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# Response of iron and zinc fortification on growth, yield and quality of spinach

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**Abstract**
A field experiment entitled "Studies on effect of fortification of soil by iron and zinc on nutritional quality of spinach" was conducted during *Rabi* season 2017-18 with the collaboration of experimental farm, Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The experiment was laid out in Randomized Block Design with three replications and eight. The results clearly indicated that various growth and yield parameters like plant height (26.03 cm), number of leaves (13.93 no. of leaves plant$^{-1}$), fresh leaf yield (232.90 q ha$^{-1}$) and dry matter yield (32.74 q ha$^{-1}$) was increased due to fortification of graded levels of iron and zinc with the RDF. The highest protein content (3.78 g 100 g$^{-1}$) and vitamin C (41.73 mg 100 g$^{-1}$) was recorded by fortification of $FeSO_4$ and $ZnSO_4$ along with RDF.

**Keywords:** Iron, zinc, fortification, growth, yield, quality and spinach

## 1. Introduction
Indian spinach (*Spinacia oleracea* L.) is one of the major leafy vegetable grown and consumed in India. In India spinach commonly known as *palak* and it is popular due to its high nutritive value belongs to genus *Spinacia*, species *S. oleracea* and family *Amaranthaceae* with Chromosome number 2n=18 (Purohit, 1968) [10]. It is a commonly grown leafy vegetable throughout the tropical and subtropical regions (Veeraragavathatham, 1998) [13].
The popular palak growing States are Uttar Pradesh, West Bengal, Punjab, Haryana, Delhi, Madhya Pradesh, Gujarat and Maharashtra. However, *palak* is not very popular in South India. It is rich and cheap source of vitamin 'A' (5862 iµ) as compared to carrot. It contains high quality of ascorbic acid (70 mg) and iron (16.2 mg) per 100 g. It is good source of folacian. The major carotenoid is lutein (1303 µg) and β- carotene (1095 µg) per 100 g edible portion. Vitamin 'C' and folate is present in *palak* is destroyed by even simple processing such as cutting and washing.
Considering the need, it is important to manage the nutrients particularly iron and zinc micronutrients for increase the growth, yield and quality of spinach under the low availability of micronutrients (Fe and Zn below critical limit). Hence, the present investigation was carried out to see the "studies on effect of fortification of soil by iron and zinc on nutritional quality of spinach".

## 2. Material and methods
### 2.1 Experimental Details
The field experiment was carried out using spinach crop (Var. Pusa All green) in *Rabi* season during years 2017-18 at Research Farm of Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. After completion of preparatory tillage operations, the experiment was laid out in Randomized Block Design comprising eight (8) treatments replicated three (3) times. Recommended dose of fertilizer was applied to the crop which was 80:40:40 kg N, $P_2O_5$ and $K_2O$ ha$^{-1}$. Composition of micronutrient 20 kg $FeSO_4$ ha$^{-1}$, 30 kg $FeSO_4$, 20 kg $ZnSO_4$ ha$^{-1}$ and 30 kg $ZnSO_4$.

### 2.2 Details of experiment

| | | | |
|---|---|---|---|
| 1. | Plot size | : | 1.5 x 1.2 m$^2$ |
| 2. | Crop Spacing | : | 15 x 10 cm |
| 3. | Method of sowing | : | Line sowing |
| 4. | Date of sowing | : | 22nd December, 2017 |
| 5. | Date of harvesting | : | 4th February, 2018 |
| 6. | Design | : | RBD |

### 2.3 Conduct of experiment
The land of the experimental site was prepared by one ploughing and two harrowing and layout was done. The sowing was carried out on 22nd December 2017 at 15 x 10 cm spacing. Calculated amount of fertilizers were applied at the time of sowing. Fertilizers were applied as per the treatment, through Urea, Diammonium phosphate, Muriate of potash, ferrous sulphate and zinc sulphate prior to sowing of spinach. All fertilizers were applied at the time of sowing below the seed except nitrogen. Nitrogen was applied in two equal splits in the form of urea. As a basal dose half of the total nitrogen was applied at the time of sowing and half remained at 21 DAS. One weeding was carried out during the crop growth period of spinach. The crop was harvested at maturity on 4th February 2018 and plot wise fresh leaf yield and dry matter yield recorded.

### 2.4 Observations recorded
#### 2.4.1 Growth parameter
##### 2.4.1.1 Plant height (cm)
Plant height from base of plant to the tip of the longest leaf was measured from five tagged plants per replication per treatment at 45 days after and their mean was worked out.

##### 2.4.1.2 Number of leaves per plant
Number of leaves per plant was at 45 days after sowing from five plants per replication per treatment and their mean was worked out.

#### 2.4.2 Fresh leaf yield and dry matter yield
The fresh leaf yields were recorded by taking fresh weight. The total yields were computed by adding the weights recorded at cutting and were expressed as q $ha^{-1}$ and on drying of fresh leaf matter dry matter yield was recorded.

#### 2.4.3 Quality parameters
##### 2.4.3.1 Protein content
The nitrogen content from the grain samples was estimated by Micro-kjeldhal's method (A.O.A.C., 1975) and N content was multiplied by 6.25 to get percent crude protein.

##### 2.4.3.2 Vitamin - C (mg $100g^{-1}$)
One gram of sample was blended with 3 per cent Meta phosphoric acid and then made up to 100 ml and filtered. From the filtrate, 10 ml sample was pipetted into conical flask and titrated with the standard dye to a pink end point (Ranganna, 1986) [11].

## 3. Results and Discussion
### 3.1 Growth parameters
#### 3.1.1 Plant height
The data on plant height of spinach at harvest stage as influenced by fortification of soil by iron and zinc were presented in Table 1.
Plant height showed significant differences due to the effect of iron and zinc fortification of soil at harvest stage. The data presented in Table 1 revealed that, the plant height at harvest stage was varied from 16.26 cm to 26.03 cm with an average of 21.84 cm. The plant height was significantly higher in treatment $T_8$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$) which was followed by treatment $T_7$ (RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$), $T_4$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$) and $T_6$ (RDF + 30 kg $ZnSO_4$ $ha^{-1}$). However, minimum plant height was noticed in treatment $T_1$ i.e. absolute control after the harvest of crop. The treatment $T_8$, $T_7$, $T_4$ and $T_6$ were at par with each other and they were significantly superior over rest of the treatments. The highest plant height may be due to the positive effects of potassium and micronutrients on vegetative growth and accumulation of metabolic materials. Similar results have been reported by Malla *et al.* (2007) [9], Kumar *et al.* (2014) [8] and Kaur *et al.* (2015) [7].

#### 3.1.2 Number of leaves
The data on number of leaves of spinach at harvest stage as influenced by fortification of soil by iron and zinc were presented in Table 1.
Number of leaves showed a significant difference due to the effect of fortification of soil by iron and zinc at harvest stage. The data presented in Table 1 revealed that, the number of leaves at harvest stage was varied from 6.93 to 13.93 with an average of 10.95. The number of leaves was significantly higher in treatment $T_8$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$) which was followed by treatment $T_7$ (RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$), $T_4$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$) and $T_6$ (RDF + 30 kg $ZnSO_4$ $ha^{-1}$). However, minimum number of leaves was noticed in treatment $T_1$ i.e. absolute control after the harvest of crop. The treatment $T_8$, $T_7$, $T_4$ and $T_6$ were at par with each other and they were significantly superior over rest of the treatments. The highest number of leaves may be due to the positive effects of RDF and micronutrients on vegetative growth and accumulation of metabolic materials. Similar results have been reported by Malla *et al.* (2007) [9], Kumar *et al.* (2014) [8] and Kaur *et al.* (2015) [7].

### 3.2 Yield parameter
#### 3.2.1 Fresh leaf yield
Perusal of data presented in Table. 2 indicates that the fresh yield of spinach. Yield showed a significant difference due to the effect of fortification of soil by iron and zinc at harvest stage. The fresh leaf yield of spinach was varied from 159.70 q $ha^{-1}$ to 232.9 q $ha^{-1}$ with an average of 197.33 q $ha^{-1}$. The yield was significantly higher in treatment $T_8$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$) which was followed by treatment $T_7$ (RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$), $T_4$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$) and $T_6$ (RDF + 30 kg $ZnSO_4$ $ha^{-1}$). However, minimum fresh leaf yield was noticed in treatment $T_1$ i.e. absolute control after the harvest of crop. The treatment $T_8$, $T_7$, $T_4$ and $T_6$ were at par with each other and they were significantly superior over rest of the treatments. This may be due fact that RDF and micronutrient are reported to enhance the absorption of native as well as added major nutrient such as N and P which might have been attributed to improvement in yield. Similar findings were also observed by Malla *et al.* (2007) [9], Balpande *et al.* (2016) [2], Hussain *et al.* (2011) [6], Thesiya *et al.* (2013) [12] and Buriro *et al.* (2015) [3].

#### 3.2.2 Dry matter yield
The dry matter yield of spinach was calculated and tabulated in Table 2. Dry matter yield showed a significant difference due to the effect of fortification of soil by iron and zinc at harvest stage. The dry matter yield of spinach was varied from 18.51 q $ha^{-1}$ to 32.74 q $ha^{-1}$ with an average of 26.16 q $ha^{-1}$. The dry matter was significantly higher in treatment $T_8$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$) which was followed by treatment $T_7$ (RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$), $T_4$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$) and $T_6$ (RDF + 30 kg $ZnSO_4$ $ha^{-1}$). However, minimum dry matter yield was noticed in treatment $T_1$ i.e. absolute control after the harvest of crop. The treatment $T_8$, $T_7$, $T_4$ and $T_6$ were at par with each

other and they were significantly superior over rest of the treatments. This may be due fact that RDF and micronutrient are reported to enhance the absorption of native as well as added major nutrient such as N and P which might have been attributed to improvement in yield. Similar findings were also observed by Malla *et al.* (2007) [9], Balpande *et al.* (2016) [2], Hussain *et al.* (2011) [6], Thesiya *et al.* (2013) [12] and Buriro *et al.* (2015) [3].

### 3.3 Quality parameters
### 3.3.1 Protein content
The data on protein content of spinach is influenced by fortification of soil by iron and zinc was presented in Table 3.
Protein content showed a significant difference due to the effect of fortification of soil by iron and zinc at harvest stage. The data presented in Table. 3 revealed that, the protein content of spinach was varied from 2.81 g $100g^{-1}$ to 3.78 g $100g^{-1}$ with an average of 3.44 g $100g^{-1}$. The protein content was significantly higher in treatment $T_8$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$) which was followed by treatment $T_7$ (RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$), $T_4$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$) and $T_6$ (RDF + 30 kg $ZnSO_4$ $ha^{-1}$). However, minimum protein content was noticed in treatment $T_1$ i.e. absolute control after the harvest of crop. The treatment $T_8$, $T_7$, $T_6$ and $T_4$ were at par with each other and they were significantly superior over rest of the treatments. RDF supply with micronutrient is commonly associated with improved protein content, N fixation and water use efficiency. At the higher concentrations, all the micronutrients significantly increase the protein content similar results were also reported by Chavan *et al.* (2012) [4] and Habbasha *et al.* (2014) [5].

### 3.3.2 Vitamin C content
The data on Vitamin C content of spinach is influenced by fortification of soil by iron and zinc were presented in Table 3.
Vitamin C content showed a significant difference due to the effect of fortification of soil by iron and zinc at harvest stage. The data presented in Table 3 revealed that, the Vitamin C content of spinach was varied from 31.05 mg per 100g to 41.73 mg $100g^{-1}$ with an average of 36.26 mg $100g^{-1}$. The vitamin C content was significantly higher in treatment $T_8$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$) which was followed by treatment $T_7$ (RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$), $T_4$ (RDF + 30 kg $FeSO_4$ $ha^{-1}$) and $T_6$ (RDF + 30 kg $ZnSO_4$ $ha^{-1}$). However, minimum vitamin C was noticed in treatment $T_1$ i.e. absolute control after the harvest of crop. The treatment $T_8$, $T_7$, $T_6$ and $T_4$ were at par with each other and they were significantly superior over rest of the treatments. Levels of Fe and Zn showed a positive relation with vitamin C content. With N nutrition with micronutrients, ascorbic acid content was increased. It may be due to the fact that ascorbic acid is a monosaccharide derivative. The plants possess necessary enzymes for conversion of glucose to ascorbic acid. Increase in N dose might have been resulted in increased production of carbohydrates (monosaccharides) which might be converted into ascorbic acid.

**Table 1:** Effect of iron and zinc fortification on plant height and number of leaves of spinach

| T. No. | Treatment | Plant height (cm) | No. of leaves $plant^{-1}$ |
|---|---|---|---|
| $T_1$ | Absolute control | 16.26 | 6.93 |
| $T_2$ | RDF (80:40:40 N, $P_2O_5$ and $K_2O$ kg $ha^{-1}$) | 18.86 | 8.16 |
| $T_3$ | RDF + 20 kg $FeSO_4$ $ha^{-1}$ | 21.55 | 10.96 |
| $T_4$ | RDF + 30 kg $FeSO_4$ $ha^{-1}$ | 24.06 | 12.86 |
| $T_5$ | RDF + 20 kg $ZnSO_4$ $ha^{-1}$ | 19.87 | 9.26 |
| $T_6$ | RDF + 30 kg $ZnSO_4$ $ha^{-1}$ | 22.72 | 12.33 |
| $T_7$ | RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$ | 25.34 | 13.13 |
| $T_8$ | RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$ | 26.03 | 13.93 |
| | Grand mean | 21.84 | 10.95 |
| | SEm (±) | 1.15 | 0.56 |
| | CD at 5% | 3.47 | 1.69 |

**Table 2:** Effect of iron and zinc fortification on fresh leaf yield and dry matter yield of spinach

| T. No. | Treatment | Fresh leaf Yield (q $ha^{-1}$) | Dry matter yield (q $ha^{-1}$) |
|---|---|---|---|
| $T_1$ | Absolute control | 159.70 | 18.51 |
| $T_2$ | RDF (80:40:40 N, $P_2O_5$ and $K_2O$ kg $ha^{-1}$) | 163.40 | 19.64 |
| $T_3$ | RDF + 20 kg $FeSO_4$ $ha^{-1}$ | 203.30 | 26.59 |
| $T_4$ | RDF + 30 kg $FeSO_4$ $ha^{-1}$ | 216.70 | 29.94 |
| $T_5$ | RDF + 20 kg $ZnSO_4$ $ha^{-1}$ | 170.10 | 21.77 |
| $T_6$ | RDF + 30 kg $ZnSO_4$ $ha^{-1}$ | 210.20 | 29.00 |
| $T_7$ | RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$ | 222.33 | 31.11 |
| $T_8$ | RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$ | 232.90 | 32.74 |
| | Grand mean | 197.33 | 26.16 |
| | SEm (±) | 7.88 | 1.35 |
| | CD at 5% | 23.80 | 4.09 |

**Table 3:** Effect of iron and zinc fortification on protein and vitamin C content of spinach.

| T. No. | Treatment | Protein (g $100g^{-1}$) | Vitamin C (mg $100g^{-1}$) |
|---|---|---|---|
| $T_1$ | Absolute control | 2.81 | 31.05 |
| $T_2$ | RDF (80:40:40 N, $P_2O_5$ and $K_2O$ kg $ha^{-1}$) | 3.19 | 33.89 |
| $T_3$ | RDF + 20 kg $FeSO_4$ $ha^{-1}$ | 3.32 | 34.18 |
| $T_4$ | RDF + 30 kg $FeSO_4$ $ha^{-1}$ | 3.59 | 37.67 |
| $T_5$ | RDF + 20 kg $ZnSO_4$ $ha^{-1}$ | 3.40 | 34.71 |

| | | | |
|---|---|---|---|
| $T_6$ | RDF + 30 kg $ZnSO_4$ $ha^{-1}$ | 3.66 | 37.81 |
| $T_7$ | RDF + 20 kg $FeSO_4$ $ha^{-1}$ + 20 kg $ZnSO_4$ $ha^{-1}$ | 3.74 | 39.07 |
| $T_8$ | RDF + 30 kg $FeSO_4$ $ha^{-1}$ + 30 kg $ZnSO_4$ $ha^{-1}$ | 3.78 | 41.73 |
| | Grand mean | 3.44 | 36.26 |
| | SEm (±) | 0.06 | 1.38 |
| | CD at 5% | 0.21 | 4.17 |

## 4. Conclusion
The present study revealed that plant height, number of leaves, fresh leaves yield and dry matter yield of spinach were favorably affected by soil application micronutrients. Soil application of Fe and Zn was found best suitable for increasing the spinach yield and maximum protein and vitamin C content. It was concluded that that micronutrient had positive effect on yield and quality of spinach.

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