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Anup Pratap Singh
Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Vijay Bahadur
Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Rajneesh Srivastva
ICAR-IIVR-KVK, Malhana Bankata Mishra Deoria, Uttar Pradesh, India

Gaurav Pratap Singh
Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Bhanu Prakash Singh
Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Ankur Pratap Singh
KNIT, Sultanpur, Uttar Pradesh, India

Corresponding Author:
Anup Pratap Singh
Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Effect of zinc oxide and iron oxide nanoparticles on growth, yield and quality traits of onion (*Allium cepa* L.)

Anup Pratap Singh, Vijay Bahadur, Rajneesh Srivastva, Gaurav Pratap Singh, Bhanu Prakash Singh and Ankur Pratap Singh

Abstract
Onions are the second most important vegetable crop after tomatoes in the world, belongs to the family Alliaceae or Liliaceae. Nano particles Interaction with plants causing many morphological and physiological changes, depending on the properties of NPs. zinc oxide nano particles (ZnONPs) increase plant growth, development and quality while iron oxide nano particles (FeONPs) increase the yield. A field experiment was conducted at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj (U.P) India, during the rabi season of 2016-17. The experiment was laid out in a Factorial Randomized Block Design with 16 treatments including control consisted of 3 levels of both ZnO and FeO in 3 replications and each replicated thrice under Allahabad agro climatic conditions. The three levels of both ZnO and FeO NPs were 250 ppm, 500 ppm and 750 ppm with control (RDF) and their combinations were allotted as 16 different treatments. Observations were recorded on growth, yield and quality characters at different days intervals. Findings revealed that the treatment T8 (500 ppm ZnO + 250 ppm FeO) found best in terms of growth traits i.e. highest plant height (60.26 cm), more number of leaves (12.54), maximum leaf length (52.79 cm), maximum stand count (100%), significantly at minimum days to maturity (134 days) which combinely influenced the yield traits i.e. widest bulb diameter (7.33 cm), widest neck diameter (4.65 cm), highest average bulb weight (109 gm), highest bulb yield per plot (1.58kg) and highest total bulb yield (15.80t/ha) in treatment T8 whereas quality traits like, total soluble solid (10.44ºBrix) and Vitamin-C (5.23 mg/100 gm) also significantly influenced with treatment T8 (500 ppm ZnO + 250 ppm FeO). The interaction between zinc oxide and iron oxide NPs had also significant effect on growth, yield and quality of onion.

Keywords: Onion, nano particles, ZnO, FeO, growth, yield and quality

Introduction
Onion (*Allium cepa* L.) belongs to the family Alliaceae or Liliaceae and is one of the most important monocotyledonous and cool season vegetable crops in India. Onions are day length sensitive, several onion types exist depending upon the latitude at which they grow. In terms of income onions are the second most important vegetable crop after tomatoes in the world (Griffiths *et al*., 2002; Mallor *et al*., 2011) [6, 12]. Onion from Central Asia, the supposed onion ancestor had probably migrated to the Near East (Grubben and Denton, 2004; Bagali *et al*., 2012) [7, 3]. Onion is a perennial plant, which is mainly cultivated for two years (Amin *et al.*, 2004) [2].

Onion is a part of regular diet of common man. It is consumed either raw or cooked along with spices and vegetables. It is rich in minerals like phosphorus and calcium and carbohydrates. It also contains Protein, Vitamin C and E (Tabor *et al*., 2004; Block, 2005; El Assi and Abu-Rayyan, 2007) [19, 4, 5]. Additionally, it has medicinal properties in the treatment and prevention a number of serious diseases (Martinez *et al*., 2007 and Stajner *et al.*, 2008) [13, 18] that attributed with onion biochemical constituents. The typical flavor of onion is due to presence of a volatile oil known as "Allyl propyl disulphide" and the red colour is due to the presence of another pigment "Quercetein".

Zinc has important functions in the synthesis of auxin or indoleacetic acid (IAA) from tryptophan as well as in biochemical reactions required for formation of chlorophyll and carbohydrates. It also regulates the functions of stomata by retaining potassium content of protective cells. The crop yield and quality of produce can be affected by deficiency of Zn (Jamali *et al.*, 2011) [21]. Iron is an element essential for plant growth and development. Iron is involved in chlorophyll formation its deficiency will cause a plant disorder known as chlorosis.

Nanoparticles like zinc oxide and iron oxide nanoparticles are being investigated as plant supplements for its promising targeted delivery approach.

Nanotechnology research is one of the major emerging areas of research with its application in science and technology for the purpose of manufacturing new materials at the nano scale level (Albrecht *et al*., 2006) [1]. Nanotechnology has the potential to revolutionize agriculture with new tools to enhance the ability of plants to absorb specific required nutrients (Savithramma *et al*., 2012) [16]. Nanotechnology also plays an important role in removal of various contaminants from the soil and water bodies by using functionalized nanoparticles and improving the shelf-life of the vegetables.

Nanoparticles (NPs) with small size and large surface area are expected to be the ideal material for use as a Zn and Fe fertilizer in plants. It has been stated that application of micronutrient fertilizers in the form of NPs is an important route to release required nutrients gradually and in a controlled way, which is essential to mitigate the problems of fertilizer pollutions (Naderi and Abedi, 2012) [14]. Earlier reports suggested that zinc oxide nano particles (ZnONPs) increase plant growth, development and quality while iron oxide nano particles (FeONPs) increase the yield.

Materials and Methods

The present investigation entitled "Effect of nano-particles of zinc oxide and iron oxide on growth, yield and quality of Onion (*Allium cepa* L.)" was carried out at Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) in the year 2016-17 during winter season. The experiment was laid out in a Factorial Randomized Block Design with 16 treatments including control consisted of 3 levels of both ZnO and FeO in 3 replications and each replicated thrice under Prayagraj agro climatic conditions. The three levels of both ZnO and FeO NPs were 250 ppm, 500 ppm and 750 ppm with control (RDF) and their combinations were allotted as 16 different treatments *viz*. T_0 (Control), T_1 (250 ppm ZnO), T_2 (500 ppm ZnO), T_3 (750 ppm ZnO), T_4 (250 ppm FeO), T_5 (500 ppm FeO), T_6 (750 ppm FeO), T_7 (250 ppm ZnO + 250 ppm FeO), T_8 (500 ppm ZnO + 250 ppm FeO), T_9 (750 ppm ZnO + 250 ppm FeO), T_{10} (250ppm ZnO + 500ppm FeO), T_{11} (500ppm ZnO + 500 ppm FeO), T_{12} (750 ppm ZnO + 500 ppm FeO), T_{13} (250 ppm ZnO + 750 ppm FeO), T_{14} (500 ppm ZnO + 750 ppm FeO) and T_{15} (750 ppm ZnO + 750 ppm FeO). The plants were sprayed 2 times (15 days interval) with graded concentrations of nanoparticles along with sticker. Observations were recorded on growth, yield and quality characters at different days intervals. The methods adopted for preparation of zinc and iron nanoparticles were as follows:

Synthesis of nanoparticles

Zinc

Zinc nanoparticles were prepared by dissolving 0.1M Zinc sulphate. In 25 ml of distilled water, then 0.1M PEG was added to the mixture solution of 25 ml of 0.2 M Sodium hydroxide and 0.1 ML of 0.1 M sodium borohydride was added to the mixture under vigorous stirring at room temperature white precipitate was obtained. The precipitate was then washed with distilled water and finally dried in vaccum oven at 70 °C. The sample was stored in distilled water. The concentration of the nanoparticles obtained was calculated by differential weight analysis.

Iron

Iron nanoparticles were prepared by dissolving 0.1M ferrous sulphate. In 25 ml of distilled water, then 0.1M PEG was added to the mixture solution of 25 ml of 0.2M Sodium hydroxide and 0.1 ml of 0.1M sodium borohydride was added to the mixture under vigorous stirring at room temperature black precipitate was obtained. The precipitate was then washed with distilled water and finally dried in vaccum oven at 70 °C. The sample was stored in distilled water. The concentration of the nanoparticles obtained was calculated by differential weight analysis.

Solution of zinc

A colorless solution was formed after dissolving zinc sulphate in distilled water in presence of PEG which is working as capping agent to prevent nanoparticles from aggregation, after addition of $NaBH_4$ and NaOH white particles were formed which indicate formation of zinc nanoparticles. Similar result was obtained by Revina *et al*., (2007) [22].

The concentration of zinc nanoparticles prepared was calculated by different weight analysis as:

Weight of empty aluminium foil = w_1= 0.33 g

Weight of aluminium foil with 1ml zinc solution (after drying) = W_2 = 0.34 g

Concentration = W_2-W_1= 0.01g/ml = 10 mg/ml.

Solution of Iron

A greenish coloured solution was obtained after dissolving ferrous sulphate in distilled water in the presence of PEG which is working as capping agent to avoid aggregation of nanoparticles. After addition of $NaBH_4$ and NaOH, black coloured particles are formed which indicates the formation of iron nanoparticles Zahang *et al*., (2010) [23].

The concentration of iron nanoparticles prepared was calculated by differential weight analysis as:

Weight of empty aluminium foil = W_1= 0.165 g

Weight of aluminium foil with 1ml iron solution (after drying) = W_2 = 0.33 g

Concentration = 0.17 g/ml = 17 mg/ml

Results and Discussion

Growth parameters

Plant height, stand count, number of leaves and leaf length were recorded to determine the growth of onion plants as influenced by different doses of ZnO NPs and FeO NPs and their interactions. The data presented in table (1) depicted that highest plant height (59.78 cm), maximum number of leaves (12.33), maximum leaf length (49.68 cm) and maximum stand count (100%) was recorded due to ZnO NPs treatments which was significantly greater than To (control) whereas due to FeO NPs treatments growth of onion was influenced as highest plant height (59.37 cm), maximum number of leaves (11.78), maximum leaf length (50.21 cm) and maximum stand count (96.67%) which was significantly greater than To (control).

There was a significant interaction between Zinc oxide and iron oxide (ZnO and FeO) on growth of onion in terms of highest plant height (60.26 cm), maximum number of leaves (12.54), maximum leaf length (52.79 cm) and maximum stand count (100%), recorded in T_8 (500 ppm ZnO + 250 ppm FeO) which was higher than other treatments. As compared to other treatments T_0 (control) exhibited poor performance in growth of onion.

The increase in vegetative growth in onion might be due to fundamental role of Zn in protecting and maintaining structural stability of cell membranes (Welch *et al.*, 1982) [24] and use in protein synthesis, membrane function, cell elongation as well as tolerance to environmental stresses (Cakmak, 2000) [25]. Above findings are closely related with Laware *et al*. (2014) [11] in onion. Similarly Prasad *et al*. (2012) [15] observed beneficial effects of NPs in enhancing plant growth, development and yield in peanut at lower doses, but at higher concentrations ZnO NPs were detrimental just as the bulk nutrients.

Yield parameters

The result of the analysis of variance indicated that yield of onion was significantly affected by the interaction effect of different doses of ZnO NPs and FeO NPs. Moreover, the main effect of ZnO NPs and FeO NPs also revealed significant effect on yield and its contributing traits. The data depicted in table (2) clearly shows that minimum numbers of days to maturity (136.83 days), widest bulb (6.71 cm) correlated with widest neck (3.56 cm), highest bulb weight (91.83 gm), higher bulb yield per plot (1.35kg) and highest bulb yield (t/ha) (13.5t/ha) was recorded due to ZnO NPs treatments which was significantly greater than To (control) while due to FeO NPs treatments yield traits of onion was influenced as minimum numbers of days to maturity (136.25 days), widest bulb (6.92 cm) correlated with widest neck (3.52 cm), highest bulb weight (90.42 gm), higher bulb yield per plot (1.38 kg) and highest bulb yield (t/ha) (14.05t/ha) which was significantly greater than To (control).

There was a significant interaction between Zinc oxide and iron oxide (ZnO and FeO) on yield of onion in terms of minimum numbers of days to maturity (134 days), widest bulb (7.33cm) correlated with widest neck (4.65 cm), highest bulb weight (109 gm), higher bulb yield per plot (1.58 kg) and highest bulb yield (t/ha) (15.8t/ha), recorded in T_8 (500 ppm ZnO + 250 ppm FeO) which was higher than other treatments. Whereas in comparison with other treatments, T_0 (control) recorded lowest in terms of yield and related traits. Sheykhbaglou *et al.* (2010) [17] also reported application of nano iron oxide at the concentration of 0.75g/L increased pod dry weight in soybean. Similarly Kazemi (2013) [9] reported significant effect of foliar application of zinc (50 and 100 mg L^{-1}) and iron (100 and 200 mg/L) and their combination on vegetative, reproductive growth, fruit quality and yield of tomato plants and Hamid Reza Bozorgi (2012) [26] in eggplant.

Quality parameters

The main effect of ZnO NPs and FeO NPs significantly influenced the quality of onion. The two factors interaction also influenced the quality parameters significantly. The data presented in table (3) depicted that Total soluble solid (ºBrix) and Vitamin C increased significantly in response to increased rate of ZnO NPs across the basic rate of the FeO NPs except in treatment combination of nil NPs application of which it decreased. The highest total soluble solid (9.56ºBrix) and Vitamin C (4.98 mg/100 gm) was recorded due to ZnO NPs treatments where due to FeO NPs treatments quality of onion was influenced as highest total soluble solid (9.55ºBrix) and Vitamin C (4.95 mg/100 gm) which was significantly greater than To (control).

There was a significant interaction between Zinc oxide and iron oxide (ZnO and FeO) on quality of onion in terms of highest total soluble solid (10.44ºBrix) and Vitamin C (5.23 mg/100 gm), observed in T_8 (500 ppm ZnO + 250 ppm FeO) which was higher than other treatments. As compared to other treatments T_0 (control) exhibited poor quality of onion. Similarly Kazemi (2014) [10] reported that foliar application of Zn at 50 mg L^{-1} and Fe at 100 mg L^{-1} and their combination increased yield and quality of cucumber.

Table 1: Effect of different doses of Iron oxide and Zinc oxide nano particles on growth of onion at maurity.

Levels of ZnO Nano particles	Plant Height (cm)				Mean (ZnO) Nano particles	Number of Leaves				Mean (ZnO) Nano particles
	Levels of FeO (Nano-particles)					Levels of FeO (Nano particles)				
	F_0-(control)	F_1-(250 ppm)	F_2-(500 ppm)	F_3-(750 ppm)		F_0- (control)	F_1- (250 ppm)	F_2- (500 ppm)	F_3- (750 ppm)	
Z_0 (control)	53.76	58.54	59.51	57.88	57.42	10.41	11.00	10.74	10.47	10.65
Z_1 (250pp)	57.19	58.56	58.76	58.96	58.37	10.85	10.60	11.47	11.73	11.16
Z_2 (500pp)	60.05	60.26	59.09	59.71	59.78	12.20	12.54	12.45	12.15	12.33
Z_3 (750pp)	59.01	59.78	60.11	59.96	59.71	12.27	12.44	12.47	11.88	12.26
Mean (FeO)	57.50	59.29	59.37	59.13		11.43	11.64	11.78	11.56	
		F-test	**S. Em. (±)**	**C.D. at 5%**		**F-test**	**S. Em. (±)**	**C.D. at 5%**		
Due to ZnO		S	0.86	2.99		S	0.09	0.30		
Due to FeO		S	0.37	1.07		S	0.05	0.14		
Interaction (Z x F)		S	0.74	2.15		S	0.10	0.28		

Levels of ZnO Nano particles	Leaf Length (cm)				Mean (ZnO) Nano particles	Stand Count (%)				Mean (ZnO) Nano particles
	Levels of FeO (Nano-particles)					Levels of FeO (Nano particles)				
	F_0-(control)	F_1-(250 ppm)	F_2-(500 ppm)	F_3-(750 ppm)		F_0-(control)	F_1- (250 ppm)	F_2- (500 ppm)	F_3- (750 ppm)	
Z_0 (control)	46.07	49.45	51.58	48.92	49.00	66.67	70.67	74.67	76.00	72.00
Z_1 (250pp)	49.72	50.96	49.17	48.86	49.68	81.33	85.33	89.33	88.00	86.00
Z_2 (500pp)	47.29	52.79	47.55	47.91	48.89	92.00	100.00	92.00	93.33	94.33
Z_3 (750pp)	46.33	46.75	52.55	49.34	48.74	92.00	94.67	96.00	93.33	94.00
Mean (FeO)	47.35	49.99	50.21	48.76		83.00	87.67	88.00	87.67	
		F-test	**S. Em. (±)**	**C.D. at 5%**		**F-test**	**S. Em. (±)**	**C.D. at 5%**		
Due to ZnO		S	0.74	2.58		S	2.98	10.30		
Due to FeO		S	0.41	1.18		S	0.50	1.45		
Interaction (Z x F)		S	0.81	2.37		S	1.00	2.90		

Table 2: Effect of different doses of Iron oxide and Zinc oxide nano particles on yield and related traits of onion.

Levels of ZnO Nano particles	Days to Maturity				Mean (ZnO) Nano particles	Bulb Diameter (cm)				Mean (ZnO) Nano particles
	Levels of FeO (Nano-particles)					Levels of FeO (Nano particles)				
	F_0-(control)	F_1-(250 ppm)	F_2-(500 ppm)	F_3-(750 ppm)		F_0-(control)	F_1- (250 ppm)	F_2- (500 ppm)	F_3- (750 ppm)	
Z_0 (control)	139.67	138.00	138.33	138.33	138.58	6.02	6.56	6.73	6.41	6.43
Z_1 (250pp)	138.33	138.00	138.00	138.33	138.17	6.46	6.45	7.13	6.52	6.64
Z_2 (500pp)	138.00	134.00	137.33	138.67	137.00	6.51	7.33	6.49	6.48	6.70
Z_3 (750pp)	138.00	135.00	135.33	139.00	136.83	6.73	6.36	7.32	6.42	6.71
Mean (FeO)	138.50	136.25	137.25	138.58		6.43	6.68	6.92	6.46	
		F-test	S. Em. (±)	C.D. at 5%		F-test	S. Em. (±)	C.D. at 5%		
Due to ZnO		S	1.40	4.85		S	0.19	0.65		
Due to FeO		S	0.36	1.05		S	0.04	0.11		
Interaction (Z x F)		S	0.72	2.10		S	0.08	0.22		

Levels of ZnO Nano particles	Neck Diameter (cm)				Mean (ZnO) Nano particles	Average bulb weight (gm)				Mean (ZnO) Nano particles
	Levels of FeO (Nano-particles)					Levels of FeO (Nano particles)				
	F_0-(control)	F_1-(250 ppm)	F_2-(500 ppm)	F_3-(750 ppm)		F_0-(control)	F_1- (250 ppm)	F_2- (500 ppm)	F_3- (750 ppm)	
Z_0 (control)	2.90	3.16	2.98	3.12	3.04	60.33	77.33	95.00	95.67	82.08
Z_1 (250pp)	2.92	3.26	3.20	3.05	3.11	77.00	68.00	75.67	73.33	73.50
Z_2 (500pp)	3.48	4.65	3.01	3.09	3.56	88.00	109.00	84.33	63.67	86.25
Z_3 (750pp)	3.35	3.02	4.59	3.00	3.49	95.00	88.67	106.67	77.00	91.83
Mean (FeO)	3.16	3.52	3.44	3.06		80.08	85.75	90.42	77.42	
		F-test	S. Em. (±)	C.D. at 5%		F-test	S. Em. (±)	C.D. at 5%		
Due to ZnO		S	0.29	0.99		S	7.70	26.65		
Due to FeO		S	0.08	0.23		S	2.12	6.19		
Interaction (Z x F)		S	0.15	0.45		S	4.24	12.37		

Levels of ZnO Nano particles	Bulb Yield / plot (kg)				Mean (ZnO) Nano particles	Total Bulb Yield (t/ha)				Mean (ZnO) Nano particles
	Levels of FeO (Nano-particles)					Levels of FeO (Nano particles)				
	F_0-(control)	F_1-(250 ppm)	F_2-(500 ppm)	F_3-(750 ppm)		F_0-(control)	F_1- (250 ppm)	F_2- (500 ppm)	F_3- (750 ppm)	
Z_0 (control)	0.97	0.99	1.42	1.39	1.19	9.71	9.90	14.21	13.95	11.94
Z_1 (250pp)	1.44	1.19	1.40	1.25	1.32	14.43	11.93	13.99	13.58	13.48
Z_2 (500pp)	1.36	1.58	1.16	1.06	1.29	11.64	15.80	12.46	10.57	12.62
Z_3 (750pp)	1.07	1.35	1.56	1.42	1.35	10.72	13.50	15.56	14.21	13.50
Mean (FeO)	1.21	1.28	1.38	1.28		11.62	12.78	14.05	13.08	
		F-test	S. Em. (±)	C.D. at 5%		F-test	S. Em. (±)	C.D. at 5%		
Due to ZnO		S	0.11	0.37		S	0.65	2.24		
Due to FeO		S	0.03	0.08		S	0.28	0.82		
Interaction (Z x F)		S	0.05	0.15		S	0.56	1.64		

Table 3: Effect of different doses of Iron oxide and Zinc oxide nano particles on quality of onion.

Levels of ZnO Nano particles	Bulb Yield / plot (kg)				Mean (ZnO) Nano particles	Total Bulb Yield (t/ha)				Mean (ZnO) Nano particles
	Levels of FeO (Nano-particles)					Levels of FeO (Nano particles)				
	F_0-(control)	F_1-(250 ppm)	F_2-(500 ppm)	F_3-(750 ppm)		F_0-(control)	F_1- (250 ppm)	F_2- (500 ppm)	F_3- (750 ppm)	
Z_0 (control)	0.97	0.99	1.42	1.39	1.19	9.71	9.90	14.21	13.95	11.94
Z_1 (250pp)	1.44	1.19	1.40	1.25	1.32	14.43	11.93	13.99	13.58	13.48
Z_2 (500pp)	1.36	1.58	1.16	1.06	1.29	11.64	15.80	12.46	10.57	12.62
Z_3 (750pp)	1.07	1.35	1.56	1.42	1.35	10.72	13.50	15.56	14.21	13.50
Mean (FeO)	1.21	1.28	1.38	1.28		11.62	12.78	14.05	13.08	
		F-test	S. Em. (±)	C.D. at 5%		F-test	S. Em. (±)	C.D. at 5%		
Due to ZnO		S	0.11	0.37		S	0.65	2.24		
Due to FeO		S	0.03	0.08		S	0.28	0.82		
Interaction (Z x F)		S	0.05	0.15		S	0.56	1.64		

References

1. Albrecht MA, Evans CW, Rasto CL. Green chemistry and the health implications of nanoparticles. Green Chem. 2006;8(5):417-32.
2. Aminpoure R, Jafari A. Fundamental of onion seed production. Isfahan Agriculture Ministry; c2004. p. 60.
3. Bagali AN, Patil HB, Guled MB, Patil RV. Effect of scheduling of drip irrigation on growth, yield and water use efficiency of onion (*Allium cepa* L.). Journal of Agricultural Science. 2012;25(1):116-119.
4. Block E. Biological activity of allium compounds: recent results. Acta Hort. 2005;688:41-57.
5. EL-Assi N, ABU-Rayyan A. Yield and quality of onion bulbs as affected by manure applications. Acta Hort.

2007;741:265-271.
6. Griffiths G, Trueman L, Crowther T, Thomas B, Smith B. Onions a global benefit to health. Phytother. Res. 2002;16(7):603-615.
7. Grubben JH, Denton DA. Plant Resources of Tropical Africa. PROTA Foundation, Wageningen; Backhuys, Leiden, CTA, Netherlands; c2004.
8. Hamid Reza Bozorgi. Effects of foliar spraying with marine plant *Ascophyllum nodosum* extract and nano iron chelate fertilizer on fruit yield and several attributes of eggplant (*Solanum melongena* L.). ARPN Journal of Agricultural and Biological Science. 2012;7(5):357-362.
9. Kazemi M. Effect of Foliar Application of Iron and Zinc on Growth and Productivity of Cucumber, Bull. Env. Pharmacol. Life Sci., 2013;2(11):11-14.
10. Kazemi M. Influence of foliar application of Iron, Calcium and Zinc Sulfate on vegetative growth and reproductive characteristics of Strawberry Cv. 'Pajaro' Trakia Journal of Sciences. 2014;12(1):21-26. ISSN 1313-7050.
11. Laware SL, Raskar S. Influence of Zinc Oxide Nanoparticles on Growth, Flowering and Seed Productivity in Onion. Int. J Curr. Microbiol. App. Sci. 2014;3(7):874-881
12. Mallor C, Balcells M, Mallor F, Sales E. Genetic variation for bulb size, soluble solids content and pungency in the Spanish sweet onion variety Fuentes de Ebro. Response to selection for low pungency. Plant Breed. 2011;130:55-59.
13. Martinez MC, Corzo V, Villamiel M. Biological properties of onions and garlic. Trends in Food Science & Technology. 2007;18:609-625.
14. Naderi MR, Abedi A. Application of nanotechnology in agriculture and refinement of environmental pollutants. Journal of Nanotechnology. 2012;11(1):18-26.
15. Prasad TNVKV, Sudhakar P, Sreenivasulu Y, Latha P, Munaswamy V, Reddy KR, *et al*. Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut. J. Plant Nutr. 2012;35(6):905-927.
16. Savithramma N, Ankanna S, Bhumi G. Effect of nanoparticles on seed germination and seedling growth of Boswellia Ovalifoliolata- an Endemic and endangered medicinal tree taxon. Nano vision. 2012;2(1-3):61-68.
17. Sheykhbaglou R, Sedghi M, Tajbakhsh M, Shishevan, Sharifi RS. Effects of Nano-Iron Oxide Particles on Agronomic Traits of Soybean. Not Sci. Biol. 2010;2(2):112-113.
18. Stajner DR, Igic BM, Popovic, Malencic D. Comparative study of antioxidant properties of wild growing and cultivated *Allium* species. Phytotherapy Res. 2008;22(1):113-117.
19. Tabor G, Getahun D, Zelleke A. Influence of storage duration on field sprouting, maturity and yield of some garlic (*Allium sativum* L.) cultivars at Debre Zeit, Ethiopia. J. Hortic. Sci. Biotechnol. 2004;79:871-876.
20. Zhang J, Xu Y, Liu Z. Study of the alleviate of earthworm manure oncontinuous cropping obstacle of cucumber growth in plastic greenhouse. North Hortic. (in Chinese with English abstract). 2010;4:58-60.
21. Jamali D, Neville B. Convergence versus divergence of CSR in developing countries: An embedded multi-layered institutional lens. Journal of Business Ethics. 2011 Sep;102(4):599-621.
22. Revina AA, Oksentyuk EV, Fenin AA. Synthesis and properties of zinc nanoparticles: the role and prospects of radiation chemistry in the development of modern nanotechnology. Protection of Metals. 2007 Nov;43(6):554-9.
23. Zhang X, Shu CW. On positivity-preserving high order discontinuous Galerkin schemes for compressible Euler equations on rectangular meshes. Journal of Computational Physics. 2010 Nov 20;229(23):8918-34.
24. Welch JG. Rumination, particle size and passage from the rumen. Journal of animal science. 1982 Apr 1;54(4):885-94.
25. Cakmak I. Tansley Review No. 111 Possible roles of zinc in protecting plant cells from damage by reactive oxygen species. The New Phytologist. 2000 May;146(2):185-205.
26. Bozorgi HR. Effects of foliar spraying with marine plant Ascophyllum nodosum extract and nano iron chelate fertilizer on fruit yield and several attributes of eggplant (*Solanum melongena* L.). Journal of agricultural and biological science. 2012;7(5):357-62.