

Effects of Nano-Iron Oxide Particles on Agronomic Traits of Soybean

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Abstract

This study was performed to determine the effect of nano-iron oxide on soybean yield and quality. Field experiment was designed based on randomized complete block design with three replications. Treatments were five levels of nano-iron oxide (0, 0.25, 0.5, 0.75 and 1 g l⁻¹). Results showed that nano-iron oxide at the concentration of 0.75 g l⁻¹ was increased leaf + pod dry weight and pod dry weight. The highest grain yield was observed with using 0.5 g l⁻¹ nano-iron oxide that showed 48% increase in grain yield in comparison with control. Other measured traits were not affected by the iron nano- particles.

Keywords: nano-iron oxide, soybean, pod dry weight

Introduction

Soybean (*Glycine max* (L) Merr.) belongs to *Fabaceae* family and is an annual crop. Due to having useful compounds such as unsaturated fatty acids, protein, mineral salts and plant secondary metabolites such as isoflavin, soya bean has many important roles in human and animal nutrition. Achieving optimum quantity and increasing quality of soybean seeds depend upon many factors among which, weed control and plant nutrition have critical importance (Sedghi, 2007). Iron is one of the essential elements for plant growth and plays an important role in the photosynthetic reactions. Iron activates several enzymes and contributes in RNA synthesis and improves the performance of photosystems (Malakouti and Tehrani, 2005). Soybean is sensitive to iron deficiency, but different genotypes are various in efficiency of iron consumption. Application of iron in low-iron soils can increase grain yield in soybean (Ghasemi *et al*, 2006). Iron compounds can use as foliar on leaves and as seed coating (Debermann, 2006). Nano-technology can present solution to increasing the value of agricultural products and environmental problems. With using of nano-particles and nano-powders, we can produce controlled or delayed releasing fertilizers. Nano-particles have high reactivity because of more specific surface area, more density of reactive areas, or increased reactivity of these areas on the particle surfaces. These features simplify the absorption of fertilizers and pesticides that produced in nano scale (Anonymous, 2009). There are a few reviews about the effects of nano-particles on plants. Studies showed that the effect of nano-particles on plants can be beneficial (seedling growth and development) or non-beneficial (to prevent root growth) (Zhu *et al*, 2008). This experiment was conducted to investigate the effects

of nano-iron oxide particles on soybean yield and agronomic traits.

Materials and methods

This field experiment was conducted on clay soil in Agricultural Research Station of Urmia University during 2009-2010 growing season to investigate the effects of nano-iron oxide on yield and agronomic traits of soybean (cultivar 'L17'). Urmia is located on the north-west of Iran with 1320 meters altitude, 45°5' longitude, and 37°32' latitude. According to soil analysis performed prior to sowing, the pH of soil was 7.6 and electrical conductivity (EC) of extract was 1.1 ds.m⁻¹ soil texture was clay. The experimental design was randomized complete block design with three replications. Treatments were controlled (without nano-iron oxide application) and 4 levels of nano-iron oxide application including 0.25, 0.5, 0.75 and 1 g l⁻¹. Soybean seeds were inoculated with *Bradyrhizobium japonicum* before planting. Nano-iron oxide were sprayed at three stages including 4 leaves (V4 in Fehr and Caviness (1977) scale), 8 leaves (V8) and grain filling stage (R4). In order to determine the pod weight, at the time of harvest, four plants from each plot were sampled and four pods per plant were selected. After determining fresh weight, pods were placed in the oven with at 48°C for 48 hours and then were weighted with four digits scale. At the end of the growing season and after the browning of pods, plants were harvested from 2 m² considering the border effect. Ten randomly selected plants per plot from harvested samples were used to measure desired characteristics. The statistical procedure was performed by SAS 9.1 computer software and means were compared by Duncan's multiple range test.

Results and discussion

Results showed that the effect of nano-iron oxide on the leaf plus dry pod weight was significant (Tab. 1). At the same time, the effect of nano-iron oxide on dry pod weight during the final stage of growth was significant (Tab. 1). Application of nano-iron oxide at the concentration of 0.75 g l^{-1} caused an increase in dry pod weight and dry weight of leaf plus pod (Tab. 2). Researchers have

Tab. 1. Analysis of variance for traits in soybean

SOV	df	Plant height	Plant diameter	No. of sub-branches	No. of filled pod/plant	Hollow pod number/plant	Total no. of grains per plant	Total grain weight	Shoot weight	Leaf + pod weight	100 grain weight	Pod dry weight	Yield
Replication	2	2.1 ^{ns}	0.012 ^{ns}	0.46 ^{ns}	293.06 ^{ns}	68.6	3283.8 ^{ns}	16.09 ^{ns}	122.7	6.7 ^{ns}	0.61 ^{ns}	0.009	164.559
Treatment	4	46.2 ^{ns}	0.008 ^{ns}	0.26 ^{ns}	570.6 ^{ns}	21.16 ^{ns}	4267.7 ^{ns}	67.5 ^{ns}	19.5 ^{ns}	77.9	0.57 ^{ns}	0.002	411.307
Error	8	38.04	0.005	1.21	840.5	10.26	5733.9	51.9	18.8	19.9	0.64	0.004	57.366
%CV		5.9	2.4	13.02	20.3	21.3	20.5	15.9	17.1	10.8	5.9	5.11	9.54

ns, ** and *, are non-significant, significant at 1% and 5% level, respectively

Tab. 2. Effect of various concentrations of nano-iron oxide on some agronomic traits in soybean

Nano-iron oxide (g lit^{-1})	Pod dry weight (g)	Leaf + pod dry weight (g)	Yield (g m^{-2})
0	0.41 ^b	32.35 ^b	60.94 ^b
0.25	0.42 ^{ab}	42.35 ^{ab}	76.78 ^{ab}
0.5	0.44 ^{ab}	42.45 ^{ab}	90.22 ^a
0.75	0.48 ^a	45.84 ^a	88.33 ^a
1	0.45 ^{ab}	42.32 ^{ab}	80.39 ^{ab}

Means with different letters at each column have statistically different at 5% level

shown that the application of nano-iron oxide significantly affects peanut and causes increasing growth and photosynthesis. Nano-iron oxide compared to other treatments such as organic materials and iron citrate facilitated the photosynthate and iron transferring to the leaves of peanut (Liu *et al.*, 2005). At the same time, the use of nano calcium carbonate compared to humic acid and organic fertilizer, caused more tillering in peanuts, and low concentrations of nano calcium carbonate caused increasing the number of leaf and leaf area, dry weight, soluble sugar and peanut protein (Liu *et al.*, 2005). The use of iron fertilizer increased the mean of total iron concentration and total absorption of iron in soybean, but had no significant effect on copper concentration. Average concentrations of iron and phosphorus on the grain did not affect, but the ratio of phosphorus to iron increased (Ghasemi *et al.*, 2006). Iron at concentration of 2.5 mg kg^{-1} in soil increased dry matter weight of soybean, but higher levels of iron decreased soybean growth (Chakraborty *et al.*, 2002). The use of iron as Fe-EDDHA significantly increased the concentration and total absorption of iron in soybeans (Roomizadeh and Karimian, 1996).

Conclusions

Among the investigated traits, nano-iron oxide had significant effects on the dry pod weight; leaf plus dry pod,

and yield. Application of nano-iron oxide at 0.75 g l^{-1} compare to other treatments had maximum effect on dry pod weight. It seems that the use of iron nano-particles causes increasing in pod and dry leaf weight and finally will increase total yield. Before the recommendation of these materials, additional testing is required and influence of the nano-particles on soybean products must be evaluated.

This research is continuing for determining of the effects of nano-iron oxide on soybean grain quality.

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