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*Original article*

# Effect of different moisture regimes and iron sulfate on the growth and content of some elements in wheat (*Triticum aestivum* L.), cv. Roshan

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## Introduction

Many arid and semi-arid agricultural areas are facing with shortages of water and nutrients, especially micronutrients. Drought stress is one of the most important environmental stresses that seriously damage the growth and development of crops, limits the production and productivity of plants more than any other environmental factor. The use of micronutrients can partially alleviate the negative effects of this environmental stress on the growth and production of crops. Iron micronutrient plays an essential role in some biological and physiological processes such as respiration, photosynthesis and chlorophyll biosynthesis and is also effective in diastases as well as in chlorophyll production. According to the above, the main purpose of this experiment was to investigate the growth response of Roshan cultivar to applying iron sulfate fertilizer in different moisture conditions and to investigate changes in the content of some plant elements under these conditions.

## Materials and methods

In order to evaluate the growth and uptake of iron and other nutrients by wheat, cv. Roshan, a two-factor factorial experiment was conducted in 2012 in the Research Greenhouse of the Faculty of Agriculture, University of Birjand. The first factor was consisted of four different levels of ferrous sulfate (0, 50, 100 and 150 $mg.kg^{-1}$ soil) and the second factor included two soil moisture treatments including 50 and 100% soil field capacity. After preparing the pots and applying experimental treatments, the seeds were planted and after emergence, the plant density was set to 10 plants in the pot. Moisture levels were applied from the beginning of experiments and watering the pots was done daily based on the weight of the pots and taking into account 20% drainage of soil moisture (in each irrigation treatment). Sampling was done after 8 weeks (early stem elongation stage) and at this time some morphological traits (number of leaves, leaf area, number of tillers and plant height) and the SPAD index and relative water content of leaves were measured. The iron, potassium, nitrogen and protein contents of the plants were also determined for each pot separately. Analysis of variance was performed using SAS software and mean comparison was performed using FLSD test at a significant level of 5%.

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## Results and discussion

As soil moisture decreased from 100 to 50% of field capacity, plant height (5.8%), number of stems (37%), number of leaves (22%), stem diameter (15.8%), leaf area (33%), relative leaf water content (16.8%) and SPAD index (5.45%) decreased. The results also showed that in the control treatment (without iron fertilizer), the highest amount of SPAD index (38.8) was obtained, which with an increase of ferrus sulfate to 150 $mg.kg^{-1}$ of soil, it decreased by 5.8%. Also, with the increase in soil water content to 100% of field capacity, the percentage of protein, nitrogen and potassium of wheat plants decreased by 9.2, 17.18 and 23.7%, respectively, compared to 50% of field capacity. The iron content of leaf in 100% of the field capacity was equal to 142.7 $mg.kg^{-1}$ dry matter, which decreased by 27% by reducing the soil water content to 50% of the field capacity. Increasing the iron fertilizer from zero to 50, 100 and 150 $mg.kg^{-1}$ soil caused the leaf nitrogen percentage to increase by 5, 9.5 and 7.2%, respectively. Leaf iron content in these levels of iron fertilizer was 35.8, 97.8 and 57.8% higher than the non-use of iron sulfate, respectively. Finally, biomass production was reduced by 31% compared to 100% of field capacity and finally water use efficiency was not affected by any of the experimental treatments. Finally, the watering at 50% of field capacity decreased the biomass production by 31%, compared to the 100% field capacity, and the water use efficiency was not affected by any treatments.

## Conclusion

In general, the results of this experiment showed that with decreasing soil moisture level, a decrease occurs in the amount of plant dry matter. Increasing the level of ferrous sulfate only led to an increase in the leaf nitrogen and also a 100% increase in the iron content of the leaves, which in turn can play a role in improving drought resistance.

***Keywords*****:** Chlorophyll, Dry matter, Leaf iron concentration, Nitrogen, Water stress

**Table1. Some physical and chemical properties of selected field's soil for pot experiments**

| Soil texture | Fe (DTPA) | Field capacity | Organic matter | TNW | Mn | Ca | Cl | Na | pH | EC |
|---|---|---|---|---|---|---|---|---|---|---|
| | $mg.kg^{-1}$ | | % | ----------meq/l---------- | | | | | | $dS.m^{-1}$ |
| Loam | 7.20 | 13.2 | 0.29 | 15 | 4.4 | 4.8 | 6.6 | 2.6 | 8.16 | 0.87 |

**Table 2. Analyze of variance some growth treads of wheat (Roshan cultivar) influence of soil moisture different level and Iron sulfate**

| S.O.V | df | Mean Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Height plant | Leaf number | Stem number | Stem diameter | Leaf area | RWC | Spad Index |
| **Block** | 3 | $6.376^{ns}$ | $93.03^{ns}$ | $10.031^{ns}$ | $0.057^{ns}$ | $2546.98^{ns}$ | $43.819^{ns}$ | $4.156^{ns}$ |
| **Iron (Fe)** | 3 | $5.972^{ns}$ | $14.78^{ns}$ | 1.781ns | $0.008^{ns}$ | $2774.87^{ns}$ | $26.383^{ns}$ | $15.316^{*}$ |
| **Soil moisture levels (S)** | 1 | $19.515^{*}$ | $2831.3^{**}$ | $427.78^{**}$ | $1.308^{**}$ | $219585^{**}$ | $1812.62^{**}$ | $35/490^{**}$ |
| **S×Fe** | 3 | $3.55^{ns}$ | $20.61^{ns}$ | $1.614^{ns}$ | $0.023^{ns}$ | $975.59^{ns}$ | $8.823^{ns}$ | $17.857^{**}$ |
| **Erorr** | 21 | 4.327 | 59.79 | 7.245 | 0.024 | 3717.98 | 17.776 | 3.368 |
| **CV%** | | *8.00* | *10.15* | *16.66* | *6.63* | *14.59* | *5/14* | *5.08* |

$^{**}$ ,$^{*}$ and $^{ns}$ significant at P=0.05, 0.01 and no significant, respectively.

**Table 3. Mean comparison of wheat (Roshan cultivar) measured growth traits under different soil moisture levels**

| Soilmoisture (%FC) | Height plant | Leaf number | Stem number | Stem diameter | Leaf area | RWC | Spad Index |
|---|---|---|---|---|---|---|---|
| | cm | | | mm | $mm^2$ | % | |
| **100%** | 26.675[a] | 85.562[a] | 19.812[a] | 2.555[a] | 500.687[a] | 89.393[a] | 36.53[b] |
| **50%** | 25.203[b] | 66.75[b] | 12.5[b] | 2.150[b] | 335.012[b] | 74.314[b] | 38.2[a] |

Dissimilar letters in each column indicate significant differencesat 5% level using the FLSD test

**Table 4. Mean squares of leaf protein, nitrogen, potassium percentage and iron concentration, dry weight and water use efficiency in wheat (Roshan cultivar) under different soil moistures and Iron sulfate levels**

| | | Mean Squares | | | | | |
|---|---|---|---|---|---|---|---|
| **S.O.V** | **df** | **Protein** | **Nitrogen** | **Potassium** | **Iron** | **dry weight** | **Water use efficiency** |
| **Block** | 3 | $0.214^{ns}$ | $0.0043^{ns}$ | $0.085^{ns}$ | $164.675^{ns}$ | $0.002^{ns}$ | 0.0002 |
| **Iron (Fe)** | 3 | $1.788^{ns}$ | 0.054* | $0.016^{ns}$ | $4441.602^{**}$ | $0.007^{ns}$ | 0.0003 |
| **Soil moisture levels (S)** | 1 | $56.60^{**}$ | $1.390^{**}$ | $3.290^{*}$ | $13358.54^{**}$ | $0.239^{**}$ | 0.000003 |
| **S × Fe** | 3 | $0.521^{ns}$ | $0.011^{ns}$ | $0.172^{ns}$ | $1213.451^{*}$ | $0.002^{ns}$ | 0.000003 |
| **Erorr** | 21 | 0.617 | 0.016 | 0.061 | 260.680 | 0.006 | 0.0002 |
| **CV%** | | *5.91* | *6.14* | *10.33* | *12.55* | *16.93* | *11.99* |

$^{*}$, $^{**}$ and $^{ns}$ significant at P=0.05, 0.01 and non significant, respectively

**Table 5. Mean compression of leaf protein (%), nitrogen (%) and potassium content (%) and iron concentration (mg/kg) and dry weight (per plant) in wheat (Roshan cv.) at different levels of soil moisture**

| Soil moisture (%FC) | Protein | Nitrogen | Potassium | Iron | Dry weight |
|---|---|---|---|---|---|
| | ----------%---------- | | | $mg.kg^{-1}$ | $g.pl^{-1}$ |
| **100%** | 11.955[b] | 1.91[b] | 2.066[b] | 142.734[a] | 0.562[a] |
| **50%** | 14.615[a] | 2.326[a] | 2.708[a] | 103.761[b] | 0.389[b] |

Dissimilar letters in each column indicate significant differences at 5% level using the FLSD test

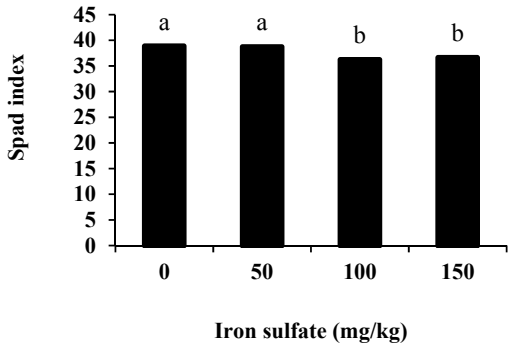


**Fig. 1. Wheat SPAD index response to different levels of Iron sulfate application**

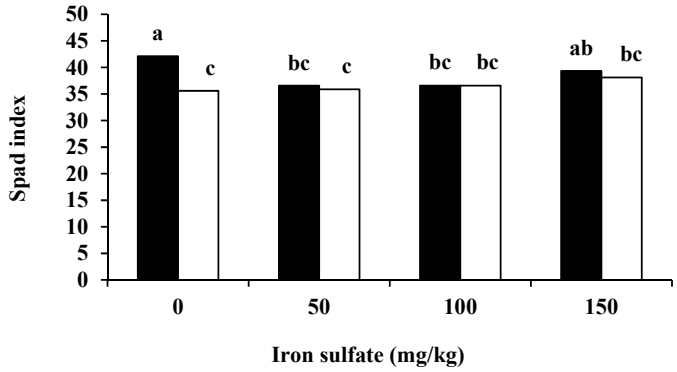


**Fig. 2. Changes in chlorophyll index (SPAD) of Roshan wheat cultivar grown under two moisture conditions (100% of field capacity, black columns, and 50% of field capacity, white columns) in response to different levels of Iron sulfate application.**

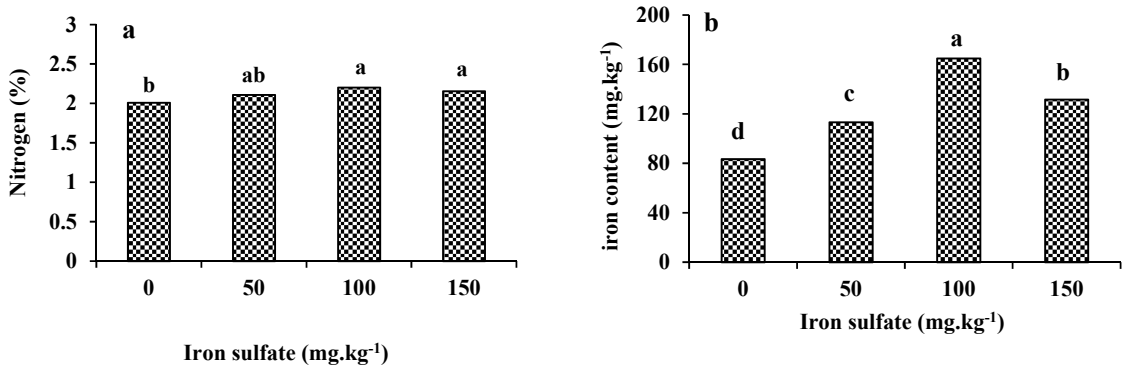


**Fig. 3. Mean comparison of (a) leaf nitrogen (%) and (b) leaf iron concentration (mg.kg$^{-1}$) as affected by different levels of Iron sulfate soil application**

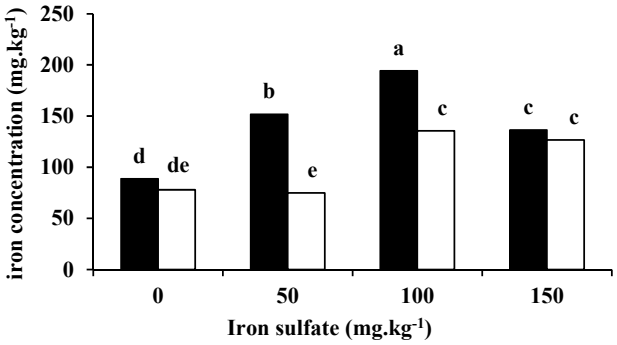


**Fig. 4. Changes in leaf iron concentration (mg.kg$^{-1}$) of Roshan wheat cultivar, grown in 100% of field capacity moisture conditions (black columns) and 50% of field capacity (white columns), in response to different levels of Iron sulfate application**

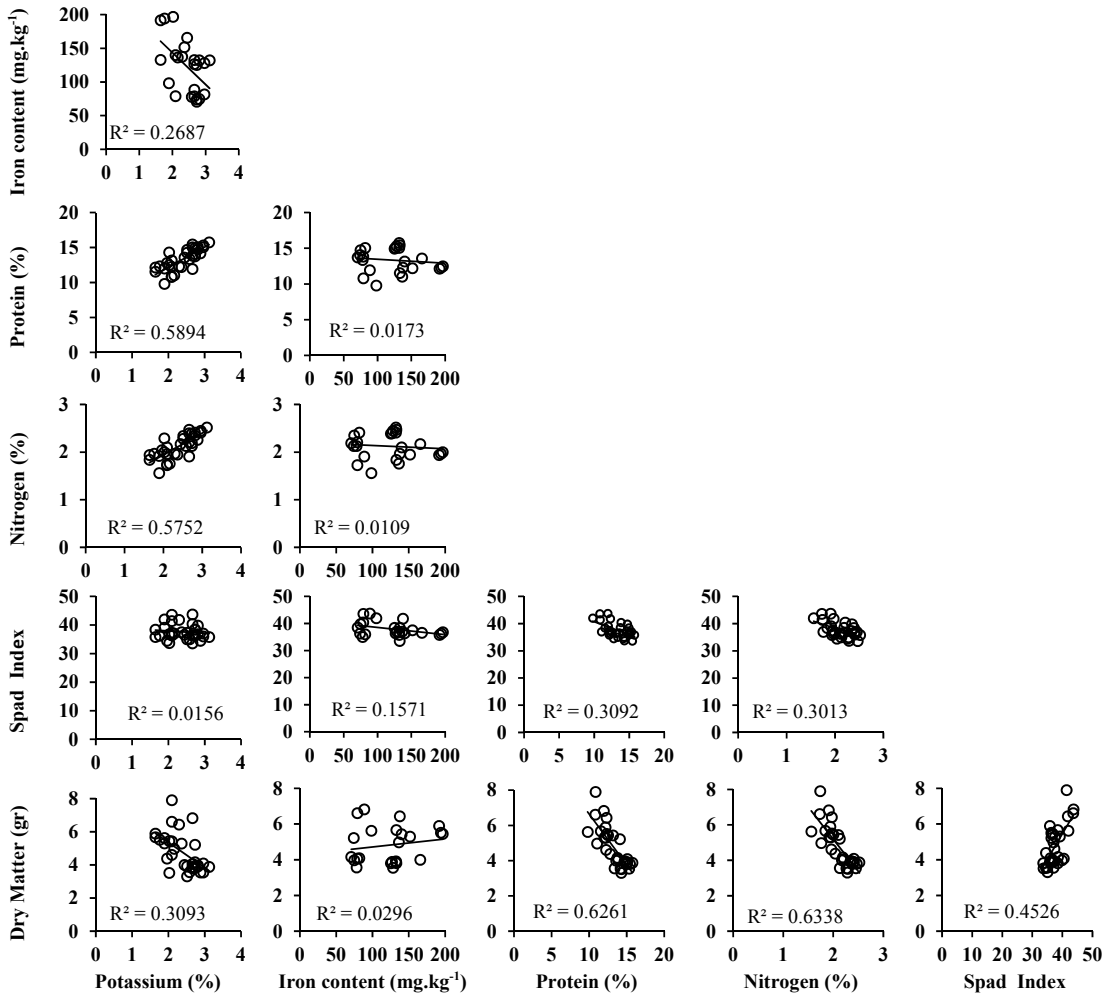


**Fig. 5. The relations between dry matter, nitrogen (%), potassium (%), protein (%), iron content and SPADIndex**