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Efficiency of applying Fe and Zn singly or in various combinations as nano and non-nano forms of foliar spray on snap bean (Phaseolus Vulgaris).

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Abstract

16 combinations of 4 Fe and 4 Zn foliar spray solutions of Fe_0, Fe_1, Fe_2 and Fe_3 and similars of Zn_0,Zn_1, Zn_2 and Zn_3 (mgL^{-1}) i.e. 0, 250-nano, 500-nano and 1000-micro (ordinary) FeL^{-1} were sprayed on snap bean (Phaseolus Vulgaris). Sources were $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$. Spraying was done on days 37, 44 , 51 and 58 after seeding. Plants of Zn_0Fe_1 gave the lowest fresh yield of 652 $kgha^{-1}$, while plants of Zn_2Fe_3 gave the highest yield of 1156 $kgha^{-1}$ with an increase of 77.3% over the lowest Applying Zn or Fe singly or various combinations proved of positive effect. A decrease in yields occurred by application of Zn and Fe at the high dose of 1000 mgL^{-1} indicating a retarding effect at such high concentrations.

Keywords: nano fertilizer, snap bean, foliar spray.

Introduction

Application of nano fertilizers is a new way to increase nutrient use efficiency in crop production. Nano particles have extremely small size of few nanometers' diameter which have properties of high specific area and a high surface energy which render them highly efficient as fertilizers ((**Lal, 2008 and Shebl et al., 2019)**.

Zinc (Zn) is an essential micronutrient for plant and iron (Fe) is another important micronutrient ; both are needed for proper healthy plant growth (**Tilman et al., 2002; Mueller et al., 2012**).

Within the framework of sustainable agriculture, applying nano fertilizers is one of the most promising approaches to insure increased crop production. **DeRosa et al. (2010)** considered fertilizer nanotechnology a potential solution for the low efficiency of fertilizer application.

Kalra et al. (2020) stressed the importance of micronutrients to plant and human health. Bioavailability of micronutrients occurs in about fifty percent of the world arable lands **(Marschner 1986**). **Shang et al. (2019)** stated that nano technology can enhance bioavailability of nutrients. In order to ensure agricultural practices which are safe in environment, nanotechnology can render slow or controlled release of fertilizer nutrients. Nanotechnology has gradually moved from the lab-based experimental trials to practical applications.

The current study aims at assessing foliar spray of nano Fe and Zn in comparison with non-nano (micro-) ordinary Fe and Zn on snap bean "Pole Bean" (*Phaseolus Vulgaris*) which one of the most important economic members of the ***Fabaceae*** crops in Egypt.

Materials and methods.

A field was carried out during the winter season of 2017 to assess foliar spray of nano Fe and Zn in comparison with non-nano (micro-) Fe and Zn on snap bean (*Phaseolus Vulgaris*). The experimental design was a randomized complete block factorial. **First Factor** Fe solutions of Fe_0, Fe_1, Fe_2 and Fe_3 of (mgL^{-1}) 0, 250-nano, 500-nano and 1000-micro (ordinary) FeL^{-1} respectively.

Second factor: Zn solutions of Zn_0, Zn_1 , Zn_2 and Zn_3 concentrations exactly as Fe.

Sources were $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$. Spraying was done on 4 occasions: days 37, 44, 51 and 58 after seeding. Treatment combinations are 16 (4 Fe X 4 Zn) in triplicates with 10.5 m^2 plots. Seeds were sown (2 seeds per hill) on the 15th of February 2017 on one side of the ridge in hills 15-cm apart. Bean pods were harvested after 80 days of growth. The soil was a slightly alkaline sandy loam (Table 1)

Table 1. Properties of the 0-30-cm soil of the experimental field

Property	Value	Property	Value
Particle size distribution		Soluble ions ($mmolcL^{-1}$)	
Sand %	77.9	Ca^{2+}	6.6
Silt %	12.0	Mg^{2+}	3.5
Clay %	10.1	Na^{+}	10.8
Texture*	Sandy Loam	K^{+}	0.5
Saturation percent	35	Cl^{-}	10.4
		SO_4^{2-}	5.9
Water holding capacity	25	HCO_3^{-}	4.5
		CO_3^{2-}	0.0
Chemical properties		Available N	9

		,, ,, P	9
		,, ,, K	42
Organic matter (g kg_{-1})	5	,, ,, Fe	9
		,, ,, Zn	5
$CaCO_3$ (g kg^{-1})	51	* According to the International Soil Texture Triangle (Moeys, 2016).	
pH(1:25 w:v soil/ water)	7.5		
EC "paste extract" (dSm^{-1})	2.18	** Extracts are: KCl (for N); DTPA and NH_4HCO_3. (For P, K ,Fe and Zn).	

Results and Discussion

Fresh yield of pods (Table 2)

Treatments receiving no Zn but low nano Fe (Zn_0Fe_1) gave the lowest yield of 652 $kgha^{-1}$, while plants receiving high nano-Zn with high ordinary Fe (Zn_2Fe_3) gave the highest yield of 1156 $kgha^{-1}$ with an increase of 77.3% over the lowest. This shows the importance of applying nano Zn along with iron in enough doses to obtain increased plant growth and yield. **Bastani et al (2018)** found that application of nano-Fe increased tobacco (***Nicotiana tabacum***) growth. **Karimi, et al (2014)** emphasized the need for applying Fe and Zn to plants. **Karimi et al. (2014)** obtained increased yields of mung beans (*Vigna Radiate* L.).) upon applying nano-iron chelate as foliar application.

The main effect of Fe shows lowest given by Fe_0 and highest given by Fe_2 with a pattern of $Fe_2 > Fe_1 \geq Fe_3 \geq Fe_0$ and increases of 19.1, 3.5 and 1.7% given by Fe_2 ,Fe_1 and Fe_3 respectively over Fe_0.

The main effect of Zn fertilization shows lowest given by Zn_0 and highest given by Zn_1 with a pattern of $Zn_1 \geq Zn_3 \geq Zn_2 > Zn_0$; and increases of 19.2, 14.9 and 11.7% given by Zn_1, Zn_3 and Zn_2 respectively over that of Zn_0. A decrease in yields occurred by application of Zn and Fe at the high dose of 1000 mgL^{-1} indicating a retarding effect at such high concentrations.

Bashir et al. (2016) stated that modulating Fe and Zn transport in chloroplast enhances plant growth development and metabolism. **Bastani et al. (2020)** reported positive response upon applying Fe in nano-form to tobacco plants (*Nicotiana tabacum*) .

Table 2. Response of snap bean to Fe and Zn foliar spray: Pods fresh yield ($kgha^{-1}$)

Zn fertilization (Zn)	Fe fertilization (Fe)				Mean
	Fe_0	**Fe_1**	**Fe_2**	**Fe_3**	
Zn_0	998	933	934	841	821
Zn_1	652	1018	1072	863	979
Zn_2	993	802	1094	960	917
Zn_3	978	848	1156	848	943
Mean	863	893	1028	878	
LSD 0.05 Zn: 31 ; Fe: 31 ; ZnFe: ns					

Notes**:** Fe_0, Fe_1, Fe_2 and Fe_3; also, Zn_0, Zn_1, Zn_2 and Zn_3 are solutions of (mgL^{-1}) 0, 250-nano, 500-nano and 1000 normal source respectively. Sprayed on days 37, 44,51and 58 after seeding}

Dry yield of pods (Table 3)

The pattern of response to treatments resembled that concerning pod fresh yield. However plants receiving the high dose of both Zn and Fe (Zn_2Fe_2) gave the lowest yield of 67.9 $kgha^{-1}$ while those receiving Zn_3Fe_2 gave the highest yield of 137.5 $kgha^{-1}$ surpassing the lowest by 102.5%.

The main effect of Fe shows lowest given by Fe_0 and highest given by F_2 with a pattern of $Fe_2 > Fe_1 \geq Fe_3 > Fe_0$ and increases averaging 19.0, 3.4 and 1.7% given by Fe1 , Fe_3 and Fe_2 respectively.

The main effect of Zn fertilization shows lowest given by Zn_0 and highest given by Zn_1 with a pattern of $Zn_1 \geq Zn_3 > Zn_2 > Zn_0$; and increases averaging 19.2, 14.9 and 11.7% given by Zn_3, $Zn_1$and Zn_2 respectively.

Table 3. Response of snap bean to Fe and Zn foliar spray: Pods dry yield ($kgha^{-1}$)

Zn fertilization (Zn)	Fe fertilization (Fe)				Mean
	Fe_0	Fe_1	Fe_2	Fe_3	
Zn_0	107.1	110.1	110.2	99.2	96.9
Zn_1	67.9	120.1	126.5	101.8	115.5
Zn_2	117.2	94.6	128.7	113.3	108.2
Zn_3	115.4	100.1	137.5	100.1	111.3
Mean	101.9	105.4	121.3	103.6	
LSD 0.05 Zn: 4.5 ; Fe: 4.5 ; ZnFe: ns					
See footnotes of Table 2 for treatment designations					

Shaban et al. (2019) noted positive response to nano Zn application to white beans **(***Phaseolus vulgaris*)**.** Therefore a balanced Zn/Fe combination is important for highest growth and productivity of bean pods (**Cakmak, 2008, Moghadam et al. 2012, Bashir et al. 2016 and Rudani and Prajapat 2018)**. **Karimi (2014)** noted increased yields upon applying nano-Fe to mung beans (*Vigna radiata*) . **Maralian (2010)** noted favourable response on growth and yield of wheat upon applying nano Fe and Zn. **Janmohammadi et al. (2016)** reported increased maize yield upon applying nano-nutrients as foliar spray. **Rose et al. (2019)** applied foliar zinc sulfate and zinc nanoparticles in coffee (***Coffea arabica*** L.) and obtained a positive response.

Although Fe is an essential micronutrient, it may be toxic when in excess because it can react with oxygen which catalyzes formation of free radicals to oxidize organic molecules, thus leading to cell death **(Briat et al., 2010)**

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