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Effect of Biological and Chemical Fertilizers on Yield and Yield Components of Some Maize Hybrids in South West of Iran (Shoushtar Region)

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ABSTRACT

In order to investigate effect of application of Nitroxin and nitrogen chemical fertilizer on yield and yield components, split plot experiment on the basis of Randomized Complete Block Design with four replications was conducted. Four levels of Nitrogen fertilizer (N_1: 100% chemical fertilizer, N_2: 75% chemical fertilizer + 100% biological fertilizer, N_3: 50% chemical fertilizer + 100% biological fertilizer, N_4: 25% chemical fertilizer + 100% biological fertilizer) in main plots and three Maize Hybrids (H_1: S.C. 704, H_2: Mobin, H_3: Karun 701) in subplots were studied. Results showed that the highest grain yield belonged to 50% chemical fertilizer + 100% biological fertilizer and Karun hybrid, and the lowest one belonged to 75% chemical fertilizer + 100% biological fertilizer and S.C. 704. Maximum biological yield belonged to 50% chemical fertilizer + 100% biological fertilizer and Karun hybrid. The highest harvest index belonged to 100% chemical fertilizer and Mobin hybrid and the minimum harvest index in treatment of 75% chemical fertilizer + 100% biological fertilizer and S.C. 704 hybrid was seen. 1000-grain weight in treatment of 100% chemical fertilizer and Mobin hybrid have maximum rate. Maximum number of grain per ear and grain per row belonged to the treatment with 100% chemical fertilizer and S.C. 704 hybrid. In maize which require high nutrition for optimal yield, Biological fertilizer application alone cannot replace chemical fertilizers, but they can be used as supplements for chemical fertilizers. Finally application of N fertilizer level at 50% chemical fertilizer + 100% biological fertilizer and Karun hybrid were recommended.

Keywords*:* *Corn, Hybrids, Nitrogen, Nitroxin.*

INTRODUCTION

Due to high cost of the chemical fertilizers production and environmental problems, it is necessary to revise the methods for increasing production. In this regard, application of biological products seems to be a fundamental solution. The bio-fertilizers are usually made from soil; so, they improve soil structure, increase product, and reduce diseases (Kouchebagh *et al*., 2012).

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Micro organisms as an integral part of the soil are able to improve the growth of their host plant by increasing the solubility of ingredients as well as increasing the absorptive surface of roots especially in soils with low fertility (Azcon and Atrash, 1997). In sustainable agriculture system, biological fertilizers play an important role in crop production and increasing soil fertility conservation (Sharma, 2003). Chemical fertilizers are not based on above concepts due to excessive reliance on non-renewable energy sources. Therefore, depending on these materials in sustainable production reduces by replacing them with other materials (Khavari 1998). Today, bio-fertilizers in some cases as an alternative and in most cases as supplement chemical fertilizers can ensure sustainability of production in agricultural systems (Vessey, 2003). Bio-fertilizers are able to fix atmospheric nitrogen in the available form for plants (Kouchebagh *et al*., 2012). In order to Integrated nutrient management, strategies involving chemical fertilizer and the bio-fertilizer have suggested enhancing the sustainability of crop production (Manske *et al*., 1998). In recent years the Bio-fertilizers have emerged as a promising component of integrating nutrient supply system in agriculture. Our whole system of agriculture depends in many important ways, on microbial activities and there appears to be a tremendous potential for making use of micro organisms in increasing crop production, Microbiological fertilizers are an important part of environment friendly sustainable agricultural practices (Bloemberg *et al*., 2000). Bio-fertilizers are able to fix atmospheric nitrogen in the available form for plant (Chen, 2006) and have beneficial upon plant growth by production of antibiotic (Zahir *et al*., 2004). Azotobacter is used as bio-fertilizer in the cultivation of most important crops (Yasari and Patwardhan, 2007). Nitrogen supply through high consumption of fertilizer is one of the causes of the pollution of water cycle in nature and its production is very expensive and costly, so replacement it with biological fertilizer is highly important (Chandrasekar *et al*., 2005). Bio-fertilizers have the significant advantages to chemical fertilizers; for instance, they do not produce toxic and bacterial substances in the food chain, are able to reproduce spontaneously, can improve the physical and chemical properties of the soil, are affordable economically and are acceptable environmentally (Shaukat *et al*., 2006). Application of Nitroxin biological fertilizer in the sesame plant increases number of seeds per capsule, seed weight, biological function, and seed yield (SajjadiNik, 2010). 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). According to (Hamidi *et al*., 2009), plant height and plant diameter in corn increase much more in the effect of inoculation with Azospirillum Azotobacter bacteria than non-inoculated. Besides, inoculation of wheat seeds with bacteria such as Azotobacter and Azospirillum can lead to stem dry weight, and dry weight of plants (De Freitas, 2000). In an experiment the effect of Azotobacter on growth characteristics, showed that the inoculation with Azotobacter has significantly affected grain weight per plant, total plant weight, grain yield and the nitrogen content of grain, compared with control (Eidy Zadeh *et al*., 2012). Mycorrhiza cause more efficient phosphorus uptake, decrease risk of soil erosion and reduces phosphorus leaching. Mycorrhizal functions are, however, very sensitive for human activities. They can be totally suppressed but also the remarkably improved by an appropriate cropping system where crop rotation has a marked impact (Dodd *et al*., 1990; Jonson *et al*., 1991). Application of mycorrhiza and non symbiotic nitrogen fixing bacteria have been shown to enhance soil fertility and availability of nutrients for the plants (Cardoso and Kuyper, 2006, Dodd, 2000), and to increase photosynthesis and water use efficiency (Estrada-Luna and Davies, 2003; Auge 2000; Gosling *et al*. 2006; Wu and Xia, 2006), and also resistance to biotic and non biotic stresses (Jeffries *et al*., 2003). Hamidi *et al* (2009) studied the effect of increasing the growth of bacteria on some corn hybrids and reported that the use of bacteria increases during pollination, tasseling, flowering, grain filling and grain yield. Grain yield increase with application of bio-fertilizers is due to evolve long grain filling period and increase absorption of nutrients from the soil. In addition, the effect of biological fertilizers on the dry matter and photosynthesis is also reported (Geneva *et al*., 2006). Sharifi and Hagh Nia (2007) stated Nitroxin fertilizer had a significant effect on all the measured traits except 1000-grain weight. The research was carried out to investigate the effect of combination of biological and chemical fertilizers on yield and yield components of grain maize hybrids in warm and dry climate region.

MATERIALS AND METHODS

Field and Treatment Information's

The research was conducted in 2013 at split plot experiment based on Randomized Complete Block Designs (CRBD) with the four replications at Experimental Field of Shoushtar region in south west of Iran (32°30' N, 48°20' E and altitude 18 m) with moderate winters and hot summers. Four levels of Nitrogen fertilizer (N_1: 100% chemical fertilizer, N_2: 75% chemical fertilizer + 100% biological fertilizer, N_3: 50% chemical fertilizer + 100% biological fertilizer, N_4: 25% chemical fertilizer + 100% biological fertilizer) in main plots and three Maize Hybrids (H_1: S.C. 704, H_2: Mobin, H_3: Karun 701) in subplots were studied.

Crop Management

Phosphorus and potassium fertilizers were provided from 150 kg.ha^{-1} triple superphosphate and 150 kg.ha^{-1} potassium sulfate. Biological fertilizer of Nitroxin was used as much as 2 liters per hectare as combined with seeds. Nitrogen chemical fertilizer was provided from the urea source, 50% during planting and 50% during 8-leaf stage. To determine some physical and chemical properties of the soil in the region two samples were taken from the depths of 0-30 and 30-60 cm (Table 1).

Table 1. Physical and chemical properties of experimental field

Soil depth (cm)	0-30	30-60
Acidity (pH)	8.46	8.50
Electrical conductivity (ds. m^{-1})	4.07	2.69
Organic carbon (%)	0.507	0.351
Absorbable phosphorus (ppm)	8	7
Absorbable potassium (ppm)	180	170
Soil tissue	Loam	Loam

Each sub plot included the 6 planting lines with a length of 5 m. The distance between row and inter row were 75 and 18 cm respectively. Irrigation was done every 3 or 4 days and after the plant establishment it was done every 7 to 10 days if necessary. The weeds were controlled via Cruise herbicide by 2 $l.ha^{-1}$ at 4-to-5-leaf stage and Krakrown pesticide by 1 $l.ha^{-1}$ against leaf and stem borer larvae.

Traits measure

The studied traits included grain yield, biological yield, 1000-grain weight, number of grain per ear, number of grain per row, number of rows per ear, and harvest index. In order to determine the number of grain rows per ear, number of grain per row and number of grain per ear samples including 10 plants were selected randomly from each experimental unit and the mean values for each trait were recorded. After drying the samples (48 hours in oven at 75 °C) and weighing, the biological yield was obtained. After separating grain from the selected plants and weighing them, grain yield was calculated based on 14% moisture. In order to 1000-grain weigh, 5 samples of seed containing 100 grain were separated and the means were calculated. The final harvest area of each plot was 1.5 m^2.

Statistical analysis

Te analysis of variance was done by Minitab software (Ver. 14) and the means were compared using Duncan's multi range test at 5% probability level.

RESULTS AND DISCUSSION

Number of grain per row

According to ANOVA results effect of fertilizer combination, different hybrids, and interaction effect of treatments on the number of grain per row were significant at 1% probability level (Table 2). Mean comparison results of fertilizer combination showed highest and lowest number of grains per row belonged to the treatments with 100% urea + 0% Nitroxin and 75% urea + 100% Nitroxin (Table 3). Among the hybrids, the highest and the lowest number of grains per row by 37.95 and 31.95 belonged to SC. 704 hybrid and Mobin hybrid, respectively (Table 4). The highest number of grain per row was observed in 100% urea + 0% Nitroxin + S.C. 704, and the lowest number of grains per row was in 25% urea + 100% Nitroxin + Mobin hybrid (Table 5). Those results had conformity with the findings of some researchers (Taghi Zadeh and Seyed Sharifi, 2008, Valad Abadi, 2005). Increase of nitrogen application removes nitrogen restrictions for maize, increases photosynthetic and productive efficiency of plant, and consequently increases the number of grain per row (Taghi Zadeh and Seyed Sharifi, 2008). Amou Aghaei *et al*. (2003) believe that hormonal effect induced by growth promoting bacteria directly increases the number of grain per row, it seems that the increase of nitrogen can increase assimilates for filling grain particularly on top of the ear and increase of nutrients will have more effect on number of grain per row.

Number of rows per ear

The ANOVA results showed that effect of different hybrids on number of grain rows per ear was significant at 1% probability level but the effect of fertilizer combination and the interaction effect of treatments were not significant (Table 2). Among the hybrids, the highest and the lowest number of rows per ear belonged to Mobin hybrid and Karun hybrid, respectively (Table 4).

Table 2. Summary results of analysis variance of traits

S.O.V	df.	Grain yield	Biological yield	Harvest index	1000-grain weight	Number of grain per row	Number of rows per ear	Number of grain per ear
Block	3	$2.257^{n.s}$	6.436^{*}	$8.10^{n.s}$	$42.9^{n.s}$	33.143^{**}	$0.8641^{n.s}$	5183^{*}
Fertilizer	3	4.706^{*}	16.935^{**}	190.47^{**}	2602.1^{*}	32.525^{**}	$0.7419^{n.s}$	7809^{**}
Error a	9	1.174	0.924	25	462.5	3.202	0.7285	1075
Hybrid	2	$0.493^{n.s}$	21.069^{*}	$114.64^{n.s}$	5281.8^{**}	159.641^{**}	2.3377^{**}	25655^{**}
Fertilizer × hybrid	6	$4.021^{n.s}$	$8.707^{n.s}$	215.71^{**}	$1382^{n.s}$	41.632^{**}	$0.3744^{n.s}$	8004^{**}
Error b	24	1.825	4.229	44.22	611.3	6.189	0.3808	1842
CV (%)		11.65	9.87	11.89	8.05	7	4.26	8.36

*, **, ns respectively indicate significant at 5% and 1% probability levels and non-significant.

Table 3. Mean comparison of fertilizer combination on measured traits.

Fertilizer	Grain yield ($t.ha^{-1}$)	Biological yield ($t.ha^{-1}$)	Harvest Index (%)	1000-grain weight (g)	Number of grain per row	Number of rows per ear	Number of grain per ear
100% urea + 0% Nitroxin	12.17^{a*}	20.11^{b}	61.88^{a}	304.83^{ab}	37.01^{a}	14^{a}	487.493^{b}
75% urea + 100% Nitroxin	10.78^{b}	20.18^{b}	53.68^{b}	298.75^{b}	33.95^{a}	14^{a}	544.73^{a}
50% urea + 100% Nitroxin	11.99^{ab}	22.60^{a}	53.22^{b}	328.66^{a}	34.25^{a}	14^{a}	498.58^{b}
25% urea + 100% Nitroxin	11.44^{ab}	20.45^{b}	55.95^{ab}	296.58^{b}	36.86^{a}	14^{a}	522.347^{ab}

*Means, in each column, followed by similar letter are not significantly different at the 5% probability level- using Duncan's Multiple Range Test.

Table 4. Mean comparison of maize hybrids on measured traits.

Hybrids	Grain yield ($t.ha^{-1}$)	Biological yield ($t.ha^{-1}$)	Harvest Index (%)	1000-grain weight (g)	Number of grain per row	Number of rows per ear	Number of grain per ear
SC.704	11.7294 a*	21.4525 a	54.8938 a	289.813 b	37.95 a	14.575 a	552.875 a
Mobin	11.4006 a	19.5175 b	59.2663 a	326.063 a	31.95 b	14.7938 a	472.805 b
Karun	11.6713 a	21.5538 a	54.405 a	305.75 b	36.6625 a	14.05 b	514.19 a

*Means, in each column, followed by similar letter are not significantly different at the 5% probability level- using Duncan's Multiple Range Test.

Table 5. Mean comparison of interaction effects of treatments on measured traits.

Treatment	Grain yield ($t.ha^{-1}$)	Biological yield ($t.ha^{-1}$)	Harvest Index (%)	1000-grain weight (g)	Number of grain per row	Number of rows per ear	Number of grain per ear
100 % chemical +704 hybrid	12.445 ab*	20.4075 bc	60.9925 b	270.75 e	4245 a	14.6 ab	619.22 a
100 % chemical + Mobin hybrid	12.6575 a	17.2975 d	74.03 a	347.25 a	3185 de	15.5 a	493.78 bc
100% chemical + Karun hybrid	11. 43 abc	22.625 ab	50.645 cde	296.5 bcde	3675 bc	14.2 b	521.2 b
75% chemical + 100% biological + 704 hybrid	10.1625 c	21.2675 abc	47.97 e	290 cde	326 cde	14.5 ab	472.78 bc
75% chemical + 100% biological + Mobin hybrid	11.08 abc	20.35 bc	54.2925 bcde	308 bcde	3285 cde	14.8 ab	487.24 bc
75% chemical + 100% biological + Karun hybrid	11.1075 abc	18.9475 cd	58.7975 bcd	298.25 bcde	364 bc	13.8 b	502.46 bc
50% chemical + 100% biological + 704 hybrid	11.445 abc	22.845 ab	50/1475 de	311.5 abcd	347 bcd	14.8 ab	513.62 b
50% chemical + 100% biological + Mobin hybrid	11.5525 abc	20.945 bc	55/665 bcde	328 ab	3295 cde	14.5 ab	477.02 bc
50% chemical + 100% biological + Karun hybrid	12.9775 a	24.0375 a	53.85 bcde	346.5 a	351 bcd	14.4 ab	505.12 b
25% chemical + 100% biological + 704 hybrid	12.865 a	21.29 abc	60.465 bc	287 cde	4205a	14.4 ab	605.88 a
25% chemical + 100% biological + Mobin hybrid	10.3125 bc	19.4775 cd	53.0775 bcde	321 abc	3015e	14.375 ab	433.18 c
25% chemical + 100% biological + Karun hybrid	11.17 abc	20.605 bc	54.3275 bcde	281.75 de	384 ab	13.8 b	527.98 b

*Means with similar letters are not significantly different from each other at 5% probability level.

The highest number of rows per ear was observed in 100% urea + 0% Nitroxin + Mobin hybrid, and the lowest one were in treatments with 75% urea + 100% Nitroxin + Karun hybrid and 25% urea + 100% Nitroxin + Karun hybrid (Table 5). The results were consistent with findings of Alipour and Seyed Sharifi (2007). Decrease of nitrogen leads to decrease the number of grain rows per Ear through the reduction of leaf area development, photosynthesis rate, number of Ear florets and increase of leaves aging and grains abortion (Moser *et al*., 2006).

Number of grain per ear

Effect of fertilizer combination, different hybrids, and interaction effect of treatments on the number of grain per ear were significant at 1% probability level (Table 2). The interaction effect of the treatments showed that highest and lowest number of grains per ear by 619.22 and 433.18 belonged to treatments with 100% urea + 0% Nitroxin– S.C. 704 and 25% urea + 100% Nitroxin – Mobin hybrid (Table 5). Those results were consistent with finding of Hemati (2010). Nutrients availability particularly nitrogen during the critical stage of grain formation influences the number of grain through increasing plant growth rate which leads to strong correlation between the number of grain per ear and leaf area index at the silking stage (Hamidi, 2006). Nitrogen enhances assimilates availability for Ear through the duration of photosynthesis and number of grain per ear increases due to decrease of grains competition for nutrients (Hamzeie and Sarmadi Nayebi, 2009). Nitroxin effectively increased number of grain per ear by expanding area and depths of root and azotobacter ability in nitrogen fixation and production of plant growth regulating hormones (Hamidi *et al*., 2009).

1000-Grain Weight

The effect of fertilizer combination and different hybrids on 1000-grain weight were significant at 5% and 1% probability level respectively, but the interaction effect of treatments was not significant (Table 2). Mean comparison results of fertilizer combination showed that the highest and the lowest of 1000-grain weight belonged to the treatments with 50% urea + 100% Nitroxin and 25% urea + 100% Nitroxin (Table 3). Mobin hybrid had highest of 1000-grain weight and then SC. 704 hybrid had the lowest amount of that trait (Table 4). That result was similar to findings of Hemati (2010) and El-Kholy *et al*. (2005). By increasing assimilates and their mobilization when the grains change into dough, nitrogen has caused the increase of grain weight in ear (Sharifi, 2010). Due to producing plant hormones, bio-fertilizer, through stimulating cell division, increase the reservoir capacity in plant and develop the root and provide conditions for nutrients uptake lead to increase of photosynthesis, when plant approaches to maturity stage, it transfers assimilates into reproductive grains (Biswas *et al*., 2008).

Grain Yield

The effect of fertilizer combination on grain yield was significant at 5% probability level but effect of different hybrids and interaction effect of treatments on grain yield were not significant (Table 2). The highest and lowest grain yield belonged to the treatments with 100% urea + 0% Nitroxin and 75% urea +100% Nitroxin, respectively (Table 3). Other researchers have reported same findings (Hemati, 2010, Biari *et al*., 2008, Cakmakc *et al*., 2006). The increase of nitrogen consumption lead to produce of more assimilates and dry matter and higher yield (Asadpour and Fayaz Moghadam, 2007). Growth promoting bacteria increase the duration of pollination, tasseling, flowering, grain filling stage and grain yield, increase of maize grain yield through the application of biological fertilizers results from longer duration of grain filling stage and the increase of nutrients uptake from soil due to the increase of the total volume of maize roots (Hamidi *et al*., 2009). Total nitrogen uptake in organic nutrition method is less than chemical method, but the continuous release of nitrogen from manure leads to more duration of nitrogen uptake rather than chemical fertilizer leads to the improvement of grain yield (Kramer *et al*., 2002).

Biological Yield

The effect of fertilizer combination on biological yield was significant at 1% level and the effect of different hybrids was significant at 5% level, but the interaction effect of treatments was not significant (Table 2). The highest and the lowest biological yield belonged to treatments with 50% urea + 100% Nitroxin by 22.61 $t.ha^{-1}$ and 100% urea+ 0% Nitroxin, respectively (Table 3). Among the maize hybrids, the highest and the lowest biological yields belonged to Karun and Mobin hybrids (Table 4). Other researchers have reported the same findings (Hemati, 2010, Hamzeie and Sarmadi Nayebi 2009, Shaharoona *et al*., 2006). Due to the positive role of the growth promoting bacteria in production and regulation of the growth promoting hormones, the surface and depth of the root will increase and uptake of water and nutrients will increase (Kramer *et al*., 2002). Consequently the growth and the photosynthesis will be improve and assimilate production will enhance which increases grain yield and biological yield (Balogh *et al*., 2006).

Harvest Index

The effect of fertilizer combination and interaction effect of treatments on harvest index were significant at 1% level but the effect of different hybrids wasn't significant (Table 2). Effect of treatments showed that highest and lowest harvest index belonged to treatments with 100% urea + 0% Nitroxin– Mobin hybrid and 75% urea + 100% Nitroxin SC. 704 hybrid (Table 5). The results were similar to findings of Hemati (2010) and Izadi and Imam (2010). Increase of harvest index due to the increase of nitrogen fertilizer in maize can physiologically attributed to the increase of leaf area continuity and, nitrogen availability. In fact by creating balance between the nutrients biofertilizers increase both vegetative and reproductive growth and by creating adequate destination (grain), the assimilates will mobilize into grains and ultimately the harvest index of plant grain increase (Kachranloei, 2010).

CONCLUSION

The results of the experiment showed that in some plants such as maize which require high nutrition for optimal yield, Biological fertilizer application alone cannot replace chemical fertilizers, but they can be used as supplements for chemical fertilizers. According to the results, application of N fertilizer level at 50% chemical fertilizer + 100% biological fertilizer and Karun hybrid are recommended.

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