Yield characteristics of sunflower Helianthus annuus L. treated with conventional or Nano-magnesium and their combination

Mohammed Sattar Saleh Mahdi
Department of Biology, College of Education, University of Al-Qadisiyah, Iraq, moh.sattar22@gmail.com

Dhafer Abdul-Kazim Jameel
Department of Biology, College of Education, University of Al-Qadisiyah, Iraq, dhafir.altaweel@qu.edu.iq

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 yield characteristics including the number of days required for 50% flowering, disc diameter, number of seeds per disc, fertilization rate, seed weight, and percentage of oil in the seeds.

Keywords: *Helianthus annuus, Sunflower, Magnesium, Nano-fertilizers, Plant oil.*

INTRODUCTION

The sunflower plant (Helianthus annuus L.) belongs to the Compositae family (Asteraceae). The sunflower crop is distinguished by its advanced rank after the peanut, Arachis hypogaea L., and the soybean, L. Glycine max, in terms of oil production. Global production of sunflower seeds from 2004 to 2006 increased from 26 to 31 million metric tons (Ingale and Shrivastava 2011). It is believed that the North American Indians were the first to cultivate the sunflower plant, and then its cultivation spread to the southwest of the American continent, then to Europe through Spain and then Russia (Sedlárová et al., 2013). In Iraq, the sunflower was cultivated in the northern and central regions of Iraq, where this plant was known in the mid-twentieth century on a large scale in Sulaymaniyah Governorate (Abdullah and Al-Mosawi, 2010). Sunflower seeds are an important food source for humans because they are rich in oil that is used for cooking, in addition to the oil containing a high percentage of unsaturated fatty acids and fat-soluble vitamins (Babaei et al., 2012). Nanotechnology has an important role in increasing productivity and improving the quality of food produced by farmers. It is believed that this modern technology will secure the world's growing food needs as well as provide a range of environmental, health, and economic benefits. Nanotechnology has established itself in agricultural science-related industries as a leading problem-solving technology (Mousavi and Razaei, 2011). Nanotechnology can be a tool that assists farmers in facing challenges in managing existing crop technologies by obtaining high yields with less use of industrial chemicals (Prasad et al., 2014). Nanotechnology plays a major role in the agricultural sector, by providing a large number of various nanomaterials, which are used as chemical fertilizers that improve soil properties and increase crop growth, which reflects positively on increasing agricultural land production and crop quality. Nanotechnology has been applied in the manufacture of special types of biologically and environmentally compatible insecticides with the aim of rapid and effective pest management (Saleh, 2015). Aslani et al. (2014) showed that the entry of nanoparticles into a plant cell leads to a change in gene expression that leads to biological pathways that affect plant development and growth. Nanoparticles have unique properties that modify the physicochemical properties of plants and give different effects on plant growth. In general, this depends on the surface composition of the nanoparticles, their shape, chemical composition, size, concentration, and aggregation pattern. The response of plants to nanoparticles varies according to the growth stage and plant type. These fertilizers are environmentally friendly and are among the newly adopted steps toward achieving sustainable agriculture. One of these fertilizers, which has an effective importance for plant growth, is magnesium, which is considered one of the major elements and is absorbed by the plant in an amount similar to phosphorus. Magnesium is important in the formation of the chlorophyll molecule, as it represents the central atom in the chlorophyll molecule and represents the basic element for the production of Adenosine triphosphate (ATP), which is rich in energy to activate the activity of enzymes necessary for some chemical reactions in plant growth. Magnesium also participates in the building of ribosomes, which are the centers for manufacturing proteins in cells. It also contributes to the transfer of sugars from their production sites in the leaf to other parts of the daughters to be used in the construction and energy formation processes. Fertilizing by adding magnesium is necessary when the magnesium in the soil becomes insufficient to meet the plant's need. Therefore, adding magnesium helps to improve growth and increase production (Mikkelsen, 2010).

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 conventional 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, as 10 seeds were planted in each pot 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, conventional 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.

Studied Characteristics

At the end of the experiment, data were collected for growth and yield indicators, which included, number of days required for 50% flowering, disc diameter, number of seeds per disc, fertilization rate, seed weight, and percentage of oil in the seeds.

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

Number of days to flowering 50% (day)

The results of the statistical analysis indicated that there was a significant number of days to flowering in the treatment of conventional magnesium spray at concentrations of 10 g. L-1 and 15 g. L-1 with an average of 62.75 days and 62.91 days, respectively, compared to the control treatment with an average of 76.75 days. A significance was also found in the number of days to flowering for plants treated with Nano-magnesium at a concentration of 2 g L-1, with an average of 61.58 days, compared to the control which resulted in 66.75 days. The interaction between the two study factors recorded significantly the lowest number of flowering days at the concentration of 10 g. L-1 of conventional magnesium and 2 g. L-1 Nano-magnesium averaged 55.66 days, compared to the control with the highest average recording 87.33 days (Table1).

Table 1. Effect of fertilization with conventional and/or Nano-magnesium and their interactions on No. of days to flowering of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	87.33	74.33	72.33	73.00	76.75
5	73.66	69.33	60.66	62.66	66.58
10	71.33	64.66	55.66	59.33	62.75
15	70.33	65.33	57.66	58.33	62.91
Average	75.66	68.41	61.58	63.33	
LSD (P≤0.05)	Conv. M= 0.053		Nano-M=0.053		Inter.= 0.66

Disc diameter (cm)

The results showed (Table 2) that the disk diameter 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 12.27 cm compared to control plants with an average of 7.22 cm. In a similar way, the average disc diameter also increased in the treatment of Nano-magnesium at 2 g. L-1 with an average of 12.30 cm with a significant difference from the control plants with the lowest average of 7.30 cm. The highest average disc diameter was recorded in the interaction of 10g.L-1 conventional magnesium with 2 g.L-1 of Nano-magnesium with an average of 15.40 cm, compared to the control with a minimum average of 4.05 cm.

Table 2. Effect of fertilization with conventional and/or nano magnesium and their interactions on disc diameter (cm) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	4.05	7.03	9.22	8.60	7.22
5	6.17	8.25	11.50	10.02	8.98
10	9.23	11.76	15.40	12.72	12.27
15	9.78	10.14	13.08	11.15	11.03
Average	7.30	9.29	12.30	10.62	
LSD (P≤0.05)	Conv. M= 0.41		Nano-M=0.41		Inter.= 0.50

Number of seeds (seed.disc-1)

The results of the statistical analysis indicated that there was a significant increase in number of seeds/disc in the treatment of conventional magnesium spray at concentrations of 10 g. L-1 with an average of 555.25 seed.disc-1 and 62.91, compared to the control treatment with an average of 409.00 seed.disc-1. A significance was also found in the number of seeds/disc for plants treated with Nano-magnesium at a concentration of 2 g L-1 with an average of 560.00 seed.disc-1 compared to the control which resulted in 410.25 seed.disc-1. The interaction between the two study factors recorded significantly the highest number of seeds/disc at the concentration of 10 and 15 g.L-1 of conventional magnesium in combination with 2 g. L-1 Nano-magnesium averaged 619.00 seed.disc-1 and 612.00 seed.disc-1 respectively, compared to 254.00 seed.disc-1 in the control (Table3).

Table 3. Effect of fertilization with conventional and/or Nano-magnesium and their interactions on No. of seeds per disc of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	254.00	387.00	500.00	495.00	409.00
5	412.00	457.00	509.00	498.00	469.00
10	507.00	524.00	619.00	571.00	555.25
15	468.00	502.00	612.00	562.33	536.08
Average	410.25	467.50	560.00	531.58	
LSD (P≤0.05)	Conv. M= 22		Nano-M=22		Inter.= 27

Fertilization rate (%)

The results of (Table 4) indicated that the fertility rate increased in all concentrations of sunflower plants treated with conventional magnesium, especially at a concentration of 10 g.L-1 with an average of 88.49% compared to the control treatment with an average of 73.62%. The fertilization rate of the sunflower plant increased significantly in the treatment of nano-magnesium at a concentration of 2 g.L-1 with an average of 89.85%, compared to 74.96% in the control treatment. The results recorded the highest significant fertility rate in the interaction of 10 g.L-1 conventional Magnesium with 2g.L-1 of Nano-magnesium with an average of 93.07%, compared to the control plants with the lowest average of 53.15%.

Table 4. Effect of fertilization with conventional and/or Nano-magnesium and their interactions on fertilization rate (%) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	53.15	77.48	83.79	80.09	73.62
5	81.41	85.22	91.15	87.57	86.33
10	83.06	87.56	93.07	90.27	88.49
15	82.23	85.37	91.39	89.41	87.10
Average	74.96	83.90	89.85	86.83	
LSD (P≤0.05)	Conv. M= 0.39		Nano-M=0.39		Inter.= 0.49

Seed weight (g)

Both conventional and nano-magnesium fertilization (Table 5) affected the seed weight of all treatments. A significant increase was observed in the seed weight of the sunflower plant, with the highest average being 0.16 g using 10 g.L-1 of conventional magnesium compared to an average of 0.11 gm in the control-treated plants. Nanomagnesium also affected and recorded the highest average seed weight of 0.16 g when it was used at a concentration of 2 g. L-1, with a significant difference from the control treatment plants that recorded 0.12 g. The effect of the interaction between the two study factors was significant for all the concentrations, as the highest seed weight was recorded at the concentration of 10 g.L-1 of conventional Magnesium interacted with 2g.L-1 of nano-magnesium with an average of 0.18 g compared to the control plants with the lowest average of 0.08 g.

Table 5. Effect of fertilization with conventional and/or Nano-magnesium and their interactions on seed weight (g) of sunflower plants

Conventional magnesium g.L^{-1}	Nano-magnesium **g.L^{-1}**				**Average**
	0	**1**	**2**	**3**	
0	0.08	0.11	0.14	0.12	0.11

5	0.12	0.14	0.15	0.14	0.13
10	0.15	0.16	0.18	0.17	0.16
15	0.14	0.15	0.17	0.16	0.15
Average	0.12	0.14	0.16	0.14	
LSD (P≤0.05)	Conv. M= 0.2		Nano-M=0.2		Inter.= 0.3

Seed Oil Percentage (%)

Similar to the previous results, a significant effect of spraying with conventional and nano magnesium was found on the percentage of oil in sunflower seeds (Table 6). As for conventional magnesium, the highest average percentage of oil was recorded in the treated plants with a concentration of 10 g. L-1 with an average of 29.40% compared to the control plants which resulted in 24.20%. It was also observed that all concentrations of nano-magnesium treatment were significant in increasing the seed content of oil, as the highest average was 30.22% at a concentration of 2 g. L-1 while it was 25.89% in the control treatment. The results also indicated a significant interaction treatment, which recorded the highest percentage of oil at a concentration of 10 g. L-1 of conventional magnesium and 2 g.L-1 of nan-magnesium averaged 33.68%, compared to the control plants, which amounted to 18.53%.

Table 6. Effect of fertilization with conventional and/or Nano-magnesium and their interactions on sunflower seed content of oil (%)

Conventional magnesium $g.L^{-1}$	Nano-magnesium $\mathbf{g.L^{-1}}$				**Average**
	0	**1**	**2**	**3**	
0	18.53	27.87	25.64	24.77	24.20
5	27.41	28.97	32.48	27.07	28.98
10	29.69	25.11	33.68	29.13	29.40
15	27.95	24.39	29.10	30.78	28.05
Average	25.89	26.58	30.22	27.93	
LSD (P≤0.05)	Conv. M= 0.35		Nano-M=0.35		Inter.= 0.44

DISCUSSION

The results of the current study showed that there was a clear significant effect on yield characteristics (number of days flowering 50%, disc diameter, number of disc seeds, fertilization percentage, seed weight, oil percentage) when using each of normal magnesium and nano magnesium and their mixture (Tables 1 to 6). Magnesium is involved in many basic plant physiological processes and performs critical functions in photosynthesis and photoprotection, the breakdown of carbohydrates within plants besides being responsible for the synthesis of chlorophyll (Trankner et al., 2018). Magnesium activates certain enzymes including glutathione synthase, Ribulose 1,5-Bisphosphate (Rubisco) Carboxylase/ Oxygenase, phosphoenolpyruvate carboxylase (PEPcase), RNA polymerase, protein kinases, phosphatase and ATPases, which are essential enzymes for photosynthetic activity, as they directly affect plant growth and development (Rodrigues et al., 2021). Salcido-MartíNez et al. (2020) demonstrated that the use of Nano-magnesium had a significant and positive effect on the physiological and chemical characteristics of green pea yield. It led to a high increase in the photosynthetic pigments and biomass, as well as an increase in the enzyme activity of the Nitrate Reductase. According to the aforementioned results, the importance of using nanomaterials or Nano-fertilizers in the field of agriculture and improving plant traits is evident. This is consistent with many recent studies regarding the use of nanotechnology and Nano-fertilizers in improving many plant traits, including yield quantity, the amount of chlorophyll, flowering, the length of plant shoot and root part, the percentage of oils, and the number of seeds (Fatemi et al., 2021).

Reference

Abdullah, S. and Al-Mosawi , K. (2010) . Fungi associated with seeds of sunflower (Helianthus annuus L.) cultivars grown in Iraq . Phytopathologia , 57: 11–20 .

Al-Hasnawi, Arshad Naji and Jamal Ahmad Abbas (2013). Effect of Cytokinin (Benzyl Adenine) and Magnesium Chelate on Growth and Flowering of Chrysanthemum hortorum Hort.. Jordan Journal of Agricultural Sciences. 9 (2): 225-238.

Aslani, F.; Bagheri, S.; Julkapli, N.M.; Juraimi, A.; Farahnaz Sadat Hashemi, F.S. and Baghdadi, A. (2014). Effects of engineered nanomaterials on plants growth: An Overview. The Scientific World Journal, 2014: 1-28.

Babaei, M.; Ardakani, M.; Rejali, F.; Rad, A.; Golzardi, F.and Mafakheri ,S.(2012). Response of agronomical traits of sunflower (Helianthus annuus L.) to coinoculation with glomus intraradices and pseudomonas fluorescens under different phosphorus levels. Ann. of Bio. Res.,3 (8): 4195-4199.

Fatemi, A., Moaveni, P., Daneshian, J., Mozaffari, H., & Ghaffari, M. (2021). Effect of Foliar Application of Magnesium Nanoparticles on Morphophysiologic Characteristics of Sunflower Cultivars under Drought Stress. Journal of Crops Improvement, 23(3), 321-333.

Ingale,S.and Shrivastava , S. (2011). Chemical studies of new varieties of sunflower (Helianthus annuus) LSF-11 and LSF-8 seeds. Agric. Biol. J. N. Am., 2(8): 1171-1181.

Mikkelsen, R. (2010). Soil and fertilizer magnesium. Better crops, 94(2), 26-28.

Mousavi, S.; Rezaei, M.(2011). Nanotechnology in agriculture and food production. J. Appl. Environ. Biol. Sci., 1(10):414-419.

Prasad , R., V. Kumar and K. Prasad . (2014) . Nanotechnology in sustainable agriculture: Present cancers and future aspects. African Journal Biotechnology. 13(6):705-713

Rodrigues, V. A., Crusciol, C. A. C., Bossolani, J. W., Moretti, L. G., Portugal, J. R., Mundt, T. T., Lollato, R. P. (2021). Magnesium foliar supplementation increases grain yield of soybean and maize by improving photosynthetic carbon metabolism and antioxidant metabolism. Plants, 10(4), 797 .

Salcido-MartíNez, A., Sanchez, E., Licon-Trillo, L. P., Perez-Alvarez, S., Palacio-MáRquez, A., Amaya-Olivas, N. I., & Preciado-Rangel, P. (2020). Impact of the foliar application of magnesium nanofertilizer on physiological and biochemical parameters and yield in green beans. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 48(4), 2167.

Saleh, Mahmoud Mohamed Salim (2015). Nanotechnology and a New Scientific Era - King Fahd National Library, King Abdulaziz City for Science and Technology - Riyadh. Kingdom of Saudi Arabia.

Sedlarova, M., Trojanova, Z. and Lebeda, A. (2013). Distribution and harmfulness of (Plasmopara halstedii) on sunflower in the Czech republic, 49 (1).

Tränkner, M., Tavakol, E., & Jákli, B. (2018). Functioning of potassium and magnesium in photosynthesis, photosynthate translocation and photoprotection. Physiologia plantarum, 163(3), 414-431.

Vrbničanin,S.; Božić , D.; Malidža , G.; Dušanić ,N.; Pavlović , D.and Barac , M. (2008). Tolerance of sunflower (Helianthus annuus L.) Toimazethap . Helia, 31(48): 85-94.