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Study of Source Limitation and Combined Effect of Chemical and Biological Fertilizer on Yield and Qualitative Traits of Seed (lipid, Nitrogen and Protein Content) Corn

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RESEARCH ARTICLE

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ABSTRACT

BACKGROUND: Nitrogen is a basic plant component, playing a decisive role in the intensification of plant production. Bio-fertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, both, in association with plant roots and without it, insoluble soil phosphates and produces plant growth substances in the soil.

OBJECTIVES: The current study was conducted to investigate the integrated management of biological and chemical fertilizers on seed qualitative traits and crop production of single cross 701 corn under warm and dry climate condition.

METHODS: This research was carried out via split plot experiment based on randomized complete blocks design with four replications along 2013-2014 year. The main factor included combination nitrogen fertilizer and biologic fertilizer; Nitroxin (a_1: 100 Nitrogen fertilizer × 100% biofertilizer, a_2: 75% Nitrogen fertilizer × 100% biofertilizer, a_3: 50% Nitrogen fertilizer × 100% biofertilizer, a_4: 25% Nitrogen fertilizer × 100% biofertilizer) and Defoliation (b_1: non defoliation, b_2: Cut lower leaves of the cob, b_3: Cut upper leaves of the cob) belonged to sub plot.

RESULT: Assessment analysis of variance showed effect of combination urea and Nitroxin (instead seed lipid content), defoliation and interaction effect of treatments on all measured traits was significant at 5% probability level. Evaluation mean comparison result of interaction effect of treatments indicated maximum amount of measured characteristics (instead seed nitrogen content) was noted for 50% nitrogen fertilizer × 100% biofertilizer × non defoliation and the lowest ones belonged to 25% nitrogen fertilizer × 100% biofertilizer × cut upper leaves of the cob.

CONCLUSION: According to the results, it seems that biological fertilizers in combination with chemical fertilizers provide increased access to food and increase the quantitative and qualitative yield of grain and increase the amount of nutrients in the seed. Also defoliation had great effect on nutrient content. Defoliation the upper leaves of the cob increases the amount of these elements but reduces the economic performance of the single-cross 701 hybrid.

KEYWORDS: *Defoliation, Maize, Nitroxin, Single Cross 701, Urea.*

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1. BACKGROUND

Nutrient management may be achieved by the involvement of organic sources, biologic fertilizers, and micro nutrients (Singh *et al*., 2002). Indiscriminate use of chemical fertilizers to achieve high yield and to compensate for lack of nutrients and consequently the increase of production costs and destruction of soil and water resources have made the specialists interested in healthy and stable crop systems in terms of ecology (Tilak *et al*., 1992). Nitrogen is important for plant growth, however plants have a limited ability to extract it from the environment, and thus need microbes involved in "nutrient recycling," to help a plant uptake and absorb these nutrients at optimal concentration, while plants donate waste byproducts to microbes for food. With this symbiotic relationship, plants develop stronger and bigger root systems. The larger the plants' roots, the more living space and food there is for the microbes to use. In a way, microorganisms serve as biofertilizers (El-kholy, 2005). Chemical fertilizers are significant to succor nutrients in soil. Heavy doses of chemical fertilizers and pesticides are commonly used in order to enhance corn yields. Excessive nitrogen content in soil causes an inappropriate high uptake of this macronutrient by plants, which may result in inadequate growth and development due to the accumulation of nitrogen compounds in plant tissue (Szulc, 2013). Organic farming has emerged as an important priority area globally in view of the growing demand for safe and healthy food and long term sustainability and concerns on environmental pollution associated with indiscriminate use of agrochemicals. Though the use of chemical inputs in agriculture is inevitable to meet the growing demand for food in world, there are opportunities in selected crops and niche areas where organic production can be encouraged to tape the domestic export market. Biofertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, both, in association with plant roots and without it, insoluble soil phosphates and produces plant growth substances in the soil. They are in fact being promoted to harvest the naturally available, biological system of nutrient mobilization (Venkatash-Warlu, 2008). Nitroxin contains nitrogen fixation bacteria 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). Nouraki *et al*. (2016) reported mixing of biofertilizers with chemical fertilizers decreases the needs of chemical fertilizers up to 25% and these results are comparable to the application of 100% chemical fertilizers. So, the best hybrid maize is the S.C 704 that has good yield potential when the chemical fertilizer is used at either 25% or 50% of the current application when mixed with bio-fertilizer.

2. OBJECTIVES

The current study was conducted to investigate the integrated management of biological and chemical fertilizers on

seed qualitative traits and crop production of single cross 701 corn under warm and dry climate condition.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was carried out via split plot experiment based on randomized complete blocks design with four replications along 2013-2014 year. Place of research was located in Gotvand city (latitude: 32 30' N, longitude: 48 20' E and 18 meters above sea level) in Khuzestan province (Southwest of Iran). The main factor included combination nitrogen fertilizer and biologic fertilizer; Nitroxin (a_1: 100 Nitrogen fertilizer × 100% biofertilizer, a_2: 75% Nitrogen fertilizer × 100% biofertilizer, a_3: 50% Nitrogen fertilizer × 100% biofertilizer, a_4: 25% Nitrogen fertilizer × 100% biofertilizer) and Defoliation (b_1: non defoliation, b_2: Cut lower leaves of the cob, b_3: Cut upper leaves of the cob) belonged to sub plot. This experiment had 36 plots. The total number of plots was 48. The total area of the experimental plot, including the distances between the experimental units and irrigation canals, was about 2170 m^{-2}. Each plot consisted of 6 lines with a distance of 75 cm and 5 meters length. The distance between the shrubs on every row was 18 cm.

3.2. Farm Management

Phosphorus and potassium fertilizers were used at rate of 150 $kg.ha^{-1}$ triple super phosphate 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 the experiment field

Soil depth (cm)	0-30	30-60
Acidity (pH)	8.44	8.51
Electrical conductivity ($ds.m^{-1}$)	4.07	2.69
Organic carbon (%)	0.51	0.36
Phosphorus (ppm)	8	7
Potassium (ppm)	181	171
Clay (%)	26	24
Silt (%)	41	40
Sand (%)	33	32
Soil texture	Loam	Loam

Each sub plot included the 6 planting lines with a length of 5 m. The distance between row and seed on the 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.

3.3. Measured Traits

To determine the percentage of grain protein, the percentage of grain nitrogen was first measured by Kjeldahl method, which includes digestion, distillation and titration. To measure the amount of seed protein by multiplying the percentage of seed nitrogen by a factor of 6.25, the amount of protein in the seed was obtained. Then, by multiplying the percentage of protein in each treatment by

its seed yield, the protein yield for each treatment was calculated (Keeney and Nelson, 1982). Seed oil percentage was used Soxhlet method (Cox and Cherney, 2005).

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done by SAS (Ver.8) software and LSD test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Seed yield

Result of analysis of variance (ANOVA) revealed the effect of combination urea and Nitroxin, defoliation and interaction effect of treatments on seed yield was significant at 5% probability level (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated the maximum seed yield (14460 kg.ha^{-1}) was noted for 50% nitrogen fertilizer × 100% biofertilizer × non defoliation and the lowest one (10550 kg.ha^{-1}) belonged to 25% nitrogen fertilizer × 100% biofertilizer × cut upper leaves of the cob (Table 3). 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 the plant absorbable phosphate. Therefore, they increase the yield and its components of the plant (Tohidi Moghaddam *et al*., 2007; Lin *et al*., 2002). The mature upper leaves of the plant usually send their grown material to the growing meristems of the aerial parts and the young leaves of the immature young and the lower leaves of the plant provide the material needed by the root system. The transfer of the cultivated material from the middle leaves continues in both directions. During the reproductive period, the leaves adjacent to the ear are the great sink of the crop (Stewart *et al*., 2003).

Table 2. Result analysis of variance of studied traits

S.O.V.	df	Seed yield	Lipid	Protein	Nitrogen
Replication	3	1.897^{ns}	0.19069^{ns}	0.9393^{ns}	670^{ns}
Combination Urea × Nitroxin (C)	3	8.528*	0.21563^{ns}	3.0696*	6077*
Error I	9	0.884	0.19173	0.7233	1538
Defoliation (D)	2	80.347*	3.69165*	16.4173*	13553*
N×C	6	3.143*	2.62226*	3.7281*	6078*
Error II	24	0.883	0.06541	0.3525	2197
CV (%)	-	11.42	6.61	7.89	9.2

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

4.2. Lipid

According result of analysis of variance (ANOVA) effect of combination urea and Nitroxin was not significant but effect of defoliation and interaction effect of treatments on lipid content was significant at 5% probability level, respectively (Table 2). Assessment the mean comparison result of interaction effect of treatments indicated the maximum lipid content (4.35%) was noted for 50% nitrogen fertilizer × 100% biofertilizer × non defoliation and lowest one (3.35%) belonged to 25% nitrogen fertilizer × 100% biofertilizer × cut upper leaves of the cob (Table 3). Nitrogen fertilizer increases the 1000-seed weight as well as the protein percentage and decreases oil content (Maghsoudi *et al*., 2014). Steer *et al*. (1990) stated that there is a negative relationship between the nitrogen availability and oil percentage. Maghsoudi *et al*. (2014) reported the effect of biologic fertilizer on the seed yield is significant, also in the inoculated treatment with the bacteria, the oil percentage increased by 10% compared to the control treatment (no inoculation).

Table 3. Mean comparison interaction effect of treatments on studied traits

Treatment	Seed yield ($kg.ha^{-1}$)	Lipid (%)	Protein (%)	Nitrogen ($mg.kg^{-1}$)
100 Nitrogen fertilizer × 100% biofertilizer × Non defoliation	12740	4.09	8.15	4.08
100% Nitrogen fertilizer × 100% biofertilizer × Cut lower leaves of the cob	12170	3.73	7.18	3.70
100% Nitrogen fertilizer × 100% biofertilizer × Cut upper leaves of the cob	10830	3.89	7.79	5.45
75% Nitrogen fertilizer × 100% biofertilizer × Non defoliation	12810	4.12	8.3	3.76
75% Nitrogen fertilizer × 100% biofertilizer × Cut lower leaves of the cob	10780	3.59	7.09	3.94
75% Nitrogen fertilizer × 100% biofertilizer × Cut upper leaves of the cob	10870	3.51	7.31	4.12
50% Nitrogen fertilizer × 100% biofertilizer × Non defoliation	14460	4.35	8.33	2.93
50% Nitrogen fertilizer × 100% biofertilizer × Cut lower leaves of the cob	11990	3.66	6.92	4.82
50% Nitrogen fertilizer × 100% biofertilizer × Cut upper leaves of the cob	11520	3.39	7.44	4.24
25% Nitrogen fertilizer × 100% biofertilizer × Non defoliation	13740	3.90	7.41	4.93
25% Nitrogen fertilizer × 100% biofertilizer × Cut lower leaves of the cob	11440	3.84	7.39	3.51
25% Nitrogen fertilizer × 100% biofertilizer × Cut upper leaves of the cob	10550	3.35	6.33	5.83
$LSD_{5\%}$	1.95	0.36	0.84	66.61

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

4.3. Protein

Result of analysis of variance revealed effect of combination urea and Nitroxin, defoliation and interaction effect of treatments on protein content was significant at 5% probability level (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum protein content (8.33%) was noted for 50% nitrogen fertilizer × 100% biofertilizer × non defoliation and lowest one (6.33%) belonged to 25% nitrogen fertilizer × 100% biofertilizer × cut upper leaves of the cob (Table 3). With increasing access to nitrogen, the percentage of grain protein also increased, which was consistent with the results of Ghani *et al*. (2000). These results prove the positive effect of biofertilizer in improving plant nutritional conditions. Inoculation of bacteria in that treatment regulates growth and increases physiological and metabolic activities in the crop (Ram Rao *et al*., 2007). Increase protein percentage with using bio-fertilizers is due to the effect of bacterial inoculation that increased the effective regulation of the growth, physiological and metabolic activity of the plant (Eidy Zadeh *et al*., 2012).

4.4. Nitrogen

According result of analysis of variance effect of combination urea and Nitroxin, defoliation and interaction effect of treatments on nitrogen content was significant at 5% probability level (Table 2). Assessment mean comparison result of interaction effect of treatments indicated maximum nitrogen content (5.83%) was noted for 25% nitrogen fertilizer × 100% biofertilizer × cut upper leaves of the cob and lowest one (2.93%) belonged to 50% nitrogen fertilizer × 100% biofertilizer × non defoliation (Table 3). As a result of combining chemical fertilizer with biological fertilizer, it was observed that grain nitrogen increased as the use of chemical fertilizer alone. In the case of leaf cutting, it seems that the lower leaves of the cob play a greater role in the amount of grain nitrogen. Because with the presence of these leaves and cutting the leaves above the cob, the amount of grain nitrogen was increased. That matter is consistent with the observations of Tind *et al*. (2002).

5. CONCLUSION

According to the results, it seems that biological fertilizers in combination with chemical fertilizers provide increased access to food and increase the quantitative and qualitative yield of grain and increase the amount of nutrients in the seed. Also defoliation had great effect on nutrient content. Defoliation the upper leaves of the cob increases the amount of these elements but reduces the economic performance of the single-cross 701 hybrid.

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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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