Vegetative growth response of sunflower Helianthus annuus L. to foliar treatments with conventional or Nano-magnesium and their combination

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Abstract

This experiment was conducted in the Al-Najaf Al-Ashraf nursery / Al-Hanana neighborhood to study the effect of conventional magnesium and nano-magnesium fertilizer and their interactions in improving yield characteristics of sunflower Helianthus annuus L. The results of the experiment showed a significant improvement in the studied plant growth characteristics including plant height (cm), leaf area (cm2), No. of leaf/plant, shoot fresh and dry weight (g), plant content of total chlorophyll.

Keywords: *Helianthus annuus, sunflower, magnesium, nano-fertilizers, plant health.*

INTRODUCTION

The Compositae is one of the largest plant families, comprising 800 genera and about 20,000 species, most of which are annual or perennial herbaceous plants, and some are shrubs. One of the members of this family is the genus Helianthus, which includes 49 species and 19 subspecies, of which 12 annual species and 37 perennial species spread in different regions of the world (Funk et al., 2005). The sunflower plant, L. Helianth annuus, is an annual plant (Kholghi et al., 2011). The original home of the sunflower plant is mostly North America, specifically southwestern North America (Parmeshwar et al., 2012). The plant was used as food by the American Indians living there, and from there it spread to the rest of the continent by movement. Archaeological evidence revealed that the sunflower was cultivated by the Native Americans in an American city 4000 years ago, and from there it spread to other parts of the world such as Europe and Russia, which are among the main producers of the plant (Madani, 2013). The vegetative parts are used as green fodder, in the manufacture of silage, and the crop remaining is used in livestock feed. The seeds are also used for human food, bird feed, and in the manufacture of vegetable butter, soap, polishing compounds, dyes, paper, plastics, and cosmetics (Tayfour and Rashid, 1990). Magnesium (Mg) is an essential nutrient for many organisms including plant and animal species as well as humans, and in plants, its deficiency may cause a decrease in productivity and quality in agriculture (Hermans et al., 2004). Magnesium is an integral part of chlorophyll, photosynthesis, enzyme activator, nucleic acid builder, and carbohydrate metabolism, and catalyzes the uptake and transport of phosphorus (Nguyen et al., 2016). Magnesium is absorbed by plants in small quantities compared to calcium and potassium, as the concentration of magnesium in plant tissues is about 0.3-0.6% of the dry matter. Magnesium is found in the seeds and leaves more than in the stems and roots, and the plant content depends on the available amount of magnesium in the soil (Al-Naimi, 1990). Magnesium plays a major and direct role in many vital processes in the plant by its participation in the synthesis of a number of plant components or its stimulation of vital functions (Srivastava, 2010). Nanoparticles are defined as groups of atoms ranging in size from 1-100 nanometers, and the physical and chemical properties of nanomaterials can become very different from those of the same material in a larger mass form (Biswas and Dey, 2015). The nanotechnology revolution has radically changed the field of global agriculture and nanomaterials, as nano fertilizers have sparked a comeback to meet the expectations of global demand for food and sustainable agriculture as well. In order to mitigate macro- and micronutrient deficiencies through increased nutrient use efficiency and to overcome the chronic problem of eutrophication, nano-fertilizers can be the best alternative to conventional fertilizers (Shukla et al., 2019).

MATERIALS AND METHODS

Normal magnesium fertilizer was prepared with three levels of 5, 10 and 15 g/L, in addition to a concentration (0) of the control treatment. The required amount of regular magnesium fertilizer was dissolved in distilled water and the volume was completed to one liter to obtain the mentioned concentrations according to the instructions of the producing company. Mg nanoparticles were prepared with three levels of 1, 2 and 3 g/L and a concentration of 0 for the control treatment. The required amount of magnesium nano-fertilizer was dissolved in distilled water and the volume was completed to 1 liter to obtain the required concentrations according to the instructions of the Green Iranian Company (producing nano-fertilizers). Sunflower seeds were sown in pots containing mixed soil at a ratio of 3:1 soil and peat moss, respectively, and the experimental soil properties (physical and chemical) were analyzed (Table1). Each pot was planted with 10 seeds on 28/8/2022 for the autumn season. The pots were watered immediately after planting with water, and watering was repeated according to the plant's need for water. The first fertilization was carried out on 9/26/2022, using different concentrations of nano-magnesium sprayed on the shoots of the plant using a 2-liter hand sprayer at 5:00 pm (to avoid high temperatures during the day and to increase the absorption efficiency) (Al-Hasnawi and Jamal, 2013) . Ordinary magnesium levels were added in the same way as nano magnesium. As well as the overlapping (combination) of enriched nano magnesium and normal magnesium, where nano magnesium was sprayed first, and after half an hour, regular magnesium was sprayed with the same date and the same method. The second spraying treatment was in the same way previously mentioned on 10/16/2022.

Table1: Physical and chemical properties of the experimental soil before planting

Soil properties	Values
(pH) pH(H20)	7.8
C.E.C (Cation Exchange Capacity)	4.30
Total Nitrogen %	17.4
Available P (ppm)	47.55
Exchangeable K (Cmol/kg)	112.67
Exchangeable Na (Cmol/kg)	135.6
Exchangeable Mg (Cmol/kg)	.3217

Exchangeable Ca (Cmol/kg)	219
Extractable Fe (ppm)	12.1
Extractable Mn (ppm)	1.88
Extractable Zn (ppm)	0.23
% Organic matter %	3.3
Bulk density	1.98
Sand %	.1256
Clay %	13.5
Silt %	30.38

Studied Characteristics

At the end of the experiment, data were collected for plant growth characteristics including plant height (cm), leaf area (cm2), No. of leaf/plant, shoot fresh and dry weight (g), plant content of total chlorophyll.

Experiment design and data analysis

The experiment was conducted according to a randomized complete block design (RCBD) that included two factors and their interactions with three replicates for each treatment. Means were compared and significant differences were observed using the randomized least significant difference test (RLSD) at a suitability level of 0.05 (Steel et al., 1997).

RESULTS

Plant height (cm)

The results of the statistical analysis indicated that there was a significant value in plant height in the treatment of regular magnesium spray at concentrations of 15 g.L-1 with an average of 46.85 cm days and 62.91 compared to the control treatment with an average of 38.98 cm. A significance was also found in plant height for plants treated with Nano magnesium at a concentration of 2 and 1 g L-1, with an average of 46.50 cm and 46.40 cm respectively, compared to the control which resulted in 40.18cm. The interaction between the two study factors recorded significantly the highest plant height using 5g.L-1 of conventional magnesium and 2g.L-1 Nano-magnesium averaged 50.60 cm, compared to the control with the highest average recording 23.45 cm (Table2).

Table 2: Effect of fertilization with conventional and/or Nano-magnesium and their interactions on plant height of sunflower plants

Conventional magnesium $g.L^{-1}$	Nano-magnesium $\mathbf{g.L^{-1}}$				**Average**
	0	**1**	**2**	**3**	
0	23.45	46.00	40.80	45.70	38.98
5	42.88	47.70	50.60	46.20	46.84
10	48.00	44.30	47.30	45.10	46.17
15	46.40	47.60	47.30	46.10	46.85
Average	40.18	46.40	46.50	45.77	
LSD (P≤0.05)	Conv. M= 0.50		Nano-M=0.50		Inter.= 0.62

Leaf area (cm2)

The results showed (Table3) that the leaf area of sunflower plants increased significantly in the treatment of spraying with conventional magnesium at a concentration of 10 g. L-1 with an average of 13.23 cm2 compared to control plants with an average of 9.29cm2. In a similar way, the average leaf area also increased in the treatment of Nano-magnesium at 2 g. L-1 with an average of 13.97 cm2 with a significant difference from the control plants with the lowest average of 8.98 cm2. The highest average leaf area was recorded in the interaction of 10 g.L-1 conventional magnesium and 2 g.L-1 of Nano-magnesium with an average of 16.93 cm2, compared to the control with a minimum average of 6.30 cm2 (Table3).

Table 3: Effect of fertilization with conventional and/or Nano-magnesium and their interactions on plant leaf area (cm2) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	6.30	8.61	9.77	12.50	9.29
5	7.43	13.49	13.80	11.62	11.58
10	11.68	11.04	16.63	13.57	13.23
15	10.54	11.55	15.71	11.68	12.37
Average	8.98	11.17	13.97	12.34	
LSD (P≤0.05)	Conv. M= 0.48		Nano-M=0.48		Inter.= 0.60

Number of leaf (leaf.plant-1)

The results of the statistical analysis (Table4) indicated that there was a significant increase in number of leaf/plant in the treatment of conventional magnesium spray at concentration of 10 g.L-1 with an average of 26.25 leaf.plant-1 compared to the control treatment with an average of 19.50 leaf.plant-1. A significance was also found in the number of leaf/plant for plants treated with Nano-magnesium at a concentration of 2g.L-1 with an average of 27.25 leaf.plant-1 compared to the control which resulted in 19.75 leaf.plant-1. The interaction between the two study factors recorded significantly the highest number of leaf/plant at the concentration of 10 g.L-1 of conventional magnesium in combination with 2g. L-1 Nano-magnesium averaged 32 leaf.plant-1, compared to 14 leaf.plant-1 in the control (Table4).

Table 4. Effect of fertilization with conventional and/or Nano-magnesium and their interactions on No. of leaf per plant (leaf.plant-1) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	14.00	21.00	24.00	19.00	19.50
5	20.00	21.00	23.00	21.00	21.25
10	24.00	24.00	32.00	25.00	26.25
15	21.00	23.00	30.00	20.00	23.50
Average	19.75	22.25	27.25	21.25	
LSD (P≤0.05)	Conv. M= 1.27		Nano-M= 1.27		Inter.= 1.57

Shoot FW (g)

The study revealed that there were significant differences in plant fresh weight rates for all concentrations of conventional magnesium under study (Table5). The highest average was recorded in plants treated with a concentration of 10 g. L-1 with an average of 30.21 g compared to the control plants with an average of 21.26 g. The results also recorded significant differences for most of the used concentrations of Nano-magnesium. The highest fresh weight of sunflower plants was recorded in the treatment of 2g.L-1 averaged 30.41 g, while control plants recorded the lowest mean, which was 20.28 g. Also, the binary interaction between the two study factors showed a significant effect in all treatments when compared with the control treatment plants with the lowest average of 15.04 g, while the highest fresh weight of sunflower plants was recorded in the interaction treatment of 10 g.L-1 conventional Magnesium with 2 g.L-1 of Nano-magnesium averages 37.17g (Table5).

Table 5: Effect of fertilization with conventional and/or Nano-magnesium and their interactions on plant shoot fresh weight FW (g) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	15.04	22.35	25.01	22.64	21.26
5	21.50	28.70	29.42	27.07	26.67
10	21.95	30.24	37.17	31.51	30.21
15	22.65	27.11	30.04	29.67	27.36

Average	20.28	27.10	30.41	27.72	
LSD ($P \leq 0.05$)	Conv. M= 0.48		Nano-M= 0.48		Inter.= 0.59

Shoot DW (g)

The results (Table6) indicated that plant shoot DW significantly differed in the treatment of conventional magnesium concentrations. The 10 g.L-1 resulted in the highest average of 3.72g compared to the control treatment with an average of 2.16. A significance was also found in plant height for plants treated with Nano magnesium at a concentration of 2 and 3 g L-1, with an average of 3.73 and 3.71 respectively, compared to the control which resulted in 2.48g. The interaction between the two study factors recorded significantly the highest shoot DW in the interaction of 10g.L-1 of conventional magnesium and 2g.L-1 Nano-magnesium recording 4.78g, compared to the control with the lowest average of 1.20g (Table6).

Table 6: Effect of fertilization with conventional and/or Nano-magnesium and their interactions on plant shoot dry weight DW (g) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	1.20	2.31	2.40	2.75	2.16
5	2.70	3.38	3.77	3.97	3.45
10	2.98	3.02	4.78	4.12	3.72
15	3.05	3.17	3.97	4.00	3.54
Average	2.48	2.97	3.73	3.71	
LSD ($P \leq 0.05$)	Conv. M= 0.24		Nano-M= 0.24		Inter.= 0.29

Plant content of total chlorophyll (mg.100g-1)

In case of plant content of total chlorophyll, the results showed (Table7) that there was a significant increase in all the treatments of conventional magnesium. The concentration of 10 g. L-1 had the highest average of 34.84 mg.100g-1 compared to control plants with an average of 21.91 mg.100g-1. In a similar way, the average of total chlorophyll also increased in the treatment of Nano-magnesium at 2 g. L-1 with an average of 35.42 mg.100g-1 with a significant difference from the control plants with the lowest average of 22.34 mg.100g-1. The plant content of total chlorophyll was at its highest average in the interaction treatment of 10 g.L-1 conventional magnesium and 2 g.L-1 of Nano-magnesium resulting in an average of 42.68 mg.100g-1, compared to the lowest average of 15.42 mg.100g-1 in the control (Table7).

Table 7: Effect of fertilization with conventional and/or Nano-magnesium and their interactions on plant content of total chlorophyll (mg.100g-1) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	15.42	20.17	26.34	25.73	21.91
5	21.53	29.28	36.08	33.55	30.11
10	26.78	34.29	42.68	35.64	34.84
15	25.65	29.52	36.61	36.73	32.12
Average	22.34	28.31	35.42	32.91	
LSD ($P \leq 0.05$)	Conv. M= 0.41		Nano-M= 0.41		Inter.= 0.51

DISCUSSION

The results of the current study showed that there was a clear significant effect when using regular and nano-magnesium and their interactions on all growth characteristics of the sunflower plant under study, which included plant height, average leaf area, number of leaves, fresh and dry weights, and total chlorophyll content in the leaves (Tables 2 to 7).

The significant increase in vegetative growth indicators using magnesium is generally attributed to the role of magnesium in cell functions such as activation of enzymes, photosynthesis and carbohydrate metabolism. Magnesium also helps in accelerating the activity of enzymes and plays an important role in the reactions of energy transfer and carbohydrate metabolism and increases growth, height, size and weight. This is consistent with the results of Ilyas et al. (2014), Ayyub et al. (2012), Kasinath et al. (2015), Janet et al. (2016) and EL Hadidi et al. (2017) who showed a significant increase in the vegetative growth characteristics of plants treated with magnesium in different crops. The current study showed a clear improvement in most of the vegetative traits when using nano-fertilizers, which gave better results than conventional fertilizers. The reason is that traditional fertilizers contain particles with a size exceeding 100 nanometers, which makes them difficult for plants to absorb. This often led to a decrease in plant utilization of fertilizers, i.e. a decrease in the efficiency of using traditional fertilizers such as magnesium. Therefore, increasing the efficiency of fertilizer used by plants can be achieved through nano-fertilizers, which have atom sizes ranging from 1-100 nanometers (Liu and Lal, 2014).

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