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Influence of Chemical and Biological Fertilizers on Agro-Physiological Characteristics of Corn (*Zea mays* L., S.C. 703)

Felora Shamoradi [1], Seyed Keyvan Marashi [2]*

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

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ABSTRACT

In order to investigate the effect of sugarcane compost on consumption of nitrogenous fertilizers in corn fields, a research project was conducted according split plot experiment based on randomized complete block design with three replications along 2015 year. The main plot included different chemical nitrogenous fertilizer (Zero; control, 60 and 120 $kg.ha^{-1}$ pure nitrogen from urea source). Biological nitrogenous fertilizers in three levels (Azotobacter, Nitrokara and non-application of biofertilizer) belonged to sub plots. The results of analysis of variance revealed that the effect of different levels of nitrogenous chemical fertilizer on plant height, leaf area index and total dry matter were significant at 1% probability level. But the differences were not significant for crop growth rate and net assimilation rate. The effect of different levels of biological nitrogenous fertilizers in all traits was significant at 1% probability level. The interaction effect of treatments on leaf area index at the stage of silk emergence was only significant at 5% probability level and was not significant difference for other traits. According the mean comparison result of chemical fertilizer the maximum and minimum values of the studied traits were observed in terms of consumption of 120 $kg.ha^{-1}$ of urea and non-application of chemical fertilizer (control). Among different levels of biological fertilizer, the maximum and minimum amount were observed in traits of application of Nitrokara and without biological fertilizer treatment. In general, the results of the current experiment indicated that the use of chemical nitrogenous fertilizer and biological fertilizers in field with sugarcane compost had a positive effect on all studied traits and the best situation was obtained in 120 $kg.ha^{-1}$ through chemical fertilizer and simultaneous use of Nitrokara fertilizers which could be of interest to researchers and farmers.

Keywords*:* *Azotobacter*, *Dry matter*, *Net assimilation rate.*

***Corresponding Author:** Seyed Keyvan Marashi ✉ Marashi_47@yahoo.com

INTRODUCTION

The use of renewable resources and inputs is one of the fundamental principles of sustainable agriculture that enables maximum crop productivity and minimal environmental risk (Kizilkaya, 2008). Crops require food elements to grow and produce. These elements are available to plants through soil and fertilizers. Management of the use of chemical fertilizers, especially nitrogen, is one of the most common and the most popular for crop research, because the deficiency and exacerbation of this element are both harmful (Murdock *et al.*, 1997). Fertilizer management plays an important role for obtaining satisfactory yields and to increase crop productivity. Nutrient management may be achieved by the involvement of organic sources, bio fertilizers, and micronutrients (Singh *et al.*, 2002). Nitrogen fertilizer is a key nutrient in the production of non-legume crops. It is a component in many biological compounds that plays a major role in photosynthetic activity and crop yield capacity (Cathcart and Swanton, 2003) and its deficiency constitutes one of the major yield limiting factors for cereal production (Shah *et al.*, 2003). Nitrogen is the most limiting essential nutrient for maize production (Aftab *et al.*, 2007). Nitrogen has positive effect on storage of protein in Maize seed and hence, the rates of this element are effective in its distribution in plant (Souza *et al.*, 1998). A low nitrogen content in the soil leads to poor absorption of micronutrients by plants, which may be insufficient for the complete development of the plant tissue (Szulc, 2013). On the other hand, an excessive accumulation of mineral nitrogen in the soil poses a risk of water pollution as a result of nitrate leaching by precipitation (Ladha *et al.*, 2005). The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000). More recently, attention is focused on the global environmental problems. The world elite society is giving emphasize on utilization of organic wastes, farm yard manure, compost, vermin compost and poultry manures as the most effective measure to save the environment to some extent. Organic materials are the safer sources of plant nutrient which have no detrimental effect to crops and soil. Cow dung, farm yard manure, poultry manure and also green manure are excellent sources of organic matter as well as primary plant nutrients (Pieters, 2005). After the industrial revolution widespread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems (Hasan uzzaman *et al.*, 2010). Organic manure is cheap and could be used as a substitute for chemical fertilizers (Delate and Camberdella, 2004). 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). Chemical fertilizers have several negative impacts on environment and sustainable agriculture. Therefore, bio fertilizers are recommended in these conditions and growth prompting bacteria uses as a replacement of chemical fertilizers (Wu *et al.*, 2005). Growth promoting bacteria induced increasing plant yield as clone in plants root (Gholami *et al.*, 2009). Growth prompting bacteria are including *Azotobacter*, *Azospirillum* and *Pseudomonas* (Banerjee *et al.*, 2006). Tilak (1992) reported positive effects of double-inoculation of *Azotobacter* and *Azospirillum* on dry matter of maize and sorghum. 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 bio-fertilizers (Kemal and Abera, 2015). The application of bio fertilizers has become of great necessity to get a yield of sufficient high quality and to avoid environmental pollution (Shevananda, 2008). Biological fertilizers are obviously an important part of a sustainable agricultural system and have an important role in crop production by maintaining soil fertility (Chen, 2006). Biological fertilizers are produced from a variety of micro organisms that have the ability to convert nutrients from non-absorbable to absorbable forms (Yu and Wong, 2005). Bio-fertilizer usually contains microorganisms having specific function such as *Azospirillum* to fix nitrogen and P solubilizing bacteria to solubilize P from the soil and fertilizer to be available to the plants (Saraswati and Sumarno, 2008). Application of bio-fertilizers became of great necessity to get a yield with high quality and to avoid the environmental pollution (Shevananda, 2008). In maize, application of bio-fertilizers increased growth and yield in many researches. Increased root, shoot weight with dual inoculation in maize have been reported by (Chabot *et al*., 1993), while grain yields of the different maize genotypes treated with *Azospirillum* spp. Seed inoculation with Rhizobium , phosphorus solubilizing bacteria, and organic amendment increased seed production of the crop (Panwar *et al*., 2006). Among microorganisms, The *Azotobacter* has attracted more attention because of their ability to communicate with important crop plants such as wheat, corn, and sorghum (Hegde *et al*., 1999). *Azotobacter* is a free-living bacteria that stabilizing the molecular nitrogen for stimulating and enhancing plant growth through nitrogen fixation (Pandey *et al*., 1998), increasing the production of hormones (Hegde *et al*, 1999), B vitamins (Rao and Pillai, 1982), the development of the root system and the release of organic acids in the rhizosphere (Gaind and Gaur, 1989). Rai and Caur (1998) studied *Azotobacter* and *Azospirillum* and double-inoculation and alone inoculation effects on wheat growth and yield. Double-inoculation of *Azotobacter* and *Azospirillum* had positive effects on plant height, spike length, grain yield, biological yield and harvest index in various wheat genotypes. It is proved that hormones such as oxine, giberline and cytokenine are synthesized by many *Azotobacter* spp (Singh *et al*., 2004). The Nitroxin biological fertilizer also contains nitrogen stabilizing bacteria, which is produced and supplied with the approval of the country's research institutes (Asadi Kupaland and Isa Zadeh Laserjan, 2009). 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 (Fulchirri and Frioni, 1994). According to the Mohammed *et al*. (2001), the use of bio-fertilizers offers agronomic and environmental benefits to intensive farming systems in Egypt, and the data showed that using *Azospirillum* brasilense or commercial bio fertilizers in cereals with a half nitrogen rate (144 Kg N ha) caused a significant increase in yield. Further, seed inoculation with Rhizobium, phosphorus solubilizing bacteria, and organic amendment increased the seed production of the crop (Panwar *et al*., 2006). In maize, application of biofertilizers increased growth and yield in many researches. Increased root, shoot weight with dual inoculation in maize have been reported by (Chabot *et al*., 1993), while grain yields of the different maize genotypes treated with *Azospirillum* spp. Seed inoculation with Rhizobium , phosphorus solubilizing bacteria, and organic amendment increased seed production of the crop (Panwar *et al*., 2006). Beyranvand *et al.* (2013) suggested that effect of nitrogen and phosphate bio-fertilizers were evaluated the positively, there were an increase in plant height, ear weight, and number of grain per cob, grain yield and biomass yield. Increasing yield was attributed to the plant growth promoting substances by root colonizing bacteria more than the biological nitrogen fixation, stated that yield increased due to promoting root growth which in turn enhancing nutrients and water uptake from the soil (Lin *et al*., 1983). Combined application of organic fertilizer and urea fertilizer or combination urea fertilizer and polyamines significantly increased yield, vegetative growth and chlorophyll index (Zeid, 2008). For gave to highest seed yield in agriculture addition to both nitrogen and phosphate fertilizer is very important (Shaban, 2013). Plant physiologists apply growth indices as useful tools for quantitative analysis of growth in different subjects such as plant breeding, plant ecology and physiology (Poorter and Garnier, 1996). One of the most accurate ways to study plant reactions to environmental conditions is through evaluation of physiological growth indicators (Karimi and Siddique, 1991). Some researcher have emphasized the crucial role of physiological features in crop performance improvement but detailed and comprehensive studies in this area have not conducted yet and effective morphological limitations on yield have not recognized. Yield is a complex feature which depends on the function of physiological combined processes in particular, the limiting components that change with the cultivar (Azarpour *et al*., 2014). Given the importance of nitrogen fertilization on the yield in grain from the corn plant, it is necessary to know what the best dose is for each variety as well as its influence on components of yield and other agronomic parameters in order to obtain better knowledge of said productive response. Physiological growth analysis is the important in prediction of yield. Growth analysis is a way to assess what events occurs during plant growth. Growth analysis is a suitable method for plant response to the different environmental conditions during plant life (Tesar, 1984). Nitrogen is one of the important agronomy factors which has a significant impact on growth indices and by selecting the appropriate amount of nitrogen, balanced complex of growth indices will be create in canopy which lead to yield improvement since the most indicators of growth are related to leaf area index in some way. Leaf area index changing through alteration in nitrogen fertilizer levels is one of the most practical ways. In every region, leaf area index which produces the maximum yield is different and it should be obtained by the local research (Azarpour *et al*., 2014). Yield is a complex trait resulting from interaction of morphological, physiological and environmental parameters on the growth of plants. Identification of the variations of morphological and physiological traits influencing the yield of a plant in a certain environment is an essential tool for selecting and breeding of yield (Azarpour *et al*., 2014). 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). The above indices plus crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), leaf area duration (LAD), leaf area rate (LAR), leaf weight rate (LWR) and specific leaf area (SLA) are indices which often use for evaluation of plant productivity capability and environmental efficiency (Anzoua *et al*., 2010; De Sclaux *et al*., 2000). Leaf area index (LAI) and dry matter production is the main growth factor which may directly reflect to cotton yield. Growth analysis parameters like crop growth rate (CGR) are product of LAI. Relative growth rate (RGR) measures the increase in dry matter with a given amount of assimilatory material at a given point of time (Rajput *et al*., 2017). Total dry matter is influenced by RGR (Egly and Guffy, 1997). Sharifi *et al*., (2014) reported that during plant growth stages RGR values are interrelated to dry matter accumulation and crop growth rate. The amount of growth and photosynthetic translocation is related to nutrients availability (Munir *et al*., 2012). Dwyer and Tewart (1986) reported that leaf area index is major factor determining photosynthesis and dry matter accumulation. Crop growth rate is related to leaf area index, for this reason that crop growth rate changes is depended to two parameters: namely leaf area index and net assimilation rate. Leaf area index is the component of crop growth analysis that accounts for the ability of the crop to capture light energy and is critical to understanding the function of many crop management practices. Leaf area index can have importance in many areas of agronomy and crop production through its influence on: light interception, crop growth weed control, crop-weed competition, crop water use, and soil erosion. To measure LAI, scientists generally have cut a number of plants at the soil surface, separated leaves from the other plant parts, and measured the area of individual leaves to obtain the average leaf area per plant. The product of leaf area per plant and the plant population gives the LAI. Alternatively, LAI could be measured none destructively with this procedure if area of individual leaves was determined by some combination of leaf length and width measurements (Shirkhani and Nasrolahzadeh, 2016). Jafari Haghighi and Yarmahmodi (2011) by evaluate the effects of chemical and biological fertilizers on physiological traits of corn under different irrigation regime reported to achieve high yield use biological fertilizer cannot sufficient but integrated application of fertilizers (Biological and Chemical fertilizers) became causes significant increase in yield can be advised. Hokm Alipour and Hamele Darbandi (2011) reported application of nitrogen fertilizer has positive effects on yield and physiological growth indices of maize cultivars, it can be suggested that use korduna cultivar with 180 kg N ha levels. Nouraki *et al*. (2016) reported bacteria have positive role in the production of bio-fertilizers and hormones which play a significant role in regulating plant growth while mixing them with chemical fertilizers as a supplement the level and depth of the roots. This combination also increases the rate of water and nutrient absorbance which raise the rate of growth and photosynthesis. These combination also increase the grain yield, yield components, and biological function, it has been found that bio-fertilizers can be combined with chemical fertilizers in a complementary way to reduce the excessive amount of chemical fertilizers used to grow corn. It was shown that the mixing of biological fertilizers with chemical fertilizers could reduce the needs of chemical fertilizers up to 25% and these results are comparable to the application of 100% chemical fertilizers. Therefore, the best hybrid maze is the single cross 704 that has good yield potential when the chemical fertilizer is used at either 25% or 50% of the current application when mixed with the bio-fertilizer. 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 $t.ha^{-1}$). Azimi *et al*. (2013b) was reported that grain yield and biomass yield increasing with the bio fertilizer application, also which account important benefit, causing decreasing in the inputs of production because of economizing much money to chemical fertilizers and increasing in yield and biological yield. Recently, the use of sugarcane compost has been considered as one of the most important steps towards achieving sustainable agriculture and reducing fertilizer use. Sugar compost contains a large amount of organic matter, organic and inorganic nitrogen and other nutrients, which can be used as organic fertilizers with the chemical fertilizers to improve the physical and chemical properties of the soil. Since, there is a shortage of nutrients under the alone application of these fertilizers due to the gradual release of the elements from the compost. Therefore, the study was conducted to achieve the correct use of chemical fertilizers under consumption of compost conditions, especially in sustainable agriculture. So, this research was designed and performed to evaluate the reduction of chemical nitrogenous fertilizer consumption by replacing them with bio-fertilizers.

MATERIALS AND METHODS

Field and Treatment Information

This research was carried out to evaluate effect of chemical and biological fertilizer on agro-physiological traits of corn via split plot experiment based on randomized complete blocks design with three replications along 2015 year. Place of research was located in research field of the Islamic Azad University in the Weiss city at longitude 48°53'E and latitude 31°36'N in Khuzestan province (Southwest of Iran) and 51 meters above sea level. The main plot included different chemical nitrogenous fertilizer (Zero; Control, 60 and 120 $kg.ha^{-1}$ pure nitrogen from urea source). The biological nitrogenous fertilizers in three levels (*Azotobacter*, Nitrokara and non-application of the biofertilizer) belonged to sub plots. The soil properties of the experimental field mentioned in table 1.

Table 1. Physical and chemical characteristics of soil

Soil Depth (cm)	0-30
Electrical conductivity ($ds.m^{-1}$)	6.11
pH	7.15
Organic Carbon (%)	0.51
Nitrogen ($mg.kg^{-1}$)	0.04
Phosphorous ($mg.kg^{-1}$)	18.5
Potassium ($mg.kg^{-1}$)	196
Sand (%)	19
Silt (%)	49
Clay (%)	32
Soil Texture	Silty loam

Farm Management

The field preparation included the plowing with a plough machine, two vertical disk machine and Leveler for leveling the ground. After preparing the field and before planting, 30 $t.ha^{-1}$ of compost from the sugarcane residue was mixed with the soil with the help of a disk machine. Sugar compost was prepared from Shushtar Animal Feed Company under the supervision of Karoun Crop Industry Company. The field was furrows form with a furrower machine, the row spacing was 75 and the spacing of the grains in each line was 20 cm. *Azotobacter* and Nitrokara biofertilizer were used in the form of spraying on grain before planting. The amount of *Azotobacter* and Nitrokara fertilizers was consumed according to the recommendation of the producer company were 500 $ml.ha^{-1}$ and 100 $g.ha^{-1}$, respectively. Urea fertilizer was 240 kg N pure per hectare according to the custom of the region and percentage of it's used according to the type of treatment. Urea fertilizer was applied in two stages before and after planting in 4-6 leaf stage with irrigation water.

Measured Traits

Plant height in each plot was measured in 5 plants randomly up to the end of tassel. Measurement of growth indices such as leaf area index, dry matter accumulation in three stages of emergence of tassel, emergence of silk and grain filling stage were taken from 5 plants per plot. Leaf area index was measured by leaf area meter. To measure the dry matter, the samples were dried in an oven for 48 hours at 72 °C and their dry weight was determined using a digital scale with a precision of 0.01. Crop growth rate and net assimilation rate were calculated in the unit of $gr.m^{-2}.day^{-1}$ via using formula as follows between the two stages of tassel emergence until the emergence of silk (Beadle, 1987):

Equ. 1. $CGR = (W2-W1)/GA\ (T_2-T_1)$

Equ. 2. $NAR = CGR/LAI$

W_2-W_1: Dry matter weight per sample.
T_2-T_1: Time interval between sampling.
GA: Ground area occupied by the crop at the time of sampling.

Statistical Analysis

The data were analyzed by using Minitab software (Ver. 15) and mean comparison was done by Duncan test at 5% probability level.

RESULTS AND DISCUSSION

Total dry weight (TDW)

According result of analysis of variance the effect of nitrogen fertilizer and biofertilizer on total dry weight was significant at 1% probability of level, but interaction effect of treatments was not significant (Table 2). Mean comparison result indicated maximum dry weight was obtained at all stages of development and consumption of 120 $kg.ha^{-1}$ nitrogen fertilizer and minimum rate belonged to non-application of nitrogen fertilizer treatment (Table 3). It seems that increased nitrogen consumption has been effective in increasing dry matter production due to increased leaf area and absorption of solar radiation (Hokm Alipour and Hamele Darbandi, 2011). Increasing total dry matter in terms of application of nitrogen fertilizer has been reported by Hokm Alipour *et al*. (2007). Karimi (2007) stated that their use of organic fertilizers and chemical fertilizers has a greater effect than alone use of them on corn yield. Results of researches showed increase of nitrogen level has a significant effect on dry matter yield and its reason is mainly due to high nitrogen content, organic nitrogen and soil organic matter (Bennet *et al*., 1982). The results of mean comparisons also revealed that the maximum total dry weight was obtained at all stages of development in Nitrokara fertilizer and the minimum rate belonged to the nonuse bio fertilized treatment (Table 3). Increasing the total dry weight in terms of bio-fertilizers can be due to the release of the elements in compost from organic to inorganic form due to production of organic acids by bacteria and increased root area in response to secretion of various plant hormones by the biological fertilizers (Egamberdiyeva, 2007). The results of Stancheva *et al*. (1992) also showed the corn weed increased with bio-fertilizers due to inoculation of corn. The reason for this matter has been mentioned because of access and nutrient uptake.

Leaf area index (LAI)

According to result of analysis of variance the difference in leaf area index at all stages of development in terms of nitrogen fertilizer and bio fertilizer was significant at 1% probability level, also interaction effect of treatments only at the stage of silk emergence was significant at 5% probability level (Table 2). Assessment mean comparison result indicated the maximum leaf area index at all stages of development was observed in consumption of 120 $kg.ha^{-1}$ nitrogen fertilizer and the lowest one was found in nonuse nitrogen fertilizer treatment (Table 3).

Table 2. ANOVA result of measured traits

S.O.V	df	Total dry matter			Leaf area index		
		Tassel emergence stage	Silk emergence stage	Grain filling stage	Tassel emergence stage	Silk emergence stage	Grain filling stage
Replication	2	2081.7	8126	7676	0.0321	0.0011	0.011
Chemical nitrogen (N)	2	48769.1**	67332**	64940**	0.278**	0.135**	0.120**
Error I	4	119.9	729	791	0.001	0.004	0.0004
Biological fertilizer (B)	2	3898.4**	23557**	19432**	0.064**	0.101**	0.064**
N*B	4	17.3^{ns}	111^{ns}	258 ^{ns}	0.0001^{ns}	0.001*	0.0049^{ns}
Error II	12	62.8	219	155	0.0009	0.0004	0.0019
C.V (%)	-	10.8	11	10.9	10.7	10.6	11.9

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

Continue Table 2.

S.O.V	df	Plant height	Crop growth rate	Net assimilation rate
Replication	2	51.15	11.130	0.267
Chemical nitrogen (N)	2	1411.8**	11.758 ^{ns}	0.495 ^{ns}
Error I	4	19.15	2.630	0.181
Biological fertilizer (B)	2	16.15 **	37.082**	0.969**
N*B	4	3.65 ^{ns}	0.563^{ns}	0.0340^{ns}
Error II	12	2.20	0.814	0.0470
C.V (%)	-	10.8	12.7	12.7

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

Table 3. Mean comparison effect of different levels of nitrogen and biological fertilizer on measured traits

Treatments	Total dry matter ($g.m^{-2}$)			Leaf area index		
	Tassel emergence stage	Silk emergence stage	Grain filling stage	Tassel emergence stage	Silk emergence stage	Grain filling stage
Chemical nitrogenous fertilizer						
Nonuse nitrogen fertilizer (control)	920.9[c]	1 410.6[c]	1335.6[c]	4.033[c]	3.207[c]	2.158[c]
60 $kg.ha^{-1}$	1022.2[b]	1510.6[b]	1429.9[b]	4.272[b]	3.335[b]	2.297[b]
120 $kg.ha^{-1}$	1064.1[a]	1582.9[a]	1505.2[a]	4.376[a]	3.453[a]	2.388[a]
Biological fertilizer						
Azotobacter	1006.5[b]	1515.7[a]	1434.1[b]	4.268[a]	3.382[a]	2.323[a]
Nitrokara	1020.8[a]	1543.8[a]	1463.9[a]	4.283[a]	3.404[a]	2.337[a]
Nonuse bio-fertilizer	979.8[c]	1444.6[b]	1372.8[c]	4.130[b]	3.210[b]	2.184[b]

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

Continue Table 3.

Treatments	Plant height (cm)	Crop growth rate ($gr.m^{-2}.day^{-1}$)	Net assimilation rate ($gr.m^{-2}.day^{-1}$)
Chemical nitrogenous fertilizer			
Nonuse nitrogen fertilizer (control)	181.00[*c]	32.64[a]	8.07[a]
60 $kg.ha^{-1}$	189.56[b]	32.55[a]	7.61[a]
120 $kg.ha^{-1}$	205.67[a]	34.58[a]	7.87[a]
Biological fertilizer			
Azotobacter	193.33[a]	33.94[a]	7.95[a]
Nitrokara	192.22[a]	34.86[a]	8.12[a]
Nonuse bio-fertilizer	190.67[b]	30.97[b]	7.48[b]

*Similar letters in each column show non-significant difference at 5% probability level in Duncan test.

The results showed that with increasing nitrogen up to 120 $kg.ha^{-1}$, the leaf area index increased linearly. This is probably due to the gradual release of elements from the compost and their absorption by the plant. It seems that the elements in the compost do not fully meet the nutritional requirements of the plant and the consumption of nitrogen has compensated for this deficiency. Increasing in leaf area index with application of nitrogen fertilizer has been reported by Hokm Alipour *et al*. (2007). 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 (Table 3). Hamidi *et al*. (2007) showed that inoculation of corn grains with biological fertilizers increased number of leaves per plant. The researchers attributed this to the existence of positive relationships between plant and bacteria, especially through the production of growth-promoting hormone. 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. Evaluation mean comparison result of interaction effect of treatments showed maximum leaf area index (3.54 and 3.50) at the emergence stage of silk was observed in 120 kg nitrogen fertilizer with application Nitrokara and *Azotobacter* fertilizer and lowest one (3.07) found in in non-application of nitrogen and bio fertilizer (control) (Table 4). This result indicates a better effect of bio fertilizers under the consumption of more nitrogen. Other researchers also have a significant increase in maize leaf area index of up to 120 kg N ha^{-1} combined with biological fertilizers (Mirshekari *et al*., 2009). The mean of treatments with the same letters were not statistically significant with respect to the Duncan multidimensional test at 5% level.

Table 4. Mean comparison interaction effect of biological and chemical fertilizer application on leaf area index

Treatments		Leaf area index		
Chemical nitrogenous fertilizer	**Biological fertilizer**	**Tassel emergence stage**	**Silk emergence stage**	**Grain filling stage**
Nonuse nitrogen fertilizer (control)	Azotobacter	4.076 ^{*c}	3.26 ^{cde}	2.22 ^{b}
	Nitrokara	4.09 ^{c}	3.28 ^{cd}	2.23 ^{b}
	Nonuse bio-fertilizer	3.93 ^{d}	3.07 ^{d}	2.01 ^{c}
60 kg.ha^{-1}	Azotobacter	4.31^{ab}	3.37 ^{bc}	2.33 ^{ab}
	Nitrokara	4.32^{ab}	3.39^{b}	2.35 ^{ab}
	Nonuse bio-fertilizer	4.18 ^{c}	3.24^{cdef}	2.20 ^{b}
120 kg.ha^{-1}	Azotobacter	4.42 ^{a}	3.50^{ab}	2.40 ^{a}
	Nitrokara	4.43 ^{a}	3.54 ^{a}	2.42 ^{a}
	Nonuse bio-fertilizer	4.27 ^{b}	3.31 ^{c}	2.33 ^{ab}

*Similar letters in each column show non-significant difference at 5% probability level via Duncan test.

Plant height

The results of analysis of variance showed that the effect of nitrogen and biofertilizer on plant height was significant at 1% probability level, but interaction effect of treatments was not significant (Table 2). The maximum plant height by 205.67 cm was related to the consumption of 120 kg.ha^{-1} of nitrogen fertilizer and the minimum rate with 181 cm belonged to non-application of nitrogen (control) (Table 3). The reason for increasing plant height can be attributed to the role of nitrogen in the production and transfer of Cytokinin from the root to the shoot and the increase in cell division, growth and plant height (Marschner, 1995). The results of this study are consistent with the results of Torbatinejad *et al*. (2002) in sorghum and Ansarinia (2010) in sunflower. Mean comparison result of different level of biofertilizer indicated that maximum plant height (193.33 and 192.22 cm) was noted for *Azotobacter* and Nitrokara fertilizers and minimum of that (190.67 cm) belonged to non-bio-fertilized (control) treatment (Table 3). Emam and Eilkaee (2002) reported in their research on sunflower that the bacteria in Nitroxin would increase water absorption, nutrients and root development, which would be due to plant height. Hernandes *et al*. (1995) also reported an increase in the height of maize plants for inoculum conditions with Pseudomonas bacteria. In addition, it has been reported that biological fertilizers affect plant growth through the production of growth stimulators, especially Auxin (Vessy, 2003). Improve of plant height whit increasing nitrogen levels was reported whit Hokmalipour *et al*. (2010). The increase in plant height in response to application of N fertilizers is probably due to enhanced availability of nitrogen which enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation. These results are supported by the findings of Pablo *et al*. (2008). Fitter (1988) also stated that the use of growth-promoting bacteria while reducing the use of chemical fertilizers has led to an increase in the efficiency and growth of plants.

Crop growth rate (CGR)

The results of analysis of variance showed that the effect of bio fertilizer application on crop growth rate was significant at 1% probability level, but effect of nitrogen fertilizer and interactions effects of treatments was not significant (Table 2). Mean comparison result of different level of bio fertilizer indicated the maximum crop growth rate belonged to application of *Azotobacter* and Nitrokara bio fertilizers by 34.86 and 33.94 $gr.m^{-2}.day^{-1}$, respectively and the lowest one with 30.97 $gr.m^{-2}.day^{-1}$ was obtained in non-application of bio fertilizer treatment (Table 3). The results of this experiment were consistent with the findings of Hokm Alipour *et al*. (2007), which stated that inoculation of *Azotobacter* with 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 corn grains with biological fertilizers increased the growth rate of crops. The researchers reasoned this by increasing the availability of nutrients and improving the absorption of nutrients by the plant. 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. Many researchers have stated that biological fertilizers alone cannot provide the total nitrogen needed by the plant, and the positive effects of biological fertilizers on the availability of other elements such as phosphorus through increased solubility and absorption and the production of various growth-promoting hormones (Vessy, 2003).

Net assimilation rate (NAR)

The results of ANOVA revealed that the effect of bio fertilizer on net assimilation rate was significant at 1% probability level, but effect of nitrogen fertilizer and interactions effects of treatments was not significant (Table 2). According result of mean comparison of different level of bio fertilizer the maximum net assimilation rate was obtain to application of *Azotobacter* and Nitrokara bio fertilizers by 8.12 and 7.95 $gr.m^{-2}.day^{-1}$, respectively and the lowest one with 7.48 $gr.m^{-2}.day^{-1}$ was belonged to non-application of bio fertilizer (control) treatment (Table 3). It has been stated that the bacteria in biological fertilizers are probably due to stimulation of root growth and also through the stabilization and absorption of nitrogen increased leaf area, process of chlorophyllation and the more absorption of solar radiation and eventually increased the process of assimilation (Kader *et al.*, 2002). Allen *et al.* (1980) reported that in the presence of biological fertilizers, the amount of cytokinin and chlorophyll in the plant increases and these factors are effective in increasing plant growth. Farrokhi and Aradatmand Asli (2008) also stated that the application of biofertilizers leads to an increase in the absorption of carbon dioxide and the efficiency of photosynthesis in corn.

CONCLUSION

The results showed that the application of chemical nitrogenous fertilizer and biological fertilizer under sugarcane compost conditions is effective to improve physiological and morphological parameters of corn, and this effect is more pronounced in the combined application of biological with chemical fertilizers than alone application of biological fertilizer. In this research, best situation was achieved through consumption of 120 $kg.ha^{-1}$ chemical fertilizers and simultaneous consumption of Nitrokara, which could be considered by researchers and farmers.

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