Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 7, No. 4, 2021
http://JCNS.ahvaz.iau.ir
OPEN ACCESS

Response of Seed yield, Its Components and Nitrogen Use Efficiency to Apply Different level of Urea Fertilizer and Nitroxin of Barley

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RESEARCH ARTICLE

ARTICLE INFO.
Received Date: *6 Oct. 2021*
Received in revised form: *5 Nov. 2021*
Accepted Date: *10 Dec. 2021*
Available online: *30 Dec. 2021*

To Cite This Article:
Najmeh Haghighatzadeh, Mani Mojaddam. Response of Seed yield, Its Components and Nitrogen Use Efficiency to Apply Different level of Urea Fertilizer and Nitroxin of Barley. ***J. Crop. Nutr. Sci.,*** 7(4): 32-44, 2021.

ABSTRACT

BACKGROUND: Environmental factors (such as consumption of macro- and micro-fertilizers) and use of agronomic bio-fortification strategy can exert larger influences on seed yield (GY), agro-morphological traits and grain micronutrients concentration of food crops.

OBJECTIVES: Current study was done to assess effect of urea fertilizer and Nitroxin bio-fertilizer on crop production and nitrogen use efficiency of Barley.

METHODS: This research was consisted according split plot experiment based on randomized complete blocks design with three replications. The main plot included pure nitrogen sourced from urea fertilizer (a_1: 50 kg.ha^{-1}, a_2: 100 kg.ha^{-1}, a_3: 150 kg.ha^{-1}) and different level of Nitroxin biofertilizer (b_1: nonuse of Nitroxin or control, b_2: 2 L.ha^{-1}, b_3: 4 L.ha^{-1}) belonged to subplots.

RESULT: According result of analysis of variance effect of Nitrogen, Nitroxin and interaction effect of treatments (instead 1000-seed weight, harvest index, Nitrogen use efficiency and nitrogen agronomic efficiency) on all measured traits was significant. Mean comparison result of different level of Nitrogen indicated that maximum amount of number of spike per m^2 (393.02), number of seed per spike (29.55), 1000-seed weight (36.6 gr), seed yield (4051.15 kg.ha^{-1}), biologic yield (1300.47 gr.m^{-2}), harvest index (31.15%) belonged to 150 kg.ha^{-1} nitrogen and lowest one belonged to 50 kg.ha^{-1} but nitrogen use efficiency (58.23 kg. kg^{-1}) and nitrogen agronomic efficiency (10.54 kg. kg^{-1}) had reverse trend and highest amount of mentioned traits was for 50 kg.ha^{-1} nitrogen. Compare different level of Nitroxin revealed the highest amount of studied traits was noted for 4 L.ha^{-1} (Also it doesn't have significant effect with 2 L.ha^{-1}) and minimum amount belonged to control.

CONCLUSION: Due to economical aspect application 150 kg.ha^{-1} nitrogen fertilizer with 2 L.ha^{-1} Nitroxin biofertilizer produced highest crop production and it can advised to farmers in studied region.

KEYWORDS: *Biofertilizer, Cereal, Dual purpose, Nutrition, Spike.*

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1. BACKGROUND

To alleviate the negative effect of fertilizers, integrated plant nutrient management is an option as it utilizes available organic and inorganic nutrients to build ecologically sound and economically viable farming system. Research has suggested that integrated nutrient management strategies involving chemical fertilizers and bio-fertilizers enhance the sustainability of crop production. Integrated plant nutrient management is the combined use of mineral fertilizers with organic resources such as cattle manures, crop residues, urban/rural wastes, composts, green manures and bio-fertilizers (Kemal and Abera, 2015). Among the macro nutrients essential for crop growth, nitrogen (N) is a very mobile element in the soil, due to its susceptibility to leaching, de nitrification, and volatilization losses. Excessive use of N fertilizer can lead to pollution of water bodies and may lead to soil acidification. Balanced and efficient use of applied N is of paramount importance in the overall nutrient management system than any other plant nutrient in order to reduce its negative impact on the environment. Besides, even under the best management practices, 30%-50% of the applied nitrogen is lost through different routes and hence more fertilizer needs to be applied than actually needed by the crop to compensate for the loss. The transitory loss of N not only causes loss to the farmer but also causes irreversible damage to the environment. High rates of chemical fertilizer cause environmental pollution (Shamme *et al.,* 2016). Availability of nitrogen is important for growing plants. It is a main constituent of protein and nucleic acid molecules. It is also a part of chlorophyll molecules. It is well known that the use of fertilizer helps in production and is a quick method resulted in the best yields (Farooqui *et al*., 2009). Biological fertilizers cause the economic sustainability of soil resources, production, long-term maintenance and prevent of environmental pollution. On the other hand, the quality of food is a product of biological fertilizers not only consumer satisfaction but also supply and guarantee their physical health (Shoaei *et al.*, 2012). Nitroxin contains nitrogen fixation bacteria (Azotobacter) not only fixes the air nitrogen and balance the uptake of macro and micronutrients but also enhances plant growth and increase the quality and quantity of products through the synthesis and secretion of growth promoting substances (Ansari and Rousta, 2008). Nitroxin bio-fertilizers include a series of nitrogen-fixing bacteria of the genus Azotobacter, and Azospirillum that causes the growth of roots and aerial parts of the plant (Gilik *et al*., 2001). Nouraki *et al.* (2016) reported bacteria have positive role in the production of bio-fertilizers and hormones which play a significant role in regulating plant growth while mixing them with chemical fertilizers as a supplement the level and depth of the roots. This combination also increases the rate of water and nutrient absorbance which raise the rate of growth and photosynthesis. These combination also increase the grain yield, yield components, and biological function, it has been found that bio-fertilizers can be combined with chemical fertilizers in a complementary way to reduce the excessive amount of chemical fertilizers used to grow corn. It was shown that the mixing of biological fertilizers with chemical fertilizers could reduce the needs of chemical fertilizers up to 25% and these results are comparable to the application of 100% chemical fertilizers. Therefore, the best hybrid maze is the single cross 704 that has good yield potential when the chemical fertilizer is used at either 25% or 50% of the current application when mixed with the bio-fertilizer. Jafari Haghighi and Yarmahmodi (2011) in conclusion for reach to high yield in corn stated biological fertilizer cannot sufficient but integrated application of fertilizers (Biological and chemical fertilizers) became causes significant increase in yield. Charkhab and Mojaddam (2018) reported consumption 150 $Kg.ha^{-1}$ nitrogen fertilizer with 1 $L.ha^{-1}$ Nitroxin led to achieve maximum seed yield (350 $gr.m^{-2}$) and it can be advice to producers.

2. OBJECTIVES

Current study was done to assess effect of urea fertilizer and Nitroxin bio-fertilizer on crop production and nitrogen use efficiency of Barley.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was consisted according split plot experiment based on randomized complete blocks design with three replications along 2013-2014 agronomic years. Place of research was located in Ahvaz city at longitude 48°40'E and latitude 31°20'N in Khuzestan province (Southwest of Iran). The main plot included pure nitrogen sourced from urea fertilizer (a_1: 50 $kg.ha^{-1}$, a_2: 100 $kg.ha^{-1}$, a_3: 150 $kg.ha^{-1}$) and different level of Nitroxin biofertilizer (b_1: nonuse of Nitroxin or control, b_2: 2 $L.ha^{-1}$, b_3: 4 $L.ha^{-1}$) belonged to subplots. This experiment had 27 plots. Each plot consisted of 7 lines with a distance of 20 cm and 5 meters length. The experiment site had a hot climate with a moderate winter, dry and hot summer. Physical and chemical properties of studied soil were mentioned in table 1.

Table 1. Physical and chemical properties of studied soil

Depth (cm)	**EC ($ds.m^{-1}$)**	**pH**	**SP (%)**
0-30	4.31	7.3	47
P (ppm)	**K (ppm)**	**OC (%)**	**Soil Texture**
9.1	194	0.6	Clay loam

3.2. Farm Management

Based on research recommendations, seeds were planted in rows 18 cm apart at about 300 seeds per m^2 on December 2^{nd}. All nitrogen application rates, half was applied before seed sowing (incorporated by disk) and the remaining nitrogen was applied as a top dressing at the beginning of barley tillering corresponding to stage 21 of Zadoks scale. 80 kg of phosphorus from the triple superphosphate source was mixed with the soil before planting. Seeds were inoculated immediately before planting with Nitroxin bacteria according recommended method. Controlling weeds was done mechanically and manually. During the test period, no disease and pests were seen.

3.3. Measured Traits

From each experimental plot, 10 plants were harvested taking to determine the final yield. The area occupied by these 10 plants was calculated as the final yield was estimated in terms of square meters. Yield components in a crop are components of the final production of the plant and each crop has its own components. Yield components in barley plant include number of spike per m^2, number of seeds per spike and 1000-seed weight, which were harvested and measured in 10 plants. Harvest index (HI) was calculated according to formula of Gardner *et al*. (1985) as follows:

Equ.1. HI= (Seed yield/Biologic yield) × 100.

In order to measure nitrogen in the grain ripening stage, seed and straw were sampled separately and the percentage of seed nitrogen content (SNC) and straw nitrogen content (StNC) was measured by Kjeldahl method (Svecnjak and Rengel, 2006). **Equ. 2.** NUE (Nitrogen use efficiency, $Kg.Kg^{-1}$) = (Gw/Ns) (Huggins and Pan, 1993)

Ns = Nf + Nr + Nm + Nx + Nd, Gw= Seed yield ($kg.ha^{-1}$), Ns= Nitrogen storage available to the plant ($kg.ha^{-1}$), Nf= Nitrogen content of Nitrogen Fertilizer, Nr= Mineral nitrogen residues in the soil before planting, Nm= Mineralized nitrogen during the soil season, Nd= Nitrogen added to soil through atmosphere, irrigation water and running water. The amounts of other sources of mineral nitrogen (Nx, Nd) are very small and are ignored.

Equ. 3. NAE (Nitrogen agronomic efficiency, $Kg.Kg^{-1}$) = (Seed yield of fertilized plot - Seed yield of unfertilized plot) / applied N fertilizer (Fageria, 2009)

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.8) software and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Number of spike per m^2

According result of analysis of variance effect of Nitrogen, Nitroxin and interaction effect of treatments on number of spike per m^2 was significant at 1% probability level (Table 2). Mean comparison result of different level of Nitrogen indicated that maximum number of spike per m^2 (393.02) was noted for 150 $kg.ha^{-1}$ nitrogen fertilizer and minimum of that (345.1) belonged to 50 $kg.ha^{-1}$ treatment (Table 3). As for Duncan classification made with respect to different level of Nitroxin maximum and minimum amount of number of spike per m^2 belonged to 4 $L.ha^{-1}$ (384.63, Also it doesn't have significant difference with 2 $L.ha^{-1}$) and control (338.9) (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum number of spike per m^2 (425) was noted for 150 $kg.ha^{-1}$ Nitrogen and 4 $L.ha^{-1}$ Nitroxin and lowest one (330) belonged to 50 $kg.ha^{-1}$ Nitrogen and none use of Nitroxin treatment (Fig.1). Fallahi *et al.* (2008) founded that Nitroxin biofertilizer had significant effects on main yield components, seed yield; essential oil .They concluded that this bio-fertilizer can be considered as a replacement for chemical fertilizers the absorbed nitrogen during this time leads to the increase of the number of spikelet. In different experiments it was observed that the yield and its components increased in the crop inoculated with Azospirillum. Dadiyan *et al*. (2013) and Fathi (2010) reported use Nitroxin fertilizer led to increase the number of seed per row.

4.2. Number of seed per spike

Result of analysis of variance revealed effect of Nitrogen, Nitroxin and interaction effect of treatments on number of seed per spike was significant at 5% probability level (Table 2). According result of mean comparison maximum of number of seed per spike (29.55) was obtained for 150 $kg.ha^{-1}$ Nitrogen and minimum of that (21.80) was for 50 $kg.ha^{-1}$ treatment (Table 3).

Table 2. Analysis of variance of measured traits

S.O.V	df	Number of spike per m^2	Number of seed per spike	1000-seed weight	Seed yield
Replication	2	1547^{ns}	20.41^{ns}	3.2^{ns}	9120.4^{ns}
Nitrogen (A)	2	8479.3^{**}	70.24*	94.21**	50147.1**
Error I	4	570.11	13.45	5.24	2900.5
Nitroxin (B)	2	9487.01^{**}	85.11*	58.3**	46715.6**
A×B	4	10547.24^{**}	62.3*	0.06^{ns}	20546.1**
Error II	12	537.5	1.24	4.23	1854
CV (%)	-	6.31	12.67	6.33	12.94

$^{ns, *\ and\ **}$: non-significant, significant at 5% and 1% of probability level, respectively.

Continue table 2.

S.O.V	df	Biologic yield	Harvest index	Nitrogen use efficiency	Nitrogen agronomic efficiency
Replication	2	2587^{ns}	40.23^{ns}	120.2^{ns}	0.136^{ns}
Nitrogen (A)	2	90147^{*}	71.02^{**}	1840.5^{**}	1.409^{*}
Error I	4	6470.1	7.24	180.3	0.314
Nitroxin (B)	2	83355^{*}	64.32^{**}	1400.8^{**}	0.826^{*}
A×B	4	76546^{*}	0.18^{ns}	0.18^{ns}	0.001^{ns}
Error II	12	6310.8	5.16	90.68	0.29
CV (%)	-	6.44	8.5	18.62	6.91

$^{ns, *\ and\ **}$: non-significant, significant at 5% and 1% of probability level, respectively.

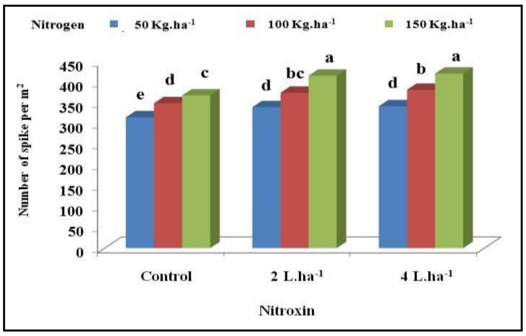

Fig.1. Mean comparison interaction effect of treatment on Number of spike per m^2
Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Evaluation mean comparison result indicated in different level of Nitroxin the maximum number of seed per spike (28.18) was noted for 4 L.ha^{-1} and minimum of that (22.04) belonged to control treatment (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum number of seed per spike (32) was noted for 150 kg.ha^{-1} Nitrogen and 4 L.ha^{-1} Nitroxin and lowest one (21) belonged to 50 kg.ha^{-1} Nitrogen and none use of Nitroxin treatment (Fig.2).

4.3. 1000-seed weight

According result of analysis of variance effect of Nitrogen and Nitroxin on 1000-seed weight was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Assessment mean comparison result indicated in different level of Nitrogen the maximum 1000-seed weight (36.60 gr) was noted for 150 kg.ha^{-1} and minimum of that (29.18 gr) belonged to 50 kg.ha^{-1} treatments (Table 3). Compare different level of Nitroxin showed that the maximum and the minimum amount of 1000-seed weight belonged to 4 L.ha^{-1} (35.74 gr) and control (28.43 gr) treatments (Table 4). Sadeghi and Kazemeini (2011) reported increasing the amount of nitrogen application increased the weight of 1000-seed in barley varieties. Since nitrogen fertilizer increases dry matter production and leaf area, barley seed also became heavier with increasing nitrogen application.

4.4. Seed yield

Result of analysis of variance revealed effect of Nitrogen, Nitroxin and interaction effect of treatments on seed yield was significant at 1% probability level (Table 2). Evaluation mean comparison result revealed in different level of Nitrogen the maximum seed yield (4051.15 kg.ha^{-1}) was noted for 150 kg.ha^{-1} Nitrogen and minimum of that (2641.34 kg.ha^{-1}) belonged to 50 kg.ha^{-1} treatment (Table 3). Between different levels of Nitroxin the maximum seed yield (3890.83 kg.ha^{-1}) was observed in 4 L.ha^{-1} and the lowest one (2380.09 kg.ha^{-1}) was found in control treatment (Table 4). Evaluation mean comparison result of interaction effect of treatments indicated maximum seed yield (4250 kg.ha^{-1}) was noted for 150 kg.ha^{-1} Nitrogen and 4 L.ha^{-1} Nitroxin and lowest one (2500 kg.ha^{-1}) belonged to 50 kg.ha^{-1} Nitrogen and none use of Nitroxin treatment (Fig.3). Azimi *et al.* (2013a) found that application of super nitroplass bio-fertilizer with Phosphate barvar2 treatment has the highest seed yield (7.6 t.ha^{-1}) and non-application of bio-fertilizers treatment has the Pishtaz cultivar has the lowest seed yield (6.3 t.ha^{-1}).

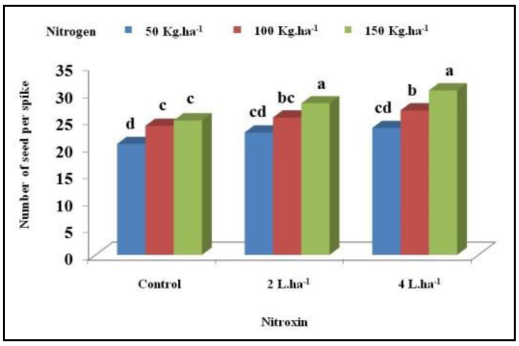

Fig.2. Mean comparison interaction effect of treatment on number of seed per spike
Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Azimi *et al*. (2013b) was reported that grain yield and biomass yield increasing with the bio fertilizer application, also which account important benefit, causing decreasing in the inputs of production because of economizing much money to chemical fertilizers and increasing in yield and biological yield. Many researchers have reported that growth-promoting bacteria, through processes such as molecular nitrogen fixation, production of growth-promoting hormones, and secretion of various enzymes such as phosphatase and organic acids cause phosphate solubilization and increase plant absorbable phosphate. Therefore, they increase the yield and yield components of the plant (Tohidi Moghaddam *et al*., 2007; Lin *et al*., 2002).

Table 3. Mean comparison effect of different level of Nitrogen on measured traits

Treatment	Number of spike per m^2	Number of seed per spike	1000-seed weight (gr)	Seed yield ($kg.ha^{-1}$)
50 $kg.ha^{-1}$	345.1c	21.8c	29.18c	2641.34c
100 $kg.ha^{-1}$	364.12b	24.37b	31.67b	3290.27b
150 $kg.ha^{-1}$	393.02a	29.55a	36.6a	4051.15a

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

Continue table 3.

Treatment	Biologic yield ($gr.m^{-2}$)	Harvest index (%)	Nitrogen use efficiency ($kg.kg^{-1}$)	Nitrogen agronomic efficiency ($kg.kg^{-1}$)
50 $kg.ha^{-1}$	1161.41c	22.74c	58.23a	10.54a
100 $kg.ha^{-1}$	1238.63b	26.56b	51.17b	7.48b
150 $kg.ha^{-1}$	1300.47a	31.15a	44.02c	5.36c

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

4.5. Biologic yield

According result of analysis of variance effect of Nitrogen, Nitroxin and interaction effect of treatments on biologic yield was significant at 5% probability level (Table 2). Mean comparison result of different level of Nitrogen indicated the maximum and the minimum amount of biologic yield belonged to 150 $kg.ha^{-1}$ (1300.47 $gr.m^{-2}$) and 50 $kg.ha^{-1}$ treatment (1161.41 $gr.m^{-2}$) (Table 3). Among different level of Nitroxin maximum biologic yield (1294.58 $gr.m^{-2}$) was obtained for 4 $L.ha^{-1}$ and minimum of that (1132.76 $gr.m^{-2}$) was for control treatment (Table 4). Assessment mean comparison result of interaction effect of treatments indicated maximum biologic yield (1325 $gr.m^{-2}$) was noted for 150 $kg.ha^{-1}$ Nitrogen and

4 L.ha^{-1} Nitroxin and lowest one (1150 gr.m^{-2}) belonged to 50 kg.ha^{-1} Nitrogen and none use of Nitroxin treatment (Fig.4). Amanolahi-Baharvand *et al.* (2014) reported integrated fertilizer (50% urea and 50% vermicompost) management improved corn growth, chlorophyll content and remobilization in corn plants. Tarang *et al.* (2013) reported applications of Nitroxin bio-fertilizer and chemical fertilizer (400 kg.ha^{-1} urea with 300 kg.ha^{-1} ammonium phosphate) had a significant effect on traits of root dry weight, number of seed per row (36.5), number of seeds per ear (458.56), 1000-grain weight, seed (13.23 t.ha^{-1}) and biological yield (26.4 t.ha^{-1}) , and harvest index (53.88%).

Table 4. Mean comparison effect of different level of Nitroxin on measured traits

Treatment	Number of spike per m^2	Number of seed per spike	1000-seed weight (gr)	Seed yield (kg.ha^{-1})
Control	338.9b	22.04b	28.43b	2380.09b
2 L.ha^{-1}	378.71a	25.51a	33.27a	3711.82a
4 L.ha^{-1}	384.63a	28.18a	35.74a	3890.83a

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

Continue table 4.

Treatment	Biologic yield (gr.m^{-2})	Harvest index (%)	Nitrogen use efficiency (kg.kg^{-1})	Nitrogen agronomic efficiency (kg.kg^{-1})
Control	1132.76b	21.01b	45.11b	5.25b
2 L.ha^{-1}	1273.17a	29.14a	53.02a	8.76a
4 L.ha^{-1}	1294.58a	30.05a	55.31a	9.38a

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

4.6. Harvest index

According result of analysis of variance effect of Nitrogen and Nitroxin on harvest index was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of Nitrogen indicated the maximum harvest index (31.15%) was obtained for 150 kg.ha^{-1} and minimum of that (22.74%) was for 50 kg.ha^{-1} treatment (Table 3). Compare different level of Nitroxin showed that the maximum and the minimum amount of harvest index belonged to 4 L.ha^{-1} (30.05%) and control (21.01%) treatments (Table 4). Harvest index shows the way of dividing the nutritional materials between the growing structures of grain and plant. As one of the components for calculating the HI is grain yield, the changes in HI depend very much on the changes of grain yield. Based on the formula of HI, every factor can change the harvest index when the grain yield is influenced more than total dry weight (Sinclair *et al.*, 1990). Han and Lee (2006) attributed the increase in corn harvest index in bio-fertilizer treatment to better absorb nutrients.

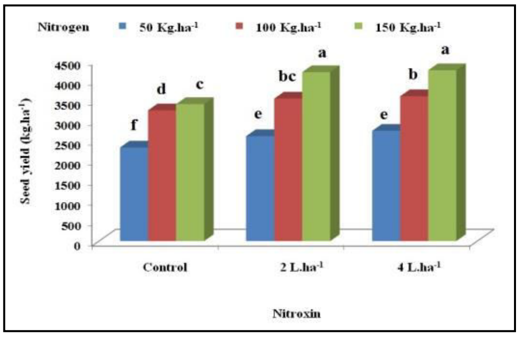

Fig.3. Mean comparison interaction effect of treatment on seed yield.
Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

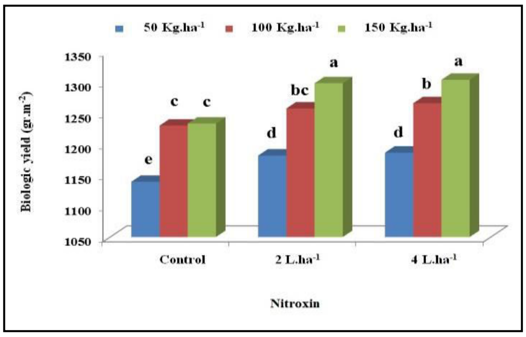

Fig.4. Mean comparison interaction effect of treatment on biologic yield.
Means with similar letters in each column are not significantly differentt by Duncan's test at 5% probability level.

Because the plant with better absorption of nutrients and increasing leaf area index can use better solar radiation and send more photosynthetic materials to seed and thus increase dry matter.

4.7. Nitrogen use efficiency

Result of ANOVA revealed effect of Nitrogen and Nitroxin on nitrogen use efficiency was significant at 1% probability level but interaction effect of treatments was not significant (Table 2). According mean comparison result of different level of nitrogen the maximum nitrogen use efficiency (58.23 $kg.kg^{-1}$) was observed in 50 $kg.ha^{-1}$ and the lowest one (44.02 $kg.kg^{-1}$) was for in 150 $kg.ha^{-1}$ treatments (Table 3). Between different levels of Nitroxin highest value of nitrogen use efficiency was belonged to 4 $L.ha^{-1}$ treatment (55.31 $kg.kg^{-1}$) and lowest one was found in control treatment as 45.11 $kg.kg^{-1}$ (Table 4). Ahmadi *et al.* (2018) reported increasing nitrogen consumption, nitrogen use efficiency decreased. It should be noted the nitrogen use efficiency is product of nitrogen uptake efficiency and nitrogen utilization efficiency.

These components are in balance with each other, so an increase in one of these components will be accompanied by a decrease in the other component (Moll *et al*., 1982). A decrease in nitrogen uptake efficiency with increasing application of nitrogen fertilizer has been reported in some studies (Haile *et al*., 2012). Nitrogen utilization efficiency is from the amount of economic production organs to nitrogen consumed as fertilizer (Hamidi and Dabbagh Mohammadinasab, 2006). Other researchers also reported that with 75 $kg.ha^{-1}$ of pure nitrogen, the highest nitrogen use efficiency was obtained, but with its increase to 150 $kg.ha^{-1}$, nitrogen use efficiency decreased (Satari *et al*., 2017).

4.8. Nitrogen agronomic efficiency

According result of analysis of variance effect of Nitrogen and Nitroxin on nitrogen agronomic efficiency was significant at 5% probability level but interaction effect of treatments was not significant (Table 2). Mean comparison result of different level of Nitrogen indicated the maximum and the minimum amount of nitrogen agronomic belonged to 50 kg.ha^{-1} (10.54 kg.kg^{-1}) and 150 kg.ha^{-1} treatment (5.36 kg.kg^{-1}) (Table 3). Among different level of Nitroxin maximum Nitroxin agronomic (9.38 kg.kg^{-1}) was obtained for 4 L.ha^{-1} and minimum of that (5.25 kg.kg^{-1}) was for control treatment (Table 4). With increasing nitrogen application, nitrogen use efficiency decreases with a significant difference between all fertilizer levels. It seems that the application of seaweed biofertilizer, in addition to providing the nitrogen required by the plant due to increased shoot growth, has increased nitrogen uptake and thus has achieved the maximum efficiency of this element in the plant. Since the efficiency of nitrogen consumption is obtained from the ratio of the amount of grain produced to the fertilizer consumption, with increasing the amount of grain produced, the efficiency of fertilizer consumption also increases (Rabiei, and Tousi Kahel, 2011). The researchers reported that the yield of safflower in terms of plant dry weight increased with decreasing nitrogen supply. Nitrogen yield ratio in safflower increased under nitrogen deficiency conditions (Mohsennia and Jalilian, 2012). Solymanifard (2020) by evaluate effect of Azotobacter and nitrogen fertilizer on Nitrogen consumption efficiency indices of safflower genotypes reported the lowest nitrogen uptake efficiency was allocated to the treatment of non-fertilizer application in the first year and the treatment of 100% nitrogen fertilizer application in the second year, which were statistically in the same class. It seems that the reason for the low efficiency of nitrogen uptake in the conditions of full application of nitrogen chemical fertilizer is largely due to the difference in the yield of safflower seed produced under the influence of nitrogen application (which directly affects the uptake of nitrogen from the soil).

5. CONCLUSION

Due to economical aspect application 150 kg.ha^{-1} nitrogen fertilizer with 2 L.ha^{-1} Nitroxin biofertilizer produced highest crop production and it can advised to farmers in studied region.

ACKNOWLEDGMENT

The authors thank all colleagues and other participants, who took part in the study.

FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

FUNDING/SUPPORT: This study was done by support of Department of Agronomy, Islamic Azad University, Ahvaz Branch.

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