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Impact of Different Crystal Sizes of Nano-Iron Oxide as Fertilizer on Wheat Plants Photosynthetic Pigments Content

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Abstract

This study was carried out to investigate the impact of Fe_2O_3 NPs synthesized from mentha, onion and moringa plant extract at the concentrations of 20,40 and 60 and 80 ppm on wheat plant as fertilizer. Plant pigments chlorophyll a, b carotenoids as well as total pigments contents were investigated. Also, total phenolic components contents in wheat shoots were determined. The results showed that the foliar application of iron oxide nanoparticles at low concentrations (20,40 and 60 ppm) induced an increment in photosynthetic pigments and total phenolic compounds contents. beyond these concentrations an inhibitory effect was shown at 80 ppm concentration. Different sizes of nanoparticles showed different impacts on the studied criteria, small particle size induced more enhancement in plant pigments and phenols contents while larger sizes showed less impact.

Keywords

Green synthesizes, Fe nanoparticles, Chlorophyll, Phenol contents, Particle size, Plant extract.

Introduction

Nanotechnology in the field of agriculture focuses currently on target farming that includes the utilize of nanoparticles with unique properties to boost crop and livestock productivity **[1 and 2]**. The unique properties of NPs include very large specific surface area, high surface energy, and quantum confinement **[3]**.

The applications of nanoparticles in agriculture also include fertilizers to increase plant growth and yield, sensors for monitoring soil quality and pesticides for pest and disease management. The traditional fertilizers are vital for plant growth and development, most of the applied fertilizers remain unavailable to plants due to several factors such as leaching and degradation by hydrolysis, insolubility and decomposition, in addition, application of conventional fertilizers at a high rate and for a long period within agriculture field have caused major environmental issues around the world. Green synthesis of NPs from its corresponding metal ions is environmentally friendly, free from chemical contamination, less expensive and safe for biological application **[4]**. Recently, Iron nanoparticles have gained great research attention in environmental applications because it offers high surface reactivity due to high the surface area **[5]**. Research on the use of iron oxide nano particles (Fe_2O_3 NPs) as a fertilizer still lags.

Wheat (*Triticum aestivum* L) is the foremost extensively grown cereal crop in the world, covering about 237 million hectares every year, accounting for a add up to of 420 million tonnes **[6]**, and for at least one-fifth of man's calorie intake **[7]**. Wheat grain is basically processed into flour (whole grain or refined) for the production of a large variety of bakery products, pastries and confectionary. Wheat is additionally utilized in the distillery (including biofuel), brewery and starch industries. Therefore, we investigated the effects of Fe_2O_3 NPs on the growth and Fe efficiency of wheat plants under to evaluate their use as a new Fe-fertilizer

Materials and Methods

Wheat plant seeds (*Triticum aestivum* cultivar Gemmeiza 11) were obtained from Field Crop Research Institute, Agricultural Research Center (ARC) Ministry of Agriculture, Giza, Egypt.

Iron oxide nanoparticles (Fe_2O_3 NPs) were provided and characterized by Plant Lab of Biology Department faculty of Education Ain-Shams university which

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synthesized using plant extracts of mentha, onion and moringa. The shape and grain size of the prepared NPs were determined as following:

1- Fe_2O_3mentha has uniform, high dispersed spherical nanoparticles with average diameter 39 nm.
2- Fe_2O_3 moringa and Fe2O3onion exhibited irregular hexagonal morphology with average diameters 57 and 72 nm, respectively.

The experiment was conducted in a greenhouse at the Faculty of Education, Ain Shams University. Homogenous seeds of wheat plants (Gemmeiza 11) were surface sterilized by 1% sodium hypochlorite solution for five minutes and then washed thoroughly with distilled water. Wheat seeds (ten seeds) were sown in pots (25 cm in diameter and 25 cm in depth) during 1 st December 2018 containing 2.5 kg of homogenous lomy clay soil. Pots were divided into four groups each group consists of 10 pot as following: 1. Group served as control (untreated with Fe_2O_3 NPs).2- Group sprayed with Fe_2O_3 NPs synthesized using mentha plant extract. 3- Group sprayed with Fe_2O_3 NPs synthesized using onion plant extract. 4- Group sprayed with Fe_2O_3 NPs synthesized using moringa plant extract. each group was divided into four subgroups and treated with different concentrations (20,40,60 and 80 ppm) of iron oxide nanoparticles. After 20 days from planting all treatments were applied as foliar spray. Once a week and repeated for three weeks. Plants from five pots were collected after two months from planting (pre-flowering stage) to study different parameters, other five pots were left giving yield to study yield characters.

Determination of photosynthetic pigments content

The methods used for chlorophylls quantitative determination were described by **Vernon and Seely [8]**. Fresh leaves were weighted and homogenized in 85% aqueous acetone for 5 minutes. Centrifugation was done then the supernatant was made up to known volume using 85% acetone. The optical density of pure 85% aqueous acetone was recorded at three wave lengths 470, 649 and 665 nm using spectrophotometer and used as blank. The chlorophyll a, b contents and total chlorophyll in pigment extract solution were calculated using the following equations: mg chlorophyll a/g tissue =11.63 (λ 665) - 2.39 (λ649) mg chlorophyll b/g tissue = 20.11(λ649) – 5.18 (λ665) For carotenoids, the concentration was carried according to **Lichtenthaler [9]** equation: mg carotenoid/ g tissue = (1000* λ 470) – (1.82 Chl a)- (85.02 Chl b)/ 198).

Total phenol content

The method used for phenolic compound extraction was that of **Daniel and George [10]** and recommended by **A.O.A.C [11]**. Extraction A known weight of fresh samples was taken and extracted with 80 % cold methanol (v/v) for three times at 90ºC. After filtration, the filtrate was made up to a known volume with cold methanol. A known volume of the extract (0.5 ml) was added to 0.5ml Folin-Cicalteu reagent and shaked well. The mixture was let to stand for 3 minutes. One ml of saturated sodium carbonate solution (25 g Na_2CO_3 were dissolved in 1000 ml distilled water at 70-80ºC and then cooled down and filtered) was added to the mixture and shaked well. The mixture was let to stand for 60 min. The optical density was measured at 725 nm using spectrophotometer. The total phenolic compounds quantity was expressed as µg/g dry weight.

Result

Photosynthetic pigments content:

Wheat plants groups showed different pigments contents in response to iron NPs treatments. These changes were illustrated in Fig. (1, A, B, C and D). The results showed significant increment in chl a, b, carotenoids and total pigments contents in plants treated with low concentrations (20, 40 and 60 ppm) iron oxide NPs, 40 ppm showed the greatest values followed by 20 and 60 ppm compared with untreated plants. On the other hand, a reduction was recorded in plants received 80 ppm concentration treatment in the same content.
It is worthy motioning that, iron oxide nanoparticles synthesized using mentha plant extract induced the greatest enhancement comparing with nanoparticles synthesized using onion and moringa extracts.

Total phenol

Wheat plant treated with iron oxide NPs in 20, 40 and 60 ppm showed significant increment in total phenolic compounds contents. Treatment with 80 ppm concentration induced significant decrease in total phenol content compared with untreated wheat plants as shown in Fig. (2). The greatest values were recorded for plants received 40 ppm mentha, onion and moringa synthesized Fe_2O_3 NPs (8.94, 6.55 and 4.79 mg/g) respectively.

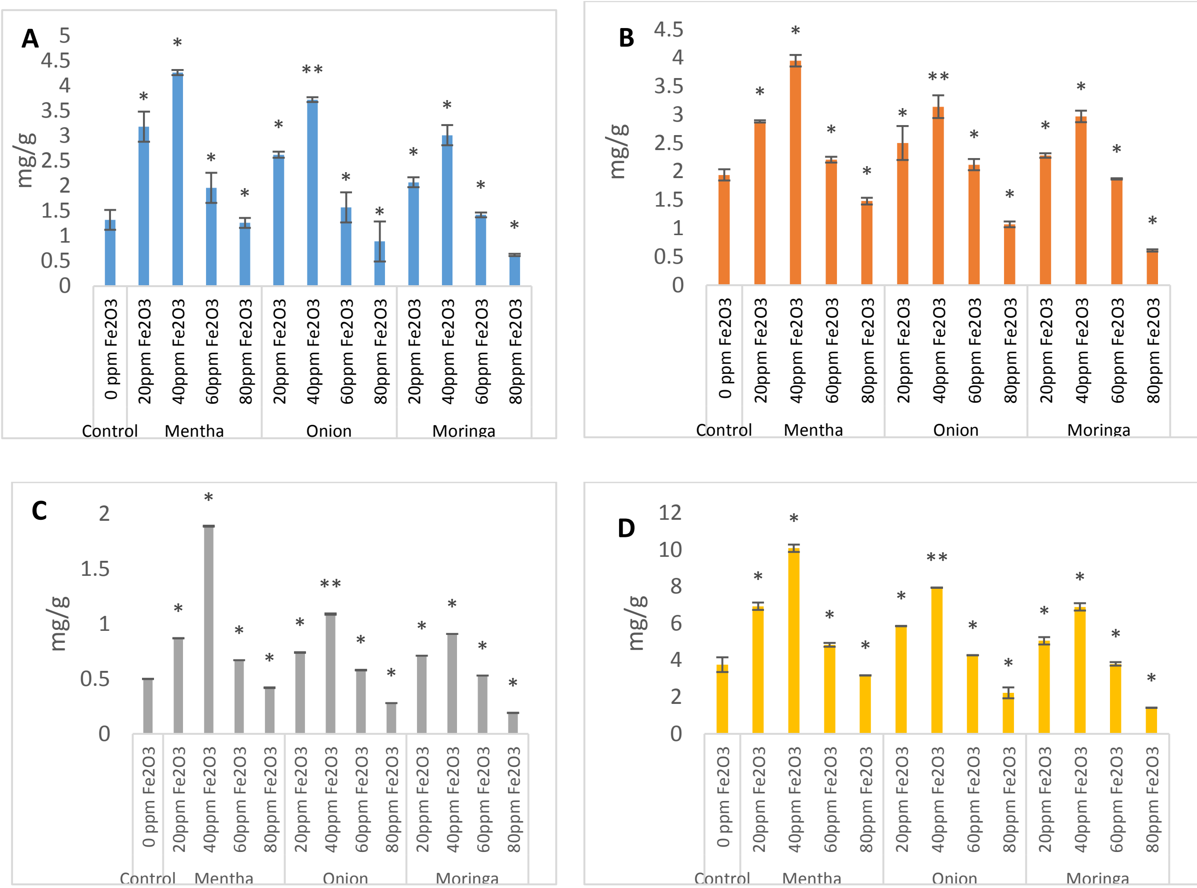

Fig. (1): The effect of foliar application of different concentrations of iron oxide nano particles synthesized using mentha, onion and moringa plant extract on photosynthetic pigments contents of wheat plants. **A:** Chl a, **B:** Chl b, **C:** Carotenoids and **D:** Total pigments. ** The mean difference is high significant at the 0.05 level. * The mean difference is significant at the 0.05 level. ^{ns} The mean difference is non-significant at the 0.05 level.

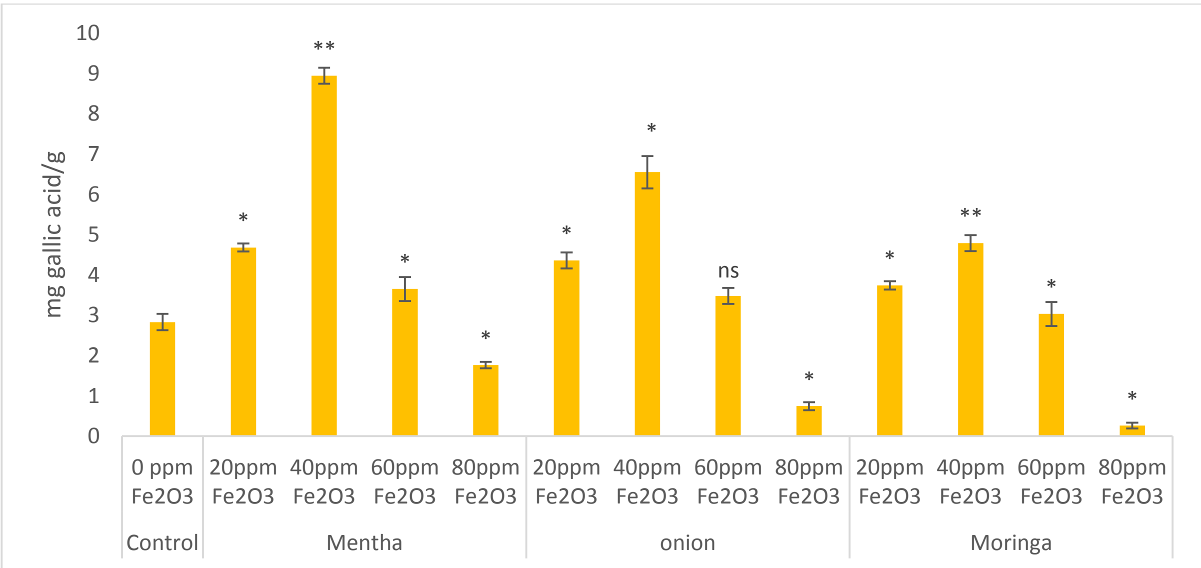

Fig (2): The effect of foliar application of different concentrations of iron oxide nano particles synthesized using mentha, onion and moringa plant extract on total phenols of wheat plants. ** The mean difference is high significant at the 0.05 level. * The mean difference is significant at the 0.05 level. ^{ns} The mean difference is non-significant at the 0.05 level.

Discussion

Pigments contents

Iron application increased chlorophyll a, b and total contents as compared with the control and higher rates were more effective. In line with our results, **Liu et al. [12]** reported that nano-Fe_2O_3 application increased chlorophyll content of peanut. That was perhaps due to the association of Fe with chlorophyll formation **Mazaherinia et al. [13]**. Several researchers confirmed that the Fe in normal forms or in nanoforms had improved leaf photosynthetic pigments and photosynthesis parameters **[14 and 15]**. This could be attributed to interference of Fe in structural and catalytic component of proteins and enzymes for normal development of pigment biosynthesis and activation of photosynthesis **[16]**. According to **Govorov and Carmeli [17]**, metal nanoparticles can induce the efficiency of chemical energy production in photosynthetic systems. However, higher content of photosynthetic pigments, i.e., chlorophyll a, chlorophyll b, and carotenoids, would increase the rate of photosynthesis, due to which there was more production of photosynthesis process, which in turn increased the weight and growth of plant as it was observed in our study.

Phenol content

Our result was agreed with **Abdel Wahab et al. [18]** results assumed that total phenolic compounds increased in red radish plants treated with iron oxide nanoparticles. Phenolic compounds have antibiotic, anti-nutritional properties and high antioxidant activity, which enable them to defend plants. It is now understood that a low concentration of Fe_2O_3 NPs has a significant impact on the production of high total phenolics to defend the wheat plant from any further damage. Apart from Fe_2O_3 NPs, the study carried out by **Ghorbanpour and Hadian [19]** proved that the optimum use of multi-walled carbon nanotubes nanoparticles (MWCNTs NPs) has a positive effect on the biosynthesis of phenolics in callus culture of *Satureja khuzestanica* due to the activation of specific key enzymes.

Conclusion

In conclusion, green synthesis of Fe_2O_3 nanoparticles by mentha, onion and moringa leaves extract is inexpensive and ecofriendly. The biosynthesized Fe_2O_3 NPs has a noticeable effect on wheat plant as increased pigment contents and stimulated the activity of phenolic contents at low concentrations (20,40 and 60ppm), on the other hand, the high concentration 80ppm caused an inhibitor effect. Small particles size synthesized by mentha extract was more effective than larger one (synthesized by onion and moringa plant extracts).

Conflicts of interest

The authors report no declaration of interest.

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تأثير الاحجام المختلفة من جزيئات أكسيد الحديد النانوية كمخصبات علي محتوي نبات القمح من الاصباغ النباتية

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المستخلص العربي

تم اختبار تأثير تركيزات مختلفة (20، 40، 60، 80 جزئ في المليون) من جزيئات أكسيد الحديد النانوية ذات الاشكال و الاحجام المتباينة و المخلقة باستخدام مستخلصات نباتية مختلفة (النعناع ، البصل ، المورينجا) علي نبات القمح كمخصبات و ذلك عن طريق رشها علي الأوراق، اظهرت جزيئات أكسيد الحديد النانوية ذات الشكل الدائري و الحجم الصغير و التي تم تخليقها باستخدام مستخلص النعناع اكثر كفاءة في استحثاث النبات لإنتاج الاصباغ النباتية المختلفة (كلوروفيل ا، ب، كاروتينات و المحتوي الكلي للأصباغ) كذلك زيادة قدرة النبات علي انتاج المواد الفينولية . كذلك اتضح من النتائج ان تطبيق التركيزات الأقل (20 ، 40، 60 جزئ في المليون)من جزيئات أكسيد الحديد النانوية علي النباتات تعتبر منشطة للنمو علي العكس من التركيز (80 جزئ في المليون) الأعلى و التي أظهرت تأثير سام علي النباتات.