



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBPAS)**

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

**IMPACT OF FOLIAR APPLICATION OF SALICYLIC ACID ON GROWTH,
YIELD AND YIELD COMPONENTS OF MAIZE PLANTS**

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ABSTRACT

Salicylic acid belongs to a group of plant phenolics. It can inhibit certain physiological and biochemical processes and enhance others. The effectiveness of application of growth regulators depends on different factors such as developmental stage of the plant, the method of application and the concentration of growth regulator. The subject of this experiment was evaluation of the effects of spraying by different concentrations of salicylic acid on growth, yield and yield components of maize plants cultivar Single Cross 704 at two stages of plant growth. The study was carried out using salicylic acid (0, 0.4, 0.8 and 1.2 mM) and time of application (before flowering and after pollination) in a factorial experiment based on randomized complete block design (RCBD) with three replications at a field in Firoozabad, State of Fars, Iran. Our results revealed that spraying by salicylic acid and the time of application altered some of characteristics of growth, yield and yield components of maize plants significantly. Under present experimental conditions, foliar application of 1.2 mM salicylic acid before flowering resulted in the highest value of kernel yield at maize plants cultivar Single Cross 704.

Keywords: Growth Regulators, *Zea mays*, Kernel Yield, Corn, SC 704

INTRODUCTION

Corn or maize (*Zea mays* L.) from family Poacea is an annual grass plant. It is an American native plant which is cultivated in numerous varieties through the world. The hybrid cultivars are preferred by farmers

because of high-grain yield [1]. It is one of the most important cereal crop grown during summer in Iran. After wheat and rice, maize is the third cereal crop grown all over the

world in a wide range of climatic conditions [2].

Natural and artificial plant growth regulators are widely applied in agriculture for manipulation of plant growth and yield [3]. Salicylic acid belongs to a group of plant phenolics and is a natural signaling molecule involved in the regulation of different physiological and biochemical processes.

Salicylic acid and related compounds can inhibit certain processes and enhance others [4]. It can regulate physiological processes such as ion uptake and inhibition of ethylene biosynthesis especially under stress conditions in plants [5, 6]. Salicylic acid is biosynthesized from the phenylalanine in plant metabolism and considered as an important signaling molecule for plant responses to abiotic stresses [7] such as heavy metals [8], herbicides [9] and low temperatures [10]. It is an important signaling compound involved in establishing local and systematic disease resistance responses of plants against pathogens [11]. Exogenous application of salicylic acid enhances plant growth and photosynthetic capacity in stress conditions [12, 13] and can enhance leaf area and plant dry matter production [14]. Salicylic acid has a significant role in plant water relations [15], photosynthesis, growth and stomatal regulation [14, 16]. It can enhance the yield

of crops [17]. It has also been reported to reverse the closure of stomata caused by abscisic acid [18]. Literature indicated that salicylic acid can enhance antioxidant enzymes activity such as superoxide dismutase, peroxidase and catalase [19].

Salicylic acid could improve physiological properties of maize seedlings under stress conditions [20]. Zamaninejad *et al.*, revealed that salicylic acid at 1 mM resulted in the highest values of yield and yield components of corn plants [21]. Singh and Kaur showed an increase in yield and number of pods in mung bean by application of salicylic acid [22]. Exogenous application of Salicylic acid can decrease the detrimental effects of stress and control growth and development in maize plants. Plants in salt stress conditions can enhance dry matter with application of salicylic acid which may be due to antioxidants and protective role of membranes [23]. El-Khallal *et al.*, reported that photosynthetic pigments of maize plants (chl a, chl b, carotenoids) increased by application of salicylic acid. Salicylic acid increased content of N, P, K⁺, Ca⁺² and Mg⁺² in maize shoots [3]. Sharafizad *et al.*, indicated that the highest yield of wheat was achieved by application of 0.7 mmol salicylic acid at vegetative stages [24].

The effectiveness of growth regulator application depends on different factors

such as the species, developmental stage of the plant, the method of application and the concentration of growth regulator. The aim of this study was evaluation of the effects of application of different salicylic acid concentrations on growth, yield and yield components of maize plants cultivar Single Cross 704 by foliar spraying at two stages of plant growth.

MATERIALS AND METHODS

Plant Materials and Experimental Conditions

This study was carried out using foliar application of salicylic acid (0, 0.4, 0.8 and 1.2 mM) on maize plants cultivar Single Cross 704 at two times (before flowering and after pollination) in a factorial experiment based on randomized complete block design (RCBD) with three replications at a field in Firoozabad (1330 m above sea level), State of Fars, Iran. Each plot (3×2.5 m) contained rows with spacing of 25 cm between plants within row and 75 cm between rows. Spraying of salicylic acid was done twice within one week both before flowering and after pollination. Before planting, potassium sulfate (150 Kg/ha) and triple super phosphate (100 Kg/ha) were mixed with soil. Urea at the rate of 250 Kg/ha was used. Finally, eight plants were randomly harvested from each plot for measurement of plant height, ear height, leaf number, stem diameter, ear diameter, ear

length, row number per ear, kernel number per row, 1000-kernel weight and kernel yield.

Statistical Analysis

Data from the experiment were subjected to analysis of variance (ANOVA) using SAS computer software at $P < 0.05$ and means compared with Duncan's new multiple range test (DNMRT).

RESULTS AND DISCUSSION

Our data indicated that spraying by salicylic acid altered some of characteristics of growth, yield and yield components of maize plants significantly (**Table 1**). The plant height was the maximum (246.4 cm) at 1.2 mM which was significantly different when compared to other concentrations. The highest value of ear height (81.5 cm) was obtained at 1.2 mM which was not significantly different when compared to 0.4 and 0.8 mM. The leaf number was not significantly different when salicylic acid was used. The highest value of stem diameter (22.6 mm) was achieved on 1.2 mM which was significantly different when compared to control and 0.4 mM. The ear diameter did not show any difference among the treatments. The maximum of ear length (24.4 cm) was obtained at 1.2 mM which was significantly different when compared to control. The kernel number per row and 1000-kernel weight were maximum (44.3 and 337.0 g, respectively) by application of

1.2 mM salicylic acid. The highest value of kernel yield (344.4 g/plant) was achieved on 1.2 mM which was significantly different when compared to other treatments.

The time of spraying by salicylic acid influenced on growth, yield and yield components of maize plants (**Table 2**). Spraying before flowering was more effective than after pollination. The highest values of plant height, ear height, stem diameter, ear diameter and ear length were obtained by spraying of salicylic acid before flowering. The leaf number and row number per ear did not show any significant difference. The maximum of the kernel number per row (45.1), 1000-kernel weight (334.5 g) and kernel yield (304.5 g/plant) were achieved by application of salicylic acid before flowering.

Salicylic acid is recognized as a novel group of phytohormones to regulate the plant growth, stomatal closure, protein synthesis and transpiration at very low amounts [3]. Salicylic acid may increase the function of photosynthetic machinery in plants by mobilization of nitrate in internal tissue or chlorophyll biosynthesis [25].

Application of salicylic acid in present study increased growth of maize plants in comparison to control. These results are in agreement with those obtained by Khodary regarding the maize [26].

Salicylic acid with decreasing evapotranspiration and increasing root development can help root to absorb more nutrients [24]. A cellular salicylic acid-binding protein which shares high sequence identity with plant catalase was identified in tobacco leaves [27], so it can play a role in controlling the stress.

Shakirova et al. revealed that salicylic acid increased cell division in meristem of wheat seedling and improved plant growth [5]. Khandaker et al. reported that application of salicylic acid at low concentrations improved plant growth but at higher concentrations decreased the growth [28]. Application of salicylic acid can increase the rate of assimilation that shows improvement in the content of chlorophyll [29]. An experiment indicated that chlorophyll and carotenoid contents of the leaves of maize increased by treatment with salicylic acid [30].

Salicylic acid can affect on membrane permeability and mitochondrial respiration [31]. Application of salicylic acid may inhibit polysaccharide hydrolyzing enzymes and/or accelerate the incorporation of soluble sugars into polysaccharides [32]. Phenolic compounds may act as a signal, which induce the differentiation processes. Because of the chelating properties of phenolic compounds, they may inactive some inhibitors [33].

Table 1: Influence of Salicylic Acid on Growth, Yield and Yield Components of Maize Plants

Salicylic acid (mM)	plant height (cm)	ear height (cm)	leaf no	stem diameter (mm)	ear diameter (mm)
0	216.2c	70.2b	13.1a	20.1b	48.1a
0.4	227.2b	74.6ab	13.3a	19.7b	48.9a
0.8	235.4b	80.5a	13.4a	22.0a	48.1a
1.2	246.4a	81.5a	13.6a	22.6a	47.1a

NOTE: In Each Column, Means with the Same Letters are Not Significantly Different at 5% Level of Duncan's New Multiple Range Test

Table 1 (continued)

Salicylic acid (mM)	ear length (cm)	row no/ear	kernel no/row	1000-kernel weight (g)	kernel yield (g/plant)
0	20.6b	15.5a	39.7b	300.1b	265.3b
0.4	21.8ab	15.0a	40.0ab	303.4b	251.2b
0.8	23.2ab	15.6a	42.9ab	312.2b	279.1b
1.2	24.4a	16.0a	44.3a	337.0a	344.4a

NOTE: In each Column, Means with the Same Letters are not Significantly Different at 5% Level of Duncan's New Multiple Range Test

Table 2: The Effect of Time of Spraying by Salicylic Acid on Growth, Yield and Yield Components of Maize Plants

Time of spraying	plant height (cm)	ear height (cm)	leaf no	stem diameter (mm)	ear diameter (mm)
Before flowering	245.6a	83.8a	13.4a	21.7a	50.0a
After pollination	217.0b	69.6b	13.4a	20.5b	46.2b

NOTE: In Each Column, Means with the Same Letters are not Significantly Different at 5% Level of Duncan's New Multiple Range Test

Table 2 (continued)

Time of spraying	ear length (cm)	row no/ear	kernel no/row	1000-kernel weight (g)	kernel yield (g/plant)
Before flowering	24.5a	15.2a	45.1a	334.5a	304.5a
After pollination	20.5b	15.8a	38.6b	291.9b	265.5b

In Each Column, Means with the Same Letters are Not Significantly Different at 5% Level of Duncan's New Multiple Range Test

CONCLUSION

Under present experimental conditions, foliar application of 1.2 mM salicylic acid can be recommended as an appropriate concentration for obtaining the highest value of kernel yield at maize plants cultivar Single Cross 704. Spraying of salicylic acid before flowering can be recommended in this study.

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