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ORIGINAL ARTICLE

Effect of Foliar Application of Iron on Morpho-physiological Traits of Wheat under Drought Stress

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ABSTRACT
An experiment was conducted in order to evaluate the effects of Fe spraying on quantitative and qualitative yield of Sirvan wheat new variety under water stress condition, in agriculture and natural resource research center of Tehran province in 2012-13. a split plot layout within randomized complete block design with three replications was used. main plots were three irrigation treatments (normal irrigation, non-irrigation at start of grain filling stage and non-irrigation at start of flowering stage) and sub plots were Fe spraying with two levels including spraying with pure water and Fe spraying with 0.5% concentration. The result showed that all traits significantly affected by stress except plant height. The most effect of stress at filling stage treatment was on thousand kernel weight and leaf area duration. Both two stress treatments caused a significant decrease of flag leaf area followed by maximum amount of LAI. Fe spraying significantly increased plant height, no. of fertile tiller and flag leaf area by 5%, 6%, and 11.7% respectively. Also, RWC increased by 8.3% respectively in this treatment. The manner of LAI changes during wheat growth period had significantly affected by Fe spraying.
Keywords:Wheat, Fe spraying,Drought stress, Morphophysiological traits

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INTRODUCTION

Drought is one of the most important stressor environmental factors, which has affected the production of agricultural products in arid and semi-arid region and it reduces the production (19 &20). Reviewing the physiologic processes associated with drought resistance seems essential in these regions. It has not been cleared yet that which parameter other than the yield of the grain may be beneficial indexes in a reformative program for drought resistance. Right now the desired and final index of drought resistance within reformative programs is the comparison of yield in an extended range of climatic conditions and the normal and stress (20).Although several morphological and physiological properties are effective on resistance or tolerance of the genotypes of wheat to stress, but because so many of them are unknown, still the yield of the grain and its components is used as the most important criterion in development of adapted numbers to the stressful conditions in many of breeding programs (26). Flowering and grain filling stages have been introduced as the most critical stages of the growth of the wheat associated with drought stress. And these stages are periods in which the wheat shows the most sensitivity to the shortage of water. Some of the researchers have reported that fine grain plants such as wheat are sensitive to drought two weeks before pollination (16 &24). And also it has been reported that applying humidity stress before the pollination stage of the wheat reduces the growth, plant height and biomass, while the main effect of stress after pollination is on the constraint of the tank and its storing capacity. A set of phenological, morphological and physiological traits have been involved in the tolerance of the wheat against drought stress, which are being identified and evaluated about the time of occurrence and time period of the persistence of stress, frequency of the occurrence of drought and the properties of soil (24).Iron (Fe) is one of the micronutrients and low consumption elements, and the shortage of it has been reported in most of the countries of the world. In these countries, in addition to the shortage of nutrient elements such as Fe, the plants are affected by environmental stresses in various ways. Most of these stresses have similar effects on the irrigation conditions of a plant. Having access to water through its biological role as a solvent and its role in transferring materials is crucially important. The purpose of the present research is to review the effect and role of consumption of the micronutrients element Fe on the production of yield and components of the yield of Sirvan wheat new variety as bearing variety to the drought stress and is also to review the effect of this element on physiological indexes of the growth of the wheat in desired conditions as well as occurrence of drought stress during the reproductive phase. Fe has an important role in the growth and balance of nutrient elements of plants (29). Sufficiency level of Fe in a plant is between 50 and 250ppm. In general, when the rate of Fe in the dry material of the plant is less than 50ppm, the plant might face shortage of Fe. Fe has an important role as a structural component and also as a cofactor for enzymatic reactions. Fe can be absorbed by the root of the plant as Fe_{2+} and Fe_{3+} and also as organic compounds as well as chelate. The ion of iron which is needed for metabolism is Fe_{2+} which is absorbed by the plant in this way. The Fe_{2+} ion has more movement in comparison with Fe_{3+} and it is useable for being engaged in the structure of organic molecules. In plants that have a high value of Fe_{3+}, the signs of shortage might be seen. There is shortage of Fe in many of the products, particularly in calcareous soils and also alkaline soils as well as acidic soils which are high in phosphor .Pazouki et al (2009), in reviewing the effect of the times of Fe spraying on the yield and the components of the yield of the fall varieties of canola in the region of the city Rey, evaluated the time of Fe sulfate spraying with a concentration of four in one thousand in four stages including lack of spraying, spraying in the stage of the start of stem elongation, spraying in the stage of the start of flowering and spraying in two stages of the start of stem elongation and start of flowering and the obtained results showed that the effect of Fe spraying on the number of pods per plant, number of grain per pod, weight of one thousand grain and grain yield became significant.

The studies of the researchers have shown that there is a shortage of Fe in 37 percent of the lands of Iran in which wheat is being cultivated . The necessity of Fe for plants had been clear since the year 1860 . Fe plays an important role in the plant metabolism, especially in the in the synthesis of chlorophyll, which is essential for plant photosynthesis (22). In many plants, the shortage of Fe leads to stimulation of several morphological and physiological reactions (25 & 23). Sharma et al (1994) stated that in plants with a shortage of Fe, the net photosynthesis reduces for each unit of level and also WUE, which is probably due to the effect of Fe on the chlorophyll of leaf and indole acetic acid hormone. Therefore, decrease of the rate of (a) and (b) chlorophyll leads to the decrease of photosynthesis rate. This matter leads to the production of dry material and therefore fewer yields. The researches have shown that with using the composts which contain Fe, the grain yield, concentration of Fe in the grain, wheat straw, percentage of protein, the number of grains in plot and the weight of one thousand grains significantly increases (16 & 17).

MATERIALS AND METHODS

This experiment was performed in the form of split plot layout within randomized complete block design with three replications in agriculture and natural resource research centre of Tehran province in 2012-13. The city Varamin is in the 40 kilometres of the southeast of Tehran. This region is confined to mountains of Gharahghaj and the city Damavand from north, to the margin of central desert from south, to the city Rey from West and to the city Garmsar from East. The height of it from the surface of the sea is approximately 1000 meters, the estimated area of the region is approximately 1500 square kilometres, the longitude of 40 degrees and 51 minutes east and the latitude of 19 degrees and 35 minutes north and the rate of first and second degree lands of it is approximately 75 thousands hectares. According to the latest metrology statistics of the past few years, the average of the annual rainfall is 120 mm and the direction of wind in the region is often from the southeast to the northwest. In this experiment, the main plots include treatments of drought stress in three stages:

1. Normal irrigation (custom of the region),
2. Non-irrigation at the time of grain filling (low stress)
3. Doing 2 times of irrigation at the time that the plant goes through the stage of the start of flowering (intense stress)

And subplots include the spraying of the element Fe in 2 stages:

1. Spraying with pure water
2. Fe Spraying from a source of Fe sulphate with the concentration of 1 percent.

The variety of the wheat that was studied in the recent experiment was the wheat new variety under drought stress of the end of the season called Sirvan. Before harvesting the product, the height of the plant was measured in each plot, in three parts of the plot by using a graded wood and from the surface of the ground (the surface of the soil on the stack) to the upper part of the awn and the average was recorded as the height of the plant. The number of fertile tiller was calculated and recorded through counting the number of formed clusters around the main cluster in each plant at the end of the growth period and at the time of maturity of the product. The relative water content (RWC) of leaf was measured with the sampling from the flag leaf at the time of the peak of the surface of the leaf in the laboratory. Three leaves were separated from the upper leaves of each plant in the middle of the day in order to determine the RWC of the leaves and among these leaves, those that were circular and with the same shape were isolated and they were quickly weighed (weight of the wet leaves) with an accurate scale (milligram), and then the samples were put in a distilled water so that they would be completely swollen up. During all of this time the containers were closed and their temperature was fixed. After the exit of distilled water, the surfaces of the samples were dried and weighed (the inflammation weight). The samples were put in aluminium containers for eight hours in the oven (drier) with the temperature of 104ºC so that the weight of the dried samples would be obtained and at the end it was measured with the aid of the following formula of the RWC of the leaves.

RWC = FW – DW/TW – Dw*100

TW: inflammation weight

DW: dried weight

FW: fresh weight

The data was analyzed by using the statistical software SAS and the average of the dada was compared by using the LSD test at the probability level of 5 percent. The figures were drawn by using the software EXCEL.

RESULTS AND DISCUSSION

Height of the plant

According to the results of variation analysis, the difference between different stages of irrigation in terms of the average of the height of the plant of the wheat was not significant. The fact that this trait did not become significant in the recent experiment is due to the end of vegetative growth period and the height of the wheat plant reaching its peak until the time of application of drought stress which is the start of the flowering stage of the wheat. The average of the height of the wheat plant Sirvan in this experiment differed from 103.2 centimeters to 104.7 centimeters.

Table 1.Analysis of the trait variation of the height of the plant, the number of fertile tiller, area of flag leaf and RWC of the leaf

Average of the squares					
Variation sources	Degree of freedom	Height of the plant	Number of fertile tiller	Area of flag leaf	RWC of the leaf
Replication	2	29.55	569.20	0.003	24.06
Drought stress	2	40.05 ns	33125**	6.42**	975.7*
Error a	4	4.38	352.8	0.002	9.74
Fe spraying	1	200.02**	2496.9**	2.77**	308.3**
Interaction	2	1.50 ns	382.4*	0.01 ns	49.26*
Error b	6	3.66	6.09	0.007	3.81
Variation coefficient 14.1 12.1					
* And ** are respectively difference in the level of 5% and 1% *ns* without significant difference					

It has been reported that if the stress occurred in the preliminary stages of the growth of the plant which is the vegetative growth period, varieties with short to medium height of the plant perform more successfully in the production of yield. While in the conditions that the stress occurs at the end of the growth period and after vegetative growth period, the varieties with medium to long heights will be successful (22). Nelson (2003) stated that the growth of drought stress in the primary stages of the growth reduces the height of the plant, but after the beginning of the vegetative growth period this effect is not significant. Moghadam (2009) and also Ehdayi (1994) have reported the relationship between the height of the plant with the yield of grain of varieties of wheat to be negative. Nonetheless, other reports (25) evaluated this correlation as a positive one. According to this, it can be concluded that the relationships of the height of the plant and the grain yield depends on the genotype kind as well as environmental conditions, especially the status of accessibility of water for the plant.

Table 2. Comparison of the average of the height of the plant, the number of fertile tiller, area of flag leaf and RWC of the leaf

Average of the traits				
Treatment	Height of the plant	Number of fertile tiller	Area of flag leaf	RWC of the leaf
Stress				
Normal irrigation (S1)	104.500 a	454.16 a	8.44 a	88.18 a
Stress at the start of grain filling (S2)	104.66 a	434.66 a	7.48 b	80.13 b
Stress at the start of flowering (S3)	103.16 a	316.83 b	6.37 c	63.20 c
Fe				
Pure water spraying (F1) Fe spraying (F2)	100.77 b	390.11 b	7.03 b	73.03 b
Interaction	107.44 a	413.66 a	7.82 a	81.31 a
S1 × F1	100.6 b	449 ab	7.98 b	82.83 b
S1 × F2	108.3 a	459 a	8.90 a	93.53 b
S2 × F1	101.3 b	425 b	7.11 c	79.26 b
S2 × F2	108.0 a	445 ab	7.85 b	81.00 b
S3 × F1	100.3 a	296 d	6.02 e	57.00 d
S3 × F2	106.0 a	337 c	6.72 d	69.40

The averages that are written in each column, which have similar letters, do not have a significant difference in terms of statistics. The height of plant is an inherited trait, but it is influenced by environmental factors such as type of the soil, humidity and nutrients to a large extent. The height of the plant at the time of maturity is considered as an important trait in reacting to drought. Although this trait, at the time of maturity of the plant, is considered as a factor in the plant's reaction to drought, but it is believed that the height of the plant does not have a particular effect on the relationship of the water in the plant by itself and determination of the proper height, for the condition of drought stress, is done by considering other agricultural considerations (12). Spraying the micronutrient element Fe significantly increases the height of the wheat plant in comparison with the treatment of spraying with pure water. The average of the height of plant increased from 100.8 centimeters for spraying with pure water to 107.4 centimeters in the treatment of spraying Fe with the concentration of 0.5 percent and this increase was significant. Forouzanfar (2012) reported a review of the effect of drought stress and Fe spraying on the morphophysiological traits and the yield of corn grains, in which drought stress generally lead to decrease of growth and Fe spraying, particularly at the concentration of 4 in one thousand increased the vegetative growth, the height of plant and the surface of the leaf. Plants under the salinity stress prevent water loss by reducing the surface of the leaf and therefore the leaves of the plants are smaller and thicker in such environments (17).

Number of Fertile Tiller

The average of the number of fertile tiller was affected by both treatments of irrigation and Fe spraying. The simple effect of the treatment of the non-irrigation stress and also the simple effect of the spraying treatment became significant at the statistical level of 1% and the interaction of stress and Fe spraying became significant at the statistical level of 5%. The drought stress significantly reduced the number of fertile tiller. The most value of this trait is about the normal irrigation treatment (conditions of no stress) with 454.1. the occurrence of stress at the beginning of the stage of grain filling (average of the 434.7 number of fertile tiller in the level unit) and also stress at the time of the start of flowering (average of the 316.8 number of fertile tiller in the level unit) percent reduced the average of the number of fertile tiller respectively 30.2% and 4.3 in comparison with the control. Nonetheless, the difference between the two levels of irrigation, normal and low stress, was not significant. The number of fertile tillers is one of the components of the yield which is controlled by the genetic factors. Nevertheless, the number of fertile tillers has a close connection with the humidity diet of the soil during the growth period of the plant as well and the number of fertile tillers can be increased with low density. The undesired effect of the main conditions of stress is due to the plant's tendency to produce more tillers compared to the typical mode. Although the production of tiller is considered more as a desirable trait, but stress begins at the start of flowering so that most of them time tillers would not reach the production of cluster and yield and from this aspect, their production is not only unbeneficial for the plant, but it might also be harmful due to the use of photosynthesis materials (7). Miralles et al (2000) reported that in plants that are under humidity stress, a 55 percent decrease was seen in the number of fertile tillers in comparison with the control sample.

The treatment of the element Fe spraying in the two sensitive stages of growth, which is the beginning of stem lengthening and the beginning of flowering, was the reason for which the production and the number of the tillers' fertility increased. The number of fertile tiller from the number 390.1 in the treatment of pure water spraying to the number 413.7 for the treatment of Fe spraying increased. This increase was significant equal to 6% and in the statistical level. Maraliyan et al (2008) studied the role of Fe and zinc spraying in the improvement of quantitative and qualitative specifications of the grain of three varieties of wheat. In this study, they reported that the effect of spraying on the average of number of fertile tiller at the probability level of one percent became significant, in a way that in the spraying treatment of the plants, the number of fertile tiller increased from the number 1.58 in plant for the control treatment to the number 2.28 in the treatment of Fe spraying. The trait of the number of fertile tiller is crucially important in the determination of the final yield and it is considered as one of the important determiners of yield in cereals. The interaction of irrigation and spraying treatments on the number of fertile tillers is significant. This matter indicates that the variations of the number of fertile tiller as a result of Fe spraying depend on the rate and type of the treatment of stress. Although the micronutrient element Fe causes improvement of the situation of fertile tillers in each three stages of the irrigation treatments and spraying increases the number of fertile tiller, but this increase is more when the stress is intensified and also in the conditions of intense stress. It seems that in normal conditions that plant has sufficient amount of water, there is sufficient accessibility to nutrient elements and the effect of Fe spraying does not include the main part, even though it is crucial. But by increasing the stress, because of the fact that the activity of some enzymes reduces and also as a result of increase of the concentration of solution of soil and following that decrease of having access to some other of these elements, the role of Fe spraying becomes more important.

Flag Leaf Area

The data of the table of variation analysis specified that the simple effects of various stages of irrigation treatment on the area of flag leaf of wheat at the statistical level of 1% are significant. The highest rate of the surface of flag leaf from the normal irrigation treatment was obtained 44.8 square centimeters. The non-irrigation in the beginning of the grain filling phase cause the area of flag leaf to significantly decrease to the rate of 4.11 percent. The treatment of non-irrigation achieved the lowest value with 6.38 square centimeters at the start of flowering and it difference with both of the two stages of irrigation was significant. Increase of the surface of flag leaf is crucially important in terms of the production rate of each ear; because a high rate of grain yield in each ear is affected by the surface of flag leaf adjacent to it. As you know all of these differences are rooted in the differences in genetic properties. The wider a root system, the better the nutrition of its plants and their growth will be and finally their organs and bodies will be developed. In this respect, Saleem et al (2010) stated that the reaction of the surface of flag leaf to nitrogen is very crucially important. Because the surface of the leaf is more for receiving the sun rays better and increasing the making of the photosynthesis materials and dry substance. Since the leaves are the main organs for photosynthesis, thus the decrease of the index of the surface of the leaf due to stress, causes the lack of creation of sufficient physiologic source in order to use the received light and provide required assimilates for filling the grains and therefore it decreases the yield, considering the fact that Fe increased the leaf surface. Therefore, it can be said that providing enough Fe for the plant increases the index of leaf surface which is in the field of producing and collecting dry substance. A similar report which was done by Acevedo et al 1979 has been presented based on the decrease of the index of leaf surface due to the drought stress. Fe spraying causes a significant increase ($P \leq 0.05$) of the average of the area of wheat's flag leaf. By doing the spraying, the average of this trait increased from 7.03 square centimeters in the treatment of non-irrigation to 7.82 square centimeters which indicated an increase that is equal to 11.2 percent. The leaf surface is crucial and essential for absorption of the light by the plant. Therefore, it has the basic effect on the yield of crop plants. In addition, the increase of the surface of green organs of the plant can be effective of the increase of photosynthesis and creation of photosynthesis materials in the plant. Having more leaf surface is great help to the increase of the rate of photosynthesis in a plant, especially about the plants with flag leaf. In this research the Fe spraying at the time of occurrence of stress of shortage of water led to having a better access to nitrogen and phosphor and increase of the surface of the flag leaf. Considering the fact that the application of various treatments of the stress of water shortage and use of Fe has been effective on the surface of the flag leaf, therefore it can be concluded that the best treatment in terms of the surface of the flag leaf can have an effective role in the improvement of the nutrition of the plant's ears (sporangium). Because the flag leaf is the best source of the production of nutrition for ears (target).

Relative Water Content of the Leaf

The simple effects of the two treatments of irrigation and also e spraying on the RWC of the wheat leaf is significant respectively at 5% and 1% of statistical level. The most RWC of the leaf was obtained from the desired treatment with a rate of 88%. Each of the both levels of stress reduces the average of RWC of the leaf. The average of RWC for the stress treatment at the time of the beginning of grain filling reduced to 68.9 percent and for the stress treatment of non-irrigation at the time of the start of flowering reduced to 66.4 percent. Nevertheless, this decrease is only significant for intense stress in comparison with the control. There was not a significant difference between two levels of stress either. The shortage of water causes a decrease of growth and development of the surfaces of the leaves by reducing the RWC of the leaf. A series of these factors will be followed by decrease of and substance creation. It seems that by doing the Fe spraying, the increase of having access to phosphor and nitrogen causes and increase of the leaf surface and more light will be absorbed by the plant. And therefore, the speed of the growth of the plant increases as well, due to more photosynthesis. Nazari (2009) studied the effect of drought stress in various stage of growth and components of grain yields of the varieties of wheat. The study reported that the difference between the four irrigation treatments (normal irrigation, non-irrigation at the stage of clustering, non-irrigation at the stage of flowering and non-irrigation at the time of grain filling) was significant in terms of RWC of the leaf. Nonetheless, among these four treatments, three treatments were put in a statistical group in this respect and this difference was just significant for non-irrigation at the stage of stem lengthening. He stated that the reason due to which the difference between the treatment of normal irrigation, non-irrigation at the stage of flowering and non-irrigation at the time of grain filling was not significant was because of time of measurement of this trait, before applying these two treatments of stress, which is at the time of completion of the growth of flag leaf. On the other hand, the flag leaves have only experienced stress of water shortage in the treatment of non-irrigation at the stage of stem lengthening. Fe spraying caused an increase in the RWC of the leaf from 73 percent to 81.3 percent and this increase was significant. And also the interaction of the drought stress and Fe spraying with the RWC of the leaf is significant as well.

Table 3.Analysis of variance of the traits of RWC of the leaf, rate of proline, percentage of protein, yield of protein and rate of the Fe of the grain

Average of the squares						
Variation sources	Degree of freedom	RWC of the leaf	Rate of proline	Percentage of protein	yield of protein	Rate of the Fe
Replication	2	24.06	0.0002	0.093	11799.2	40.54
Drought stress	2	975.7*	0.050**	9.67**	8838.2*	613.31**
Error a	4	9.74	0.0002	0.09	5715.2	4.19
Fe spraying	1	308.3**	0.005**	5.33**	60512.5**	88.06**
Interaction	2	49.26*	0.002*	1.02 ns	683.4 ns	18.74 ns
Error b	6	3.81	0.003	0.206	2129.1	5.14
Variation coefficient						
* And ** are respectively difference in the level of 5% and 1% *ns* without significant difference						

The highest rate of RWC of the leaf was recorded for the treatment of Fe spraying in the conditions of desired irrigation as 93.5 percent of RWC of the leaf. The lowest amount was obtained for the treatment which lacked the use of Fe in the conditions of non-irrigation at the start of the flowering phase with 57 percent. As it seen in the chart, doing the Fe praying caused improvement and increase of RWC of the leaf for the two stages of desired irrigation and also non-irrigation at the start of the flowering phase. Whereas the Fe spraying did not have a significant effect on the increase of the RWC of the leaf for the non-irrigation at the start of grain filling phase. It seems that Fe, by improving the conditions of growth and increasing the chlorophyll and photosynthesis leads to the increase of absorption of water and improvement of the relationships of water in the plant. The obtained results are in compliance with the results of Watson et al (2003) and Kumar and Singh (1998).

Index of the Leaf Surface

The index of the leaf surface includes the ratio of the surface of ground that has been occupied with the plant. Since the speed of the increase of the leaf surface determines the speed of the increase of the photosynthesis capacity in the plant, this is one of the basic parameters in the growth of the plant. The variation of the index of the leaf surface of wheat in various irrigation diets has been brought in chart. The variations the index of the leaf surface of wheat in the two stress treatments (non-irrigation at the start of the grain filling and non-irrigation at the start of the flowering) and also in the treatment of normal irrigation follow the same process. As the time passes, from the greening of the plant and the start of the growth of the leaves, its value increased, until the stage of the beginning of the rise of the cluster. In this stage the leaf production reached its peak, and its control was the fact that the area of flag leaf reached its peak too. And at this time the rate of the index of the leaf surface was in its highest rate. This time is also coincided with the peak of the speed of the growth of production (12). After this time, as it can be seen in the figure, the process of variation of the index of the leaf surface was downward for all of the three irrigation diets. And its rate showed a relatively similar decrease for every treatment from this point forward. This decrease was due to the start of the senescence and abscission of leaves and simultaneously the transmission of the photosynthetic compounds towards newly formed grains. But among these, some differences were observed in the regression curve of the variations of the index of leaf surface for three irrigation diets which were:

a. Until before the application of the first stress treatment (non-irrigation at the time of the start of the flowering) no kind of significant difference was seen in the process of the production and growth of the leaves in the three irrigation diets and these differences were very small.
b. For the three irrigation diets that are being discussed, the time during which the index of the leaf surface reaches the peak was different, in a way that in the treatment of normal irrigation, the maximum of the index of the leaf surface was obtained in a more number of days after the planting. For the treatment of intense stress, having access to the peak of the index of the leaf surface significantly happened very soon and the start of the drop of the curve was also sooner. This was due to the maximum durability leaves during the flowering period. The treatment of the low stress did not have a significant difference with the normal conditions in this respect, which was not far from what it was expected. Because the time of the occurrence of the stress was at the end of the period of vegetative growth and after accessing the peak of the index of the leaf surface.
c. The rate of the peak of the index of the leaf surface was also different for the three irrigation diets which have been taken into consideration. In a way that in the treatment of normal irrigation, the peak of the index of the leaf surface was more than the treatment of intense stress.
d. During the time period of the durability of the leaf surface from the time of reaching the peak of the index of the leaf surface until the start of the drop of the curve, which is coincided with the beginning of the fall of the leaves, strongly decreased in the conditions of stress and the durability of the leaf surface in the treatment of intense stress placed in the lowest level.
e. The length of the reproductive period decreased from the rise of the cluster to the time that both treatments of stress reached maturity.

The basic effective factor in high yield is producing dry substance in the level unit. Therefore, in terms of achieving more production and yield, having knowledge about the variation process of the dry weight of the plant and its connection with the accumulation of heat during the period of growth, is crucially important. In this respect, the leaves of a plant are the most important photosynthetic organs of it. The ratio if the leaf surface of the plant to the shading surface of the ground (index of the leaf surface) has been recognized as the best criterion of the capacity of producing dry substance.

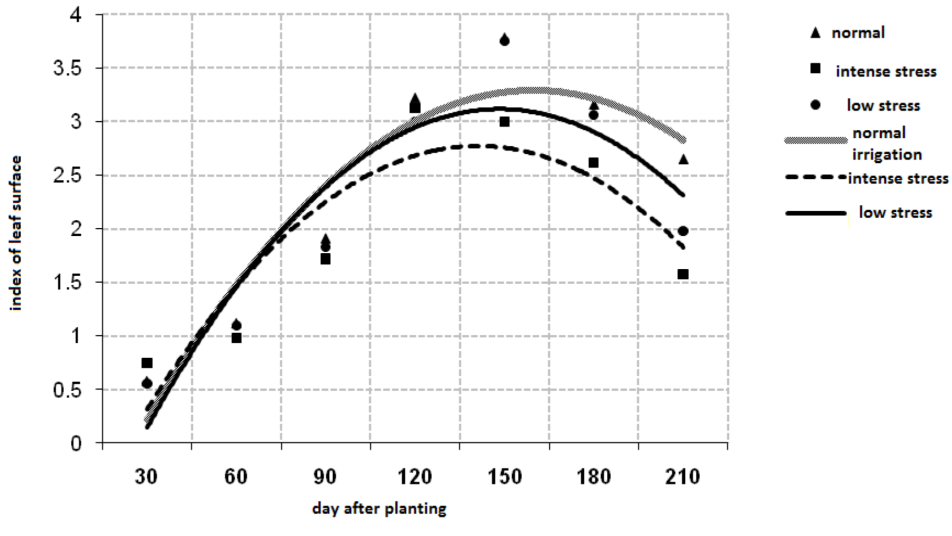

Figure 1.Variations of the index of the leaf surface in various irrigation diets

The increase of the surface of the flag leaf is crucially important in terms of the rate of production in each ear. Because a high rate of the grain yield in each ear is influenced by the surface of the flag leaf adjacent to it and since the use of zinc led to the significant increase of the surface of the leaf, its effective role in the yield of each and every one of the clusters in a plant seemed undeniable. For the treatment of non-irrigation at the start of the stage of grain filling, the process of the variation curve of the index of the surface of the leaf to the end of the flowering period and the beginning of the similar filling with irrigation treatment was normal. But from this point forward, with all that happened to the treatment of intense stress, the complexity and sooner fall of the leaves in comparison with the control treatment, led to the drop of the curve of the index of the leaf surface at the end of the period. The regression equations associated with the curve of the index of the leaf surface in each irrigation diet have been mentioned in the table.

Table 4.Regression equation and determination coefficient of the index of the leaf surface for various irrigation diets

Treatment	Regression equation	R^2
Normal irrigation	$y = -0.164x^2 + 1.748x - 1.362$	$R^2 = 0.901$
Low stress	$y = -0.191x^2 + 1.888x - 1.551$	$R^2 = 0.852$
Intense stress	$y = -0.178x^2 + 1.683x - 1.185$	$R^2 = 0.809$

The fitting of the equation and regression coefficients showed that the variation process of the index of the leaf surface follows a second degree function with the equation of y = a + bx + cx2. The process of it is similar for all of the irrigation diets but the basic difference is due to the different time of reaching the peak of the index of the leaf surface (x max) and also the rate of the peak of the index of the leaf surface at this time (Y max). In the condition of desired irrigation, the time of reaching the peak of the index of the leaf surface was obtained from the start of the planting (x max) in the 160th day. for the two stages of low stress (non-irrigation at the start of grain filling) and intense stress (non-irrigation at the start of flowering), this time was obtained respectively in the days 148.3 and 141.8. These results showed that the time of reaching the peak of the index of the leaf surface has been reduced under the influence of intense stress. On the other hand, in addition to the time of the maximum, the rate of the maximum of the index of the leaf surface (Y max) for these treatments was strongly different. In a way that the rate of the maximum of the index of the leaf surface associated with the desired irrigation was with 3.41 units. Non-irrigation reduced the maximum of the index of the leaf surface to 3.12 units. The maximum of the index of the leaf surface at the start of flowering for the non-irrigation treatment decreased to 2.79 units. The variation process of the index of the leaf surface of during the period of growth to maturity for various stages of the treatment of Fe spraying can be seen in the regression curve (chart 2). This chart indicates the connection between the rate of receiving the rays through photosynthesis surfaces of the plant (leaves) and finally quantitative produce of the plant of wheat and the role of Fe spraying in this process. Just like what was observed in the connection of the variations of the index of the leaf surface in the irrigation treatment, the general process of production, growth and reaching the maximum and peak of the index of the leaf surface was similar and included the quick growth of the leaves during the vegetative growth, the index of the leaf surface's reaching the maximum at the start of the rise of clusters and finally the fall of the leaves and decrease of the leaf surface. Nonetheless, even though there were these similarities, some differences were also seen between the three stages of the spraying. In this research, since the Fe spraying significantly ($P \leq 0.05$) increases the average of the area of the flag leaf of wheat and it increases the average of the area of the leaf from 7.03 square centimeters in the non-irrigation treatment to 7.82 square centimeters by doing the spraying. This indicates that the increase was equal to 11.2 percent. It can be concluded that the application of this element has been able to increase the rate of the production of leaves and maintain the durability of the leaf surface. This matter particularly had an effective role in reducing the damage of stress and maintaining the final yield. Doing the Fe spraying in two sensitive stages of the start of stem lengthening and the start of flowering, event at the time in which water shortage occurs, leads to having better access to nitrogen and phosphor and increase of the surface of the flag leaf. By considering the fact that the usage of various treatments of water shortage stress and use of Fe, has been effective on the surface of the flag leaf, therefore we can conclude that the best treatment in terms of the surface of the flag leaf can have an effective role in the improvement of the nutrition of the ears of the plant (sporangium). Because the best production source of nutrition for ears (target) is the flag leaf. The chart shows that from about the early days of March which is the time of the start of quick and further growth of wheat that was the result of quicker heat of the air in the year in which the study was done, the differences between the growth curve of the leaves was apparent for treatments of the use of Fe in comparison with the pure water spraying and the quick growth of the leaves in these two treatments caused the index of the leaf surface in them to increase. This advantage lasted in the rest of the period of growth as well. In comparison with the control treatment, the maximum of the index of the leaf surface was also higher for each of the two stages of spraying.

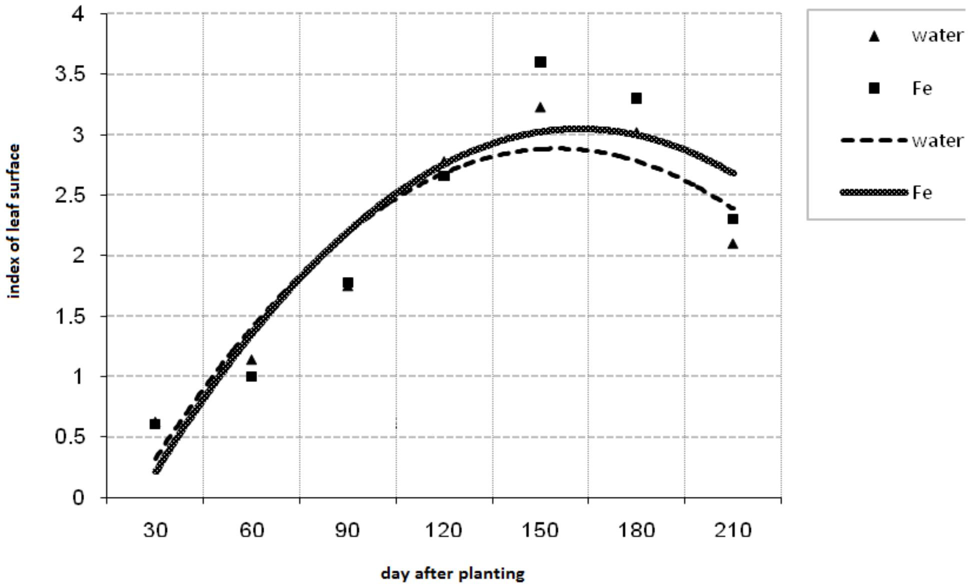

Figure 2. Variations of the index of the leaf surface in stages of the Fe spraying

Table 5. Regression equation and determination coefficient of the index of the leaf surface for stages of the Fe spraying

Treatment	Regression equation	R^2
Pure water spraying	$y = -0.148x^2 + 1.528x - 1.064$	$R^2 = 0.891$
Fe spraying	$y = -0.146x^2 + 1.579x - 1.219$	$R^2 = 0.863$

CONCLUSION

The results showed that except the height of the plant, other traits have been under the significant influence of stress. The main part of the effect of stress was associated with the decrease of the number of fertile cluster for the treatment of intense stress. Each of the two stages of stress led to a significant drop of the area of the flag leaf and following this, a significant drop of the rate of the maximum of the index of the leaf surface. The time in which the peak of the index of the leaf surface occurred for these two treatments significantly decreased due to the acceleration of the maturity of the plant. For each of the two treatments of stress, the duration of the time of durability decreased for the surface of the leaves and the fall of the leaves began more quickly. Fe spraying less to a significant increase of the height if the plant, number of the fertile tiller and area of the flag leaf, respectively 6.5%, 6% and 11.7%, in comparison with the control. And also the Fe spraying increased the RWC of the leaf for 8.3 percent. The process of the variation of the index of the leaf surface was affected by the spraying. The process of the variation of the index of the leaf surface during the period of growth to the maturity of the plant showed that although the time of the occurrence of each of the two stress treatments was immediately after reaching the maximum of the index of the leaf surface, but the indirect influence of stress on the decrease of the durability of the surface of the leaves and beginning of the early fall of the leaf and also the reduction of the time of the transmission of the photosynthesis materials from the leaves to the grain through the reduction of length of the reproductive phase affected the variations of the index of the leaf surface. And specific differences were seen in the curves of the index of the leaf surface of the stress treatments in comparison with normal conditions. The role of spraying in the increase of the speed of production and development of the stem and leaves, which was the result of the accessibility to the elements nitrogen and phosphor that had increased through the spraying at the beginning of the stem lengthening stage, and its useful effect on the increase of the index of the leaf surface and relative speed of the growth of wheat through spraying at the beginning of the flowering phase, increased the durability of leaves and transferred photosynthesis and grain yield.

The results show that TiO_2 NPs can reduce and remove micro-organisms in MS media and the best results can be achieved by using 1 w/w TiO_2 NPs in potato tissue culture media. On the basis of this study, it can be suggested that the TiO_2 NPs may be a useful material for removing the bacterial contaminants in plant tissue culture.

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