Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 4, No. 4, 2018
http://JCNS.iauahvaz.ac.ir
OPEN ACCESS

Assessment Effect of Super Absorbent Polymer and Nitroxin on Growth Curves and Corn (*Zea mays* L.) Production

Sadegh Lamochi[1], Tayeb Sakinejad*[2]

1- Graduated of MSc, Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.
2- Assistant Professor, Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.

RESEARCH ARTICLE

ARTICLE INFO.
Received Date: *8 Oct. 2018*
Received in revised form: *13 Nov. 2018*
Accepted Date: *10 Dec. 2018*
Available online: *22 Dec. 2018*

To Cite This Article:
Sadegh Lamochi, Tayeb Sakinejad. Assessment Effect of Super Absorbent Polymer and Nitroxin on Growth Curves and Corn (*Zea mays* L.) Production. ***J. Crop. Nutr. Sci.,*** 4(4): 33-46, 2018.

ABSTRACT

BACKGROUND: Nutrient management plays an important role for obtaining satisfactory yields and to increase crop productivity. Also keep soil moisture under drought stress is an important factor to produce economical production, so super absorbent polymer has great role to achieve mentioned goal.

OBJECTIVES: Present study was conducted to evaluate the effect of different level of super absorbent polymer and Nitroxin biological fertilizer on the productivity of maize and growth Indices.

METHODS: Current research was carried out according factorial experiment based on randomized complete blocks design with three replications during 2015-2016. The first factor included different level of Super Absorbent Polymer (S_1= nonuse of super absorbent polymer or control, S_2= 100 kg.ha^{-1} and S_3= 150 kg.ha^{-1} super absorbent polymer) and second factor included three level of Nitroxin (N_1= nonuse of Nitroxin or control, N_2= 1 L.ha^{-1} and N_3= 3 L.ha^{-1} Nitroxin).

RESULT: Result analysis of variance revealed effect of super absorbent polymer and Nitroxin on seed yield and biologic yield was significant but interaction effect of treatments was not significant. According result of mean comparison of different level of super absorbent that maximum seed yield (8455 kg.ha^{-1}) biologic yield (13266 kg.ha^{-1}), Leaf area index (3.5), Leaf area ratio (0.0035 m^2.gr), Relative growth rate (0.09 gr.gr^{-1}.day^{-1}), crop growth rate (35 gr.m^{-2}.day^{-1}) was noted for use 150 kg.ha^{-1} super absorbent and minimum amount of mentioned traits was belonged to control treatment. Also between different level of Nitroxin the highest amount of measured characteristics observed for 1 L.ha^{-1} treatment.

CONCLUSION: Finally according result of current research consume of 150 kg.ha^{-1} Super Absorbent Polymer and 1 L.ha^{-1} Nitroxin led to produce highest corn yield and growth indices and it can be advised to farmers in studied region.

KEYWORDS: *Crop growth rate, Fertilizer, Nitrogen, Seed yield.*

***Corresponding Author:** Tayeb Sakinejad ✉ saki1971@iauahvaz.ac.ir

1. BACKGROUND

Maize is the third most important cereal grain worldwide after wheat and rice. It is referred to as the cereal of the future for its valuable nutritional facts in human diet (Enyisi *et al*., 2014). Annual production of cereals in 2014 was more than 2.4 billion tons. The 872 million tons of cereal production was maize production. According to the reports, Iran's share of world maize production is only1.250 million tons (FAO, 2014). Analysis growth indices are a suitable method for evaluate crop response to the different environmental conditions during it life and is a tool to assess what events occurs during plant growth. (Tesar, 1984). Identification of growth physiological indices in analysis of factors affecting yield and its components has a great importance and its stability determines the dry matter production which is a criterion of yield components and in this regard leaf area index (LAI), total dry weight (TDW) and leaf dry weight (LDW) should be measured in periodic intervals during the growing season (Gardner *et al*., 1985). Suitable and useful usage of different kind of fertilizers is the main way for reformation and potential of soil fertility and increasing of crops yield (Talaei, 2012). Addition of fertilizers to supplement the natural soil fertility is essential for modern crop production, and precise management of nutrient elements is essential for a sustainable agriculture production (Barker and Pilbeam, 2006). After the industrial revolution widespread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems (Hasanozaman *et al*., 2010). Nutrient management plays an important role for obtaining satisfactory yields and to increase crop productivity. It may be achieved by the involvement of organic sources, bio fertilizers, and micro-nutrients (Singh *et al*., 2002). The amount of growth and photosynthetic translocation is related to nutrients availability (Munir *et al*., 2012). Studies have shown that long-term use of fertilizers reduces crop yields. This decrease is due to the acidification of the soil, the reduction of biological activity of the soil and the inappropriate physical properties of the soil (Alexandratos, 2003). To alleviate the problem, 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 biological fertilizers (Kemal and Abera, 2015). 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 seed yield, its 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. So the mixing of bio fertilizer with chemical fertilizers could reduce the needs of chemical fertilizers up to 25%. The bacteria in the Nitroxin biological fertilizer, in addition to stabilizing nitrogen of the air and balancing the absorption of macro and micronutrient elements, stimulate growth of the hormones by synthesizing and securing growth promoters such as hormones, although the Nitroxin produced and supplied with the approval of the country's research institutes (Fulchirri and Frioni, 1994; Asadi Kupaland and Zadeh Laserjan, 2009). The limitation of water resources in arid and semi-arid areas was the main reason that we considered water as the most important material in the production lines, although people often do not obey the irrigation water consumption rules and regulations (Cakir, 2004). Drought is one of the greatest abiotic stresses to agriculture, inhibiting plant growth and reducing productivity (Zhang *et al.,* 2008). Drought is a long period with precipitates less than average, with no sufficient moisture for maximum potential growth of the plant (Blum, 2012). Iran with average 250 millimeters of rainfall per year is considered as the arid region of the world (Ghamarnia and Gowing, 2005). In agriculture, polyacrylamide is the main synthetic polymer used, and it absorbs water through the formation of hydrogen bonds (Ahmed, 2015). In order to save soil moisture, some materials such as crop residue, mulch plants, waste, litter, straw and stubble, and other synthetic materials like Hydro plus. Super absorbent polymers are compounds that absorb water and swell into many times their original size and weight. They are lightly cross-linked networks of hydrophilic polymer chains. Super absorbents, depending on their source and structure, are divided in two main groups of natural and synthesis. They are applied in gardens, landscapes and agriculture to protect and store humidity in soils and release water slowly through soil (Orzeszyna *et al*., 2006). The problem of inefficient use of rain and irrigation water by crops is the most important in semiarid and arid regions, where shortage of water is frequently experienced and water is the main limiting factor for growth and yield of crops. In arid and semiarid regions of the world, intensive research on water management is being carried out and use of super absorbent polymers (SAP) may effectively increase water and fertilizer use efficiency in crops. The application of SAP for stabilizing soil structure resulted in increased infiltration and reduced water use and soil erosion in a furrow irrigated field (Lentz *et al*., 1998). A super absorbent polymer can hold 400 to 1500 times as much water as its dry hydrogel (Fazeli Rostampour *et al*., 2013). Polymers are safe, nontoxic, and decompose to CO_2, water, NH_4, and K^+ without any residue (Keshavars *et al*., 2012). Johnson (1984) reported an increase of 171 to 402% in water retention capacity when polymers were incorporated in coarse sand. Addition of a polymer to peat decreased water stress and increased the time to wilt (Karimi *et al*., 2009). The incorporation of superabsorbent polymer with soil improved soil physical properties (El-Amir *et al*., 1993), enhanced seed germination and emergence (Azzam, 1983), crop growth and yield (Yazdani *et al*., 2007) and reduced the irrigation requirement of plants (Blodgett *et al*., 1993). The use of hydrophilic polymer materials as carrier and regulator of nutrient release was helpful in reducing undesired fertilizer losses, while sustaining vigorous plant growth (Mikkelsen, 1994). Islam *et al.* (2011a) evaluate the effectiveness of different rates of SAP (low, 10; medium, 20; high, 30 and very high, 40 $kg.ha^{-1}$) for winter wheat production under drought-affected field and reported the optimum application rate of SAP would be 30

$kg.ha^{-1}$ as it increases both wheat yield and soil fertility. Lower rates (10 and 20 $kg.ha^{-1}$) are not sufficient and higher rate (40 $kg.ha^{-1}$) is not economic. They suggested that the application of SAP at 30 $kg.ha^{-1}$ could be an efficient soil management practice for winter wheat production in the drought-affected regions. Fallahi *et al.* (2015) by evaluate the effect of water deficit, irrigation after 120 (control), 155 (moderate water stress) and 190 mm (sever water stress) pan evaporation and super absorbent polymer rates (SAP) (0, 30, 60 and 90 $kg.ha^{-1}$) on growth, yield and water use efficiency of cotton reported that moderate water stress (irrigation intervals of aprox. 15 days) along with 60 $kg.ha^{-1}$ SAP application was the best treatment in terms of growth and yield indices of cotton, also water deficit and SAP application improved the water use efficiency (WUE) of cotton, the amount of WUE in moderate water stress treatment along with consumption of 60 or 90 $kg.ha^{-1}$ SAP was 26% higher than for control treatment.

2. OBJECTIVES

Present study was carried out to evaluate the effect of different level of super absorbent polymer and Nitroxin biofertilizer on the productivity of corn and growth curves.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was conducted to evaluate effect of super absorbent polymer and biofertilizer (Nitroxin) on growth curves and mays yield via factorial experiment based on randomized complete blocks design with three replications during 2015-2016. The first factor included different level of Super Absorbent (S_1= nonuse of super absorbent polymer or control, S_2= 100 $kg.ha^{-1}$ and S_3= 150 $kg.ha^{-1}$ super absorbent polymer) and second factor included three level of Nitroxin (N_1= nonuse of Nitroxin or control, N_2= 1 $L.ha^{-1}$ and 3 $L.ha^{-1}$ Nitroxin, used in stem elongation). Place of research was located in Izeh region at longitude 50 22′ E and latitude 31"13' N in Khuzestan province (South west of Iran). The average annual rainfall, temperature, and evaporation in the region are 694 mm, 21 C and 2000 mm, respectively. The mean metrological information of experiment location was mentioned in table 1. Before planting compound samples of the soil were taken from a depth of 0-30 cm. The dried samples of soil were passed through 2 mm sieve and some of the physical and chemical properties (soil texture, pH, salinity, organic matter, some of macro elements concentration) were measured (Table 2).

Table 1. Mean of metrological information of experiment location at 2015-2016

Month	Temperature ^{0}C		Precipitation (mm)
	Max	Min	
May	38	1.2	11.8
June	42	8.8	0.6
July	45.5	13	0
August	46	18.8	0
September	46.5	16.5	0
October	38.8	14	1.1
November	30	10	20

3.2. Farm Management

For mix seeds with bio-fertilizer of Nitroxin (Prepared by Asian love Biotechnology Company), seed was first spread on a clean plastic. Then, the appropriate amount of inoculum (1 liter per 60 kg of seed) was gradually sprayed on the seeds and by seeding the seeds inoculum was done. Then the inoculated seeds were shaded and immediately after drying, seeds planted (Akabarynia, 2004). During the planting, separate disposable gloves for each treatment were used to prevent mixing of the effects of treatments. The land preparation operations were carried out in early June 2012, in order to stimulate seed germination of the weeds, to better control them and provide adequate moisture for plowing operations, the experimental plots were irrigated before land preparation. After reaching the moisture content of the soil to the optimal level, a plow operation was carried out with Chislow's plow, and then the disc and leveler applied. Each plot with dimensions of 4.5 × 6 m and including 6 rows of planting at a distance of 75 cm and block spacing of 3 meters were considered. For application of super adsorbent treatments, it was used directly at depth of 15 cm after the preparation of the plots. The spacing of the seeds on each row was 20 and the distance on the rows was 75 cm. Maize seeds were inoculated immediately before planting with Nitroxin bacteria according recommended method. The first irrigation was carried out to optimize the bacterial placement and improve seedling emergence immediately after cultivation. Four days later, the second irrigation took place to better germination. Subsequent irrigation was performed as needed by leakage every six days. Controlling weeds was done mechanically and manually. During the test period, no disease and pests were seen. Nitroxin was applied with the second irrigation. The harvest of corn was done at the end of September in the physiological ripening stage.

Table 2. Physical and chemical properties of studied field

Potassium (ppm)	**Phosphorus (ppm)**	**Soil texture**	**Silt (%)**	**Clay (%)**	**Sand (%)**
33.7	13.6	Clay loam	38	29	33
Organic carbon (%)	**Electrical conductivity ($ds.m^{-1}$)**	**Na^{+} ($Meq.l^{-1}$)**	**Ca^{2+} ($Meq.l^{-1}$)**	**Mg^{2+} ($Meq.l^{-1}$)**	**pH**
1.3	1.59	3.75	4.4	1.9	7.5

3.3. Measured Traits

In order to measure biologic yield above the ground level, five crops within 0.5–0.6 m of a row section in each plot were cut at the ground level at ripening stage. Crop samples were dried at 65°C until constant weight was achieved. The final harvesting area was equal to 4.8 m^{-2} that was done from two middle lines of planting. Corn seed yields were determined by hand harvesting the 8 m sections of three center rows in each plot. Then, seed yield values were adjusted to 15.5% moisture content. For measure growth indices sampling was done every 10 days. At first, three plants per plot were harvested completely and then the total dry weight and leaf area were measured. To determine the total dry weight, the samples were first placed in an oven for a sufficient time at 70 °C and then weighed by a scale. To determine the leaf area index (LAI) of the linear relationship S= K. L.W was used in which S, L and W were the leaf area, L and W respectively, the maximum length and width of each leaf and K= 0.75 correction coefficient. The leaf area index was calculated from leaf area ratio to ground level. Crop growth rate (CGR), relative growth rate (RGR) and leaf area ratio (LAR) was measured according fallowing formula (Buttery, 1970; Enyi, 1962): **Equ.1.** $CGR\ (g.m^{-2}.day^{-1}) = TDM_2\text{-}TDM_1/T_2\text{-}T_1$

TDM_1= Primary dry weight (g)

TDM_2= Secondary dry weight (g)

T_1= Initial sampling time
T_2= Secondary sampling time
Equ.2. RGR ($gr.gr^{-1}.day^{-1}$)= $LnTDM_2$-$LnTDM_1/(T_2-T_1)$
Equ.3. LAR=LAI/TDM

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done by use SAS software (Ver.9.1) and Duncan multiple range test at 5% probability level. Curved was drawn with Excel software (Ver.2010).

4. RESULTS AND DISCUSSION

4.1. Seed yield

According result of analysis of variance effect of super absorbent polymer and Nitroxin on seed yield was significant at 1% probability level but interaction effect of treatments was not significant (Table 3).

Table 3. Result analysis of variance of seed yield and biologic yield.

S.O.V	df	Seed yield	Biologic yield
Replication	3	5830277^{**}	2887144^{ns}
Super absorbent (S)	2	9210172^{**}	9578926^{*}
Nitroxin (N)	2	4474239^{**}	8189055^{*}
S×N	4	1218965^{ns}	920789^{ns}
Error	24	1108197	1887471
CV (%)	-	12.34	11.38

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

Mean comparison result of different level of super absorbent indicated that maximum seed yield (8455 $kg.ha^{-1}$) was noted for use 150 $kg.ha^{-1}$ super absorbent and minimum of that (6765 $kg.ha^{-1}$) belonged to control treatment (Fig. 1). Another researcher such as Yousefi Fard and Asareh (2013) reported the use of super adsorbent polymer increased the irrigation interval from 4 to 5 days to 8 days, reduced the number of irrigation from 29 times to 76 times, increased water use efficiency by 38% and reduced the volume of consumed water to 42%, as well The corn seed yield increased by 11% compared to deficit irrigation treatment. Fazeli Rostampour and Mohebbian (2012) reported application of 90 $kg.ha^{-1}$ super absorbent under drought stress increased grain yield of corn. Between different levels of Nitroxin the maximum seed yield (8426 $kg.ha^{-1}$) was observed in 1 $L.ha^{-1}$ and the lowest one (7248 $kg.ha^{-1}$) was found in control treatment (Fig. 2).

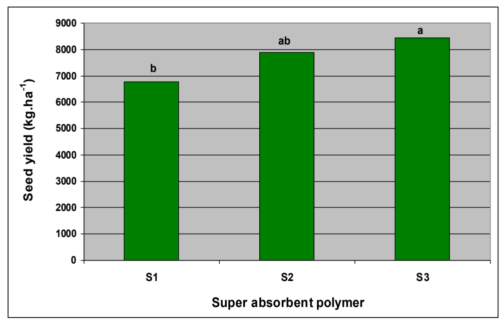

Fig. 1. Mean comparison effect of different level of super absorbent polymer on seed yield via Duncan test at 5% probability level. S_1= nonuse of super absorbent polymer or control, S_2= 100 $kg.ha^{-1}$ and S_3= 150 $kg.ha^{-1}$ super absorbent polymer.

It seems like that the increase of seed yield is due to the positive effect of nitrogen and receiving light and the increase of photosynthesis, crop growth rate, leaf area index, and leaf area duration. The results are consistent with the findings of (Nawas-Nazanat *et al.,* 2005). In another study Garg *et al.* (2005) reported increasing nitrogen to soil led to increase the plant photosynthetic efficiency and ultimately increased the seed yield and growth rate. On the other hand, since the rate of light absorption by leaves and converting it into photosynthetic materials are the other factors affecting the plant growth and production, the increase of leaf area in the farm leads to the increase of light absorption and ultimately leads to the increase of seed yield. Khadem *et al.* (2011) reported that application of manure and superabsorbent with improved soil conditions increased seed yield by 15.9% compared to the control. 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.

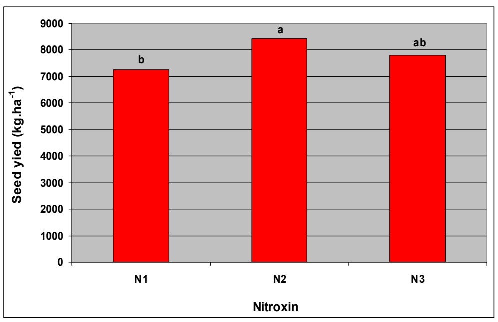

Fig. 2. Mean comparison effect of different level of Nitroxin on seed yield via Duncan test at 5% probability level. N_1= nonuse of Nitroxin or control, N_2= 1 L.ha^{-1} and 3 L.ha^{-1} Nitroxin.

4.2. Biologic yield

Result of analysis of variance revealed effect of super absorbent and Nitroxin on biologic yield was significant at 5% probability level but interaction effect of treatments was not significant (Table 3). According result of mean comparison of different level of super absorbent maximum of biologic yield (13266 kg.ha^{-1}) was obtained for 150 kg.ha^{-1} super absorbent (also it doesn't have significant difference with 100 kg.ha^{-1} super absorbent treatment) and minimum of that (11566 kg.ha^{-1}) was for control treatment (Fig. 3). Ganbari and Mir (2013) reported that the use of super adsorbent polymer under mild and severe stress reduced the effects of drought stress on corn yield, so that increasing the amount of superabsorbent from the control level to 100 kg.ha^{-1} in mild stress caused a 21% increase in seed yield and biological yield, which was 5% in severe stress. Compare different level of Nitroxin indicated the maximum biologic yield (13437 kg.ha^{-1}) was noted for use 1 L.ha^{-1} Nitroxin and minimum of that (11790 kg.ha^{-1}) belonged to control treatment (Fig. 4). Similar result observed by Tarang *et al.* (2013), they reported application of 1 L.ha^{-1} Nitroxin bio-fertilizer with chemical fertilizer had a strong effect on productivity, serves to reduce environmental pollution and led to achieve maximum amount of biologic yield. 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}).

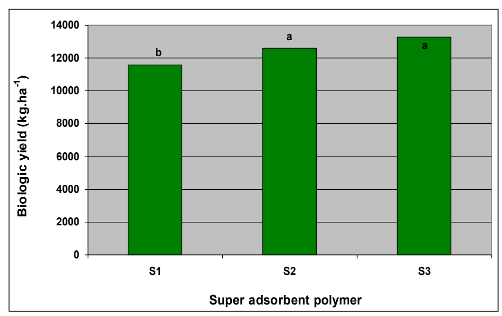

Fig. 3. Mean comparison effect of different level of super absorbent polymer on biologic yield via Duncan test at 5% probability level. S_1= nonuse of super absorbent polymer or control, S_2= 100 kg.ha^{-1} and S_3= 150 kg.ha^{-1} super absorbent polymer.

Azimi *et al.* (2013b) was reported seed 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.

4.3. Leaf area index (*LAI*)

The leaf area index was affected by the super absorbent effect. Plants under superabsorbent treatment had higher levels of leaf area index than control. The leaf area index at the beginning of the growth period was the same in all three treatments, but with past time, leaf area index increased in super adsorbent treatments (Fig. 5). In all studied treatments, with the warming weather, the period of rapid spread of leaves began, and the leaf area index was maximized with increasing trend. After this step, photosynthetic activity decreased with increasing shading and decreasing the penetration of light into the canopy, and the decrease in leaf area index curve was observed due to the yellowish and fallen leaves of the canopy. The time to reach the maximum leaf area index during the growing season was relatively concurrent for all treatments. The amount of leaf area index in treatments of 100 and 150 kg.ha^{-1} super absorbent was higher than control (Fig. 5).

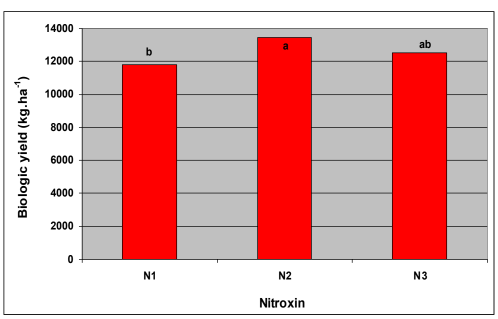

Fig. 4. Mean comparison effect of different level of Nitroxin on biologic yield via Duncan test at 5% probability level. N_1= nonuse of Nitroxin or control, N_2= 1 L.ha^{-1} and 3 L.ha^{-1} Nitroxin.

The leaf area index in plants affected with Nitroxin treatments has a similar superabsorbent trend. The leaf area index had similar trend at the beginning of growth in all treatments, but over time, leaf area index increased in Nitroxin treatments than to control. The treatment includes 1 L.ha^{-1} Nitroxin had the highest leaf area index than to another treatment (Fig. 6). Shamoradi and Marashi (2018) reported among different level of biofertilizer maximum leaf area index in tassel emergence, silk emergence and grain filling stage were 4.28, 3.40 and 2.33, respectively, due to application of Nitrokara and *Azotobacter* biological fertilizer and lowest one (4.13, 3.21 and 2.18) belonged to non-bio fertilized treatment. Sprent and Sprent (1990) reported that *Azospirillum*, Pseudomonas and *Azotobacter* bacteria, through the roots of plants, increase the moisture absorption and this extensive network through the absorption of water and nutrients and their transfer to the plant increases plant height, leaf area and dry weight.

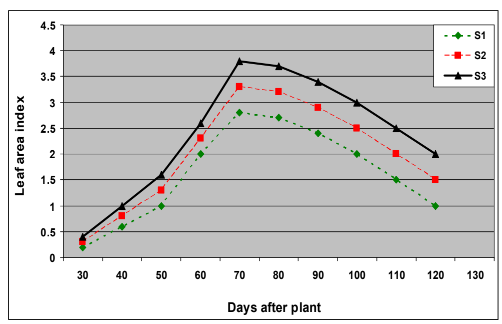

Fig. 5. Effect of different level of super absorbent polymer on leaf area index. S_1= nonuse of super absorbent polymer or control, S_2= 100 kg.ha^{-1} and S_3= 150 kg.ha^{-1} super absorbent polymer.

Jahan *et al.* (2013) reported applying amount of 80 kg.ha^{-1} super absorbent polymer led to increase corn Leaf area index by 11% compared with control. Mozzene Qamsari *et al.* (2009) reported increasing the leaf area index of maize affected super absorbent consumption in different irrigation periods may be due to the continuation of the necessary compressive potential for the leaf growth and reduction of the effect of drought stress in the plant.

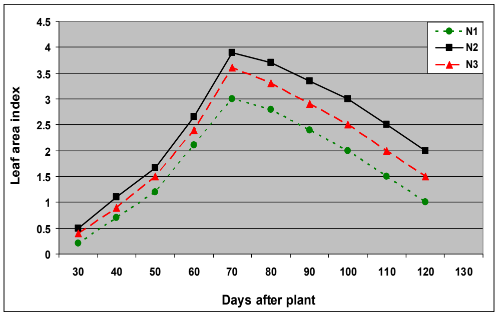

Fig. 6. Effect of different level of Nitroxin on leaf area index. N_1= nonuse of Nitroxin or control, N_2= 1 $L.ha^{-1}$ and 3 $L.ha^{-1}$ Nitroxin.

4.4. *Leaf area ratio* (*LAR*)

According to Fig. 7, 8, leaf area ratio has increasing trend in beginning of growth but over time, mentioned index decreases. At beginning of the growing season, the leaf area index increased to reach its maximum. Also, at the end of the growing season, the leaf area ratio decreases with decreasing leaf area due to drying of leaves and also increasing dry weight of the crop. Application super absorbent led to increase leaf area ratio than to control treatment. The highest leaf area ratio was observed in 150 $kg.ha^{-1}$ superabsorbent application (Fig. 7). In the early stages of growth, the index was the same for all treatments, but with the passage of time, leaf area ratio was higher in Nitroxin treatments than to control. The highest leaf area ratio was observed in treatment with 1 liter Nitroxin per hectare (Fig. 8). Islam *et al*. (2011b) reported the use of super adsorbent with the preservation of soil moisture and nutrient led to develop leaves during the early stages of growth. Karimi (2013) reported biological fertilizers increased leaf area ratio by increasing leaf area index of corn. It seems that due to activity of microorganisms, led to increase leaf area (the level of light absorption) and due to it amount of photosynthesis of the plant increases.

4.5. *Relative growth rate* (*RGR*)

The relative growth rate increased after germination stage and after had decreasing trend until ripening stage, because parts that are added to the tissue crop are not metabolically active and do not play a role in photosynthesis process. Also, due to the presence of early leaves in the shade and the aging of them, photosynthetic activity is reduced and relative growth rate is decreased.

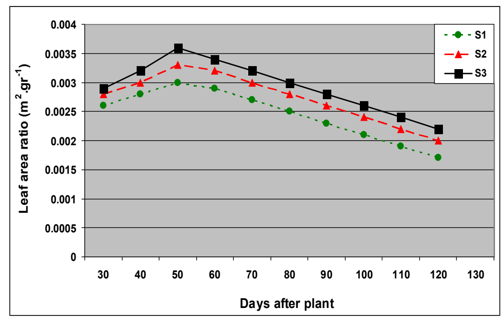

Fig. 7. Effect of different level of super absorbent polymer on leaf area ratio. S_1= nonuse of super absorbent polymer or control, S_2= 100 $kg.ha^{-1}$ and S_3= 150 $kg.ha^{-1}$ super absorbent polymer.

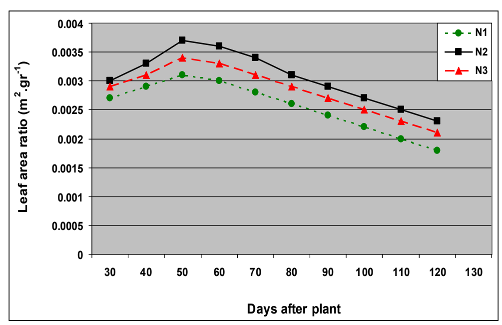

Fig. 8. Effect of different level of Nitroxin on leaf area ratio. N_1= nonuse of Nitroxin or control, N_2= 1 $L.ha^{-1}$ and 3 $L.ha^{-1}$ Nitroxin.

However, amount of dry matter increases with past time, but relative growth rates decreases due to increasing proportion of structural tissues to growing tissues (Tariqoleslami *et al*., 2012).

Relative growth rate was higher in superabsorbent treatments than to control, so 150 kg.ha^{-1} superabsorbent had highest amount RGR (Fig. 9). Relative growth rates in Nitroxin treatments had similar process with super absorbent and it's decreased via past time. So Nitroxin treatments had higher RGR than to control, and 1 L.ha^{-1} had highest amount RGR (Fig. 10).

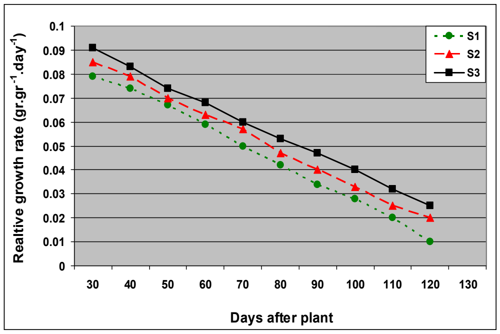

Fig. 9. Effect of different level of super absorbent polymer on relative growth rate. S_1= nonuse of super absorbent polymer or control, S_2= 100 kg.ha^{-1} and S_3= 150 kg.ha^{-1} super absorbent polymer.

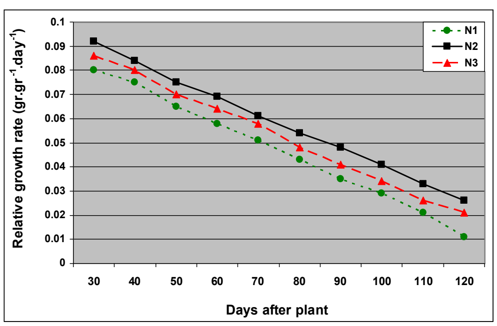

Fig. 10. Effect of different level of Nitroxin on relative growth rate. N_1= nonuse of Nitroxin or control, N_2= 1 L.ha^{-1} and 3 L.ha^{-1} Nitroxin.

4.6. Crop growth rate (*CGR*)

According Fig. 11 and 12 CGR in all treatments had increasing trend until flowering stage and after shift to decreasing trend until ripening. Application superabsorbent led to increase CGR than to control treatment, also 150 kg.ha^{-1} super absorbent treatment had higher level of CGR than to another treatments (Fig. 11). Although in beginning and end of growth 100 and 150 kg.ha^{-1} super absorbent treatment had similar process. Super absorbent can reduce degradation of chlorophyll by supplying water and nutrients, thereby increasing duration the use of light and photosynthesis, led to increase the CGR. Use Nitroxin led to increase CGR than to control treatments.

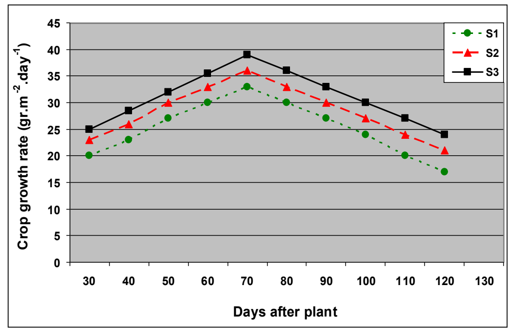

Fig. 11. Effect of different level of super absorbent polymer on crop growth rate. S_1= nonuse of super absorbent polymer or control, S_2= 100 kg.ha^{-1} and S_3= 150 kg.ha^{-1} super absorbent polymer.

Although 1 L.ha^{-1} Nitroxin had greatest effect (Fig. 12). Increasing the application of super absorbent polymer by improving the moisture content of the rhizosphere stimulated vegetative growth with increasing cellular swelling, which increased the leaf growth rate and, consequently, the crop growth rate (Islam *et al*., 2011). Similar result reported by Khorramdel *et al.* (2014). Fazeli Rostampour and Mohebbian (2012) reported increasing leaf area duration and dry matter accumulation led to increase crop growth rate. Hokm Alipour and Hamele Darbandi (2011) reported negative values of crop growth rate and relative growth rate are due to loss of leaves at the end of the growing season. So with increasing nitrogen levels at all of the corn cultivars plant height was significantly increased. Clarke and Simpson (1978) stated that simultaneously the maximum growth rate of the product was due to the increase in the durability of photosynthetic organs, which increased in the presence of biological fertilizers. Hokm Alipour *et al.* (2007) stated that the inoculation of *Azotobacter* with the *Azospirilum* compared to the control resulted in an increase in the growth rate of the crop. Wu *et al.* (2005) also reported that inoculation of the corn grains with biological fertilizers increased the growth rate of crops.

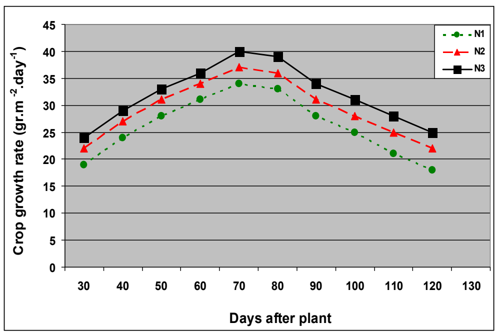

Fig. 12. Effect of different level of Nitroxin on crop growth rate. N_1= nonuse of Nitroxin or control, N_2= 1 L.ha^{-1} and 3 L.ha^{-1} Nitroxin.

5. CONCLUSION

Application of Super Absorbent Polymer and Nitroxin biologic fertilizer on seed yield, biologic yield and growth indices has significant effect than to control treatment. Totally according result of current research use of 150 kg.ha^{-1} Super Absorbent Polymer and 1 L.ha^{-1} Nitroxin led to produce highest crop yield and growth indices and it can be advised to farmers in studied condition.

ACKNOWLEDGMENT

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

FOOTNOTES

CONFLICT OF INTEREST: Authors declared no conflict of interest.

REFERENCE

Ahmed, E. M. 2015. Hydrogel, preparation, characterization, and the applications: A review. J. Adv. Res. 6(2): 105-121.

Akabarynia, A. 2004. Evaluation effect of chemical fertilizer, poultry, and intergradient fertilizer management on yield and concentration seed essence of Trachyspermum. 2nd Conf. Medicinal Plants. Shahed Univ. Tehran. Iran. (Abstract in English)

Alexandratos, N. 2003. World agriculture: Towards 2015-30. Cong. Global Food Security and Role of Sustainable Fertility. Rome. Italy.

Asadi Kupal, P. and Q. E. Zadeh Laserjan. 2009. Effect of bio-fertilizers and soil texture on rice growth. 1st Reg. Conf. Water Res. Manage. It's Role in Agri. Islamic Azad Univ. Shahreh-Ghods Branch. Iran. (Abstract in English)

Azimi, S. M., A. Farnia, M. Shaban. and M. Lak. 2013a. Effect of different bio-fertilizers on seed yield of barley, Bahman cultivar. Intl. J. Adv. Biol. Biomedical Res. 1(5): 538-546.

Azimi, S. M., E. Nabati, M. Shaban. and M. Lak. 2013b. Effect of N and P bio fertilizers on yield components of barley. Intl. J. Adv. Biol. Biomedical Res. 2(2): 365-370.

Azzam, R. A. I. 1983. Polymeric conditioner gels for desert soils. Communications in Soil Sci. Plant Analysis. 14: 739-760.

Barker, A. V. and D. J. Pilbeam. 2006. Handbook of Plant Nutrition. CRC Press. ISBN: 9780824759049.

Blodgett, A. M., D. J. Beattis, J. W. White. and G. C. Elliot. 1993. Hydrophilic polymers and wetting agents affect absorption and evaporate water loss. J. Horti. Sci. 28: 633-635.

Blum, A. 2010. Plant breeding for water-limited environments. Springer Pub. New York. USA.

Buttery, B. R. 1970. Effect of variation in leaf area index on the growth of maize and soybean. Crop Sci. 10: 9-13.

Cakir, R. 2004. Effect of water stress at different development stages on vegetative and reproductive growth of corn. Field Crops. J. 89: 1-16.

Charkhab, A. and M. Mojaddam. 2018. Evaluation of seed yield, its component and nitrogen use efficiency of sorghum in response to nitrogen and Nitroxin fertilizers. J. Crop. Nutr. Sci. 4(2): 1-19.

Clarke, J. M. and G. M. Simpson. 1978. Growth and analysis of *Brassica napus* cv., Tower. Canadian J. Plant Sci. 58: 587-595.

El-Amir, S., A. M. Helalia. and M. E. Shawky. 1993. Effects of acryhope and aqua store polymers on water regime and porosity in sandy soils. Egyptian J. Soil Sci. 4: 395-404.

Enyi, B. A. C. 1962. Comparative growth rates of upland and swamp rice varieties. Ann. Bot. 26: 467-487.

Enyisi, I. S., V. J. Umoh, C. M. Z. Whong, I. O. Abdullahi. and O. Alabi 2014. Chemical and nutritional value of maize and maize products obtained from selected markets in Kaduna State, Nigeria. African J. Food Sci. Tech. 5(4): 100-104.

Fallahi, H. R., R. Taherpour Kalantari, M. Aghhavani-Shajari. and M. Gh. Soltanzadeh. 2015. Effect of super absorbent polymer and irrigation deficit on water use efficiency, growth and yield of cotton. Not Sci. Biol. 7(3): 338-344. DOI: 10.15835/nsb.7.3.9626.

Fazeli Rostampour, M., M. Yarnia, F. Rahimzadeh Khoee, M. J. Seghatoleslami. and G. R. Moosavi. 2013. Physiological response of forage sorghum to polymer under water deficit conditions. Agron. J. 105(4): 951-959.

Fazeli Rostampour, M. and S. M. Mohebbian. 2012. Studying the effects of irrigation deficit and superabsorbent polymer on remobilization of assimilates in corn (*Zea mays* L.). Environmental Stresses Crop Sci. 4(2): 127-138.

Fulchirri, M. and I. Frioni. 1994. Azospirillum inoculation on maize: effect on yield in a field experiment in central argentine. J. Soil Biol. Bio-Chem. 26: 921-923.

Food and Agriculture Organization. 2014. Statistics. (http://www.fao.org/statistics)

Ganbari, M. and B. Mir. 2013. Evaluation effect of super adsorbent polymer on corn yield under drought stress. Second Natl. Conf. Sust. Develop. Agri. Environ. Karaj. Iran. pp: 304-311. (Abstract in English)

Gardner, F., R. Pearce. and R. L. Mitchell. 1985. Physiology of crop plants. Iowa State Univ. Press. Ames. USA.

Garg, B. K., S. Kathju. and S. P. Vyas. 2005. Salinity-fertility interaction on growth. Photosynthesis and nitrate reductase activity in sesame. Indian J. Plant Physiol. 10: 162-167.

Ghamarnia, H. and J. W. Gowing. 2005. Effect of water stress on three wheat cultivars. ICID 21st European Regional Conf. 15-19 May. Frankfurt (Oder) and Slubica. Germany and Poland.

Hasanozaman, M., K. U. Ahamed, K. Nahar. and N. Akhter. 2010. Plant growth pattern, tiller dynamics and dry matter accumulation of wetland rice (*Oryza sativa* L.) as influenced by application of different manures. Nature and Sci. J. 8(4): 1-10. *In*: Rosegrant, M. W. and J. A. Roumasset. Economic feasibility of green manure in rice-based cropping systems. Proc. Sym. Sustainable Agriculture. The Role Green Manures Crops in Rice Farming Systems. IRRI. Manila. Philippines. May 25-29. 1987-1988. pp. 11-27.

Hokm Alipour, S., R. Seyed Sharifi. and M. Ghadimzadeh. 2007. Study of plant density and nitrogen fertilizer levels on grain yield and dry matter remobilization in corn. Iranian J. Soil Res. 1(21): 21-15.

Hokm Alipour, S. and M. Hamele Darbandi. 2011. Physiological growth indices in corn (*Zea mays* L.) cultivars as affected by nitrogen fertilizer levels. World Appl. Sci. J. 15(12): 1800-1805. IDOSI Publ.

Islam, M. R., Y. Hu, Ch. Fei, X. Qian, A. E. Eneji. and X. Xue. 2011a. Application of superabsorbent polymer: A new approach for wheat (*Triticum aestivum* L.) production in drought-affected areas of northern China. J. Food, Agric. Environ. 9(1): 304-309.

Islam, M. R., Y. Hu, S. Mao, J. Mao, A. E. Enejid. and X. Xue. 2011b. Effectiveness of a water-saving superabsorbent polymer in soil water conservation for corn (*Zea mays* L.) based on eco-physiological parameters. J Sci. Food Agric. 9(1): 1998–2005.

Jahan, M., N. Kamayestani. and F. Ranjbar. 2013. Assay for applying super absorbent polymer in a low input corn (*Zea mays* L.) production system aimed to reduce drought stress under Mashhad conditions. Agro-Ecology J. 5(3): 272-281. (Abstract in English)

Johnson, M. S. 1984. Effect of soluble salts on water absorption by gel-forming soil conditioners. J. Sci. Food Agri. 35: 1063–1066.

Karimi, A., M. Noshadi. and M. Ahmadzadeh. 2009. Effects of super absorbent polymer (igeta) on crop, soil water and irrigation interval. J. Sci. Tech. Agric. Nat. Res. 12: 415-420.

Karimi, A. 2013. Evaluation seed yield and its components affected different level of Nitroxin biofertilizer. Second Natl. Conf. Sust. Agri. Environ. Karaj. Iran. pp: 111-120. (Abstract in English)

Kemal, Y. O. and M. Abera. 2015. Contribution of integrated nutrient management practice for sustainable crop productivity, nutrient uptake and soil nutrient status in Maize based cropping systems. J. Nutr. 2(1): 1-10.

Keshavars L., H. Farahbakhsh. and P. Golkar. 2012. The effects of drought stress and Superabsorbent polymer on morpho physiological traits of Pear millet (*Pennisetum glaucum*). International Res. J. Appl. Basic Sci. 3(1): 148-154.

Khadem, S. A., M. Ramroudi, M. Galavi. and M. Javad Rousta. 2011. Effect of drought stress and animal manure with super absorbent polymer on yield and its components of Corn. Iranian J. Field Crop Sci. 42(1): 115-123. (Abstract in English)

Khorramdel, S., R. A. Gheshm, A. Ghafori. and B. Esmaielpour. 2014. Evaluation of soil texture and superabsorbent polymer impacts on agronomical characteristics and yield of saffron. Saffron Res. J. 1(2): 120-135. (Abstract in English)

Lentz, R. D., R. E. Sojka. and C. W. Robbins. 1998. Reducing phosphorus losses from surface-irrigated fields: Emerging polyacrylamide technology. J. Environ. Quality. 27: 305-312.

Mikkelsen, R. L. 1994. Using hydrophilic polymers to control nutrient release. Fertilizer Res. 38: 53-59.

Moazzen Ghamsari, B., Gh. A. Akbari, M. J. Zohorian. and A. B. Nikniaee. 2009. Evaluation of yield of forage corn with application of super absorbent polymer (AB A200) under drought stress. Iranian J. Field Crop Sci. 40(3): 1-8. (Abstract in English)

Munir, A., S. Kaleem, A. Qayyum, M. Ahmad. and M. N. Abbas. 2012. Assimilate utilization wheat crop as influenced by varying nitrogen levels in rainfall area. Life Sci. Intl. J. 6(4): 2659-2662.

Nawas-Nazanat, G., M. Sawar, T. Yousaf. and A. Nasseb .2005. Yield and yield component of sunflower as affected by various NPK levels. Asian J. Plan Sci. 2(7): 561-562.

Nouraki, F., M. AlaviFazel, A. Naderi, E. Panahpoor. and Sh. Lack. 2016. Effects of integrated management of bio and chemical fertilizers on yield of maize hybrids. J. Exp. Biol. Agri. Sci. 4(4): 421-426.

Orzeszyna, H., D. Garlikowski. and A. Pawlowski. 2006. Using of geo-composite with superabsorbent synthetic polymers as water retention element in vegetative laters. Institute Agro-Physics. J. Pol. Acad. Sci. 20: 201-206.

Singh, D. K., A. K. Pandey, U. B. Pandey. and S. R. Bhonde. 2002. Effect of farmyard manure combined with foliar application of NPK mixture and micronutrients on growth, yield and quality of Onion. Newsletter-Natl. Horti. Res. Develop. Found. 21-22: 1-7.

Shamoradi, F. and S. K. Marashi. 2018. Influence of Chemical and Biological Fertilizers on Agro Physiological Characteristics of Corn (*Zea mays* L., S.C. 703). J. Crop. Nutr. Sci. 4(1): 1-16.

Sprent, J. and P. Sprent. 1990. Nitrogen Fixation Organisms. Chapman and Hall. New York. USA. 323p.

Talaei, Gh. 2012. Effect of bio and chemical fertilizers on yield and yield components of Cumin. MSc Thesis. Shahed Univ. Tehran. Iran. (Abstract in English)

Tarang, E., M. Ramroudi, M. Galavi, M. Dahmardeh. and F. Mohajeri. 2013. Effects of nitroxin bio-fertilizer with chemical fertilizer on yield and yield components of grain corn (cv. Maxima). Intl. J. Agri. Sci. 3(5): 400-405.

Tariqoleslami, M., R. Zarqami, M. Mashhadi, A. Bojar. and M. Ovaysi. 2012. Effect of Drought stress and nitrogen fertilizer on corn physiological indices. J. Agron. Plant Breed. 8(1): 161-174. (Abstract in English)

Tesar, M. B. 1984. Physiological basis of crop growth and development. Am. Soc. Agron. Madison. Wisconsin. USA. pp: 291-321.

Wu, S. C., Z. H. Caob, Z. G. Lib, K. C. Cheunga. and M. H. Wong. 2005. Effects of bio-fertilizer containing N-fixer, P and K solubilizes and AM fungi on maize growth: a greenhouse trial. Geoderma. J. 125: 155-166.

Yazdani, F., I. Allahdadi. and G. A. Akbari. 2007. Impact of superabsorbent polymer on yield and growth analysis of soybean under drought stress condition. Pakistan Journal of Biological Sciences 10: 4190-4196.

Yousefi Fard, Y. and E. Asareh. 2013. Effect of using super adsorbent, potash fertilizer and irrigation interval on corn yield. Second Natl. Conf. Sust. Agri. Environ. Karaj. Iran. pp: 111-120. (Abstract in English)

Zhang, Y. Y., Y. Li. and T. Gao. 2008. Arabidopsis SDIRI Enhance Drought Tolerance in Crop Plant. J. Biosci. Biotech. Biochem. 72(8): 2251-2254.