Response of Swiss chard cultivars (Beta vulgaris L.) to chelated Iron, nano Iron and Glomus mosseae

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Abstract

In order to investigate the effect of chelated Iron, nano Iron and Glomus mosseae on three cultivars of Swiss Chard (Beta vulgaris L.), a factorial experiment with two factors and three replications was conducted in the Directorate of Diyala agriculture, Baqubah nursery, Iraq during the season 2019-2020. The results showed that a superiority of the cultivar B. vulgaris 2 in a mean of the total yield (2715.2 g) followed by B. vulgaris 1 (2154.4 g) as compared with local cultivar B. vulgaris 3 (1902.5 g), also B. vulgaris 2 was better than B. vulgaris 1 in increase of leaf area (first harvest, 384.7 cm) and (final harvest, 772.0 cm), whereas B. vulgaris 1 caused a significant increase in total chlorophyll 0.448 mg/g and carotene 9.7 μg / 100g compared to B. vulgaris 1. Chelated Iron, nano Iron and G. mosseae recorded highest significant in the mean of the total yield (1975.7 g), leaf area (final harvest,706.1 cm), total chlorophyll (0.457 mg / g ) and carotene (9.9 μg / 100g ) as compared with control.

Keywords: Swiss chard, chelated Iron, nano Iron and Glomus mosseae.

1. Introduction

Chard or Swiss chard (Beta vulgaris spp. cicla L) is a green leafy biennial vegetable obtainable throughout the year, its belong to the Chenopodiaceae family and could be harvested during a long time period due to its planting in spring and summer of each year [1,2]. Stalks and leaves of chard contain flavonoids such as glycosides derived from apigenin, querce tin and kaempferol, minerals viz. iron, iron, calcium, potassium, magnesium, manganese and phosphorus, also phenolic acids such as p-coumaric, caffeic and syringic besides a high concentration of vitamins A, B, and C [3,4]. Diverse studies were conducted to know the impact of nanoparticles on the plant growth, as an example of this, Iron plays a vital role in the photosynthetic reactions and is considered as one of the fundamental elements for plant growth [5]. Iron deficiency result in destruction of chloroplast structure, thus loss of chlorophyll [6]. Iron increases the biomass accumulation through contributes in RNA synthesis and activating several enzymes, thus improves the performance of the photosystems [7,8]. Application of Iron compounds in plants is being by a coating of the seed and spraying of the leaves [9]. Ferrous ions are more absorbent by the plant as ferrous ion Fe2+ or ferric ion Fe3+ due to their higher solubility [10]. The micronutrients in their chelated form possess higher efficiency than conventional compounds [6,11]. The arbuscular mycorrhizal fungi (AM) are forming a symbiotic and mutual relationship with plants, where the plant takes nutrients, whereas AM fungi take carbon through a spread of fungal hyphae in the soil and mycorrhizal vesicles work as connection points between the hyphae and the plants [12]. AM fungi plays a positive role for plants through their hyphae that have ability to uptake P and transfer it to the plants [13, 14]. AM fungi lead to increase in photosynthetic rate and water use efficiency besides nutrient uptake [15]. Also, it is useful through an increase in disease resistance and drought tolerance [16]. Glomus spp. is the largest genus of arbuscular mycorrhizal (AM) fungi, which form symbiotic relationships with plant roots [17]. The objective of the present trial was to assess the effect of Glomus mosseae, chelated Iron and nano Iron on three cultivars of Swiss Chard.

2. Materials and methods

A field experiment was carried out in the Directorate of Diyala agriculture, Baqubah nursery, Iraq during the season 2019-2020. The seeds of two foreign cultivars of Swiss chard beside local cultivar were sown in plates contain pitmoss on 3/10/2019 then it was transferred to the field on 27/10/2019, the first cultivar's leaves and blades were red (fig 1), whereas the second cultivar's leaves were green with yellow blades (fig 2). Field land was prepared through plowing, disking and ridging, then the soil samples were taken that represent the plowing depth (0 - 0.15 m) in order to record the soil properties, as set out in (Table 1). Superphosphate fertilizers were added at a rate of 100 kg P2O5.ha-1 during tillage and before planting for all treatments equally. Nitrogen fertilizers in the form of urea fertilizer were applied in four times, the first when planting, the second, third and fourth after 65.90 and 135 days, respectively at a rate of 40 kg N.ha-1. The field was divided into ridge spaced 50 cm apart, space between plants 30 cm, each replicate contain 5 plants. Treatments were arranged in a factorial
experiment has two factors at which each treatment was replicated three times, the first factor included three cultivars of Swiss Chard, the second factor included adding of *Glomus mosseae*, chelated Iron and nano Iron with interaction among them. *Glomus mosseae* as commercial formulation was obtained from a ministry of science and technology and added to each seedling at rate 10 g by drill the soil near the plant at 27/10/2019. Chelated Iron and nano Iron were sprayed on the plants with concentrated 50 ppm and at a rate 3 cm³ to each plant after each harvest at rate twelve times starting from the first harvest on 11/12/2019 to final harvest on 27/4/2020. The following measurements were recorded such as total yield, leaf area, total chlorophyll and carotene, the data were analyzed by Analysis of Variance (ANOVA) [18].

![Figure 1. The first cultivar of Swiss chard with red color.](image)

![Figure 2. The second cultivar of Swiss chard with green color.](image)
3. Results

3.1. Total yield

The results in Table (2) showed significant differences among treatments represented by superiority of *B. vulgaris* 2 in a mean of the total yield of Swiss chard (2715.2 g) followed by *B. vulgaris* 1 (2154.4 g), which were significantly exceeded the local cultivar *B. vulgaris* 3 (402.5 g), whereas chelated Iron & nano Iron & *G. mosseae* recorded high significant value in mean of the total yield (1975.7 g) on all other treatments, followed by chelated Iron & nano Iron (1863.7 g), nano Iron (1797.2 g), chelated Iron & *G. mosseae* (1758.6 g) and chelated Iron (1697.3 g) compared to control (1330.2 g). The interaction between Swiss chard cultivars and other treatments showed that *B. vulgaris* 2 with chelated Iron & nano Iron & *G. mosseae* gave highest value in the total yield of Swiss chard (3100.9 g), while *B. vulgaris* 3 with control recorded lowest value in the total yield of Swiss chard (325.6 g).

| Table 2. Effect of *G. mosseae*, chelated Iron and nano Iron on total yield of Swiss chard cultivars (g/plant). |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| B                                           | A                                           |
| B. vulgaris 1 (red color)                    | B. vulgaris 2 (green color)                  | B. vulgaris 3 (local)                         |
| Mean                                         | Mean                                         |
| Control                                      | 1798.7                                      | 1866.3                                      | 325.6                                      | 1330.2                                      |
| Chelated Iron                                | 2150.7                                      | 2553.9                                      | 387.3                                      | 1697.3                                      |
| Nano Iron                                    | 2298.2                                      | 2660.2                                      | 403.3                                      | 1787.2                                      |
| *G. mosseae*                                 | 2159.1                                      | 3022.5                                      | 409.6                                      | 1863.7                                      |
| Chelated Iron & Nano Iron                    | 2206.7                                      | 2696.2                                      | 415.0                                      | 1772.6                                      |
| Chelated Iron & *G. mosseae*                 | 2140.8                                      | 3026.9                                      | 452.3                                      | 1873.4                                      |
| Nano Iron & *G. mosseae*                     | 2091.4                                      | 2794.8                                      | 389.6                                      | 1758.6                                      |
| Mean                                         | 2154.4                                      | 2715.2                                      | 402.5                                      | 1975.7                                      |
| CD 0.05                                      | A= 15.1                                     | B= 24.7                                     | A x B= 42.8                                 |

3.2. Leaf area

As shown in Table (3), *B. vulgaris* 2 was superior and achieved the highest mean of leaf area (first harvest, 384.7 cm) with significant differences from *B. vulgaris* 1 (336.7 cm). Nano Iron & *G. mosseae* gave the highest mean of leaf area (425.2 cm) with significant differences from other treatments followed by chelated Iron & nano Iron & *G. mosseae* (405.3 cm). Chelated Iron & *G. mosseae* (379.1 cm), nano Iron (356.9 cm), *G. mosseae* (352.7 cm) and chelated Iron (336.5 cm) as compared with control (313.4 cm), the interaction between Swiss chard cultivars and other treatments showed that *B. vulgaris* 2 with nano Iron & *G. mosseae* gave highest value in the leaf area of Swiss chard (446.3 cm), while *B. vulgaris* 1 with chelated Iron & Nano Iron recorded lowest value in the leaf area of Swiss chard (282.5 cm).
Table 3. Effect of *G. mosseae*, chelated Iron and nano Iron on leaf area (first harvest) of Swiss chard cultivars (cm).

|               | B. vulgaris 1 (red color) | B. vulgaris 2 (green color) | Mean  |
|---------------|---------------------------|-----------------------------|-------|
| Control       | 292.4                     | 334.5                       | 313.4 |
| Chelated Iron | 287.3                     | 385.7                       | 365.5 |
| Nano Iron     | 327.9                     | 386.0                       | 356.9 |
| G. mosseae    | 328.4                     | 377.0                       | 352.7 |
| Chelated Iron & Nano Iron | 282.5           | 350.3                       | 316.4 |
| Chelated Iron & *G. mosseae* | 367.7       | 390.6                       | 379.1 |
| Nano Iron & *G. mosseae*  | 404.2                     | 446.3                       | 425.2 |
| Chelated Iron & Nano Iron & *G. mosseae* | 403.4    | 407.3                       | 405.3 |
| Mean          | 336.7                     | 384.7                       |       |

CD 0.05: A = 8.4, B = 16.9, A x B = 23.9

Data in Table (4) showed that *B. vulgaris* 2 recorded a significant increase in mean of leaf area (final harvest, 772.0 cm) compared to *B. vulgaris* 1 (476.8 cm), chelated Iron & nano Iron & *G. mosseae* was superior and achieved the highest mean of leaf area (706.1 cm) followed by nano Iron & *G. mosseae* (660.5 cm), chelated Iron & *G. mosseae* (648.3 cm), *G. mosseae* (636.6 cm), nano Iron (617.7 cm), chelated Iron (604.7 cm) and chelated Iron & nano Iron (595.2 cm) compared to control (526.2 cm), the interaction between Swiss chard cultivars and other treatments showed that *B. vulgaris* 2 with chelated Iron & nano Iron & *G. mosseae* gave highest value in the leaf area of Swiss chard (900.3 cm), whereas *B. vulgaris* 1 with control recorded lowest value in the leaf area of Swiss chard (393.9 cm).

Table 4. Effect of *G. mosseae*, chelated Iron and nano Iron on leaf area (final harvest) of Swiss chard cultivars (cm).

|               | B. vulgaris 1 (red color) | B. vulgaris 2 (green color) | Mean  |
|---------------|---------------------------|-----------------------------|-------|
| Control       | 393.9                     | 658.4                       | 526.2 |
| Chelated Iron | 423.3                     | 786.2                       | 604.7 |
| Nano Iron     | 453.5                     | 781.9                       | 617.7 |
| *G. mosseae*  | 487.8                     | 785.5                       | 636.6 |
| Chelated Iron & Nano Iron | 493.5           | 696.8                       | 595.2 |
| Chelated Iron & *G. mosseae* | 503.3       | 793.3                       | 648.3 |
| Nano Iron & *G. mosseae*  | 547.4                     | 773.6                       | 660.5 |
| Chelated Iron & Nano Iron & *G. mosseae* | 511.9    | 900.3                       | 706.1 |
| Mean          | 476.8                     | 772.0                       |       |

CD 0.05: A = 11.8, B = 23.6, A x B = 33.4

3.3. Total chlorophyll

Analysis of variance (Table 5) showed that *B. vulgaris* 1 led to a significant increase in mean of total chlorophyll (0.448 mg/g) compared to *B. vulgaris* 2 (0.341 mg/g), also total chlorophyll was significantly increased by chelated Iron & nano Iron & *G. mosseae* (0.457 mg / g ) followed by chelated Iron & *G. mosseae* (0.418 mg / g ),chelated Iron (0.417 mg / g ), nano Iron & *G. mosseae* (0.413 mg / g ), nano Iron (0.404 mg / g ), chelated Iron & nano Iron (0.384 mg / g ) and *G. mosseae* (0.378 mg / g ) compared to control (0.284 mg / g ), the interaction between Swiss chard cultivars and other treatments showed that *B. vulgaris* 1 with chelated Iron & nano Iron & *G. mosseae* recorded the highest value in the total chlorophyll of Swiss chard (0.528 mg / g ), while *B. vulgaris* 2 with control gave lowest value in the total chlorophyll of Swiss chard (0.270 mg / g ).

Table 5. Effect of *G. mosseae*, chelated Iron and nano Iron on total chlorophyll of Swiss chard cultivars (mg / g of sample).

|               | B. vulgaris 1 (red color) | B. vulgaris 2 (green color) | Mean  |
|---------------|---------------------------|-----------------------------|-------|
| Control       | 0.297                     | 0.270                       | 0.284 |
| Chelated Iron | 0.457                     | 0.377                       | 0.417 |
| Nano Iron     | 0.471                     | 0.336                       | 0.404 |
| *G. mosseae*  | 0.407                     | 0.350                       | 0.378 |
Chelated Iron & Nano Iron 0.454 0.314 0.384
Chelated Iron & G. mosseae 0.489 0.347 0.418
Nano Iron & G. mosseae 0.480 0.345 0.413
Chelated Iron & Nano Iron & G. mosseae 0.528 0.385 0.457
Mean 0.448 0.341
CD 0.05 A= 0.013 , B= 0.025 , A x B= 0.035

3.4. Carotene
Data in Table (6) indicate that B. vulgaris 1 gave a significant increase in the mean of carotene (9.7 μg / 100g ) compared to B. vulgaris 2 (7.4 μg / 100g ), chelated Iron & nano Iron & G. mosseae was superior and achieved the highest mean of carotene (9.9 μg / 100g ) followed by chelated Iron & nano Iron (9.4 μg / 100g ), nano Iron & G. mosseae (9.3 μg / 100g ), nano Iron (8.9 μg / 100g ), chelated Iron & G. mosseae (8.8 μg / 100g ), chelated Iron (8.4 μg / 100g ) and G. mosseae (7.8 μg / 100g ) compared to control (5.8 μg / 100g ), the interaction between Swiss chard cultivars and other treatments showed that the content of carotene in leaves , positively responded to the addition of chelated Iron & nano Iron in the cultivar B. vulgaris 1, where gave highest value in the carotene (10.9 μg / 100g) as compared with control in the cultivar B. vulgaris 2, which recorded lowest value (5.4 μg / 100g).

Table 6. Effect of G. mosseae, chelated Iron and nano Iron on the carotene of Swiss chard cultivars (μg / 100g of sample).

| B          | A. vulgaris 1 (red color) | B. vulgaris 2 (green color) | Mean |
|------------|--------------------------|-----------------------------|------|
| Control    | 6.2                      | 5.4                         | 5.8  |
| Chelated Iron | 10.2                  | 6.5                         | 8.4  |
| Nano Iron  | 10.4                     | 7.4                         | 8.9  |
| G. mosseae | 9.2                      | 6.4                         | 7.8  |
| Chelated Iron & Nano Iron | 10.9             | 8.0                         | 9.4  |
| Chelated Iron & G. mosseae | 9.6               | 8.0                         | 8.8  |
| Nano Iron & G. mosseae | 10.6                | 8.1                         | 9.3  |
| Chelated Iron & Nano Iron & G. mosseae | 10.5          | 9.4                         | 9.9  |
| Mean       | 9.7                      | 7.4                         |      |
| CD 0.05    |                          |                            |      |

Discussion
The results of study reference that the addition of chelated Iron, nano Iron and G. mosseae alone or combination were significant in improvement all the measured traits in Swiss chard cultivars, the significant increase in growth parameters of Swiss chard plants is harmony with the results obtained by [10] reported that applying of 4 kg nano iron chelated kg / hectare on spinach (Virofly cultivar) led to produce 7.3 tons/ ha, which was 76% better as compared with control. Foliar application of chelated iron led to improve fruit quality, vegetative and reproductive growth of cucumber plants [19]. Nano fertilizer possesses a positive impact on spinach wet weight by increasing crop growth rate, leaf area and leaf numbers [20]. The application of Fe was showing considerable positive effects on growth measurements of soybean and cumin [21]. Addition of nano iron result in improving the quality and yield of tomato [22]. Application of Glomus mosseae can enhance the growth of plants of Mammillaria laui and Chamaecereus sylvestrii, through increasing of vegetative part [23]. [24] reported that Senna spectabilis plants that inoculated with mycorrhiza fungi led to a significant increase in root and shoot biomass of as compared with control plants. The growth increment in the shoot and root biomass for wheat cultivars was observed on the 89th after inoculation with Glomus microcarpum, which can be an effective biofertilizer for better yield in the future [25]. Infested green gram plants by Arbuscular mycorrhizal fungi (AMF) such as Glomus sp and Gigaspora sp showed significantly higher fresh weight and dry weight and enhanced the contents of chlorophyll a, b and total chlorophyll content, also the net photosynthesis by increasing total chlorophyll and carotenoid contents [26].

Conclusion
The foliar application of chelated Iron and nano Iron with the addition of Glomus mosseae in the soil were generally effective for all Swiss chard cultivars through activating the vegetative growth with an increase of total yield, leaf area, total chlorophyll and carotene. The foliar spraying with chelated Iron and nano Iron at 50 ppm being the most effective, however further investigations are required to elucidate the possible role of chelated Iron and nano Iron on plant growth regulating activity.
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