nano fertilizer source significantly enhanced plant growth parameters and nutrient content in wheat. Foliar application of tri nano mixed fertilizer of N,P and K (NPK) T_5 significantly increased plant height (cm), spike length (cm), Chlorophyll(SPAD), N,P and K content in leaves (81.55, 11.66, 55, 64, 2.88, 0.6 and 2.66 %) respectively on all di combination and control except (NP) treatment.

Further foliar feeding of nano SMP fertilizer showed significant response on these traits. However, application of higher content 11essential nutrients fertilizer T_6 recorded maximum plant height, spike length, Chlorophyll, N, P and K content in leaves (87.77cm, 12.22cm, 58.22 SPAD, 3.17%, 0.66% and 2.88 %, respectively) compare with traditional fertilizerT_7, While the presence of nitrogen in the di nanofertilizers mixtures gave the best growth criteria (Table 3).

Higher biological yield (13.364Mg ha^{-1}) and grain yield of (5.996Mg ha^{-1}) were identified in wheat grown at spraying of NSMP T_6 . The grain yield ranged from4.060 to 5.198 Mg ha^{-1}, the highest grain yield was obtained in NSMP T_6, followed by sole tri nano(N+P+K) treatment(5.642Mg ha^{-1}). The (P+K) T_4(4.575Mg ha^{-1}) foliar application increased yield but the magnitude of response was lower compared to(N+K) T_3 (4.886Mg ha^{-1}) and (N+P)T_2 treatment(4.886Mg ha^{-1}). In case of thousand grain weight, highest value was also observed in (N+P+K) T_5 (47.25g)and NSMP T_6 treatment(47.88g) , which were significantly higher than all other treatment including traditional fertilizer T_7 (45.57g) and control T_1 treatment (39.69g). As far as harvest index is concerned the highest value was observed in NSMP T_6 applied treatment, followed by nano mixture fertilizer (N+P+K)and (N+P) while lowest (P+K) (44.96, 43.18, 37.65%) respectively, Protein content of the wheat grains Protein % was obtained in T_6 as nano super micro plus fertilizer (13.69%) compared to other treatments including control (11.94%) except of tri nano (N+P+K) treatment (13.33%). While the productivity of fertilizers achieved high significantly jumps when treated T_6 and T_5 (1936.0, 1581.0 Kg Kg^{-1}) respectively compare with all treatments of foliar feeding Including the traditional fertilizer source T_7 (216.1 Kg Kg^{-1}) (Table 4).

Although fertilizers are very important for plant growth and development, most of the applied fertilizers are rendered unavailable to plants due to many factors, such as leaching, degradation by photolysis, hydrolysis and decomposition. Micronutrients exist in very small amounts in both soil and plants, but their role is as important as the primary or secondary nutrients. Important micronutrients include six elements, namely, iron, manganese, zinc, copper, boron and molybdenum (Stepien and Katarzyna, 2016; Rietra et al., 2017) The increase in plant height, total chlorophyll, concentrations of N, P and K in leaves at foliar feeding of nano super micro plus fertilizer, di combination of nano N,P and K fertilizer and commercial fertilizer NPK+TE are attributed to the role of these nutrients in stimulating plant growth. These essential elements are required for optimum growth of the plant to complete its life cycle (Ali 2012; Al-Taey et al., 2017). Macronutrients nutrients are nitrogen, phosphorus and potassium are one of the chief importance in improving quality and productivity of wheat

(Rahman et al., 2014).These functions include the synthesis of chlorophyll and thylakoid and the development of chloroplasts (Masoud et al., 2012). It also plays a role in the transfer of energy within the plant, and in many enzymatic activities and photosynthesis as well as respiration and synthesis of proteins therefore has a key role in plant growth (Ali, 2012). Roles of micronutrients in plant can include growth and metabolism associated with photosynthesis, chlorophyll formation, development of root and respiration cells and the effectiveness of enzymes involved in primary and secondary metabolism (Adhikary et al., 2010, Mer and Ama, 2014).Foliar feeding combination of N,P and K nano fertilizer showed improvements of growth and yield parameters of wheat at lower concentration (Abdel-Aziz et al., 2016). Nanofertilizer are easily absorbed by the epidermis of leaves translocated to stems which facilitated the uptake of active molecules and enhanced growth and productivity of wheat (Abdel-Aziz et al., 2018). Nano fertilizer have large surface area and particle size less than the pore size of leaves of the plant which can increase penetration into the plant tissues from applied surface and improve uptake and nutrient use efficiency and uptake of the nutrients. (Dimkpa et al., 2015 and Qureshi et al., 2018). The positive effect of foliar applied nitrogen, phosphorus, and potassium to sustain proper leaf nutrition as well as carbon balance, and improving photosynthetic capacity is well established (Gosavi et al., 2017).

Table (3): Effect of spray of Different Sources of Nano-fertilizers in plant height cm, length of spike cm , total chlorophyll SPAD and concentration of N, P and K in the leaves

Tr. NO	Plant Heigh (cm)	Length of spike (cm)	Chloro phyll SPAD	N%	P%	K%
T_1	67.22	8.44	43.44	2.00	0.22	1.22
T_2	76.78	11.00	48.66	2.76	0.46	1.88
T_3	73.33	10.77	47.84	2.53	0.33	2.20
T_4	71.55	9.97	45.78	2.34	0.40	2.33
T_5	81.55	11.66	55.64	2.88	0.60	2.66
T_6	87.77	12.22	58.22	3.17	0.66	2.88
T_7	77.78	11.00	50.55	2.55	0.46	2.22
$LSD_{0.05}$	2.142	1.098	1.133	0.303	0.017	0.108

Table (4) Effect of spray of Different Sources of Nano-fertilizers in (biological yield and grain yield, ton h^{-1}), 1000 grain weight , harvest index% ,% protein and Fertilizer productivity (Kg Kg^{-1})

Tr. N^{O}	biological yield Mg ha^{-1}	Grain yield Mg ha^{-1}	weight of 1000 grain g	Harvest index %	Protein %	Fertilizer productivity Kg Kg^{-1}
T_1	11.499	4.060	39.69	35.27	11.94	0.00
T_2	12.449	5.305	45.78	42.55	13.01	1245.0
T_3	12.289	4.886	44.84	39.79	12.37	825.0
T_4	12.138	4.575	42.21	37.65	12.15	515.0
T_5	13.047	5.642	47.25	43.18	13.33	1581.0
T_6	13.364	5.996	47.88	44.96	13.69	1936.0
T_7	12.674	5.198	45.57	41.07	12.90	569.0
$LSD_{0.05}$	0.470	0.406	1.286	4.460	0.614	216.1

The foliar application is rapid uptake of nutrients during the fast growing period of crop especially if the soil was deficient in available of soil nutrients (Wojtkowiak et al., 2014 and Al-Juthery and Saadoun, 2018). Foliar applied in combination of complete macro and micronutients, then there is a significant increase in wheat production (Afshar et al., 2014 and Zain et al., 2015). Root growth and vegetative in wheat was improved by foliar feeding of micronutrients which led to increase in uptake of macro and micronutrients (Bameri et al.,2012). Moreover, there is an increase in protein percentage of seed and yield components (Zain et al., 2015).

The increment in protein % and productivity of fertilizers can be due to the improvement in the growth and grain yield as a results of spraying high number of nutrients in nano super micro plus (Masoud et al., 2012 ; Havlin et al., 2014 and Khanday et al., 2017). The di combination spraying of N,P and K increased the yield and yield components of wheat crop (Al-Kiyyam et al.,2008; Al-Ajlouni et al.,2009; Crista et al., 2014, Zain et al., 2015;) due to its stimulating role (Mer and Ama, 2014). On the contrary, Al-Juthery et al., (2018) found that when compared to the same quantity of 11essential nutrients nano-fertilizers was significantly superior to all growth parameters.

CONCLUSION

In conclusion, foliar application of super micro plus nano fertilizer at the rate of 1 kg ha^{-1} was optimum fertilizer treatment for growth, yield, nutrient uptake and fertilizer productivity, the results in this study showed that there was generally a positive effect of combined nano N+P+K, N+P ,N+K, P+K and traditional NPK+TE nutrients supply on growth and yield parameters of wheat in Iraqi conditions compared with control.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed in collecting and analyzing data. All authors participated in writing every part of this study. All authors read and approved the final version.

REFERENCES

A.O.A.C., 2000. Official method of analysis (17thed.). Gaithersburg, MD, USA: Association of Official Analytical Chemists, 967.21.

Abdel-Aziz H.M.M., Hassaneen M.N.A. & Omer A.M. 2016.Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. Spanish Journal of Agricultural Research, 14, 1-9.

Abdel-Aziz H.M.M, Mohammed N.A.H. & Aya M.O. 2018. Effect of Foliar Application of Nano Chitosan NPK Fertilizer on the Chemical Composition of Wheat Grains. Egypt. J. Bot 58(1), 87 – 95.

Abera, T., Feyisa, D., Yusuf, H., Nikus, O., & Al-Tawaha, A.M. 2005. Grain yield of maize as affected by biogas slurry and N-P fertilizer rate at Bako, Western Oromiya, Ethiopia. Bioscience Research, 2(1): 31-38.

Abu-Darwish M.S, Abu Dieyeh Z.H., Batarseh M., Al-Tawaha A.M. & Al-dalain S.A. 2009. Trace Element Contents and Essential Oil Yields from Wild Thyme Plant (*Thymus serpyllum* L.) Grown at Different Natural-Variable Environments, Jordan. Journal of Food, Agriculture and Environment. Vol.7 (3&4) : 9 2 0 - 9 2 4

Abu Obaid, A.M., Melnyk, A.V., Onichko, V.I., Ismael, F.M., Al-Abdullah, M.J., Al-Rifaee, M.K. &Tawaha, A.M. 2018. Evaluation of Six Sunflower Cultivar for Forage Productivity Under Salinity Condition. Advances in Environmental Biology., 12(7), 13-15.

Adhikary B.H., Shrestha J. & Baral, B.R. 2010. Effects of micronutrients on growth and productivity of maize in acidic soil. Int. Res. J. Appl. Basic Sci.4, 18-15.

Afshar I., Haghighi A. R., & Shirazi M. 2014. Comparison the effects of spraying different amounts of nano zinc oxide and zinc oxide on, wheat. International Journal of Plant, Animal and Environmental Sciences.4 (3), 688.

Al-Ajlouni M.M, Al-Ghzawi A.A & Al-Tawaha A.M. 2009. Crop rotation and fertilization effect on barley yield grown in arid conditions. Journal of Food, Agriculture and Environment. Journal of Food Agriculture and Environment 88(3),869-872

Ali E.A. 2012. Effect of iron nutrient care sprayed on foliage at different physiological growth stages on yield and quality of some durum wheat (*Triticum durum* L.) varieties in Sandy Soil. Asian Journal of Crop Science, 4 (4), 139-149.

Ali N. S. & Al-Juthery H. W. A. 2017.The application of nanotechnology for micronutrient in agricultureal production (review article). The Iraqi Journal of Agricultural Sciences . (9) 48, 489-441.

Ali N.S.2011. Fertilizers technologies and uses. Baghdad University. College of Agriculture.

Al-Juthery H. W.A. & Saadoun S. F. 2018. Impact of foliar application of micronutrients nanofertilizers on growth and yield of Jerusalem artichoke .TIJAS. http://TIJAS.2018.

Al-Juthery H. W.A., Ali N. S., Al-Taee D & Ali E.A. H . M. 2018. THE IMPACT OF FOLIAR APPLICATION OF NANAOFERTILIZER, SEAWEED AND HYPERTONIC ON YIELD OF POTATO; *Plant Archive*.18(2),2207-2212.

Al-Juthery H. W. A., H. Abdul Kareem., Radhi F. Musa; R.F.Musa and A.H. Sahan. 2018. Maximize Growth and Yield of Wheat by Foliar application of Complete Nano-fertilizer and Some of Bio stimulators. *Res. Crops* 19:387-393

Al-Kiyyam M.A, Turk M., Al-Mahmoud M., &Al-Tawaha, A.M 2008. Effect of Plant Density and Nitrogen Rate on Herbage yield of Marjoram under Mediterranean conditions. American-Eurasian Journal of Agricultural and Environmental Sci. 3(2),153-158.

Al-Kiyyam M.A, Al-Tawaha A.M, Turk M,& Al-Mahmoud M. 2007. Effect of Plant Density and Nitrogen Rate on Essential Oil of Marjoram under Mediterranean conditions. Pakistan Journal of Scientific and Industrial Research .50 (6),383-388.

AL-Taey D. K. A., Al-Janabi A. S. H. & Rachid A. M. 2017. Effect of water salinity, Organic and minerals fertilization on growth and some nutrients elements in cabbage *Brassica oleracea* var apitate. *Babylon Journal of Pure and Applied Science*, 25(6) ,232- 248.

Al-Taey D. K.A., Mijwel A. K & Al-Azawy S.S. 2018. Study efficiency of poultry litter and kinetin in reduced effects of saline water in *Vicia faba*. *Research J. Pharm. and Tech.* 2018; 11(1), 294-300.

AL-Taey, D. K. A., AL-Azawi., S. S. M., AL-Shareefi, M. J. H. and AL-Tawaha, A. R. **(**2018) Effect of saline water, NPK and organic fertilizers on soil properties and growth, antioxidant enzymes in leaves and yield of lettuce (*Lactuca sativa* var. Parris Island) *Res. Crops* **19** : 441-449.

Al-Rifaee, M.. Turk, M.A., & Tawaha, A. M. 2004. Effect of Seed Size and Plant Population Density on Yield and Yield Components of Local Faba Bean (*Vicia faba* L. major. International Journal of Agriculture and Biology, 6 (2),: 294-299.

Al-Tawaha A.M., Yadav S.S., Turk M., , Ajlouni M., Abu-Darwish M.S, Al-Ghzawi A.A, Al-udatt A, & Aladaileh S. 2010. Crop Production and Management Technologies for Drought Prone Environments. Chapter in Book. Climate Change and Drought Management in Cool Season Grain Legume Crops. (Springer

Al-Tawaha A.M. & Odat N. 2010. Use of Sorghum and Maize Allelopathic Properties to Inhibit Germation and Growth of Wild Barley (*Hordeum spontaneum*). Not. Bot. Hort. Agrobot. Cluj 38 (3), 124-127.

Al-Tawaha A.M, Al-Tawaha A.M, Alu'datt M.H., Al-Ghzawi A.A., Wedyan M., Al-Obaidy S.A., & Al-Ramamneh E.M. 2018a.Effects of soil type and rainwater harvesting treatments in the growth, productivity and morphological trains of barley plants cultivated in semi-arid environment. Australian Journal of Crop Science. 12(06),975-979.

Al-Tawaha, A.R., M.A. Turk, A.R.M. Al-Tawaha, M.H. Alu'datt, M.Wedyan, E. Al-D. M. Al-Ramamneh and A.T. Hoang, 2018b. Using chitosan to improve growth of maize cultivars under salinity conditions. *Bulg. J. Agric. Sci.*, 24 (3): 437–442.

Bahmanyar M.A. & Ranjbar G.A. 2008. The role of potassium in improving growth indices and increasing amount of grain nutrient elements of wheat cultivar. J. Appld. Sci. 8, 1280-1285.

Bameri M., Abdolshahi R., Mohammadi-Nejad G., Yousefi K. & Tabatabaie, S.M. 2012. Effect of different microelement treatment on wheat

(*Triticum aestivum*) growth and yield. *International Research Journal of Basic and Applied Science*s, 3, 219-223.

Brunnert I., Wick P., Manserp S., Pohnp R. N., Grass L. K., Limbach A., Bruinink & Stark W. J. 2006. Environmental Science and Technology, 40, 4374-4381.

Chinnamuthu C.R., & Boopati P.M. 2009.Nanotechnology and agroecosystem. *Madras Agric. J.* 96,17–31.

Corbeels M., Hofman G., & Van Cleemput O. 1999. Fate of fertilizer N applied to winter wheat growing on a Vertisol in a Mediterranean environment. Nutrient Cycling in Agro-ecosyst. 53, 249-258.

Crista F., Isidora R., Florin S., Laura C &.Adina B 2012. Influence of NPK fertilizers upon winter wheat grain quality. Research Journal of Agricultural Science, 44 (3),30-35.

Dimkpa C.O., McLean J.E., Britt D.W. & Anderson A.J. 2015. Nano-CuO and interaction with nano-ZnO or soil bacterium provide evidence for the interference of nanoparticles in metal nutrition of plants. Ecotoxicology 24,119-129.

Ghorbanpour M , Manika K. & Varma A. 2017. Nanoscience and Plant– Soil Systems. Springer International Publishing.

Gosavi A. B., Deolankar K.P., Chaure J.S & Gadekar D.A. 2017. Response of wheat for NPK foliar sprays under water stress condition. International Journal of Chemical Studies. 5(4), 766-768.

Gutierrez F. J., Mussons M.L., Gaton P. & Rojo R.2011. Nanotechnology and Food Industry. Scientific, Health and Social Aspects of the Food Industry, *In Tech, Croatia* Book Chapter.

Hadis H., Gashaw M. & Wassie H 2018. Response of bread wheat to integrated application of vermicompost and NPK fertilizers. African Journal of Agricultural Research. 13(1), 14-20.

Hasaneen M.N.A.G., Heba M.M.A. & Aya M.O. 2016. Effect of foliar application of engineered nanomaterials: carbon nanotubes NPK and chitosan nanoparticles NPK fertilizer on the growth of French bean plant. Biochemistry and Biotechnology Research.Vol. 4(4), 68-76.

Havlin J.L., Tisdale S.L., Nelson W.L. & Beaton J. D .2014. Soil Fertility and Nutrient Management: An Introduction to Nutrient Management. 8th Ed. Pearson, Upper Saddle River, New Jersey. United States, 505 p.

Haynes, R.J .1980. A Comparison of two modified kjeldhal digestion techniques for Multi- element plant analysis with conventional wet and dry ashing methods *. Comm. Soil .Sci. Plant Analysis .11(5), 459-467.*

Jyothi T.V. & Hebsur N.S. 2017.Effect of nanofertilizers on growth and yield of selected cereals - A review. Agricultural Research Communication Centre 38 (2) , 112-120. www.arccjournals.com

Khanday M.U.D., Ram D., .Ali T., Mehra S., Wani S. A, Jan R., Jan R, Bhat M. A & Bhat S.J.A..2017.Strategy for Optimization of Higher Productivity and Quality in Field Crops through Micronutrients: A Review. *Economic Affairs*. 62(1), 139-147.

Laghari G.M., Oad F.C., Tunio S. D., Gandahi A.W., Siddiqui M.H., . Jagirani A.W. Oad. S.M. 2010. Growth yield and nutrient uptake of various wheat cultivars under different fertilizer regimes. Sarhad J. Agric. 26(4), 489-497.

Lee, K. D., Sulpanjani, Tawaha A.M. & Min Yang, S. 2005. Effect of Phosphorus application on yield, mineral contents and active components of *Chrysanthemum coronarium* L. Bioscience Research, 2(3): 118-124.

Liakas V., Rauckis V. & Paltanaviius. V. 2001. Influence of phosphorus and potash fertilizers on germination, tillering and overwintering of winter wheat. Mokslo Darbai. 74, 3-12.

Masoud B., Abdolshahi R.,. Nejad G.M., Yousefi K & Tabatabaie. S.M. 2012. Effect of different microelement treatment on wheat (*Triticum aestivum* L.) growth and yield. Intl. Res. J. Appl. Basic. Sci., 3 (1), 219-223.

Mer M. & Ama E.H.E 2014. Effect of Cu, Fe, Mn, Zn Foliar Application on Productivity and Quality of Some Wheat Cultivars (*Triticum aestivum* L.) Journal of Agri-Food and Applied Sciences. 2(9),283-291.

Monreal C.M., DeRosa M., Mallubhotla S.C., Bindraban P.S. & Dimkpa. C. 2015. The Application of Nanotechnology for Micronutrients in Soil-Plant Systems VFRC Report. Washington, D.C., USA.

Morales-Díaz A.B, Hortensia O.O , .Antonio J.M, Gregorio C.P., Susana G.M. & Adalberto B.M .2017.Application of nano elements in plant nutrition and its impact in ecosystems. *Adv. Nat. Sci.:* Nanosci. Nanotechnol. 8 , 013001. (13pp).

Musallam, I. W., Al-Karaki, G., Ereifej, K., & Tawaha, A.M. 2004. Yield and Yield Components of Faba Bean Genotypes Under Rainfed and Irrigation Conditions. Asian Journal of Plant Science, 3(4), 439-448.

Nikus, O., Turk, M.A., Al-Tawaha, A.M. 2004. Yield response of sorghum (*Sorghum bicolor* L.) to manure supplemented with phosphate fertilizer under semi-arid Mediterranean conditions. International Journal of Agriculture and Biology, 6(5), 889-893.

Qureshi A., Singh D.K. & Dwivedi S. 2018. Nano-fertilizers: a novel way for enhancing nutrient use efficiency and crop productivity. Int.J.Curr. Microbiol. App. Sci. 7(2), 3325-3335.

Rahman I.U., Aftab R.A., Zafar I. & Shafiul. M. 2014. Foliar application of plant mineral nutrients on wheat: A Review. RRJAAS.3 (2), 19-22.

Rietra R.P. J., Marius J. H., Chistian O.D. & Prem S.B. 2017. Effects of nutrient antagonism and synergism on yield and fertilizer use efficiency. Communication in soil science and plant analysis. 48(16),1895–1920.

Saifullah A., Ranjha M., Yaseen M. & Akhtar. M.F. 2002. Response of wheat to potassium fertilization under field conditions. Pak. J. Agric. Sci. 39 (4), 269-272.

Salim S.Ch. & Ali. N. S 2017.Guide For Chemical Analyses of Soil ,Water ,Plant and Fertilizers. University of Baghdad-College of Agriculture.pp:279.

Shabbir R.N., Ashraf M. Y., Waraich E.A., Ahmad R & Shahbaz M. 2015. Combined effect of drought stress and NPK foliar spray on growth physiological processes and nutrient uptake in wheat. Pak. J. Bot., 47(4), 1207-1216.

Singh M.D., Gautam C., Patidar O.P., Meena H.M., Prakasha G. & Vishwajith. 2017. Nano-Fertilizers is a new way to increase nutrients use efficiency in crop production. international journal of agriculture. review article. International Journal of Agriculture Sciences. 9(7),3831-3833.

Stepien A. & Katarzyna.2016. Effect of foliar application of Cu, Zn, and Mn on yield and quality indicators of winter wheat grain. Chilean journal of agricultural research 76:(2)

Sulpanjani, A., Yang M.S., Tawaha A.R.M. &. Lee, K.D 2005a. Effect of Magnesium application on yield, mineral contents and active components of *Chrysanthemum coronarium* L. under Hydroponics Conditions. Bioscience Research, 2(2),73-79.

Supanjani, Tawaha,A.M., Min Yang, M.S., And Lee, K.D. 2005b. Role of calcium in yield and medicinal quality of *Chrysanthemum coronarium* L. Journal of Agronomy, 4 (3), 188-192

Tan Z.X., Lal R. &. Wiebe K.D 2005. Global soil nutrient depletion and yield reduction. J. Sustain.Agric.26(1),123-146.

Tawaha, A.M., Singh V.P., Turk M.A. & Zheng W. 2003. A review on growth, yield components and yield of barley as influenced by genotypes, herbicides and fertilizer application. Research on Crop, 4(1),: 1-9.

Tawaha, A.M., & Turk, M.A. 2004. Field Pea Seeding Management for Semi-arid Mediterranean Conditions. Journal of Agronomy and Crop Science, 190,: 86-92.

Turk, M.A.., &. Tawaha A.R.M. 2002. Impact of seeding rate, seeding date and method of phosphorous application in faba bean (*Vicia faba* L. minor) in the absence of moisture stress. Biotecnol. Agron. Soc. Environ. 6(3), 171-178.

Turk, M.A., Tawaha, A.M. And Shatnawi, M.2003. Lentil (*Lens culinaris* Medik) Response to plant density, sowing date, phosphorus fertilization and Ethephon application in the absence of moisture stress. Journal of Agronomy and Crop Science, 189(1): 1-6.

Wojtkowiak K., Stepien A., Warechowska M.& Raczkowski M.. 2014. Content of copper, iron, manganese and zinc in typical lightbrown soil and spring triticale grain depending on a fertilizationsystem. Journal of Elementology 19,833-844.

Wojtkowiak K., & Stepien A.. 2015. Nutritive value of spelt (*Triticum aestivum* spp. *spelta* L.) as influenced by the foliar application of copper, zinc and manganese. Zemdirbyste-Agriculture 102(4),389-396.

Wu J.C.J., Guo X.S., Yang X. U.& Wang Y.Q. 2006. Effects of grain yield and quality of strong gluten wheat and interaction in combined application of nitrogen and potassium. J. Anhui. Agric. Univ. 33 (3), 302-305.

Zain M., Khan I., Qadri R. W.K., Ashraf U., Hussain S., Minhas S., Siddique, A., Jahangir M. & Bashir M. 2015. Foliar Application of Micronutrients Enhances Wheat Growth, Yield and Related Attributes . American Journal of Plant Sciences. 6,864-869.

Zhang M.D., Chun X.L. & Li. C.L. 1999. Signs of phosphate shortage in wheat and the benefits of fertilizers. J. Henan Agric. Sci. 11, 27-28.

Ziadi N., Bélanger G., Cambouris A.N, Tremblay N., Nolin M.C. & Claessens. A 2008. Relationship between phosphorus and nitrogen concentrations in spring wheat. Agron. J. 100 (1),80-86.