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Physiological and Agronomical Responses of Triticale to the Growth Bacteria, Nano Iron Fertilizer and Ordinary Iron Fertilizer Treatment

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RESEARCH ARTICLE

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ABSTRACT

BACKGROUND: Bio-fertilizers are best eco-friendly approach for plant and soil environment. Also, micronutrient element such as iron plays a key role in the formation of chlorophyll and photosynthesis.
OBJECTIVES: This study evaluated the effect of growth bacteria and Nano iron fertilizer and ordinary iron fertilizer on some physiological properties of Triticale.
METHODS: The experiment was conducted as 4×6 factorial in RCBD design with three replications at two years (2016-2017). Treatments included: Use of plant growth-promoting bacteria in four levels (Non-inoculation, inoculation with *Azotobacter crocococcus*, *Azospirillium methylpofrome* and *Pseudomonas putida*) and nano iron fertilizer in five levels (0, 0.5%, 1%, 1.5% and 2%) and ordinary iron fertilizer on two levels (2% and 0%). According to results it was founded that application of *Azotobacter crocococcus*, *Pseudomonas putida* and *Azospirillium methylpofrome* led to 15, 13 and 17% the increase of seed yield by the compare to control. In relation to Nano-Fe fertilizer, it was observed that 1% Nano-Fe fertilizer showed highest seed yield.
RESULT: The results of means comparisons for bacterial treatment showed that the highest leaf area index was related to Azotobacter treatment and the lowest amount was related to control treatment. Regarding the crop growth rate index, the results of the data analysis indicated that bacterial treatment and treatment of iron were significant at 1% level, but the interaction treatment was not significant.
CONCLUSION: Between three tested bacteria, the Azotobacter highest effects on LAI, CGR and HI, so, we propose application of nano-Fe fertilizer and plant growth-promoting bacteria together for the improving Triticale yield in Iran and similar regions.

KEYWORDS: *Azospirillium, Azotobacter, Biofertilizer, Cereal, Seed yield.*

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1. BACKGROUND

One of the biological methods for increasing the production of agricultural products is the use of terrestrial microorganism. Bio-fertilizers are made from microorganisms that help to to provide plant nutrients (Bumandalai and Tserennadmid, 2019). Bio fertilizers are mostly used to increases the microbial activity which in return increases the availability of the nutrients which can be assimilated easily by the plants (Akram *et al*., 2020). Bio-fertilizers are best eco-friendly approach for plant and soil environment (Riaz *et al*., 2020). The positive effect of growth promoting bacteria on plant growth is associated with the production of plant hormones, nitrogen fixation, organic and inorganic phosphate dissolution, and the synthesis of antibiotics and enzymes (Esitken, 2011). Also, it determined that the PGPR are correlated with the physicochemical properties of the soil (Flores-Núñez *et al*., 2018). Some research demonstrated that bio fertilizers had positive effect on crops (Kilpeläinen *et al*., 2019). Actually biofertilizers have fundamental function to the increase of soil fertility and crop production (Ji *et al*., 2019). Also, micronutrient element such as iron plays a key role in the formation of chlorophyll and photosynthesis and has a great importance in the enzymatic system and respiration of plants, therefore its application will have a positive effect on the dry matter production of the plant (Khoshgoftarmanesh *et al*., 2010). There are several reports that there is a positive effect of nano-nutrients the growth of some plants, such as wheat (Burhan and AL-Hassan, 2019).

2. OBJECTIVES

Hens, at this study, physiological and agronomical responses of triticale evaluated to the growth bacteria, nano iron fertilizer and ordinary iron fertilizer treatment.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This project was carried out in a farm located in Firoozabad, Fars province (2016-2017) with a length of 52° and 33° East and a latitude of 28° 53'N and a mean altitude of 1362 m from the sea level as a factorial in a randomized complete block design with three replications. Based on the results of soil analysis, 150 $kg.ha^{-1}$ nitrogen fertilizer from urea source and 75 $kg.ha^{-1}$ potassium sulfate fertilizer was added to all experimental plots. Treatments included: Use of growth-promoting bacteria in four levels (Non-inoculation, inoculation with *Azotobacter crocococcus*, *Azospirillium methylpofrome* and *Pseudomonas putida*) and Nano iron Fertilizer in five levels (0, 0.5%, 1%, 1.5% and 2%), and Ordinary Iron Fertilizer on Two Levels (2% and 0%), Nano iron Fertilizer used from a source of nano-iron oxide with a purity of 99 and a particle diameter of less than 30 nm were used. In the farm, the plot size was 6 × 6 / 1m. Each plot consisted of 8 planting lines with a spacing of 20 cm apart and a total area of 9.6 square meters.

3.2. Farm Management

To inoculation of seeds, seven grams of inoculum per hectare of 107 live and active bacteria has been used. Fighting with pests and diseases and control weeds was also done according to technical recommendations during the growth period.

3.3. Measured Traits

The traits included seed yield, seed number per spike, plant height and harvest index for agronomic traits and CGR (crop growth rate) and Leaf area index (LAI) for physiological traits (Buttery, 1970; Enyi, 1962).

Equ.1. CGR ($g.m^{-2}.day^{-1}$)=

TDM_2- TDM_1/T_2-T_1

TDM_1= Primary dry weight (gr),

TDM_2= Secondary dry weight (gr)

T_1= initial sampling time,

T_2= Secondary sampling time

3.4. Statistical Analysis

Statistical analysis was performed using SAS software (Kattree and Naik, 2018), and graphs were drawn with Excel software. The comparison of the meanings was done using Duncan's multiple range tests at a confidence level of 5%.

4. RESULT AND DISCUSSION

4.1. Agronomic traits

Result of analysis of variance showed effect of bacteria and nano-Fe fertilizer on seed yield was significant at 1% probability level but interaction effect of treatments was not significant (Table 1). Evaluation mean comparison result of different level of bacteria indicated maximum seed yield (532.716 gr) was noted for *Azospirillium methylpofrome* and lowest one (453.817 gr) belonged to control treatment (Table 2).

Table 1. Result analysis of variance of studied traits

S.O.V	df	Seed yield per plant	Harvest index	Leaf area index	Crop growth rate index
Block	2	865.67^{*}	0.642^{ns}	0.0032^{ns}	26.59^{ns}
Bacteria (B)	3	22671.15^{**}	60.90^{**}	0.174^{**}	313.90^{**}
Fe fertilizer (F)	5	9341.22^{**}	17.14^{**}	0.116^{**}	113.15^{**}
B × F	15	4.01^{ns}	0.66^{ns}	0.021^{ns}	0.22^{ns}
Error	46	241.07	0.030	0.0068	10.43
CV (%)	-	4.25	2.55	2.92	4.01

$^{ns, *\ and\ **}$: no significant, significant at 5% and 1% of probability level, respectively.

Table 2. Mean comparison effect of growth-promoting bacteria on studied traits

Treatments	Seed yield per plant (gr)	Harvest index (%)
Control	453.817^{c}	37.0934^{c}
Azotobacter crocococcus.	523.109^{ab}	40.7938^{b}
Pseudomonas putida	513.029^{b}	40.6952^{b}
Azospirillium methylpofrome.	532.716^{a}	41.4562^{a}

*Means with similar letters in each column are not significantly differentt by Duncan test at 5% probability level.

According to results it was founded that application of *Azotobacter crocococcus*, *Pseudomonas putida* and *Azospirillium methylpofrome* led to 15, 13 and 17% the increase of seed yield by the compare to control. In relation to Nano-Fe fertilizer, it was observed that 1% nano-Fe fertilizer showed highest seed yield (Table 2). As for Duncan classification made with respect to different level of nano-Fe fertilizer maximum and minimum amount of seed yield belonged to Nano-Fe 1% (538.65 gr) and control (473.55 gr) (Table 3). It was demonstrated that Fe has positive effects on photosynthesis pigment content and the increase of photosynthesis (Singh *et al*., 2008; Al-Amir *et al*., 2020). At this order, Hassanein *et al*. (2018) reported that bio-fertilizer led to the increase of yield and yield component of wheat. Result of analysis of variance revealed effect of bacteria and Fe fertilizer on harvest index was significant at 1% probability level but interaction effect of treatments was not significant (Table 1).

Table 3. Mean comparison effect of Nano iron fertilizer on studied traits

Treatments	Seed yield per plant (gr)	Harvest index (%)
Control	473.555^{e}	38.125^{d}
Nano-Fe 2%	488.36^{d}	39.32^{bc}
Nano-Fe 1.5%	506.325^{c}	39.62^{b}
Nano-Fe 1%	538.652^{a}	40.342^{a}
Nano-Fe 0.5%	488.028^{d}	39.062^{c}
Ordinary iron fertilizer 2%	524.624^{b}	39.527^{b}

*Means with similar letters in each column are not significantly differentt by Duncan test at 5% probability level.

Assessment mean comparison result of different level of bacteria indicated maximum harvest index (41.45%) was noted for *Azospirillium methylpofrome* and lowest one (37.09%) belonged to control treatment (Table 2). According result of mean comparison maximum of harvest index (40.34%) was obtained for Nano-Fe 1% and minimum of that (38.12%) was for control treatment (Table 3). Another trait at this research was harvest index that significantly changed in response to bacteria and Fe fertilizer. It was founded that *Azotobacter crocococcus, Pseudomonas putida* and *Azospirillium methylpofrome* led to 10, 10 and 12% the increase of harvest index in compare to control. In relation to fertilizer treatments, the highest harvest index obtained by 1% nano Fe treatment with 40.34% value, other treatment showed significant differences with control (Table 2,3).

4.2. Leaf area index

Regarding the leaf area index, the results of the data analysis indicate that bacterial treatment and treatment of ordinary iron were significant at 1% level, but the interaction was not significant (Table 1). The results of means comparisons for bacterial treatment showed that the highest leaf area index was related to Azotobacter treatment and the lowest amount was related to control treatment. The leaf area represents the amount of light received during plant growth and development and can be considered as an indicator of production. The study of the process of changes in leaf area index showed that in all treatment compounds, leaf area index up to 75 days after planting increased. It was found that the increase in leaf area under the influence of growth promoters and nano fertilizers can be attributed to the reduction of leaf aging due to increased chlorophyll production or reduction of its degradation (Figs. 1-3) (Boomsma and Vyn, 2008). Also it was reported that Bacterial inoculation treatment had positive effect on the vegetative parameters of plants comparing to control, excluding root length, root dry weight, shoot/root ratio, lead number and leaf area and canopy spread (Sharif and Shin, 2020).

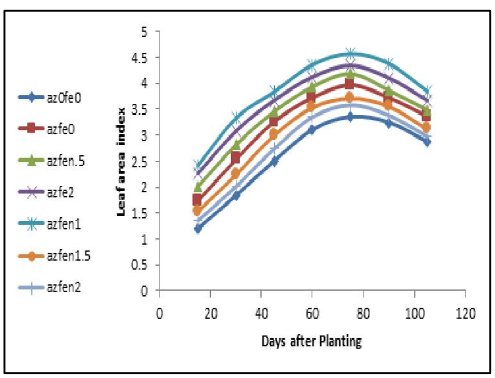

Fig. 1. Leaf area index in response to Fe and *Azotobacter crocococcus*

4.3. Crop growth rate index

Regarding the crop growth rate index, the results of the data analysis indicated that bacterial treatment and treatment of iron were significant at 1% level, but the interaction treatment was not significant (Table 1).

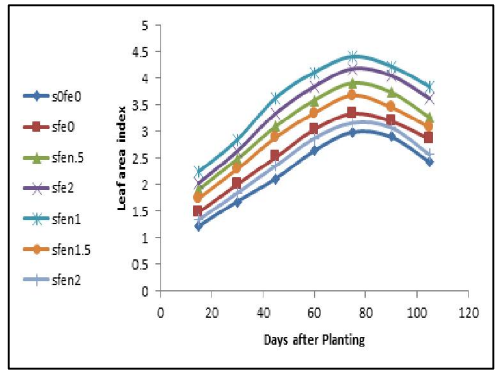

Fig. 2. Leaf area index in response to Fe and *Pseudomonas putida*

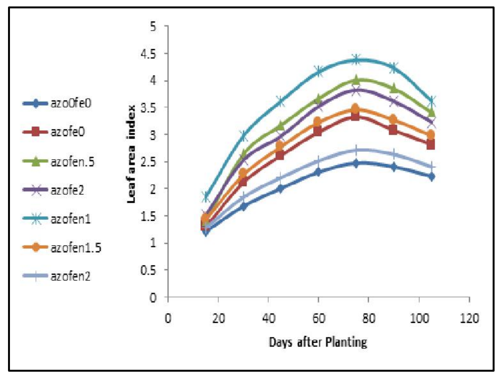

Fig. 3. Leaf area index in response to Fe and *Azospirillium methylpofrome*

Zaied *et al*. (2003), Vyas and Kaur (2019) attributed the increased growth rate of the crop due to inoculation with growth-promoting bacteria to the ability of the bacteria to increase the access to plant nutrients. Yasari and Patwardhan (2007) reported that the growth rate of canola increased by inoculation of seed with growth promoting bacteria compared to non-inoculation by 10 to 12 percent, and stated that the application of biological and chemical fertilizers to separate use as well as non-use of them, they had higher crop growth rates. Increasing the growth rate of crop production by biological fertilizers in important plants such as barley (Wu *et al*., 2005) and corn (Omara *et al*., 2017) have been reported in various studies (Figs. 4-6).

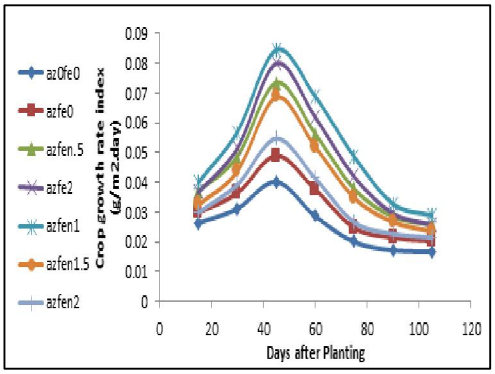

Fig. 4. Crop growth rate index in response to Fe and *Azotobacter crocococcus*

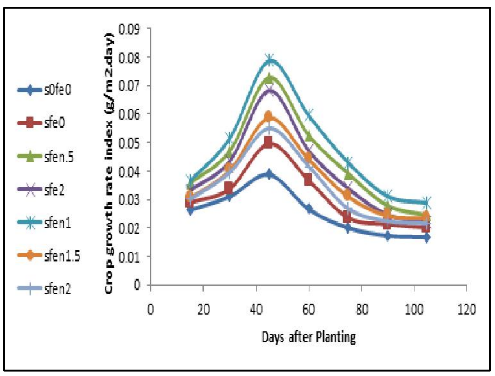

Fig. 5. Crop growth rate index in response to Fe and *Pseudomonas putida*

5. CONCLUSION

At this study we evaluated effect of plant growth-promoting bacteria, Fe nano-fertilizer on physiological and agronomical traits, results showed application of three level of bacteria led to the increase of seed yield and in relation to Nano-Fe fertilizer, the highest seed yield obtained by the 1% nano-Fe fertilizer. Between three tested bacteria, the Azotobacter highest effects on LA, CGR and HI, so, we propose application of nano-Fe fertilizer and plant growth-promoting bacteria together for the improving triticale yield in Iran and similar regions.

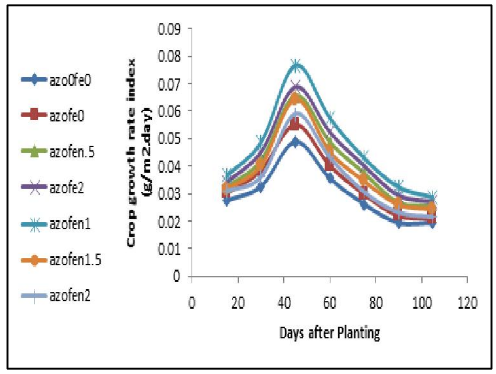

Fig. 6. Crop growth rate index in response to Fe and *Azospirillium methylpofrome.*

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FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

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