2011 International Conference on Biology, Environment and Chemistry
IPCBEE vol.24(2011) © (2011)IACSIT Press, Singapoore

Azotobacter inoculation, nitrogen fertilizer and manure levels effects on morphological characteristics of corn SC-647, in a greenhouse study

Manoochehr Farboodi[1+]; Mohammad Alizadeh[1]; Ali Faramarzi[1], Shahram Shahrokhi[1] and Alireza Fallah[2]

[1] Department of Agronomy, Miyaneh Branch, Islamic Azad University, Miyaneh, Iran
[2] Soil and Water Research Institute, Meshkin-dasht, Alborz Province, Iran

Abstract. For study the effects of different nitrogen fertilizer levels, manure and Azotobacter application on growth characteristics of corn (*Zea mays* L.) variety SC-647, an experiment was conducted in research greenhouse of Islamic Azad University, Miyaneh Branch, during autumn 2010. Experiment was carried out as factorial based on completely randomized design (CRD) with three replications. Experimental factors were Azotobacter inoculation at two levels including non inoculation (A_0) and inoculation (A_1), two manure levels (O_0 = 0 and O_1 = 10 ton.ha^{-1}) and four nitrogen fertilizer levels (N0, N75, N150, N225 kg/ha) from urea source. The studied characteristics were plant height, chlorophyll content, flowering time, nitrogen content and biomass. The results of analysis of variance indicated that main effects of the most experimental treatments and their interactions were significant for all studied characteristics. Azotobacter inoculation, nitrogen fertilizer and manure application increased growth characteristics' values in maize var. SC-647. The highest biomass, yield and chlorophyll content were observed in A1O1N3 treatment. A1O1N2 and $A_1O_1N_3$ treatments had also caused higher protein content than others. The most stem diameter and plant height was obtained in $A_1O_1N_2$ treatment. However, the lowest values for protein content, biomass, chlorophyll content, and time of flowering were produced in A0O0N0 (the control). The least stem diameter was also observed in $A_0O_0N_0$, $A_0O_0N_1$ and $A_0O_1N_0$ treatments and application of $A_0O_1N_0$ resulted in the least stem height.

Key word: Corn, *Zea mays*, Azotobacter, Biomass, Nitrogen fertilizer, Manure.

1. Introduction

Maize (*Zea mays* L.) is one of the important cereal crops next to wheat and rice in the world. The productivity of maize mainly depends on its nutrient management (Kumar *et al.*, 2007). Increasing nitrogen fertilizer, manure and Azotobacter inoculation could increase biological growth, biomass and nitrogen content of cereal crops, especially maize. Among fertilizers, manure has safe and additive effects on Azotobacter inoculation, although nitrogen fertilizer could partly compensate the availability of natural plant nitrogen needs, but its disadvantages is obvious duo to its environment hazards. Jadhav (1981) stated that dry matter and nitrogen content of maize increased by additive nitrogen fertilizer application. Sudhir *et al.* (2000) reported that an increase of biomass by application of manure and Azotobacter inoculation together with nitrogen fertilizer higher than when mineral nitrogen fertilizers were applied. Meshram et al. (1982) also reported the same results. According to Tylak *et al*. (1989), Azotobacter inoculation positively affected maize and sorghum dry matter. Majumdar *et al.* (2007) found that the interaction effect of N, farmyard manure and biofertilizer was significant on rice yield. They reported that a combined dose of 60 kg N, five tones farmyard manure and seed inoculation with Azotobacter was most suitable for the upland paddy production (3.9 ton/ha) with adequate nitrogen build up in Alison of Meghalaya region. Results of Kumari

[+] Corresponding author. Tel.: +989126547857
E-mail address: farboodi@gmail.com.

and Dhar (2010) on system productivity indicated the 50% saving of NPK in wheat by application of 60 kg N/ha (farmyard manure) + cowpea green manuring + Azotobacter in maize.

As Iranian soils have low organic matter and Azotobacter activity, the present study was conducted to investigate the efficiency of manure and Azotobacter together with mineral nitrogen application on growth characteristics of maize.

2. Materials and Methods

2.1. Greenhouse studies

The experimental plants were planted in pots which poured with nitrogen (total-N<0.01%) and organic carbon deficit soil belongs to *Taxonomic* family of *Calcareous montmorilonitic fluventic, camborthids*. Primarily, in a factorial trail based on a completely randomized design (CRD) with three replications, the seeds were treated by two levels of *Azotobacter chroococcum* including non inoculation (A0) and inoculation (A1), two levels of manure ($O_0 = 0$ and $O_1 = 10$ ton.ha^{-1}) and four levels of nitrogen (N_0, N_{75}, N_{150} and N_{225} kg.ha^{-1}) from urea source. Five seeds of corn (*Z. mays* L.) var. SC-647 then were planted in each pot. The pots were irrigated by pool water (table 2) for reaching to field capacity (FC) every three days. The measured traits and growth characteristics were biomass, kernel weight, plant height, chlorophyll content, stem diameter, flowering time and protein content.

Table 1. Field soil samples analysis used in the experiment.

Depth (cm)	pH	ECe (dS. m^{-1})	OC (%)	$CaCO_3$ (%)	Olsen-P (mg.kg^{-1})	K (mg.kg^{-1})	Sand (%)	Silt (%)	Clay (%)	SP (%)
0-30	7.8	1.7	0.1	10.25	4.7	250	32	38	30	50

2.2. Data analysis

The experiment was conducted as factorial based on completely randomized design with three replications. The data were analyzed using GLM procedure by SAS software and Duncan's multiple range tests was used for mean comparisons at 1% of probability level. Microsoft Excel was also used for graphs preparation.

3. Results and discussion

The data of analysis of variance showed that the main effect of Azotobacter (A), manure (O) and nitrogen (N) levels and their interactions including A×O, A×N, N×O and A×N×O were significant on all traits studied such as biomass, protein and chlorophyll contents, kernel weight, stem diameter, flower emergence days. Mean comparisons showed that application of $A_1O_1N_2$ and $A_1O_1N_3$ treatments resulted in the highest protein content (8.75%) in maize plant tissues and the lowest protein content (3/6%) was observed in $A_0O_0N_0$ treatment (figure 1). The $A_1O_1N_3$ and A_0O_0 treatments produced the highest and the lowest maize biomass, respectively (Figure 2).

The results obtained in the present study were in agreement with other researcher's findings. Kizilog *et al.* (2010) by a greenhouse experiment in Turkey concluded that inoculation of seeds with *Azotobacter chroococcum* increased carbohydrate and protein content of two corn varieties (Inra210 and Inra260). Jadhav (1981) also stated that dry matter and nitrogen content of maize increased by additive nitrogen fertilizer application. Meshram and Shende (1982) reported the positive effect of manure and Azotobacter application on maize biomass, too.

Table2. The mean squares of different nitrogen levels, Azotobacter *chroococcum* inoculation and manure treatments effects on maize var.SC-64 growth characteristics.

S.O.V	DF	Mean squares						
		Biomass	Protein	Chlorophyll Content	Kernel weight	Stem diameter	Plant height	Flower emergence time
Azotobacter (A)	1	5449**	323**	5.873**	191.17**	0.044**	3981.2**	336.021**
Nitrogen (N)	3	8802.3**	257.07**	0.199**	162.61**	0.041**	295.7**	196.021**
Manure (O)	1	3731.3**	95.053**	4.066**	995.9^{ns}	0.098**	399.6**	256.79**

A×O	1	767.7**	25.06**	0.383**	46.6**	0.005**	202.17**	77.531**
A×N	3	218.8**	21.04**	0.832**	80.81**	0.01**	546.2**	2.63**
N×O	3	267.4**	7.01**	0.012**	63.7**	0.009**	1.415**	8.96**
A×N ×O	3	364.8**	42.78**	0.587**	78.46**	0.001**	253.5*	20.89**
Error	32	21.12	1.28	0.00	18.74	0.00	49.6	0.043
CV (%)	-	14.78	6.66	4.2	10.84	12	26.77	0.26

* and ** : significant at 0.05 and 0.01 of probability levels, respectively.

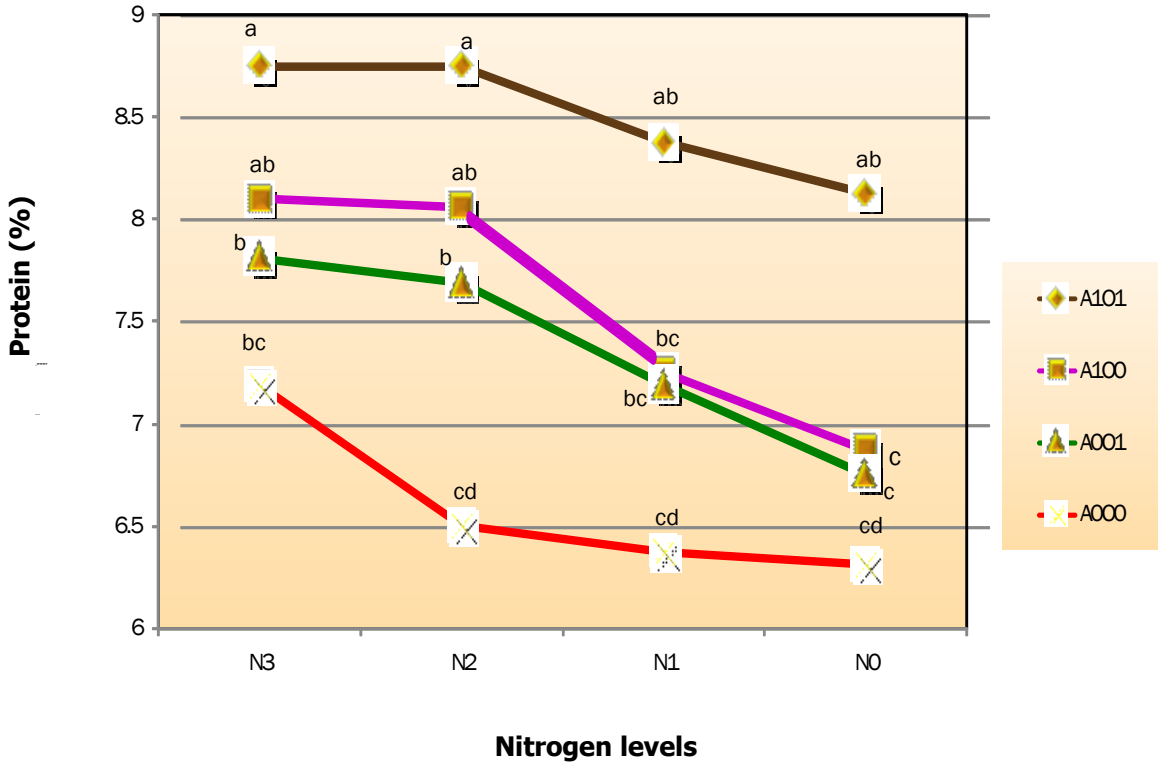

Fig.1. Mean comparison of maize protein content which affected by Nitrogen × Manure × Azotobacter inoculation treatments interactions

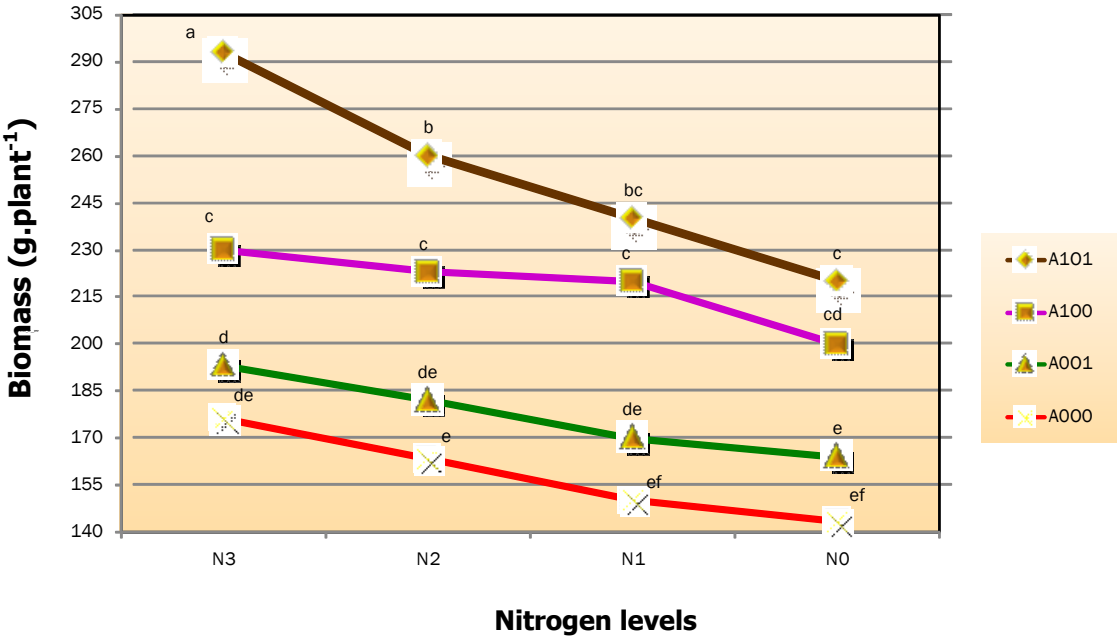

Fig.2. Mean comparison of maize dry biomass which affected by Nitrogen×Manure×Azotobacter treatments interactions

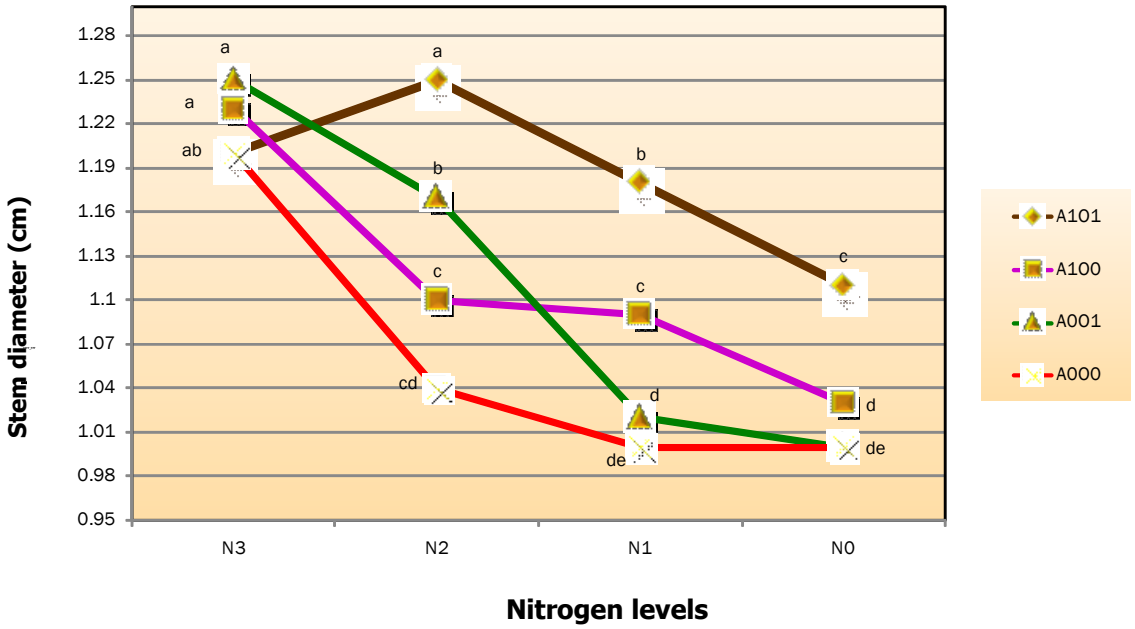

Fig.3. Mean comparison of maize stem diameter which affected by Nitrogen×Manure×Azotobacter treatments interactions

4. Conclusion

The rate of 225 kg.ha^{-1}nitrogen fertilizer and 10 ton.ha^{-1} manure application with inoculation of seeds by Azotobacter produced the maximum biomass, kernel weight and chlorophyll content. However, the rate of 150 kg/ha nitrogen is recommended because it placed in the same statistical group with 225 kg.ha^{-1} for the mentioned traits. Amount of 150 kg.ha^{-1} nitrogen fertilizer application together with manure and seed inoculation with Azotobacter was also more effective than 225 kg.ha^{-1} to achieve the maximum values of protein content, plant height, stem diameter. In conclusion, application of 150 kg.ha^{-1} nitrogen fertilizer together with 10 ton.ha^{-1} manure and inoculation of seeds by Azotobacter was recommended to obtain the reasonable growth characteristics.

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