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Evaluation Effectiveness of Chemical and Biological Fertilizers Combination on Corn (*Zea mays* L.) Yield

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RESEARCH ARTICLE

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ABSTRACT

In order to investigate the appropriate combination of chemical and bio-fertilizers and their effectiveness on corn seed yield while defoliating the upper leaves of the ear, a randomized complete block design experiment with four replications. Fertilizer treatments were applied at four levels including 100% urea, 75% urea + 100% Nitroxin, 50% urea + 100% Nitroxin, 25% Urea + 100% Nitroxin. In harvest stage the traits such as seed yield, biological yield, harvest index, 1000-seed weight, number of seeds per row, number of rows per ear, and number of seeds per ear were calculated. The results showed that the effect of fertilizer combination on studied traits was not significant. Al-though there was no significant difference between the means of seed yield, number of row per ear, number of seed per row, number of seed per ear, and biological yield, the maximum rate of traits belonged to the treatment with 50% urea +100% Nitroxin by 11.52 $t.ha^{-1}$, 14.82, 36.85, 547.59, and 21.30 $t.ha^{-1}$, respectively. In general results showed that application of bio-fertilizer in corn even when the upper leaves of ear are defoliated along with optimum consumption of chemical fertilizers improve yield and yield components.

Keywords: *Correlation, Nitroxin, Seed weight, Urea.*

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INTRODUCTION

Maize is staple food in most part of the world and has third position after wheat and rice (Kizilkaya, 2008). The increase of corn cultivated area and the significant effect of chemical fertilizers on production (Afsharmanesh, 2007) have increased productions costs and environmental dangers (Biari *et al*., 2008). Use of renewable resources and inputs is one of the principles of sustainable agriculture which causes maximum utilization and minimum environmental risks (Kizilkaya, 2008). This requires application of new farming approaches is bio-fertilizers (Sharma and Johri, 2002). Bio-fertilizers are bacterial and fungal microorganisms which in addition to biological nitrogen fixation and making the soil phosphorus soluble, affect growth, development, and yield of crops and soil properties by producing considerable rate of plant hormones (Richardson, 2001). Various studies indicate positive effects of chemical and bio-fertilizers on growth and yield of crops and medicinal plants. According to the results of experiments conducted by Shahroona *et al*. (2006) on corn, pseudomonas bacteria increased corn dry weight to 22.5% in greenhouse conditions. Moreover, in the field conditions, the combined application of nitrogen fertilizer and pseudomonas could increase dry matter production to 58% in comparison to control treatment (Shaharoona *et al*., 2006). Veisani *et al*. (2012) applied biological nitrogen and phosphate fertilizer and stated that the highest plant height, number of flowering shoots, number of leaves, and essence were observed in treatment with both biologic fertilizer, and the highest shoot dry weight, root dry weight, leaf weight, and chlorophyll were observed in chemical fertilizer application. Bio-fertilizers through the production of growth hormone especially Auxin can affect plant height (Vessy, 2003). According to (Boraste, 2009) plant height and plant diameter in corn increase much more in the effect of inoculation with the *Azotobacter* and *Azospirillum* bacteria than to the non-inoculated. Besides, inoculation of wheat seeds with the bacteria such as *Azotobacter* and *Azospirillum* can lead to stem dry weight, and dry weight of plant (Defreitas, 2000). Bacteria *Azotobacter* and *Azospirillum* increases plant growth with production of the different compounds facilitate uptake, atmospheric nitrogen fixation, dissolving mineral such as phosphate, production of Siderophore, production of plant hormones such as Auxin and gibberellins, and through enzymes involved in the manufacturing plant (Lucy and Glick, 2004). 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). In study of *Azotobacter* and *Azospirillum* bacteria on corn was found that inoculation with these bacteria increases corn yield (Biari *et al*., 2011). Application of Nitroxin biological fertilizer in the sesame plant increases number of seeds per capsule, seed weight, biological function, and seed yield (Boraste, 2009). Saeed Nejad and Rezvani Moghadam (2010) inoculated the seed of corn with phosphate solubilizing bacteria (*Pseudomonas florescence*) and nitrogen fixation bacteria (*Azotobacte* and *Azospirillum*) in individual and combined treatments and also chemical fertilizer treatment including 60 kg nitrogen and 40 kg phosphate, and reported that application of biological fertilizers significantly increased seed yield, biological yield, plant height, number of umbels per plant, number of seeds per umbel, number of seeds per plan, and 1000-

seed weight. Combination of the *Azotobacter*, *Azospirillum*, and *Pseudomonas* caused the greatest increase on the studied traits. Moreover, the greatest percentage of essence was observed in the treatments with combination of the *Azotobacter* and *Pseudomonas*. Investigating the effect of chemical and bio-fertilizers on corn showed that the effect of bio-fertilizer on plant height, crown spread circumference, inflorescence height, and stem yield at 5% level and on the number of tillers, total twig yield, and leaf yield at 1% level was significant, but the effect of chemical and bio-fertilizer combination on traits was not significant (Afkhami-Fathabad *et al.*, 2014). Leaves are vitally essential organs for photosynthesis, which is a major process affecting crop growth rates and is affected by either the number or the area of the leaves. Since the productivity of a plant depends on the efficiency of its photosynthetic processes, the growth and development of leaves (Karadogan and Akgun, 2009). Maize yield is strongly depended on leaves efficiency for absorption of solar radiation for photosynthesis process (Mouhamed and Ouda, 2006). Leaf photosynthesis can be influenced by many plant factors such as leaf age, leaf position, sink effects, and mutual shading, as well as environmental factors such as light, temperature, nutrition, and water availability (Lieth and Pasian, 1990). Defoliation or leaf damage, such as that associated with hail, frost, wind, chemicals for crop protection and insects, can decreases assimilate availability during seed filling, seed and biological yield (Echarte *et al.*, 2006). Different types of leaf clipping have various influences on dry matter accumulation when the leaf clipping occurs at the primary stage of seed development (Wang, 1996). Maize leaf clipping at early season significantly decreased the stem length and leaf area but it did not have any effect on leaf emergence (Prioul and Dugue, 1992). It was noticed that when the maize defoliation is severe and its time is closer to silking stage, forage yield would be decreased greatly (Burton *et al.*, 1995). Although, the previous studies indicated that some effects of defoliation on yield and yield component of maize, but there is little of information about the contribution rate of leaf position in maize yield and yield component, the present study was carried out to investigate the effect of chemical and bio-fertilizers on yield and yield components of seed corn S.C.704 while defoliating the upper leaves of ear.

MATERIALS AND METHODS

Field and Treatment Information

The research was carried out in 2013 in Shoushtar region in south west of Iran (32°30' N, 48°20' E and altitude 18 m) with moderate winters and hot summers. To investigate the effect of combination of biological and chemical fertilizers on yield and yield components of seed corn S.C. 704 while defoliating the upper leaves of ear. The experiment was conducted at randomized complete block design with four replications. The combination of biological and chemical fertilizers was applied at four levels including 100% chemical fertilizer (N_1), 75% chemical fertilizer + 100% biological fertilizer (N_2), 50% chemical fertilizer+100% biological fertilizer (N_3), 25% chemical fertilizer+ 100% biological fertilizer (N_4).

Crop Management

Chemical fertilizers included nitrogen (400 kg. ha^{-1}), phosphorus (150 kg. ha^{-1}), and potassium (150 kg. ha^{-1}). Half of the nitrogen chemical fertilizer was used as the base and the second half was used (4-5 leaf stage) and the phosphorus and potassium fertilizers were used (at late July before planting). Biological fertilizer of Nitroxin was used as much as 2 liters per hectare combined with seeds at 4-5 leaf stage. The plot size was 4.5×5 m, the distance between the furrows was 75 cm, inter row space was 18 cm. the distance between blocks was 2 m and between plots was 1.5 m. Seeds were planted manually on August 11, 2013. The first irrigation was done one the day after planting and the next irrigations were done every 7 days until the end of growth season. The soil properties were mentioned in table 1.

Table 1. Physical and chemical properties of the field soil

Soil depth (cm)	0-30	30-60
Acidity (pH)	46.8	50.8
Electrical conductivity ($ds.m^{-1}$)	4.07	69.2
Organic carbon (%)	0.50	0.35
Absorbable Phosphorus (ppm)	8	7
Absorbable potassium (ppm)	180	170
Clay (%)	24	24
Silt (%)	42	42
Sand (%)	34	31
Soil texture	Loam	Loam

Traits measure

Total dry matter, relative seed yield and components were estimated after the physiological maturity by harvesting interior rows (the outer rows excluding at least 0.5 m from either end of the rows. The samples were for 48 hours in the oven at 72-75 centigrade and dry weight was measured. To calculate the number of seeds per row and number of row per ear, of each plot, 10 ears was selected randomly and number of seeds per row , number of rows per ear were counted, and average 10 ear were considered as the number of seeds per ear and number of rows per ear for that plots.

Statistical analysis

The 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 row per ear

Effect of applied treatments on the number of rows per ear was not significant (Table 2). There was no significant difference between the combination of chemical and the bio-fertilizers but reduction of urea fertilizer to 50% maximized the number of rows per ear by 14.82 (Table 3). There was a positive significant correlation between the number of rows per ear and the number of seeds per ear ($r=0.526^{**}$) at 1% level (Table 4). It seems like that the decrease of nitrogen leads to the reduction of the leaf area, rate of photosynthesis, number of florets and number of rows per ear. The results of the experiment were consistent with the findings of Seilsepour *et al*. (2002) on cotton. Reduction of nitrogen leads to decrease number of seed per ear through reduction of leaf area development, rate of photosynthesis, number of florets per ear and the increase of leaves aging and seeds abortion (Meena *et al*., 2013).

Seed yield

Table 2 showed the combination of chemical and bio-fertilizers had no significant effect on seed yield. Simple correlation results showed there was a positive significant relationship between seed yield and biological yield, number of seeds per row and number of seeds per ear at 1% level (Table 4). Similar results were obtained in corn with application of phosphate solubilizing bacteria in combination with chemical fertilizers (Afkhami-Fathabad *et al*., 2014, Yazdani *et al*., 2009).

Table 2. The analysis of variance result effect of combination fertilizers on studied traits

S.O.V	df	Number of row per ear	Seed yield	Number of seed per row	Number of seed per ear	1000-seed weight	Biological yield	Harvest index
Replication	3	1.023*	0.429*	2.11*	27.19*	19.84*	15.24*	9.50*
Combination fertilizers	3	0.755 ns	1.998ns	9.53ns	4480*	3535*	20.54ns	45.43ns
Error	12	0.885	1.055	15.32	5180	2093	8.96	81.16
CV%	-	8.1	13.39	11.34	10.12	18	22.24	14.3

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

Table 3. Mean comparison effect of different level of combination fertilizers on studied traits

Treatments	Number of row per ear	Seed yield ($t.ha^{-1}$)	Number of seed per row	Number of seed per ear	1000-seed weight (g)	Biological yield ($t.ha^{-1}$)	Harvest index (%)
100% urea + 0% Nitroxin	14.21b	10.83a*	36.00a	510.30c	306.66b	18.36b	54.76c
75% urea + 100% Nitroxin	14.57b	10.89a	35.22a	517.70b	326.65a	20.12a	56.47b
50% urea + 100% Nitroxin	14.82a	11.52a	36.85a	547.59a	284.75c	21.3a	55.47c
25% urea + 100% Nitroxin	14.47b	10.55a	34.84a	503.89d	303.33b	18.91b	59.20a

*The numbers with at least one similar letters in each column are not significantly different at 5% probability level.

Seed filling period is the main stage of corn yield formation and long duration of this period makes it possible to the transfer more assimilates from source to destination and consequently increases the seed yield. Increase of nitrogen consumption through the effect on physiological processes such as the increase of leaf area index and leaf area continuity leads to production of more assimilates, dry matter and the higher seed yield (Fahramand. and Mobasser, 2013). Application of the plant growth regulator promoting bacteria will increase the period of pollination, tasseling, flowering consistency, seed filling and seed yield. So, it seems like that increase of the corn seed yield through application of bio-fertilizer is due to extension of seed filling period and increase of the nutrients uptake from soil because of increase of total volume of corn roots (Jalilian and Delkhoshi, 2014; Mohammadi *et al*., 2012).

Number of seed per row

Table (2) showed that number of seed per row was not influenced by fertilizer treatments. Although the effect of combination of fertilizers on number of seeds per row was not significant, the maximum and minimum number of seeds by 36.85 and 34.84 belonged to the treatment with 50% urea + 100% Nitroxin and 25% urea + 100% Nitroxin (Table 3). There was positive significant correlation between the number of seeds per row and the number of seeds per ear ($r= 0.920^{**}$) at 1% level (Table 4). Access to sufficient nitrogen led to the decrease of competition between plants and increase of the number of seeds per row which was consistent with the findings of Vessy (2003).

Table 4. Evaluation correlation between measured traits

Traits	Seed yield	Biological yield	Harvest index	1000-seed weight	Number of seeds per row	Number of rows per ear	Number of seeds per ear
Seed yield	1	-	-	-	-	-	-
Biological yield	0.586^{**}	1	-	-	-	-	-
Harvest index	0.213^{ns}	-0.181^{ns}	1	-	-	-	-
1000-seed weight	0.121^{ns}	0.183^{ns}	0.233^{ns}	1	-	-	-
Number of seeds per row	0.523^{**}	0.463^{**}	-0.003^{ns}	-0.477^{**}	1	-	-
Number of rows per ear	0.283^{ns}	0.209^{ns}	0.189^{ns}	-0.207^{ns}	0.156^{ns}	1	-
Number of seeds per ear	0.558^{**}	0.482^{**}	0.063^{ns}	-0.487^{**}	0.920^{**}	0.526^{**}	1

$^{ns, *, and **}$: respectively mean non-significant, significant at 5% and 1% probability levels.

Number of seed per ear

Table (2) showed that ratio of combination of chemical and bio-fertilizers had significant effect on number of seed per row at 5% probability level. The results showed that in spite of significant difference, the lowest number of seed per ear by 503.89 belonged to the treatment with consumption of the lowest amount of urea and Nitroxin and the highest number of seed per ear by the 547.59 belonged to the most appropriate combination of fertilizers (50% urea + 100% Nitroxin) (Table 3). Nutrients availability particularly nitrogen in the critical period of seed formation influences the number of seeds through the increase of plant growth rate which lead to strong correlation between the number of seeds per ear and leaf area index at silking stage. Nitrogen causes the availability of assimilates for the ear through photosynthesis continuity and due to the decrease of competition between seeds for nutrients the number of seeds per ear will increase (Mohammadi *et al*., 2012).

1000-seed weight

The ANOVA results showed that effect of applied treatments on 1000-seed weight was significant at 5% probability level (Table 2). However, the highest weight of 1000-seed belonged to the treatment with 75% urea + 100% Nitroxin and the lowest one belonged to the treatment with 50% urea and 100% Nitroxin (Table 3). There was a negative significant correlation between 1000-seed weight and the number of seeds per row ($r=-0.477^{**}$) and the number of seeds per ear ($r=-0.487^{**}$) at 1% level (Table 4). Nitrogen increased the rate of assimilate and its mobilization when the seeds became dough and increased the weight of seeds. By accelerating and enhancing this event, bio-fertilizers increase the weight of seed weight. Researchers attributed the increased absorption of nutrients required by plants to the application of chemical and bio-fertilizer and consequently the increase of photosynthesis process, and stated that carbohydrate and nitrogen stored during the flowering stage would determine the rate of seeds in corn ear and nitrogen deficiency would reduce the seed weight via decreasing photo assimilate (Mohammadi *et al*., 2012).

Biological yield

Table (2) showed that ratio of combination of chemical and bio-fertilizers had significant effect on biological yield at 5% probability level. Although effect of applied treatments on biological yield was not significant, the minimum biological yield belonged to the treatment with 100% urea and the maximum biological yield by belonged to the treatment with 50% urea + 100% Nitroxin. There was positive significant correlation between the biological yield and the number of seeds per row ($r= 0.463^{**}$) and the number of seeds per ear ($r=0.482^{**}$) at 1% level (Table 4). Biofertilizers provide good nutritional conditions by making nitrogen available and lead to the increase of plant growth and biological yield (Boraste, 2009). By enhancing nitrogen efficiency and uptake, bio-fertilizers improve the growth of shoots and consequently increase biological yield. Consumption chemical fertilizer along with biological fertilizer increases chemical elements uptake which leads to the increase of biological yield in corn. Because in presence of large amounts of nitrogen the assimilates investment in leaves and stem increases and consequently the accumulated substances in seed will increase, too (Cheema *et al*., 2010). Nitrogen deficiency due to reduction of leaf area continuity and reduces the photosynthesis, and consequently biological yield decreases, too. Researchers have reported the increase of dry weight of corn plant due to application of biological fertilizer in comparison to the control treatment (Jalilian and Delkhoshi, 2014).

Harvest index

The ANOVA results showed that effect of applied treatments on harvest index was not significant (Table 2). Although the effect of treatments on harvest index was not significant, the treatments with 25% urea+ 100% Nitroxin and 100% urea + 0% Nitroxin had the highest and the lowest harvest index by 59.20% and 54.76%, respectively (Table 3). Physiologically, the increase of harvest index due to the increase of nitrogen fertilizer in corn can be attributed to the increase of leaf area continuity which, in turn, increases the lifetime of the photosynthetic organs (Soleiman zadeh and Ghooshchi, 2013). Nitrogen availability facilitates nitrogen remobilization and increases the harvest index. By balancing the nutrients required by plant, bio fertilizers enhance both vegetative and the reproductive growth and by creating adequate destination (seed), the produced assimilates are mobilized into seeds and ultimately the harvest index increases (Azim zadeh and Azim zadeh, 2013).

CONCLUSION

In bio-fertilizer treatment with 50% urea, the highest rate of seed yield was observed. Similar results were achieved in the research on corn through the application of the phosphate solubilize bacteria in combination with the chemical fertilizers (Afkhami Fathabad *et al*., 2014; Yazdani *et al*., 2009). Yield components were also affected by the fertilizer treatment and produced the highest amounts. According to the researchers reports, the plant growth promoting bacteria increase the yield and yield components of the plant via various processes such as the nitrogen fixation, production of the growth promoting hormones, and the various enzymes secretion like phosphates and organic acid which cause phosphate solubility and increase plant absorbable phosphate (Vessy, 2003; Seilsepour *et al*., 2002). The research conducted by the Velmurugan *et al*. (2008) showed significant increase of the yield of medicinal plant of *Curcuma longa* L due to the application of *Azospirillum lipoferrum*. Bio-fertilizers can increase dry matter yield by increasing the capability of auxin transfer into the shoots and the increase of plant height and consequently the increase of the number of leaves (Vadassery *et al*., 2008). On the other hand, as the number of leaves increases, rate of assimilates increases and more assimilates are stored in corn ear seeds. In the present research, in spite of the removal of upper leaves, this capability was observed in the minimum amount of the chemical fertilizers consumption. So, application of bio-fertilizers even under the removal of the upper leaves of ear in corn can appropriate the supplement for chemical fertilizers and their optimal consumption to increase the yield, yield components and to protect environment.

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