J. Basic. Appl. Sci. Res., 3(2)180-185, 2013
© 2013, TextRoad Publication

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Growth Analysis of Corn (*Zea mays* L.) as Influenced by Indole-Butyric Acid and Gibberellic Acid

Vahid Ghodrat[1], Mohammad Javad Rousta[2] and Abbas Karampour[3]

[1, 3] Department of Agriculture, Arsanjan Branch, Islamic Azad University, Arsanjan, Iran
[2]National Salinity Research Center, Yazd, Iran

ABSTRACT

The aim of present investigation was to study the effect of Indole - butyric acid (IBA) and Gibberellic acid (GA_3) on growth of corn (*Zea mays* L.) single cross 704. Two field experiments during the 2009-10 and 2010-11 growing seasons were conducted near the city of Shiraz. The experiment was randomized complete blocks, split plot design with three replications. The foliar application of two growth regulators (GA_3, IBA) in two physiological sensitive growth phases, i.e. 4 to 6 leaf and flowering stages constituted the main plots and concentration of 0, 50 and 100 mg L^{-1} of both IBA and GA_3 formed the subplots. Evaluated physiological traits include, net assimilation rate, crop growth rate and leaf area index. Compared to the control, the greatest leaf area index is obtained by applying GA_{3-50} in 4-6 leaf stage of growth. The highest increase of crop growth rate (11.4 gr m^{-2} day^{-1}) belonged to $IBA_{100}GA_{3-100}$ treatment in 4 to 6 leaf stage. The best net assimilation rate was obtained in the treatment $IBA_{100}GA_{3-50}$ with 2.72 gr m^{-2} day^{-1}. Totally, the results show that in both stages of growth, application of IBA and GA_3 improves growth parameters.

KEYWORDS: Spray, IBA, GA_3 and corn.

INTRODUCTION

Certainly, sustainable production can be achieved by selecting effective approaches, which make maximum use of the means of production to stimulate high yield, preserve water and soil and produce better long-term profit. However, to obtain a favorable yield there first needs to be an understanding of the morphological and physiological parameters of the plant, the roles of the various yield components, and identification of the most important factors instrumental in increasing those components. Therefore, identification of these relevant factors can potentially increase yield [1]. There is an important relationship between source and sink in plant physiology. The fact that source or sink can limit the yield is a challenging subject to plant physiologists. One of the effective factors that can control the size of sink and source are plant growth regulators [2]. IBA increases the ability of cell division in meristematic zones of plant and hence the ability of plant to absorb nutritive material which finally lead to the increase of grain yield [3]. The other regulator, GA, also increases the sink strength via increasing the length and growth rate of cells [3]. Additionally, both growth regulators increase the strength of physiological source by increasing chlorophyll [4] and effective age of leaves [5] which also lead to the increase of grain yield per area. Some researchers have shown that spraying GA_3 or IAA on leaves considerably increases the growth rate of corn [6]. In another experiment, application of 2-4-D (in low concentration act like IAA) has increased length, number of leaves and grain yield [7]). Also, Cao and coworkers [8] showed that application of GA_3 increased the growth, protein secretion, and starch accumulation in maize endosperm suspension cells. Spraying different concentration of gibberellic acid over the plans at 3-4 leaf growth stage increase seed yield and yield components in soybean [1]. Considering the successful applications of natural growth regulators mentioned above, this work is conducted to investigate the best time and concentration to implement two growth regulators- i.e., IBA and GA_3. To achieve this, we have studied the important factors such as leaf area index, crop growth rate and net assimilation rate of corn.

MATERIALS AND METHODS

A field experiment was performed near the city of Shiraz in Iran (53°13'N, 27°17'E) during 2009-2010 and 2010-2011growing seasons. The soil texture was Clay Loam. The result of soil analysis is shown in Table 1. The experiment was randomized complete blocks, split plot design with three replications. The foliar application of two growth regulators (GA_3, IBA) in two physiological sensitive growth phases, i.e. 4 to 6 leaf and flowering stages constituted the main plots and concentration of 0, 50 and 100 mg L^{-1} of both IBA and GA_3 formed the subplots.

Corresponding author: Vahid Ghodrat, Department of Agriculture, Arsanjan Branch, Islamic Azad University, Arsanjan, Iran. Tel: (+98)9177126168. Email: vahid.ghodrat@gmail.com

Each experimental plot had an area of 16 m^2 including five planting rows of 3m length and 0.6m distance from one another. Each two plants were 20cm apart. The test crop was corn (*Zea mays* L.) single cross 704. Required nitrogen and phosphorous were applied to each plot as urea (0.46 N) and ammonium phosphate (0.17 N, 0.26 P) at the rate of 400 and 250 kg ha^{-1} based on soil analysis, respectively. Half of the nitrogen fertilizer (urea) was top dressed at the 6-leaf stage. The plots were regularly hand weeded and irrigated by furrow irrigation at weekly intervals. The growth regulators were weighed out and dissolved in small volume of ethanol and then brought up to the required volumes by tap water. The growth regulators were used as foliar application by a back-pack sprayer system consisting of a hand-held boom with nozzles 0.76 m apart. Plots were sampled at 2-weekly intervals from after sowing to final harvest. At each sampling 5 plants from the central three rows of each plot were taken for laboratory measurements of LAI and dry matter. Crop growth rate (CGR), net assimilation rate (NAR) and leaf area index (LAI) was determined using the following equations:

Leaf Area Index (LAI) was calculated from the following formula:

$$LAI = \frac{\text{Leaf area}}{\text{Land area}} \quad [9]$$

Crop Growth Rate (CGR) and Net Assimilation Rate (NAR) were determined by the formula given by [10]

$$CGR = \frac{1}{P} \times \frac{W_2 - W_1}{t_2 - t_1} \quad (\text{g m}^{-2}\ \text{day}^{-1})$$

$$NAR = \frac{W2 - W1}{T2 - T1} \times \frac{\text{Ln LA}_2 - \text{Ln LA}_1}{\text{LA}_2 - \text{LA}_1} \quad (\text{g m}^{-2}\ \text{day}^{-1})$$

P = ground area
W_1 = total dry matter at time T_1
W_2 = total dry matter at time T_2
LA = Total leaf area
LA_1 = Total leaf area at time T_1
LA_2 = Total leaf area at time T_2
Ln = Natural logarithm

Data were analyzed using ANOVA, by SAS software. The means were compared using Duncan multiple range test ($p < 0.05$). The results of two years were very similar and therefore, the result of experiment in 2010 has been only reported in this study.

Table 1: Soil physicochemical characteristics of the experimental field.

Physicochemical characteristics	
Physical characteristics	
Classification	**Clacixerollic,**
Xeropchrepts	
Field capacity (%)	**32**
Wiling point (%)	**14**
Silt (%)	**45**
Clay (%)	**36**
Sand (%)	**20**
Soil texture	**Clay Loam**
Chemical characteristics	
Soil pH	**7.5**
Potassium (mg kg^{-1})	**561**
Phosphorus (mg kg^{-1})	**12**
Organic carbon (%)	**0.84**
Organic matter (%)	**0.91**
Total nitrogen (%)	**0.112**
Fe (mg kg^{-1})	**3.9**
Mn (mg kg^{-1})	**0.8**
Zn (mg kg^{-1})	**0.62**
Cu (mg kg^{-1})	**2.3**
Electronic conductivity (dSm^{-1})	**0.55**

RESULTS AND DISCUSSION

Leaf Area Index (LAI)

Leaf area index is considered to have the most important role among the various factors that affect the growth and yield of plant. The reason is that dry matter accumulation in growth period is a function of sunlight absorption and thus a function of LA according to Buger-Lamberg-Bear law [11]. Additionally, the grain yield is directly affected by leaf area index. Our results indicate that the application of different concentrations of IBA in both stages of growth lead to an increase of LAI compared to the control treatment. As it is shown in table (2), IBA treatment in 4-6 leaves stage is more effective than the flowering stage. The concentration of IBA, however, does not drastically change the leaf area. Treatments with GA_3 also increase the leaf area index compared to the control. The greatest LAI is obtained by application of $GA_{3\text{-}50}$ in 4-6 leaf stage of growth. The interaction effect of IBA and GA_3 shows that the best result is obtained for treatment with $GA_{3\text{-}100}$ regardless of the concentration of IBA. Totally, the most effective treatments to increase LAI are $GA_{3\text{-}50}$ treatment in 4-6 leaf stage and combined application of IBA_{100} and $GA_{3\text{-}50}$ in flowering stage (Table 2). These findings are in agreement with Khan *et al.* [12] and Ashraf *et al.* [13] who investigated the effect of gibberellic acid on mustard and wheat, respectively. Moreover, IBA application for baby corn by Thavaprakaash *et al.* [7] has led to the increase of LAI in agreement with our results.

Table 2. Effect of different application time (4-6 leaf stage or flowering stage), IBA levels and GA_3 levels on LAI

LAI		
	4-6 leaf	**flowering**
Control	3.14F	3.17F
IBA_{50}	4.33ABCD	4.15BCDE
IBA_{100}	4.33ABCD	4.17ABCDE
$GA3_{50}$	4.77A	4.13BCDE
$GA3_{100}$	4.48ABC	3.84DE
$IBA_{50}GA3_{50}$	4.17ABCDE	3.67EF
$IBA_{50}GA3_{100}$	4.48ABC	4.07BCDE
$IBA_{100}GA3_{50}$	3.91CDE	3.97BCDE

Means with the same letter(s) are not significantly different using Duncan (0.05)

Crop Growth Rate (CGR)

CGR is an index of canopy photosynthesis and its trend represents the rate of biological yield (dry weight) accumulation [14]. Results showed that the growth rate increases by application of growth regulators, reaches its maximum value at flowering stage and decreases afterwards. Application of 100mg L^{-1} IBA and GA_3 in 4-6 leaf stage showed the highest amount of CGR 8.6 and 10. gr m^{-2} day^{-1}, respectively. Interaction effects between IBA and GA_3 showed that the highest increase of crop growth rate (11.4 gr m^{-2} day^{-1}) belonged to $IBA_{100}GA_{3\text{-}100}$ treatment as illustrated in Figure. 1. In the flowering stage, the best results are obtained for treatment with IBA_{50} and $GA_{3\text{-}50}$ with CGR 6.8 gr m^{-2} day^{-1} and 6.8 gr m^{-2} day^{-1}, respectively. In the study of the interaction effect in flowering stage the best result was obtained for $IBA_{100}GA_{3\text{-}100}$ with CGR 7.3 gr m^{-2} day^{-1} as it can be seen in Figure. 2. The results are in good agreement with findings of [15] and [16].

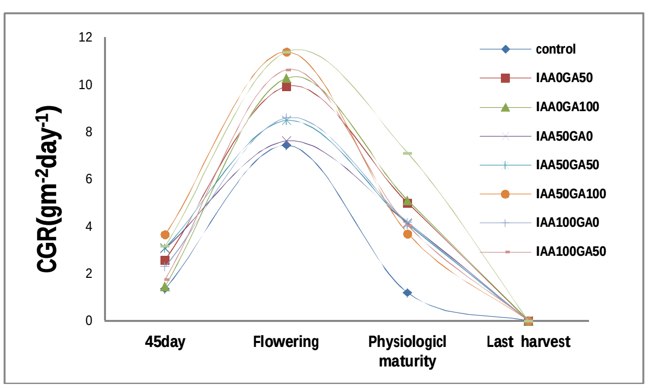

Figure 1. Effect of Indole - butyric acid and Gibberellic acid levels on Crop Growth Rate (CGR) of corn plant in 4 to 6 leaf phase (2010)

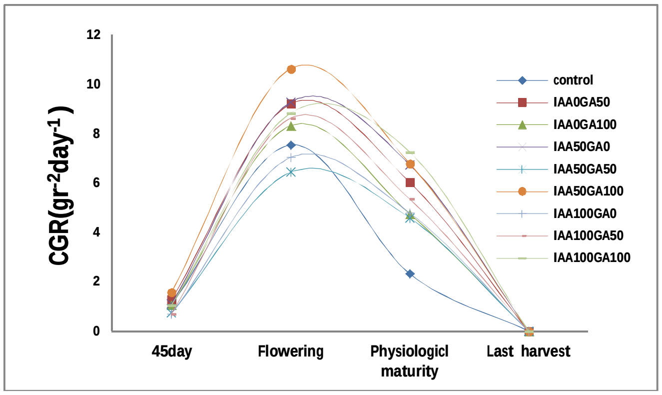

Figure 2. Crop Effect of Indole - butyric acid and Gibberellic acid levels on Crop Growth Rate (CGR) of corn plant in flowering stage (2010)

Net Assimilation Rate (NAR)

The net assimilation rate represents the amount of produced dry matter per leaf area per unit of time and is thus a measure of leaf photosynthetic efficiency. It is well-known that in first stages of growth almost all of the leaves are exposed to the sunlight and the assimilation rate is in its highest level. As the plants grow and LAI increases gradually fewer leaves receive full sunlight and therefore the net assimilation rate decreases [14]. In this experiment, the net assimilation rate shows a decreasing pattern by time, however, the patterns were not similar for all treatments. For example, in 4-6 leaves stage the best result in both IBA and GA_3 obtained for concentration of 50mg L^{-1} with NAR 2.53 gr m^{-2} day^{-1} and 2.71 gr m^{-2} day^{-1}, respectively. In this stage, the interaction effect of GRs gives the best result for $IBA_{100}GA_{3\text{-}50}$ treatment with net assimilation rate 2.72 gr m^{-2} day^{-1} as shown in Figure. 3. In flowering stage, application of 50 mg L^{-1} of GA_3 and IBA were more effective than others with NAR 1.5 gr m^{-2} day^{-1} and 1.6 gr m^{-2} day^{-1}, respectively. In this stage, the best result was obtained for $IBA_{100}GA_{3\text{-}100}$ treatment with NAR 1.8 gr m^{-2} day^{-1} (See Figure. 4.). Our findings are in agreement with results of Shaker *et. al* [15] and Rahman *et. al* [16].

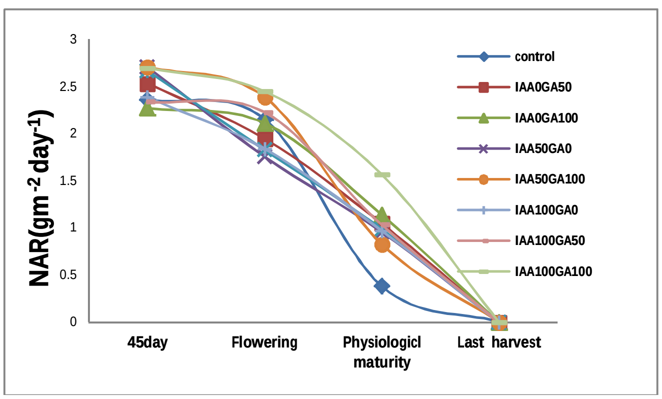

Figure 3. Effect of Indole - butyric acid and Gibberellic acid levels on Net Assimilation Rate (NAR) of corn plant in 4 to 6 leaf phase (2010)

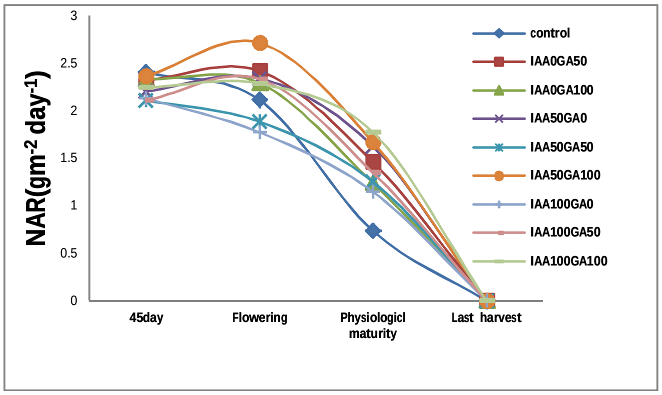

Figure 4. Effect of Indole - butyric acid and Gibberellic acid levels on Net Assimilation Rate (NAR) of corn plant in flowering stage (2010)

CONCLUSION

In this experiment physiologic properties of maize under the influence of IBA and GA_3 application in 4-6 leaf as well as flowering stage were studied. Our results indicate that using growth regulators in higher concentrations or implementing a combination of regulators are more effective. In 4-6 leaf stage, the leaf area index, crop growth rate and net assimilation rate are significantly affected by application of growth regulators which implies that these GRs have increased the power of source and thus increased the transport of assimilates to the sink including roots and young leaves. In flowering stage, the ears begin to appear and leaves are in their maximum growth rate. Therefore, the application of GRs affects the power of sink. According to our results, we suggest that the plants be treated in 4-6 leaf stage when maize is planted to produce corn silage and in both stages if it is planted to produce corn seed.

REFERENCES

1. Azizi, K.H., J. Moradii, S. Heidari, A. Khalili and M. Feizian, 2012. Effect of different concentrations of gibberellic acid on seed yield and yield components of soybean genotypes in summer intercropping. Inte. J. Agi. Sci., 2(4): 291-30

2. Taiz, L. and E. Zeiger, 2002. Plant physiology, 3rd edition, Sinauer Associates Inc. Pub., M.A.

3. Arteca, R. N., 1996. Plant Growth substances, principles and applications, Chapman & Hall, N.Y.

4. Wareing. P.F., M.M. Khalifa and K.J. Treharne, 1968. Rate-limiting processes in photosynthesis at saturating light intensities. Nat., 222: 453-457

5. Nooden, L.D. and A.C. Leopold, 1978. Phytohormones and the endogenous regulation of senescence and abscission. In phytohomones and related compounds, a comprehensive Treatise. Vol. 2: Phytohormones and the Development of Higher plants, Elsevier, Amsterdam, pp., 329-370

6. Koter, M., J. Czapla, G. Nowak and J. Nowak, 1983. Study on use of growth regulators in agricultural production. 1. Effect of GA_3, IAA, and kinetin on growth and development of bean, maize and flax. Plant. Phy. bioch., 36:17-27

7. Thavaprakaash, N., K. Velayudham and L. Gurusamy, 2007. Influence of herbicides growth regulators on growth and yield of Baby Corn (*Zea mays* L.). Int. J. Agr. Res., 2(8): 731-735

8. Cao, H. and C. Shannon, 1997. Effect of gibberellin on growth, protein secretion, and starch accumulation in maize endosperm suspension cells. J. Plant. Gro. Reg., 16(3): 173-140

9. Watson, D.J., 1952. The physiological basis of variation in yield. Adv. Agron., 4: 101-145

10. Hunt, R., 1978. Plant Growth Analysis *(Studies in Biology)*, Edward Arnold Ltd., London , pp: 67

11. Tollenar, M. and A. Aguidera, 1991. Radiation use efficiency of an old and a new maize hybrid. Agron. J. 84:483-562

12. Khan, N. A., M. Mobin and Samiullah, 2005. The influence of gibberellic acid and sulfur fertilization rate on growth and S-use efficiency of mustard (*Brassica juncea*). J. Plant. Soil., 270(1): 269-274

13. Ashraf, M., F. Karim and E. Rasul, 2002. Interactive effects of gibberellic acid (GA_3) and salt stress on growth, ion accumulation and photosynthetic capacity of two spring wheat (*Triticum aestivum* L.) cultivars differing in salt tolerance. J. Plant. Gro. Reg., 36(1): 49-59

14. Gardner, F. P., R.B. Pearce and R.L. Mitcheii, 1985. Physiology of Crop Plant, Iowa State University Press. Ames, Iowa

15. Sarkar, P.K., M.S. Haque and M.A. Karim, 2002. Growth analysis of soybean as influenced by GA_3 and IAA and their frequency of application. Pakistan J. Agr., 1(4): 123-126

16. Rahman, M.S., N.I.M.A. Tahar and M.A. Karim, 2004. Influence of GA_3 and MH and their time of spray on dry matter accumulation and growth attributes of Soybean. Pakistan J. Bio. Sci., 7(11):1851-1857